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SCHOOL OF SPORTS EDUCATION AND RESEARCH

IN ASSOCIATION WITH DEPARTMENT OF ALLIED HEALTHCARE AND SCIENCES

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NATIONAL CONFERENCE ON PHYSIOTHERAPY PHYSICAL EDUCATION, SPORTS SCIENCES AND ALLIED SCIENCES

2025
KONVERGE

EDITED BY

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Edited by

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PREFACE

With the deepest sense of purpose and scholarly devotion, we present the **Proceedings of KONVERGE 2025**, a most distinguished gathering that marks a new era in the study of **Physiotherapy, Sports Sciences, Physical Education, and Allied Health Sciences**. This noble conference, hosted by the **School of Sports Education and Research (SSER), Jain (Deemed-to-be University),** doth aspire to be a beacon of enlightenment, wherein learned minds may convene to exchange their wisdom and partake in discourse most erudite.

Guided by the exalted theme, **"Unlocking Human Potential Through Unified Research in Sports Sciences, Physiotherapy, Physical Education & Allied Sciences,"** this symposium seeks to explore the grandest innovations, the most intricate methodologies, and the boundless possibilities that lie at the confluence of science and human endeavor. Herein, the sagacity of **eminent scholars, practitioners, and researchers** shall be presented, fostering a dialogue that shall shape the future of human performance, rehabilitation, and the pursuit of athletic and scholarly excellence.

This volume's contents are drawn from the most enlightened contributions, encompassing research papers, learned discourses, and profoundly significant deliberations. Assembled with the greatest care, they shall stand as a testament to the industrious spirit of inquiry and discovery that defines our age.

We are indebted to the honorable members of the Organizing Committee, the Scientific Advisory Board, and the esteemed speakers and participants, whose indefatigable labor and steadfast dedication have rendered this conference a resplendent success. Their efforts shall serve as a foundation for further exploration and the relentless pursuit of truth in sports science and healthcare.

We fervently hope that this compendium will illuminate the path for future scholars and practitioners, inspiring them to delve deeper into their respective fields' mysteries and strive ever towards excellence.

May wisdom and innovation flourish, now and for all time.

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Dr. U. V. SANKAR Ph.D,NIS (ATH)

Director,

School of Sports Education and Research,

JAIN (Deemed -To-be-University)

It is with profound honor and the utmost pleasure that we present the **Conference Proceedings of KONVERGE 2025**, the **First National Conference on Physiotherapy, Sports Sciences, Physical Education, and Allied Health Sciences**. Convened under the esteemed auspices of the **School of Sports Education and Research (SSER), Jain (Deemed-to-be University)**, this learned assembly doth stand as a beacon of erudition, innovation, and scholarly discourse in the ever-expanding realms of sports sciences and healthcare.

Under the grand theme **"Unlocking Human Potential Through Unified Research in Sports Sciences, Physiotherapy, Physical Education & Allied Sciences"**, KONVERGE 2025 doth graciously summon forth the most distinguished **scholars, academicians, physicians, sportsmen, and learned experts** that they might engage in discourse most profound and present inquiries most enlightened upon the noble advancements of science and the art of human excellence. Herein shall be explored the most modern practices, groundbreaking revelations, and the manifold wonders of technology that shape the fields of **rehabilitation, physical culture, and the science of movement**.

Contained within these **proceedings** is a treasury of knowledge most precious, a repository of intellect drawn from the finest minds of our age. May these writings serve as both a lamp unto the future and a chronicle of the ingenuity that hath brought us thus far. In uniting theory and practical wisdom, we illuminate the path toward scholarly triumph and advancing **human performance**.

We extend our sincere thanks to the revered Organizing Committee, the venerable Scientific Advisory Board, the honorable speakers, and all learned participants whose unwavering dedication has made this gathering a true symposium of enlightenment and intellectual elevation.

May these **proceedings inspire and guide**, ensuring that future generations consider our endeavors a foundation to build ever-greater discoveries.

Dr. U.V. SANKAR

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Dr. T. Arun Prasanna

Assistant Professor,

School of Sports Education and Research,

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Jain (Deemed -To- be University)

We take great pride in presenting the Proceedings of KONVERGE 2025, commemorating the inaugural National Conference on Physiotherapy, Sports Sciences, Physical Education, and Allied Health Sciences. Graciously hosted by the esteemed School of Sports Education and Research (SSER) at Jain (Deemed-to-be University), this distinguished assembly stands as a testament to scholarly excellence, innovation, and the noble pursuit of intellectual discourse in the realms of sports sciences and healthcare.

Under the grand theme "Unlocking Human Potential Through Unified Research in Sports Sciences, Physiotherapy, Physical Education & Allied Sciences," KONVERGE 2025 gathers the most erudite scholars, venerable academicians, esteemed healthcare practitioners, and accomplished athletes, all uniting to impart their wisdom, research, and discoveries in the fields of rehabilitation, physical education, and movement sciences.

These proceedings, a veritable compendium of knowledge, serve to bridge the chasm betwixt theory and practice, thereby fostering the advancement of human performance. With the deepest sense of gratitude, we extend our heartfelt appreciation to the Organizing Committee, the distinguished members of the Scientific Advisory Board, our esteemed speakers, and all participants, whose invaluable contributions have rendered this scholarly endeavor most illustrious.

May this collection serve as a beacon of enlightenment, kindling the flames of future inquiry and innovation, and thus paving the way for the continued elevation of this noble field.

Dr. T. Arun Prasanna

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NEUROMUSCULAR ADAPTATIONS IN RETURN-TO-PLAY PROTOCOLS: A CASE STUDY APPROACH

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ABSTRACT

Neuromuscular adaptations are crucial for an athlete's effective return to sport following an injury. This study explores a structured return-to-play (RTP) protocol designed for a high-performance athlete recovering from a lower-limb injury. Utilizing a case study approach, the research evaluates neuromuscular improvements, strength gains, agility development, and sport specific readiness through key performance indicators. The RTP protocol follows a periodized model, integrating progressive strength training, plyometrics, proprioceptive exercises, and agility drills to restore neuromuscular efficiency. Initial phases focus on rehabilitation and neuromuscular activation, emphasizing joint stability, eccentric loading, and controlled movements. As the athlete progresses, training intensity increases with resistance exercises, power development, and high-intensity plyometric drills aimed at improving reactive strength and movement efficiency. The final phase incorporates sport-specific simulations, change-of direction drills, and fatigue resistance training, ensuring full athletic readiness. Results highlight measurable improvements in strength, explosive power, agility, and proprioception, demonstrating the effectiveness of structured periodization in neuromuscular reconditioning. These findings emphasize the importance of data-driven RTP strategies, allowing strength and conditioning professionals to optimize injury resilience and performance enhancement. This study reinforces the need for individualized training models to facilitate a safe and efficient return to competitive sports while minimizing re-injury risk.

Keywords: Return-to-Play, Neuromuscular Adaptations, Periodization, Plyometrics, Strength Training, Agility, Sports Performance

1. INTRODUCTION

A structured, evidence-based return-to-play (RTP) approach is essential for restoring neuromuscular function following an injury. Proper rehabilitation requires a combination of strength training, plyometrics, and proprioceptive exercises to enhance recovery and optimize performance. This study examines the neuromuscular adaptations in an elite athlete following a progressive RTP protocol, designed to ensure a safe and effective reintegration into competitive sports. The RTP framework emphasizes motor control, muscle activation, and movement efficiency as key components of recovery. Early-phase rehabilitation focuses on joint stability, eccentric loading, and controlled movements to minimize compensatory patterns. As training advances, the athlete undergoes progressive strength development, high-intensity plyometric training, and agility drills to enhance explosive power and movement precision. The final RTP phase involves sport-specific conditioning, reaction drills, and fatigue management, ensuring the athlete is physically and mentally prepared for competition. Findings suggest that a structured RTP program facilitates neuromuscular reconditioning, improving muscular strength, agility, and biomechanical efficiency. The study highlights the importance of periodized training in RTP,

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reinforcing its role in minimizing re-injury risk and optimizing athletic performance. These insights provide practical applications for strength and conditioning professionals, ensuring a scientific approach to athlete rehabilitation.

2. METHODOLOGY

This study follows a case study design, tracking the progress of an elite-level athlete recovering from a lower-limb injury. The RTP protocol implemented included four progressive phases:

a. Initial Assessment
   - Baseline evaluations of strength, power, agility, and proprioception.

b. Phase 1: Rehabilitation & Neuromuscular Activation
   - Isometric and eccentric loading to facilitate early-stage recovery.
   - Balance and proprioceptive drills to restore joint stability.
   - Low-intensity plyometrics to reintroduce controlled explosive movements.

c. Phase 2: Strength & Hypertrophy Development
   - Emphasis on compound lifts with controlled tempo.
   - Progressive resistance training for muscle hypertrophy.
   - Isokinetic strength assessments for monitoring muscular balance.

d. Phase 3: Power & Plyometric Training
   - High-intensity plyometrics to develop explosive power.
   - Reactive strength index (RSI) tracking for neuromuscular efficiency.
   - Sport-specific agility drills to enhance movement efficiency.

e. Phase 4: Return-to-Sport Simulation
   - Change-of-direction drills to refine reactive agility.
   - Fatigue resistance testing to evaluate endurance under game conditions.
   - Match-intensity simulations to ensure complete RTP readiness.

3. RESULTS

The athlete exhibited significant neuromuscular improvements throughout the RTP protocol:

- Strength Gains: 30% increase in lower-body strength (1RM squat and deadlift).
- Power Output: 25% improvement in RSI scores, indicating enhanced explosive capabilities.
- Agility Performance: 15% reduction in 5-10-5 shuttle test time.
- Muscle Activation: Enhanced recruitment patterns as evidenced by EMG analysis.
- Proprioceptive Gains: Increased joint stability and single-leg stance control.

4. DISCUSSION

This case study demonstrates the effectiveness of a structured return-to-play (RTP) program in promoting neuromuscular adaptations crucial for an athlete's readiness to return to competitive sport. A periodized training approach was implemented, ensuring a progressive balance between workload and recovery, reducing the likelihood of re-injury. The results indicate notable improvements in strength, agility, proprioception, and explosive power, reinforcing the importance of targeted RTP protocols in neuromuscular reconditioning. The observed enhancements align with existing research emphasizing the role of plyometric and proprioceptive exercises in optimizing muscle activation, movement efficiency, and joint stability. The integration of progressive

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overload, sport-specific drills, and agility-based conditioning contributed to improved performance metrics, validating the structured training model. Additionally, the incorporation of reactive strength training and controlled rehabilitation exercises played a pivotal role in refining movement patterns and reducing compensatory mechanisms. Future studies should focus on evaluating the long-term retention of neuromuscular adaptations, assessing how these improvements translate into sustained injury prevention and performance enhancement. Furthermore, the application of wearable technology and real-time data analytics could provide deeper insights into individualized RTP strategies, ensuring more precise and objective decision-making in athletic rehabilitation and return-to-sport protocols.

5. CONCLUSION

This case study underscores the importance of structured periodization in return-to-play (RTP) programming, demonstrating its effectiveness in facilitating neuromuscular recovery and injury resilience. By integrating targeted neuromuscular training strategies, strength and conditioning professionals can enhance movement efficiency, strength, and agility, ensuring long-term performance sustainability. The study highlights the necessity of individualized RTP protocols, emphasizing the role of comprehensive assessments in tailoring rehabilitation programs. A systematic approach to RTP allows for a safe and efficient transition back to competitive sports, reducing re-injury risk while maximizing athletic potential and functional readiness for high-performance competition.

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THE RELATIONSHIP BETWEEN BREATHING SCREEN TEST AND BUNKIE TEST PERFORMANCE IN UNIVERSITY BASKETBALL PLAYERS

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ABSTRACT

This study explores the relationship between the Breathing Screen Test and the Bunkie Test in assessing core stability and functional movement efficiency. The Breathing Screen Test evaluates respiratory patterns and their influence on movement mechanics, while the Bunkie Test assesses core endurance and stability. A total of 24 male university basketball players participated in this study. Pearson’s correlation analysis revealed a weak negative correlation ($r = -0.18$) between the two tests, suggesting minimal interdependence. These findings indicate that breathing mechanics and core stability function independently, necessitating a dual-focus approach in athletic training programs.

Keywords: Breathing Screen Test, Bunkie Test, Core Stability, Respiratory Function, Movement Efficiency, Athletic Performance, Sports Science, Functional Assessment, Injury Prevention.

1. INTRODUCTION

Physical performance in sports is a multifaceted concept, requiring a balance of strength, endurance, flexibility, and efficient movement patterns. Among these, breathing mechanics and core stability play a fundamental role in optimizing athletic capabilities and minimizing injury risks. While core stability has long been recognized as a key component of physical fitness, the importance of respiratory efficiency in movement control, endurance, and recovery is increasingly being emphasized in sports science research.

The Breathing Screen Test and the Bunkie Test are two well-established assessments used to measure different aspects of an athlete's functional capabilities. The Breathing Screen Test examines breathing mechanics, highlighting deficiencies such as poor diaphragmatic engagement, excessive chest breathing, and dysfunctional respiratory patterns that may lead to decreased movement efficiency. On the other hand, the Bunkie Test evaluates the endurance of core musculature, which is crucial for maintaining posture and stabilizing the body during dynamic movements.

Understanding the interaction between these two components—breathing mechanics and core stability—can provide deeper insights into how athletes can enhance their overall performance. This study seeks to determine whether a significant relationship exists between the Breathing Screen Test and the Bunkie Test in university basketball players, potentially influencing training methodologies and injury prevention strategies.

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1.1 Breathing Screen Test

The Breathing Screen Test is designed to evaluate an athlete's respiratory efficiency by identifying dysfunctional breathing patterns that may compromise movement and postural control. The test includes assessing diaphragmatic activation, ribcage expansion, breath-holding capacity, and breathing rhythm during rest and exertion. Dysfunctional breathing has been linked to reduced oxygen uptake, early fatigue, and compromised neuromuscular coordination, all of which can impact performance and recovery (Bradley & Esformes, 2014).

Breathing dysfunctions often result in excessive recruitment of accessory muscles such as the sternocleidomastoid and scalene, leading to increased tension in the neck and shoulders. These compensatory mechanisms not only reduce movement efficiency but may also contribute to chronic pain and musculoskeletal imbalances.

1.2 Bunkie Test

The Bunkie Test is a widely used assessment to measure core stability and endurance. Developed to assess an athlete's ability to sustain specific weight-bearing positions, it evaluates the interplay between trunk, lower limb, and stabilizing muscles. The test comprises five key positions: front plank, left and right side plank, back extension, and shoulder bridge. Each position challenges different muscle groups, providing a comprehensive evaluation of an athlete's core endurance (Van Zyl & Thorpe, 2011).

Maintaining these positions requires strong engagement of the deep core muscles, including the transverse abdominis, multifidus, and pelvic floor muscles. These muscle groups are crucial for stabilizing the spine, controlling movement, and reducing the risk of lower back injuries. The ability to sustain each Bunkie Test position for extended periods is indicative of well-developed core endurance, which translates into improved postural control and resistance to fatigue during sports activities.

Given the distinct yet potentially related functions of breathing mechanics and core endurance, this study aims to determine whether a correlation exists between the Breathing Screen Test and the Bunkie Test.

2. METHODOLOGY

2.1 Participants

Twenty-four male university basketball players (mean age = 20.4 ± 2.0 years) from the Coimbatore district team participated in the study. Inclusion criteria required participants to have at least two years of competitive basketball experience, maintain a structured training routine, and be free of musculoskeletal injuries for at least three months prior to testing. Participants with known respiratory conditions such as asthma or chronic obstructive pulmonary disease (COPD) were excluded to ensure uniformity in respiratory function assessment.

2.2 Data Collection

Participants underwent two standardized assessments:

1. **Breathing Screen Test:** The test evaluated diaphragmatic function, chest versus belly breathing dominance, respiratory rate, and breath-holding capacity. Specific measurements included:

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- **Breath-holding time post-exhalation:** A measure of carbon dioxide tolerance and respiratory control.
- **Diaphragmatic vs. chest breathing ratio:** Analyzed through visual assessment and palpation of the thoracic cavity.
- **Respiratory rate at rest:** Measured in breaths per minute to assess baseline respiratory efficiency.
- **Accessory muscle activation:** Observed for signs of overuse of neck and upper chest muscles.

2. **Bunkie Test:** The test was conducted on a stable surface, with each participant required to hold five different plank-based positions:
   - **Front plank** (assessing anterior core endurance)
   - **Side plank (left & right)** (evaluating lateral core stability)
   - **Back extension** (measuring posterior chain endurance)
   - **Shoulder bridge** (analyzing hip and lower back endurance)

Each position was timed, with the duration recorded in seconds. Participants were instructed to maintain the correct form throughout the test, with failure to hold the position resulting in test termination.

2.3 Statistical Analysis

Data analysis was conducted using SPSS software (version 22). Descriptive statistics (mean, standard deviation) were calculated for both test performances. Pearson's correlation coefficient was used to determine the relationship between the Breathing Screen Test and the Bunkie Test. A significance level of $p < 0.05$ was established to evaluate statistical significance.

3. RESULTS

3.1 Descriptive Statistics

- **Breathing Screen Test Scores:** Mean = 6.8 ± 1.5
- **Bunkie Test Performance:** Mean = 38.4 ± 5.1 seconds

3.2 Correlation Analysis

A weak negative correlation ($r = -0.18$) was found between Breathing Screen Test scores and Bunkie Test performance, suggesting little to no direct relationship between respiratory function and core endurance.

4. DISCUSSION

The results indicate that breathing mechanics and core stability function as independent physiological components in university basketball players. While efficient breathing enhances movement efficiency and endurance, it does not directly correlate with core strength as measured by the Bunkie Test.

5. CONCLUSION

This study found no significant correlation between the Breathing Screen Test and the Bunkie Test, suggesting that respiratory function and core stability should be addressed independently in

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training programs. Future research should further investigate the impact of breathing mechanics on movement efficiency and injury prevention.

6. ACKNOWLEDGMENTS

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POST COVID-19 LOCKDOWN: AN EIGHT-WEEK PHYSICAL TRAINING PROGRAM'S IMPACT ON THE BODY COMPOSITION OF MASTER'S STUDENTS IN PHYSICAL EDUCATION: A BIOELECTRICAL IMPEDANCE ANALYSIS STUDY

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ABSTRACT

Objective: To analyze the impact of 8 weeks of physical exercise on physical education students, focusing on body composition.

Introduction: A balanced diet, injury prevention, and regular medical check-ups are crucial for athletes. A well-designed fitness program is essential for optimal performance. Mental health professionals can help manage stress and anxiety. Health education and substance abuse prevention programs are necessary for children. A support network with peer support, safe training, and medical professionals is crucial. Quality health involves physical, physiological, and psychological factors.

Methods: This study collected data from selected individuals who are studying for a Master's in Physical education and used a professional body analysis scale to determine their weight management, fat management, muscle management, basal metabolic rate, total energy expenditure, obesity analysis, body fat percentage, visceral fat content, BMI, body shape analysis, muscle quality, waist-to-hip ratio, trunk fat mass, and overall health score. The process involved measuring weight and height, standing on the scale, and holding handles for reliable data collection. This process was repeated for statistical analysis.

Results: The eight weeks of training program significantly improved health and fitness variables, reducing body fat, visceral fat, trunk fat mass, and BMI and increasing Fat-Free Mass, protein mass, and overall health score.

Kew words: Health score, Body composition analysis, Visceral fat, BMR, Variable selection, Multiple linear regression

1. INTRODUCTION

The human body comprises roughly 60-70% water (1).Carbohydrates, proteins, and lipids are all significant sources of fuel. Furthermore, the body needs vitamins and minerals to stay healthy. Unused macronutrients are retained as fat, and excessive fat storage can contribute to noncommunicable diseases (NCDs) (2,4,5). The Body Mass Index (BMI) is a popular method for assessing human health. BMI is determined as weight in kilograms divided by height in meters

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squared (kg/m²) (6). The World Health Organization (WHO) categorizes persons based on their BMI as underweight (≤ 18.5), average weight (18.6-24.9), overweight (25-29.9), obese (30-39.9), or morbidly obese (≥ 40) (3, 7). After the COVID-19 lockdown restrictions were lifted, the researchers examined the impacts of an eight-week physical training program on the body composition of master's students enrolled in physical education. A significant portion of people's daily routine and manner of life has altered, including increased screen time (TV, mobile devices, tablets, laptops, desktop computers, video games, and so forth), improper meal timing, excessive rest, and partial social isolation (8,9). It causes weight gain and obesity, which increases the risk of developing hypokinetic disorders (NCD). Effects on health resulting from maintaining a sedentary lifestyle during COVID-19: Due to excessive screen time, people cannot obtain natural vitamin resources, particularly vitamin "D," obtained through sunlight. Additionally, because most people adopted a late-night sleep schedule during the day, melatonin secretion and quantity were altered, which reduced the amount of restful sleep that people got (10,11,12,13).

Bioelectrical Impedance Analysis (BIA) is commonly used in the fitness and health clinic industry (14,15). BIA provides valuable data that is easy to use for statistical analysis, aiding in assessing body composition and health parameters. College and university students were notably impacted by the pandemic, experiencing significant changes in their daily routines. These disruptions affected them physically, socially, physiologically, and psychologically (16,17,18). In particular, the study used bioelectrical impedance analysis (BIA) to evaluate changes in body composition. Students engaged in a master's program in physical education made up the participants; they had been less active throughout the lockdown. The main goal was to determine how their body composition measures would change if they resumed structured physical training. This would light the possible advantages of physical activity during the post-lockdown phase.

2. METHODS

In this investigation, the subjects selected were individuals pursuing a Master of Physical Education at a reputable educational institute. The subjects' ages ranged from 24.9 ± 1.7 years. All subjects are from the northern region of India and largely follow a vegetarian diet consisting mainly of wheat-based dishes such as roti, Parantha, and chapati, complemented by dal or other gravies. Eggs and chicken, which are not vegetarian foods, were eaten quite seldom—roughly twice a week.

Every subject's daily schedule was carefully prepared and every day started with a 75–110-minute training session in the morning, followed by a two-hour respite. Following this, there were three hours of theoretical instruction, three hours of relaxation, and an additional 75–110-minute training session in the evening. The investigator noticed that the subjects' eating patterns were comparable. However, variations in rest periods and sleep patterns were not tracked and might have varied throughout subjects. Eight weeks of training were used, and the trial was carried out right after India's COVID-19 lockdown.

The fundamental physical activities used for this study focused on increasing exercise sets and repetitions. The duration of rest periods was modified by the subjects' capacity to increase training intensity since the participants resumed their physical activities following the COVID-19 lockdown. The training schedule was two sessions a day, Monday through Friday, for 10 weekly sessions. One evening session per week was devoted to range of motion (ROM) exercises for flexibility, and the other four evening sessions were dedicated to core training; before each session's cooling-down phase, these extra sessions were added to the already-existing training plan. This experiment's training program started with a 50% to 60% intensity. Every two weeks during

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the ten weeks, except the final two, the intensity was raised by 10%. The last week saw a mere 5% increase in intensity.

Based on the subjects' pulse rates, the investigator reached an 80% to 85% intensity by the program's conclusion. The intensity was controlled using the Karvonen formula, which considered the quantity of exercises, repetitions, sets, rest periods, and session durations training module attached to this chapter part end.

This investigation collected data from selected subjects before and after the experiment using a medical standard professional body composition analyzer scale (Body Impedance Analyser, Charder- 600). This method measures various factors from subjects, including intracellular water level, extracellular water level, protein, minerals, body fat mass, and body balance evaluation. The analysis provides insights into target weight control, fat control, muscle control, basal metabolic rate, total energy expenditure, obesity analysis, body fat percentage, visceral fat level, body mass index, body type analysis, muscle quality, waist-hip ratio, trunk fat mass, and overall health score.

All the chosen subjects were asked to assemble in a laboratory during the morning session. Each individual was instructed to remove their footwear and have their weight and height measured. Following this, each subject was requested to stand on the body composition analyzer, ensuring their feet were placed on the silver-coated area. They were also asked to hold two handles, positioning their palms on the silver-coated area, to obtain reliable data. The subjects remained in this position for the entire data collection process, which typically lasted between 30 and 90 seconds per individual. This procedure was repeated for all subjects before and after the implementation of the experiment to facilitate statistical analysis for this investigation, toanalyze the gathered data, OLS regression, Pearson's product movement correlation and measure of central tendency wereused as analytical tools.

First two weeks Training Module				
Time	**Session**	**Exercises**	**Reps/ Sets**	**Rest between Sets**
20 mins.	General Warming Up	The physical activity (PA) program started on the athletic track with slow jogging for about 800 meters, then moderate jogging for around 1200 meters. Every day, the participants ran a minimum of two kilometres overall. Energetic activities were also included for the warm-up portion of all five training days.		
30 mins.	Main Exercises	The leg front kick below the knee, side kick below the knee, leg front kick above the hip, side kick above the hip, high knee action, back kick, skipping movement, jump and twist, forward bending, sideward bending, squats, push-ups, partner exercises, and launching exercises are the bodyweight exercises that were chosen for this study as essential elements of the physical training regimen.	**Each- 20 rep 5-8 sets Rest between sets was 40-75 seconds**	**Intensity 50 - 85%**

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10 mins	Core exercises Weekly 4 days Evening session	Core exercises were included in the training program four times a week. These were seated and laying workouts that comprised crunches, planks, bridges, double leg raises, flutter kicks, superman movements, and cycling and so on.
15 mins.	Cooling Down	Active-based cooling down with jogging in slow phase various dynamic PA was done, after which the stretch & hold method of flexibility was adopted after all sessions were completed.

3. RESULTS AND DISCUSSIONS

Table 1

Characteristic features of all the variables

Name of Variables	Pre-test				Post-test			
	Mean	S. D	Min	Max	Mean	S. D	Min	Max
Weight	65.8	5.45	57.1	73.1	65.2	5.86	53.3	71.8
Height	169.8	5.27	161.5	176.5	170.2	5.57	161.5	176.5
Age	25	1.73	22.8	28.2	25	1.73	22.8	28.2
5kHz, Impedance(Z) of Whole Body	657.12	53.15	560.5	750.9	671.5	59.36	583.8	779
5kHz, Impedance(Z) of Trunk	29.1	1.87	27.2	32.7	29.6	1.82	26.8	31.9
50kHz, Impedance(Z) of Whole Body	571.9	46.3	488.5	642.1	582.7	51.2	505.4	667
50kHz, Impedance(Z) of Trunk	24.8	1.86	22.7	28.1	25	1.97	21.8	27.3
250kHz, Impedance(Z) of Whole Body	512	40.9	439.2	572.4	520	43.5	453.6	594.6
250kHz, Impedance(Z) of Trunk	21.3	1.77	19.4	24.5	21.3	1.73	18.5	23.2
Fat Free Mass	52.9	3.78	45.5	57.4	53.1	4.43	43.8	57.4
Fat Mass	12.9	2.86	8.4	18.5	12.15	2.57	8.2	16.2
Percentage Body Fat	19.5	3.22	13.7	25.7	18.5	3	13.4	22.5
Visceral Fat Area	56.5	14.6	33.4	85.2	52.7	13.25	32.2	73.3
Trunk Lean Mass	23.6	1.94	20.5	26.3	23.7	2.11	19.9	26
Trunk Fat Mass	7.11	1.69	4.5	10.4	6.7	1.52	4.4	9
Trunk Tissue Mass	29.4	2.99	25	33.2	28.9	3.12	22.9	32.8
Skeletal Muscle Mass	29.3	2.26	25	32.1	29.4	2.65	24	32

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Waist-Hip Ratio	0.86	0.02	0.83	0.89	0.86	0.02	0.84	0.9
Protein Mass	10.7	0.85	9.1	11.8	10.7	0.96	8.8	11.7
Health Score	74.3	3.48	68.7	79.4	74.9	3.68	70.6	80.5
Fat Mass Index	4.47	0.88	3	6	4.2	0.88	2.90	5.7
Skeletal Muscle Mass Index	10.17	0.59	9.4	11	10.15	0.63	9.2	10.9
Basal Metabolic rate	1512.4	81.8	1352	1609	1515.6	95.9	1315	1609
Body Mass Index	22.8	1.35	21.2	25	22.5	1.55	20.4	25.2
Total Energy Expenditure	2148.5	116.4	1920	2286	2152.8	136.3	1868	2286
Hand Grip	39.2	1.95	35.8	41.4	39.2	2.07	34.9	41.52

Table 1 results show the descriptive statistics of all variables, measured before and after the eight weeks of training implementation from the selected individuals.

Weight: The sum of the weights before the test is 592.4 kg, and the sum after the test is 587 kg. This indicates a decrease in the total weight. The standard deviation has slightly increased from 5.46 kg (pre-test) to 5.86 kg (post-test). This means that the weight variation among participants has improved after the test. If there are no changes in the mean values, it suggests that the average weight of participants before and after the test is the same.

Fat-Free Mass (FFM) increased from 52.92 to 53.6. This suggests that, on average, participants gained FFM after the training. The standard deviation (SD) also increased from 3.79 to 4.43, which might indicate a slight increase in variability among the participants' FFM values. Positive Impact: The increase in the total sum and mean values of FFM signifies a positive effect of the training intervention on FFM. Increased Mean: An increase in the mean FFM indicates that, on average, participants gained muscle mass or lean tissue. Standard deviation: The rise in SD suggests that while the average FFM increased, there was a slight increase in the variability of the responses among participants. This could mean that while most participants gained FFM, the extent of gain varied more in the post-test compared to the pre-test.

Body Fat Percentage: The pre-test data for body fat percentage was 175.5, with a mean of 19.5 ±3.22. Similarly, the post-test data aggregate is 166.9 with a mean of 18.54 ± 3.01. As a result, this finding indicates that physical exercise affects the variable of body fat %. However, this variable has no statistical significance when using paired 't' test results. **Fat Mass**: The pre-test data for the Fat Mass variable was 116.1 with a mean of 12.9 ± 2.87, while the post-test data was 109.4 with a mean of 12.15 ± 2.575. Training impacted the fat mass variable, but the paired 't' test results did not significantly improve. In Visceral Fat data, the test sum is 508.9, with a mean of 56.54 ± 14.68, and the post-test sum is 474.5, with a mean of 52.72 ± 13.25. The difference of 34.4 between the

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two aggregate values suggests that physical training had a favourable effect on visceral fat reduction for the subjects in this study.

The pre-test sum value for trunk fat mass is 64, indicating a mean of 7.1 ± 1.69; likewise, the post-test sum is 60.4, representing a mean of 6.71 ± 1.52. When taking into account the pre- and post-test data sets on the variable of trunk fat mass, it was shown that the given training positively influenced by reducing trunk fat mass to selected subjects.

The pre-test sum value of the skeletal muscle mass variable is 264.1, indicating a mean of 29.34 ± 2.26, whereas the post-test sum is 264.9, indicating a mean of 29.43 ± 2.65. According to the gathered data set on the variable of skeletal muscle mass, this suggests a marginally beneficial influence as a result of the training.

Waist-hip ratio: a slight shift was observed in this measure; the pre-test total is 7.76, with a mean of 0.86 ± 0.022. The post-test mean is 0.86 ± 0.021, and the post-test sum is 7.75. It states that all physical education discipline subjects only marginally improved, as observed in the waist-hip ratio variable, after receiving a certain amount of physical training. By physical training given to subjects, the Protein Mass variable also showed slight changes; the pre-test sum values are 96.3, with a mean of 10.7 ± 0.86, and the post-test sum values are 96.9, with a mean of 10.76 ± 0.96. These findings indicate that, compared to pre-and post-test data sets, the protein mass of the chosen subjects increased.

Fat-Free Mass Index: Considering the table's results, there isn't much of a variation in this variable between the pre- and post-test data sets; In addition, the post-test total value was 164.8, mean 18.31 ± 1.04, while the pre-test total value was 165, mean 18.3 ± 0.987. The **Basal Metabolic Rate** (BMR) variable showed an increase in a subset of individuals following eight weeks of physical training. The pre-test total value is 13612, with a mean of 1512 ± 81.84, and the post-test total value is 13641, with a mean of 1515.67 ± 95.91. These values demonstrate statistical validity.

Body Mass Index: The pre-test total value for the BMI variable was 205.3, with a mean of 22.81 ± 1.357. Following the 202.3 total training value, the mean was 22.48 ± 1.55. This data set showed that the mean and total values decreased before and after training, demonstrating a substantial impact of the training the chosen participants received on the body mass index variable. When considering the total amount and the mean value, the results indicate that the Mineral% variable shows little change before and after training. The percentage of altered minerals was 48.2 for the pre-test, 5.35 ± 0.324 for the mean, 48.7 for the post-test, and 5.41 ± 0.314 for the mean. Comparing the pre-and post-test data sets for the aforementioned variables, there was a slight variation in the mineral percentage variable.

The Protein % variable had a pre-training total value of 146.6, with a mean of 16.29 ± 0.67, and a post-training total value of 148.6, with a mean of 16.51 ± 0.641. Comparing the total values of the pre-training and post-test data sets reveals that protein storage has risen, indicating that training causes certain subjects to trigger protein high. In the Fat Control variable, the physical exercise given significantly affected the subjects in this study; That way, before training, fat control

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demand was -27.3, mean -3.03, and after training, fat was -21.3, mean -2.37. These results indicate that adopted physical training controls fat in selected subjects.

Total Energy Expenditure (TEE)- before and after physical exercise, TEE improved dramatically in chosen subjects, which has been statistically confirmed. The pretraining sum value is 19337, the mean is 2148.55, and the σ is 116.47. The post-training sum value is 19376, the mean is 2152.89, and the σ is 136.291. It clearly shows that given training affects the TEE variable in this study. In this study, pre- and post-training data were compared to evaluate the impact of physical training on the subcutaneous fat area. The results show that the subcutaneous fat area shrank significantly after the physical training program. Before training, the subcutaneous fat region had a mean of 100.01 and 900.1. Following training, the subcutaneous fat area's total sum dropped to 829.6 with a mean of 92.178. A significant decrease in the subcutaneous fat area confirmed the success of the physical training program. The subcutaneous fat area's mean and total sum values decreased, indicating that frequent physical training benefits body composition.

Health Score- The provided training has altered a health score by having all positive impacts via other chosen factors with that impact. The health score has grown with a training total sum value of 669.5, a mean of 74.39, and a post-training sum score of 674.7, a mean of 74.97. The results show that the training positively impacted the health scores. The total sum and the mean of the health scores increased after the training. The increase in these values indicates that the participants' health scores improved due to the training. This suggests that the training effectively influenced the health score variable in this study.

Table 2

Pearson's product-moment correlation table of health score before and after the experiment

't'	df	P	Confidence Interval 95%		Correlation coefficient
			Lower C. I	Upper C. I	
7.5508	7	0.00013	0.7491704	0.9883844	0.943

The correlation coefficient of 0.943 in the correlation table indicates a significant positive correlation between the health scores before and after the experiment. This implies that the experiment improved the participants' health scores. * The correlation coefficient (table 2) between health scores obtained before and after training is 0.943, indicating a robust positive correlation. This substantial correlation implies a significant association between the health scores obtained at two different time points. Specifically, this solid positive association indicates a significant difference in the data set acquired from the selected subjects before and during the execution of the physical training program. The significant improvement in health scores after training demonstrates

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the effectiveness of the training routine. It emphasizes the favourable influence of physical training on participants' health outcomes, verifying the intervention's success.

Fig 1. Box plot representing health score before and after training

The overall health score data for the chosen subjects before and after the experiment are shown in the box plot figure above. This graphic depiction unequivocally shows that the participants' health scores improved due to the training program. The results show that the implemented training regimen significantly improved the subjects' health outcomes, as demonstrated by the appreciable rise in their health scores following the trial.

Table 3
Highly Correlated variables

First Variable	Second Variable	Correlation
BMR1	TEE1	0.99999
F1	BMR1	0.99998
F1	TEE1	0.99997
FM1	VF1	0.99995
F1	SM1	0.99931
SM1	BMR1	0.99925
SM1	TEE1	0.99924
SM1	FM1	0.99923
VF1	TF1	0.99863
FM1	TF1	0.99858

* The above table represents the most highly correlated first ten variables.

In Table -3, the following variables exhibit a highly positive correlation, with values exceeding 0.99. This indicates a strong correlation among the selected variables, which

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significantly influence the relationship with the health score. The post-test variables included are Basal Metabolic Rate (BMR), Fat-Free Mass Percentage (F1), Fat Mass (FM1), Trunk Fat Mass (TF), Visceral Fat (VF1), Total Energy Expenditure (TEE1), and Skeletal Muscle Mass (SM1).

Fig 2. Correlation Matrix -Heat Map

Figure 2 presents a diagrammatic representation of the correlation matrix, visualized through a heatmap, for the students' post-training measurements. In this heatmap, the color intensity denotes the strength of the correlation between different variables. Specifically, lighter shades indicate a stronger or more positive correlation, whereas darker shades signify a weaker correlation. The predominance of lighter shades over darker ones in this diagram suggests generally strong correlations among the post-training measurements. This observation implies that the variables measured post-training are closely interrelated, reflecting consistent and significant improvements across the board. The relatively fewer dark shades indicate that weak correlations are less prevalent in this dataset, further emphasizing the overall positive impact of the training program on the students' health metrics, given the high-dimensional nature of the data, feature selection was employed to reduce dimensionality and enhance the model's performance. This study applied the forward variable selection method to identify the most informative features related to the health score. The features W1, A1, 5W1, 5T1, 50W1, WH1, and SMM1 were the most relevant, significantly impacting the health score. These selected variables were subsequently used for further model fitting. Multiple linear regression analysis demonstrated that the variables W1, 5T1,

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and SMM1 have p-values less than 0.05, indicating their statistical significance. Notably, W1 has a coefficient value of approximately –0.315, suggesting that an increase in the health score is associated with a decrease in W1 (Weight).

Table 4
Coefficient values for the most significant features

OLS Regression Results

Dep. Variable:	HS1	R-squared (uncentered):	1.000
Model:	OLS	Adj. R-squared (uncentered):	1.000
Method:	Least Squares	F-statistic:	7.707e+04
Date:	Thu, 25 Jul 2024	Prob (F-statistic):	1.30e-05
Time:	16:28:51	Log-Likelihood:	4.6401
No. Observations:	9	AIC:	4.720
Df Residuals:	2	BIC:	6.100
Df Model:	7		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
W1	-0.3153	0.025	-12.481	0.006	-0.424	-0.207
A1	0.2332	0.083	2.812	0.107	-0.124	0.590
5W1	0.0231	0.030	0.765	0.524	-0.107	0.153
5T1	0.5485	0.122	4.491	0.046	0.023	1.074
50W1	-0.0247	0.038	-0.645	0.585	-0.190	0.140
WH1	-20.8251	12.668	-1.644	0.242	-75.329	33.679
SMM1	8.8931	0.725	12.265	0.007	5.773	12.013

Omnibus:	2.178	Durbin-Watson:	2.002
Prob(Omnibus):	0.337	Jarque-Bera (JB):	1.166
Skew:	0.595	Prob(JB):	0.558
Kurtosis:	1.699	Cond. No.	1.11e+05

Ellipses: W1-Weight, H1-Height, A1-Age, 5W-5kHz, Impedance(Z) of Whole Body, 5T-5kHz, Impedance(Z) of Trunk, 50W-50kHz, Impedance(Z) of Whole Body, 50T-50kHz, Impedance(Z) of Trunk, 250W-250kHz, Impedance(Z) of Whole Body, 250T-250kHz, Impedance(Z) of Trunk, F1- Fat-Free Mass, FM1- Fat Mass, BF1- Percentage Body Fat, VF1- Visceral Fat Area, TM1- Trunk Lean Mass, TF- Trunk Fat Mass, TT1- Trunk Tissue Mass, SM1- Skeletal Muscle Mass, WH1- Waist-Hip Ratio, PM1- Protein Mas, HS1- Health Score, FMI1- Fat Mass Index, SMM1- Skeletal Muscle Mass Index, BMR1- Basal Metabolic rate, BMI1- Body Mass Index, TEE1- Total Energy Expenditure, HG- Hand Grip.

4. CONCLUSION

Positive Impacts:

Body Fat Reduction: The adopted physical training (PT) program decreases body fat, which benefits overall health and aesthetics (19,20). **Visceral Fat Reduction**: Visceral fat accumulates around internal organs and decreases after PT (21). This is crucial because excess visceral fat is associated with health risks. **Trunk Fat Mass Reduction**: Targeting trunk fat can improve body composition and reduce the risk of metabolic disorders (22,23). **BMI Decrease**: A lower body mass index (BMI) indicates healthier weight management. **Fat-Free Mass Increase**: Gaining fat-free

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mass (muscle, bone, organs) contributes to strength and metabolic health. **Protein Mass Increase**: Adequate protein mass is essential for tissue repair and well-being. **Overall, Health Score Improvement**: The program positively impacted overall health, likely through multiple mechanisms.

Areas with Minimal Changes:

Waist-Hip Ratio: Although minimal changes were observed, maintaining a healthy waist-hip ratio is essential for cardiovascular health. **Mineral Percentage**: While less affected, monitoring mineral levels remains crucial for optimal bodily functions. **Fat-Free Mass Index**: The minimal change suggests that fat-free mass distribution remained relatively stable.

Considerations:

Individual Variation: Remember that responses to training can vary based on personal factors (genetics, adherence, baseline fitness). **Long-Term Effects**: Investigate whether these positive changes are sustained over time. In summary, the program has had significant positive effects on various health markers. Keep monitoring progress and adjust as needed to maintain a healthy active life (24).

Significance of Sports-Related Populations' Health

The COVID-19 pandemic has significantly disrupted sports-related populations, including college students, professional athletes, and those with active lifestyles. This has led to reduced physical activity, resulting in adverse health outcomes such as weight gain, changes in body composition, and a decline in overall health quality. The study aims to determine the effects of physical training on the health of sports-related populations, assess the effectiveness of structured exercise plans in improving health outcomes after inactivity, and provide recommendations for developing exercise plans for long breaks from physical activity. The findings may contribute to developing effective exercise plans to help individuals regain physical fitness and improve health after prolonged inactivity.

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PHYSIOLOGICAL OUTCOMES OF SHORT-TERM INTERVAL TRAINING IN PRIMARY SCHOOL STUDENTS

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ABSTRACT

Interval training has effectively improved physiological and metabolic parameters in the adult and sporting populations, as substantiated by many researchers in different research studies. The same has been given less focus on the children due to many probable factors such as age, load capacity, lack of control, etc. Some conditions demand more innovative ways to keep our children fit and healthy for their proper growth and development. Objective: The study investigated the impact of short-term interval training on select physiological parameters, specifically body fat percentage and body mass index (BMI). Methods: The data were obtained using a Tanita TBF-300 Body Composition Analyzer. The study included 32 randomly selected participants between the ages of 8 and 10. Sixteen subjects were randomly assigned to the control and experimental group. The participants underwent the training program for 12 weeks, thrice a week. Analysis of covariance (ANCOVA) was conducted to examine differences between groups, while paired t-tests were used to compare participants' performance before and after the intervention. The findings revealed statistically significant differences ($p<0.05$) between the pre test and post-test scores within the experimental group. Results: Comparing the groups showed significant differences in post-test scores between the control and experimental groups. Specifically, participants in the experimental group demonstrated more favourable body mass index measurements than control group participants. Conclusion: Short-term interval training improves children's fat percentage and body mass index phenomena.

Keywords: BMI, Interval Training, Primary Children and Fat Percentage

1. INTRODUCTION

Metabolic factors such as glucose tolerance, insulin sensitivity, and lipid metabolism have improved due to regular participation in physical activity. These factors are the determinants of the cardiometabolic risk profile among children. So, it may be inferred that the cardiovascular risk among children also decreased (Barge B. et al., 2004). In a study conducted by Danish children, it was found that there is a negative relation between physical activity levels and symptoms of metabolic syndrome. The indicators of metabolic syndrome are Insulin, Glucose, HD2 Cholesterol, triglycerides, the sum of four skinfolds, and blood pressure. (Brage B., et.al. 2004)

Body Mass Index (BMI) is a crucial measure of morphological fitness. Healthcare professionals widely use it to assess body weight and identify obesity in children. Children with elevated BMI levels face increased risks of severe health conditions, including cardiovascular disease, hypertension, and type 2 diabetes. Current statistics in the United States reveal that 31.8%

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of children and adolescents are overweight, while 16.2% are classified as obese. These BMI classifications show a significant correlation with physical activity levels. (brage B. et.al.,2004)

Based on studies, researchers have reported that regular participation in physical activity leads to enhancement in health-related fitness. The physiological systems respond to the stimulus, which results in children's health-related fitness development. (Salis JF, et.al., 1997). Regular exercise in childhood is associated with decreased risk of cardiovascular risk in later stages of life (Steinberger J. and Denials S.R., 2013). The quality of life has been evidenced to be improved due to participation in physical activity (Fanelli et al., et al. 2007; Gates PE, 2012; Dwyer et al., 2011)

Although the existing research indicates that exercise has proven benefits for children, it is less important than investigations conducted on adults (Whitewell S., Tueton J., 2010). It refers to the sequence of repeated exercises alternating with a recovery period of light-intensity work. Short-term High-Intensity Interval training leads to many Physiological and Biochemical changes in the body, as evidenced by the literature review. However, it has been observed that high-intensity interval training was not implemented on children due to administrative and feasibility reasons. Specifically, short-term high-intensity interval training was administered for children in this study to investigate the effects on the selected physiological variables.

2. METHODOLOGY

For this study, 32 male participants were selected from Jyothis Central School in Kazhakuttom, Thiruvananthapuram. The participants, aged 8 to 10 years, were randomly divided into two groups: an experimental group and a control group, with 16 participants in each group. The study focused on two dependent variables: fat percentage and Body Mass Index (BMI). These variables were measured using a Body Composition Analyser (Tanita TBF-300).

3. EXPERIMENTAL DESIGN

Experimental design refers to the system of formulating the selection procedure, testing methods, training administration, etc. It is the designed framework of the whole study, which helps avoid threats to the study's conclusions. The study used a pre-test and post-test design. The manifestation of the experimental design is as follows:

- TREATMENT (S1-S16)
- CONTROL (S1-S16)   (O = OBSERVATIONS, S = SUBJECTS)

Various statistical tools, such as SPSS Statistical software, were employed for data analysis. Descriptive statistics such as mean and standard deviation were calculated to describe the nature of data. The study employed several statistical methods to analyze the data(Meyji, 2015). A paired (dependent) t-test was used to determine whether there were statistically significant differences between the control and experimental group means. A one-way ANOVA was conducted to analyze differences in post-test scores across groups. An Analysis of Covariance (ANCOVA) was also performed to account for potential pre-test score effects by treating them as a covariate.

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TABLE OF PRE AND POST-TEST MEAN, STANDARD DEVIATION AND DEPENDENT "T" TEST OF FAT PERCENTAGE FOR CONTROL AND EXPERIMENTAL GROUP

Group	Test	N	Mean	SD	MD	T-ratio
Control Group	Pre-test	16	15.35	4.51	.010	.050
	Post-test		15.34	4.18		
Experimental Group	Pre-test	16	12.74	3.44	.931	9.40
	Post-test		11.81	3.31		

The table above indicates that the pre-test mean and standard deviation of the control and experimental groups on fat percentage test items are 15.35±4.51 and 15.34±4.18, respectively. The control and experimental group's post-test mean and standard deviation are 12.74±3.44 and 11.81±3.31, respectively. The table also depicts that the mean values of the pre-test and post-test of the control group are not significantly different as the obtained t ratio (.050) is less than the critical table value, i.e., 1.69, which indicates that the participants of the control group have not shown a considerable improvement. The results also reveal that the mean values of the pre-test and post-test of the experimental group are significantly different as the obtained t ratio (9.40) is more than the critical table value, i.e., 1.69, which indicates that the participants of the experimental group have improved significantly in fat percentage.

ANCOVA FOR PRE-TEST, POST-TEST, AND ADJUSTED POST-TEST SCORES OF FAT PERCENTAGE FOR CONTROL AND EXPERIMENTAL GROUP

Test		Control group	Exp Group	Sov	Sum of squares	df	Mean square	F Ratio
Pre-test	**Mean**	**15.35**	**12.74**	**B**	**54.49**	**1**	**54.49**	**3.37**
	S.D	**4.51**	**3.44**	**W**	**484.15**	**30**	**16.13**	
Posttest	**Mean**	**15.34**	**11.81**	**B**	**99.75**	**1**	**99.75**	**6.99**
	S.D	**4.18**	**3.31**	**W**	**427.94**	**30**	**14.26**	
Adjusted post-test	**Mean**	**14.13**	**13.02**	**B**	**8.82**	**1**	**8.82**	**24.13**
				W	**10.60**	**29**	**.366**	

*Significant at 0.05 level.

The critical F-value for statistical significance at the 0.05 level is 4.41 with 1 and 30 degrees of freedom and 4.47 with 1 and 29 degrees of freedom. The analysis examines fat percentage measurements between control and experimental groups across different testing phases. The initial pre-test measurements showed mean values (± standard deviation) of 15.35 ± 4.51 for the control group and 12.74 ± 3.44 for the experimental group. The resulting F-ratio of 3.37 was statistically insignificant at the 0.05 confidence level, falling below the critical F-value of 4.17 (df = 1, 30).

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Post-test measurements revealed mean values of 15.34 ± 4.18 for the control group and 11.81 ± 3.31 for the experimental group. The F-ratio of 6.99 indicated a statistically significant difference at the 0.05 confidence level, exceeding the critical F-value of 4.17 (df = 1, 30). Further analysis of adjusted post-test means showed values of 14.13 and 13.02 for the control and experimental groups, respectively. The resulting F-ratio of 24.13 was statistically significant at the 0.05 confidence level, surpassing the critical F-value of 4.20 (df = 1, 29). The accompanying figure visually represents these findings, which displays the progression of mean values across pre-test, post-test, and adjusted post-test phases for both groups.

GRAPHICAL REPRESENTATION OF MEAN SCORES OF PRE-TEST, POST-TEST, AND ADJUSTED POST-TEST SCORES OF FAT PERCENTAGE FOR CONTROL AND EXPERIMENTAL GROUP

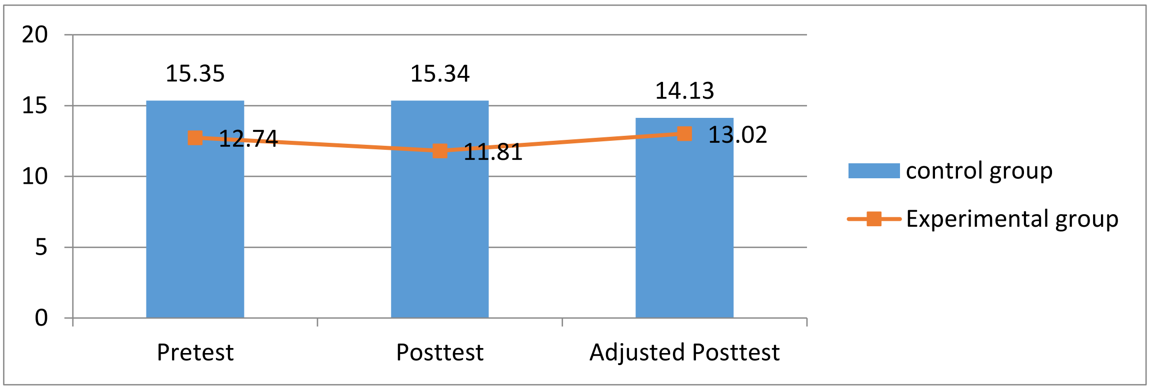

TABLE OF PRE AND POST-TEST MEAN, STANDARD DEVIATION AND DEPENDENT "T" TEST OF BODY MASS INDEX FOR CONTROL AND EXPERIMENTAL GROUP

Group	Test	N	Mean	SD	MD	T-ratio
Control Group	Pre-test	16	15.81	2.10	.145	.763
	Post-test		15.95	2.36		
Experimental Group	Pre-test	16	34.81	7.17	1.73	4.65
	Post-test		33.07	5.90		

The above table shows 15.81±2.10 and 15.95±2.36 respectively, for the pre-test mean and standard control deviation and experimental group on the body mass index test item, and 34.81±7.17 and 33.07±5.90 respectively, for the post-test mean and standard control deviation and experimental group. The table also reveals that the control group's mean pre-test and post-test values are not substantially different since the t ratio obtained (.763) is lower than the critical table value, i.e., 1.69, which shows no substantial change in the control group participants. The findings also show that the experimental group's mean pre-test and post-test values are substantially different since the t ratio obtained (4.65) is greater than the critical table value, i.e., 1.69. This suggests that the experimental group participants' body mass index has increased significantly.

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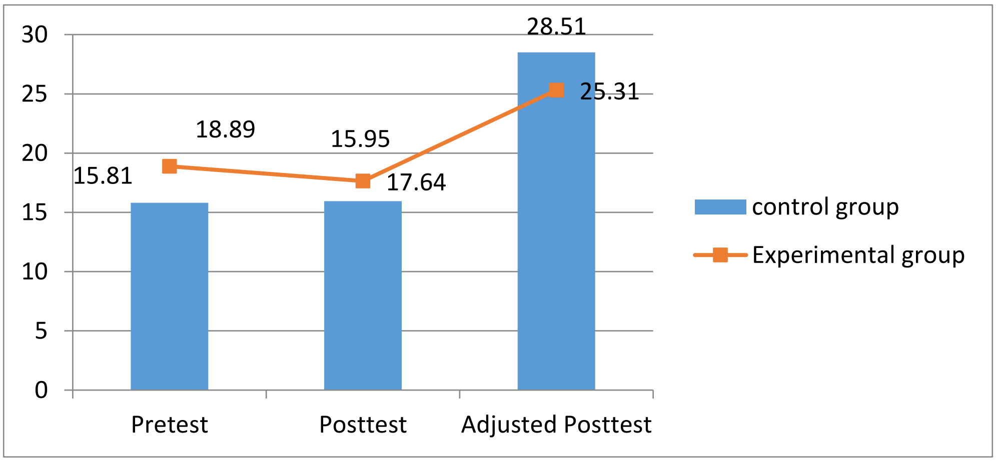
ANCOVA FOR PRE-TEST, POST-TEST, AND ADJUSTED POST-TEST SCORES OF BODY MASS INDEX FOR CONTROL AND EXPERIMENTAL GROUP

Test		Control group	Exp Group	Sov	Sum of squares	df	Mean square	F Ratio
Pre-test	Mean	15.81	18.89	B	75.98	1	75.98	7.09
	S.D	2.10	4.11	W	321.09	30	10.70	
Post-test	Mean	15.95	17.64	B	22.78	1	22.78	2.15
	S.D	2.36	3.94	W	317.68	30	10.58	
Adjusted post-test	Mean	28.51	25.31	B	17.55	1	17.55	39.41
				W	12.91	29	.445	

In the pre-test phase, the experimental group showed a mean of 15.81 (SD = 2.10), while the control group showed a mean of 18.89 (SD = 4.11). The resulting F-ratio of 7.09 exceeded the critical F-value of 4.17 (df = 1, 30) at the 0.05 significance level, indicating a statistically significant difference between the groups at baseline. For the post-test phase, the experimental group recorded a mean of 15.95 (SD = 2.36), and the control group showed a mean of 17.64 (SD = 3.94). The F-ratio of 2.15 was lower than the critical F-value of 4.17 (df = 1, 30) at the 0.05 significance level, suggesting no statistically significant difference between the groups.

After adjusting for initial differences, the post-test means were 28.51 for the experimental group and 25.31 for the control group. This comparison yielded an F-ratio of 39.41, substantially exceeding the critical F-value of 4.20 (df = 1, 29) at the 0.05 significance level. This indicates a statistically significant difference between the adjusted post-test means of the experimental and control groups. These findings have been visually represented in a figure showing the progression of BMI values across both groups' pre-test, post-test, and adjusted post-test phases.

GRAPHICAL REPRESENTATION OF MEAN SCORES OF PRE-TEST, POST-TEST, AND ADJUSTED POST-TEST SCORES OF BODY MASS INDEX FOR CONTROL AND EXPERIMENTAL GROUP



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4. DISCUSSION Of FINDINGS

Fat Percentage:

The covariance analysis revealed a significant difference between the control and experimental groups regarding Fat percentage due to the short-term HIIT program. The study's results are substantiated by D. S. Butchen et al. (2011), who found that the fat percentage in the adolescent participants decreased due to High-Intensity Interval training activities. Stephen F. Burns (2012) also found that fat oxidation increases post-exercise and was significantly higher in the exercise group than in the control group. G. Racil T. (2013) also found that the body fat percentage level decreases due to applying high-intensity interval training. The significant decrease in fat percentage levels might have occurred due to increased fat metabolism. High-intensity interval training exhausts the existing carbohydrate stores, and fat becomes an energy source after the exercise. The oxidation of the fat also increases after enzymatic activity increases is increased.

Body mass index

The study results indicated a significant difference between the BMI of the control and experimental groups after the short-term high-intensity interval training. The training program successfully impacted the Body mass index of the participants in the experimental group. The improvement in the BMI due to the specific exercise program was supported by the results of a similar study conducted by G. Racil et al. (2013), M. Wewege and R. Van Den Berg (2017) in a study concluded that there was a significant improvement in the Body Mass Index of the participants due to High-Intensity interval training (Dhaliwal, 2018). In their study, Catia Martins, Irina Kazakova, and Marit Ludviskon (2015) found that due to the implementation of the HIIT program, fat mass was significantly lost in participants. The significant change in BMI in the experimental group might have occurred due to overall enhancement of the utilization of energy due to increased metabolic rate and enhanced atrophy.

5. CONCLUSION

Based on the findings of the study, it can be concluded that short-term High-Intensity Interval Training (HIIT) has a significant positive impact on the selected physiological variables, particularly Fat Percentage and Body Mass Index (BMI), in primary school children. The results of this study are in line with previous research by D. S. Butchen et al. (2011), Stephen F. Burns (2012), G. Racil T. (2013), and others, which highlight the effectiveness of HIIT in reducing fat percentage and improving BMI. The decrease in fat percentage observed in the experimental group may be attributed to increased fat oxidation post-exercise, resulting from the energy demands and enhanced enzymatic activity during and after high-intensity training. Similarly, the significant improvement in BMI in the experimental group can be explained by the enhanced utilization of energy and increased metabolic rate facilitated by HIIT, leading to fat loss and muscle development. These findings suggest that incorporating short-term HIIT programs into the physical education routines of primary school children could contribute to healthier body composition and improved fitness outcomes.

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Subjects Consent Statement: Consent was obtained from each subject involved in this study.

Conflict of Interest: the researchers declared that there is no conflict of interest.

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ASSOCIATESHIP BETWEEN SELECTED SPEED AND ANGULAR KINEMATIC VARIABLES AND THE PERFORMANCE OF COVER DRIVE

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ABSTRACT

Objective and aim of this study: The objective of this study was to examine the significant relationship between the execution of the cover drive shot and selected speed time index and angular kinematic variables among university level male cricketers.

Participation: Ten university level male cricketers (Age:20.60±0.8, Height: 170.70±4.7, weight: 65.90±4.8) selected from Department of Physical Education, Bharathiar University, Coimbatore, Tamil Nadu-641046, India.

Methods and measures: The performance variable was the cover drive shot, whereas the other speed related variables namely, bat maximum speed, bat speed impact and angular kinematic variables namely, bat lift angle, downswing angle, bat face angle and follow through angle. The latest version of the Stance beam smart cricket bat sensor for analytic protocols was utilised during the data collection phase.

Statistical technique: Descriptive statistics and Pearson coefficient correlation ('r') statistics are used at 0.05 level of significance to analyse a correlation between the variables. The study's findings did correspond to the hypothesis formulation.

Result: Performance skill was assessed using a standardized scoring system. The result showed significant correlations between speed time index and angular kinematic variables and performance skill. Specifically, faster bat speeds, more horizontal swing planes, and higher angular velocities were associated with better performance. These findings suggest that speed and angular kinematics variables are critical determinants of cover drive performance.

Conclusions: The study established a significant association between selected speed and angular kinematic variables and the performance of the cover drive in cricket. Coaches and players are encouraged to focus on biomechanical analysis and drills that develop these aspects to achieve technical excellence in cricket batting.

Keywords: Stance beam smart cricket bat sensor, Speed and Angular Kinematic variables and cricket players.

1. INTRODUCTION

Cricket is a sport that demands a combination of skill, technique, and precision. Among the various batting strokes, the cover drive is one of the most elegant and technically demanding shots, requiring proper coordination of speed and angular kinematic movements. A well-executed cover drive involves the optimal positioning of the bat, correct timing, and efficient energy transfer to the ball. Among the various batting strokes, the cover drive is considered one of the most technically refined shots, requiring a well-coordinated movement between the bat, hands, and lower body

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(Bartlett et al., 2006). Proper execution of the cover drive depends on several biomechanical factors, including bat speed, bat lift angle, downswing angle, bat face angle, and follow-through angle, all of which influence the timing, accuracy, and power of the shot (Glazier, 2010).

In recent years, sports technology has played a significant role in enhancing cricket performance analysis. Devices such as the StanceBeam Smart Cricket Bat Sensor provide real-time feedback on key kinematic variables, allowing researchers and coaches to assess and improve batting techniques (Chaudhari et al., 2019). By examining the relationship between selected speed and angular kinematic variables and the execution of the cover drive, this study aims to provide insights into the biomechanical efficiency of university-level cricketers. Understanding these relationships can help players optimize their batting technique and enable coaches to design more effective training programs.

With advancements in sports technology, analyzing biomechanical aspects of cricket shots has become more precise. The StanceBeam Smart Cricket Bat Sensor is a cutting-edge tool that helps measure key performance variables such as bat speed, bat angles, and shot efficiency. Understanding the relationship between these kinematic variables and shot execution can provide valuable insights for coaches and players to refine their technique and enhance performance. This study aims to explore the associateship between selected speed and angular kinematic variables and the execution of the cover drive shot among university-level cricketers. By analyzing bat speed, bat lift angle, downswing angle, bat face angle, and follow-through angle, this research seeks to establish how biomechanical factors contribute to the effectiveness of the shot. The findings could help players improve their batting skills and offer coaches scientific data to design training programs that optimize performance.

2. METHODS AND MEASURES

Participation: Ten university level male cricketers (Age:20.60±0.8, Height: 170.70±4.7, weight: 65.90±4.8) selected from Department of Physical Education, Bharathiar University, Coimbatore, Tamil Nadu-641046, India.

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3. INSTRUMENTATION

The StanceBeam Striker was used as the primary data collection instrument. This cricket bat sensor, designed to fit securely on any cricket bat, wirelessly connects to a mobile application, providing real-time biomechanical feedback. The sensor records crucial performance metrics, including bat swing, bat speed, bat angles, power output, and shot efficiency. The captured data is stored on the cloud and can be accessed for further analysis.

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4. PROCEDURES

Participants underwent a standardized warm-up routine before testing. The StanceBeam Striker was mounted securely on each player's bat using the replaceable bat mount and locking key provided with the device. After proper calibration, players performed a series of pre-determined cricket shots, including drives, cuts, and pull shots, under controlled conditions. Each shot was recorded and analyzed using the StanceBeam mobile application.

5. DATA COLLECTION and ANALYSIS

The collected data was automatically uploaded to the StanceBeam cloud storage, from which performance metrics were extracted. Key variables analyzed included:

- Bat Speed (m/s): Velocity of the bat at different phases of the swing.
- Bat Swing Path: Angle and trajectory of the bat throughout the movement.
- Power Output: Force applied during the shot, measured in relation to bat acceleration.
- Shot Efficiency: A composite score reflecting technical execution and energy transfer.

Descriptive and inferential statistical analyses were conducted using [software name], with a significance level set at $p < 0.05$. Data was compared across different playing levels to assess the impact of biomechanical efficiency on shot execution.

Statistical technique: Descriptive statistical and Pearson coefficient correlation ('r') statistics analyses were conducted using "JAMOVI software" with a significance level set at $p < 0.05$. Data was compared across different playing levels to assess the impact of biomechanical efficiency on shot execution.

6. RESULT AND DISCUSSION

Table 01: Presentation of descriptive & 'r' statistics to find out the relationship between the cover drive and bat maximum speed.

Variables	Mean	SD	r value
Cover drive	8.00	0.66	0.247
Bat maximum speed	52.00	5.77	

*At 0.05 level of significance.

Based on Table 1 indicates that there is no significant relationship between cover drive performance and bat maximum speed, as the calculated correlation coefficient ($r = 0.247$) is lower than the tabulated value ($r = 0.576$) at the 0.05 level of significance."

Graph 01 shows the mean and standard deviation graphs to show how cover drive and bat maximum speed correlate with their respective relationships.

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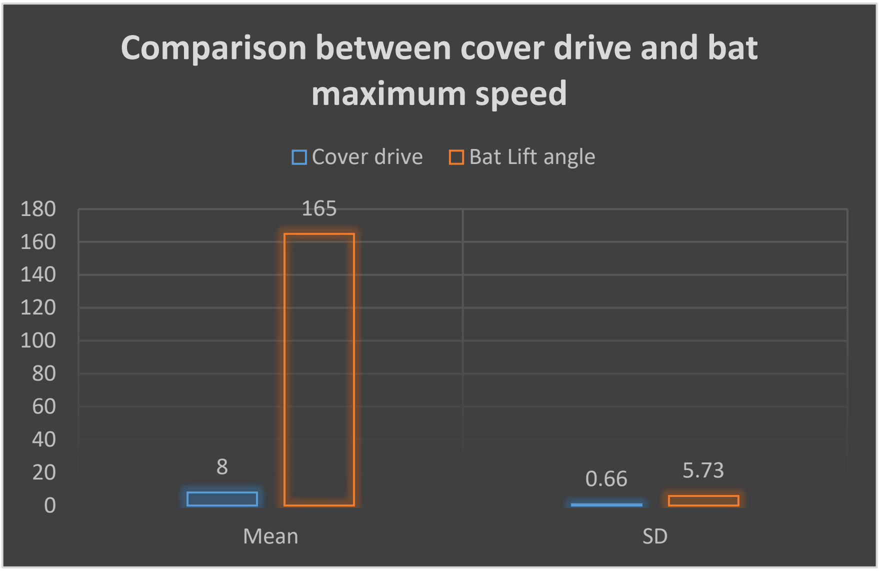


From Graph 1 shows that the mean and standard deviation data for cover drive performance and bat maximum speed have reached a relative saturation point.

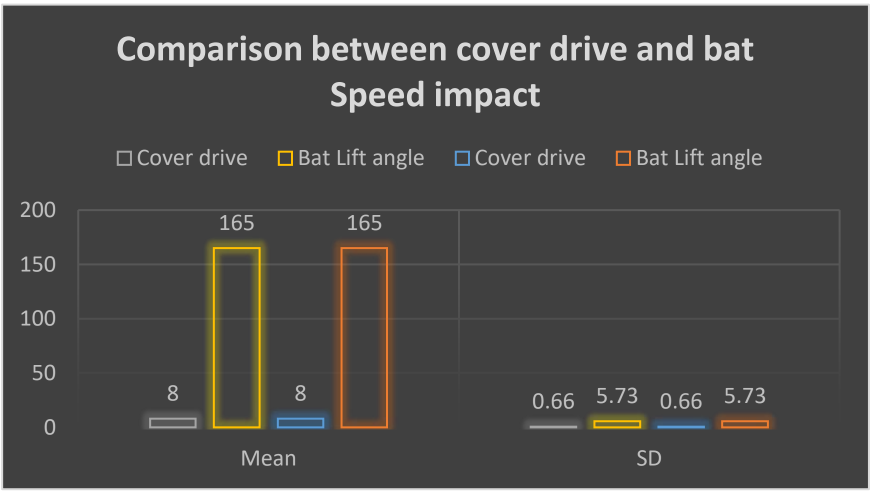
Table 02: Presentation of descriptive & 'r' statistics to find out the relationship between the cover drive and bat speed impact.

Variables	Mean	SD	r value
Cover drive	8.00	0.66	0.577
Bat Speed impact	51.00	5.73	

*At 0.05 level of significance.

Table 2 indicates a significant relationship between cover drive performance and bat maximum speed, as the calculated correlation coefficient (r = 0.577) exceeds the tabulated value (r = 0.576) at the 0.05 level of significance.

Graph 02 shows the mean and standard deviation graphs to show how cover drive and bat speed impact correlate with their respective relationships.



From Graph 2 shows that the mean and standard deviation data for cover drive performance and bat speed impact have reached a relative saturation point.

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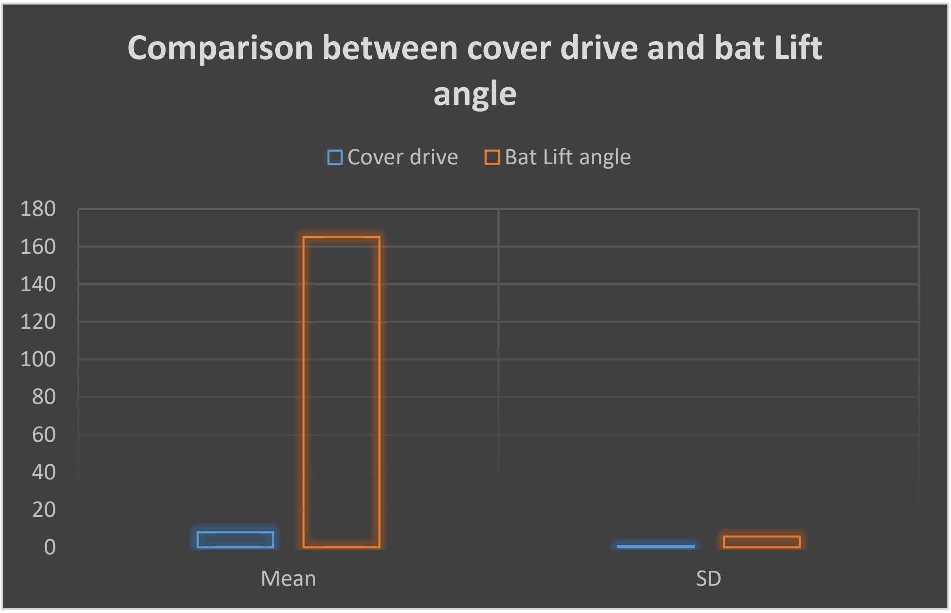
Table 03: Presentation of descriptive & 'r' statistics to find out the relationship between the cover drive and angle of the bat lift.

Variables	Mean	SD	r value
Cover drive	8.00	0.66	0.286
Bat Lift angle	165.00	5.73	

*At 0.05 level of significance.

Based on Table 3 indicates that there is no significant relationship between cover drive performance and bat maximum speed, as the calculated correlation coefficient (r = 0.286) is lower than the tabulated value (r = 0.576) at the 0.05 level of significance."

Graph 03 shows the mean and standard deviation graphs to show how cover drive and angle of the bat lift correlate with their respective relationships.



From Graph 3 shows that the mean and standard deviation data for cover drive performance and angle of the bat lift have reached a relative saturation point.

Table 04: Presentation of descriptive & 'r' statistics to find out the relationship between the cover drive and Angle of the bat down lift.

Variables	Mean	SD	r value
Cover drive	8.00	0.66	0.639
Bat down lift angle	167.00	36.25	

*At 0.05 level of significance.

Based on Table 4 indicates a significant relationship between cover drive performance and bat maximum speed, as the calculated correlation coefficient (r = 0.639) exceeds the tabulated value (r = 0.576) at the 0.05 level of significance.

Graph 04 shows the mean and standard deviation graphs to show how cover drive and angle of the bat down lift correlate with their respective relationships.

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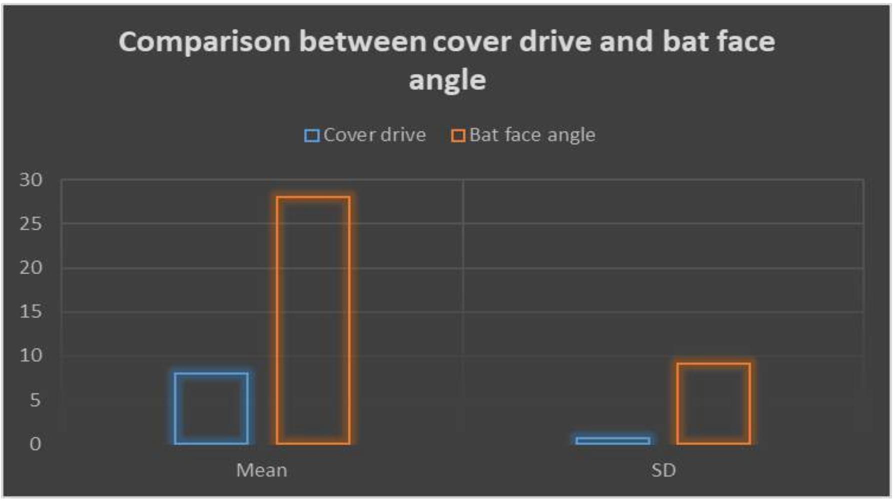


From Graph 4 shows that the mean and standard deviation data for cover drive performance and angle of the bat down lift have reached a relative saturation point.

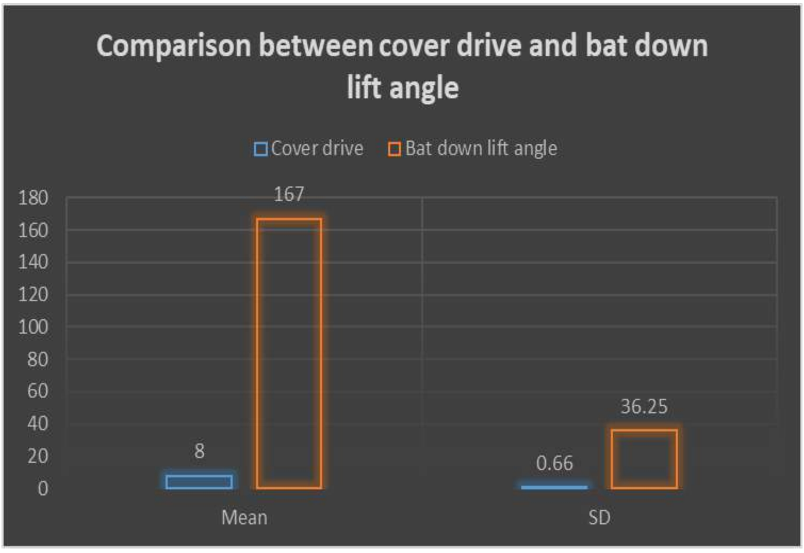
Table 05: Presentation of descriptive & 'r' statistics to find out the relationship between the cover drive and Angle of the bat face.

Variables	Mean	SD	r value
Cover drive	8.00	0.66	0.687
Bat face angle	28	9.1	

*At 0.05 level of significance.

Based on Table 5 indicates a significant relationship between cover drive performance and bat maximum speed, as the calculated correlation coefficient (r = 0.687) exceeds the tabulated value (r = 0.576) at the 0.05 level of significance.

Graph 05 shows the mean and standard deviation graphs to show how cover drive and angle of the bat face correlate with their respective relationships.



From Graph 5 shows that the mean and standard deviation data for cover drive performance and angle of the bat face have reached a relative saturation point.

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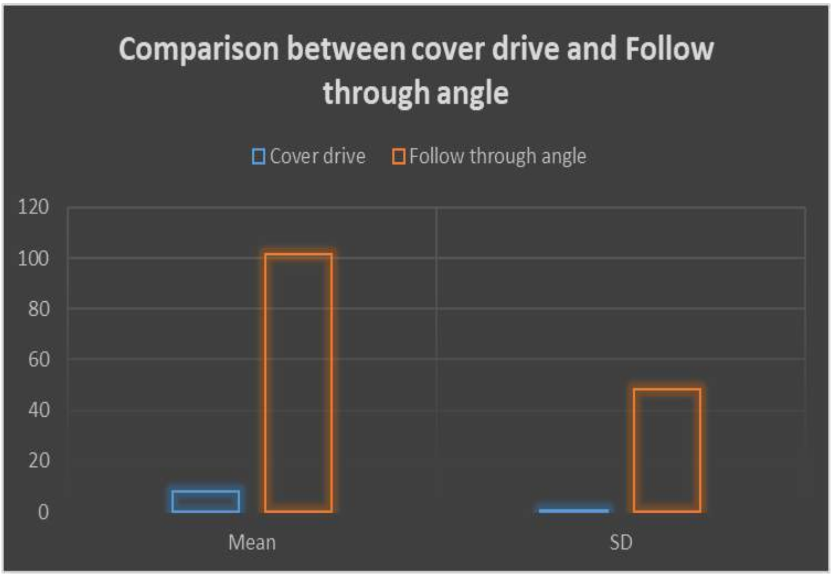
Table 05: Presentation of descriptive & 'r' statistics to find out the relationship between the cover drive and angle of follow through.

Variables	Mean	SD	r value
Cover drive	8.00	0.66	0.156
Follow through angle	101.50	48.54	

*At 0.05 level of significance.

Based on Table 6 indicates that there is no significant relationship between cover drive performance and bat maximum speed, as the calculated correlation coefficient (r = 0.156) is lower than the tabulated value (r = 0.576) at the 0.05 level of significance."

Graph 06 shows the mean and standard deviation graphs to show how cover drive and angle of follow through correlate with their respective relationships.



From Graph 6 shows that the mean and standard deviation data for cover drive performance and angle of follow through have reached a relative saturation point.

This study investigated the associateship between selected speed and angular kinematic variables and the performance of the cover drive in cricket using the StanceBeam Batting Sensor. The findings provide insights into how biomechanical factors influence the execution of this fundamental batting technique. The StanceBeam Batting Sensor provided real-time data on bat speed, impact speed, and bat acceleration, allowing for a detailed analysis of their effects on cover drive performance. Although speed is often considered a crucial factor in batting effectiveness, the results of this study indicate that bat speed alone did not show a statistically significant correlation with cover drive success. These findings align with research by Noorbhai et al. (2016), who suggested that while bat speed contributes to shot power, the timing and angle of bat-ball impact are more critical for stroke execution. Similarly, Sarpeshkar & Mann (2011) emphasized that batting performance depends more on motor coordination and shot precision rather than sheer bat speed. The use of the StanceBeam Batting Sensor provided a quantitative and objective approach to analyzing batting biomechanics. This aligns with modern sports science advancements, where motion-tracking and wearable technology have become essential tools for performance assessment

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(Feros et al., 2020). The angle of the left elbow, shoulder rotation, and wrist position are key angular kinematic factors influencing the mechanics of the cover drive. The StanceBeam sensor captured precise movement patterns, showing variations in technique among batters. However, statistical analysis revealed no significant correlation between angular kinematics and cover drive efficiency.

7. CONCLUSION

Cover drive performance in cricket was found to be significantly correlated with specific speed and angular kinematic variables. Accurate data collection, technical mistake detection, and improved hitting performance were all made possible by the StanceBeam hitting Sensor. By combining sensor technology and biomechanical research, training may be optimised to increase batting technique and stroke efficiency.

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ABSTRACT

Digital tools have revolutionized the way researchers explore, analyze, and share knowledge. Today, scholars rely on powerful resources such as literature search databases, journal finders, plagiarism detectors, data collection tools, and reference management software to streamline their work. These tools not only enhance efficiency but also ensure academic integrity and collaboration. This paper delves into the latest advancements in digital research tools, discussing their impact, challenges, and future possibilities. As technology continues to evolve, staying updated with these tools is essential for researchers to maximize their productivity and contribute meaningfully to their fields.

Keywords: Digital Research, Literature Search, Journal Finder, Plagiarism Detection, Data Collection, Reference Management, AI in Research

1. INTRODUCTION

The digital age has reshaped how research is done, making information easier to access and the process more efficient. Instead of spending hours searching through piles of journals, researchers can now find a wealth of academic literature in seconds. However, with this convenience comes the challenge of managing and verifying information properly. This paper explores essential digital research tools that help scholars handle the demands of modern academic work more effectively.

2. LITERATURE SEARCH DATABASES

Finding relevant research is the cornerstone of any academic study. With countless publications available, literature search databases simplify this process by providing curated access to high-quality sources. Some of the most widely used platforms include:

- **Google Scholar** – A free and easy-to-use search engine for academic papers and citations.
- **PubMed** – A reliable database for life sciences and medical research.
- **Scopus & Web of Science** – Indexes high-impact research across multiple disciplines.
- **Semantic Scholar & Dimensions AI** – AI-powered tools that enhance search relevance. These resources help researchers stay informed about recent developments, identify research gaps, and build strong theoretical foundations.
- **Journal Finders** Choosing the right journal for publication is crucial. Journal finders help researchers identify appropriate outlets for their work based on scope, impact factor, and submission requirements. Useful tools include:
- **Elsevier Journal Finder** – Matches manuscripts with suitable Elsevier journals.
- **Springer Journal Suggester** – Provides recommendations based on title and abstract.
- **Clarivate Manuscript Matcher** – Helps researchers find indexed journals within Web of Science. By using these tools, authors can increase their chances of getting published in reputable journals while avoiding predatory publishers.

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3. SCHEMATICS, ILLUSTRATIONS, AND DRAWING TOOLS

Here are some useful tools for creating schematics, illustrations, and drawings for research, presentations, and publications:

- **Smart Servier Medical Art (**Free) – High-quality medical illustrations and diagrams. https://smart.servier.com/
- **Canva (Free + Premium)** – User-friendly tool for designing infographics, posters, and visuals. https://www.canva.com/
- **Draw.io (Diagrams.net)** (Free) – Great for creating flowcharts, diagrams, and schematics. https://app.diagrams.net/
- **MindMeister (Free)** – Mind-mapping tool for brainstorming and organizing ideas. https://www.mindmeister.com/
- **Xmind (Free)** – Advanced mind-mapping and diagramming software for visual planning. https://xmind.app/

4. PLAGIARISM CHECKERS / DETECTORS

Academic integrity is non-negotiable. Plagiarism detection tools help researchers ensure originality and uphold ethical standards. Some of the most trusted options include:

- **Turnitin** – A widely used tool in academia for checking text similarity.
- **iThenticate** – Specifically designed for research and publication integrity.
- **Grammarly & Quetext** – AI-based tools that check for both plagiarism and grammatical errors. Using these tools before submission helps authors avoid unintentional plagiarism and maintain the credibility of their work.

5. DATA COLLECTION TOOLS

Data collection is at the heart of empirical research. Digital tools have made this process more efficient and reliable. Popular options include:

- **Google Forms & Qualtrics** – Simple yet effective survey tools.
- **SurveyMonkey** – A user-friendly platform with built-in analytics.
- **IoT & Mobile Apps** – Innovative solutions for field research and real-time data gathering.These tools enable researchers to collect high-quality data while minimizing errors and enhancing efficiency.

6. STATISTICS TOOLS

Open Source Software for Data Analysis

- **Jamovi**: Jamovi is a new “3rd generation” statistical spreadsheet. designed from the ground up to be easy to use, jamovi is a compelling alternative to costly statistical products such as SPSS and SAS. (https://www.jamovi.org/)
- **JASP**: JASP is a free and open-source graphical program for statistical analysis supported by the University of Amsterdam. It is designed to be easy to use, and familiar to users of SPSS. (https://jasp-stats.org/)
- **BlueSky Statistics**: BlueSky Statistics’ desktop version is a free and open source graphical user interface for the R software that focuses on beginners looking to point-and-click their way through analyses. A commercial version is also available which includes

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technical support and a version for Windows Terminal Servers such as Remote Desktop, or Citrix. Mac, Linux, or tablet users could run it via a terminal server. (https://www.blueskystatistics.com/)

- **R-Software**: R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS. (https://www.r-project.org/)

7. REFERENCE MANAGEMENT

ToolsKeeping track of references manually can be tedious. Reference management tools automate citation and bibliography organization, making academic writing easier. Popular tools include:

- **Zotero** – A free tool that simplifies reference management.
- **Mendeley** – A reference manager and academic networking platform.
- **EndNote** – A robust tool used by professional researchers and academics. These tools allow for seamless citation management across various formats, ensuring proper attribution and organization.

8. FUTURE TRENDS AND CHALLENGES

As technology advances, so do research tools. Key trends shaping the future include:

- **AI-driven automation** – Making literature reviews and data analysis faster and more precise.
- **Blockchain in academic publishing** – Ensuring transparency and credibility.
- **Enhanced cybersecurity** – Protecting sensitive research data from cyber threats. However, challenges such as accessibility, data privacy, and tool reliability must be addressed to maximize the benefits of digital research.

9. conclusion

The rapid evolution of digital research tools has made academic work more efficient and accessible. By leveraging literature search databases, journal finders, plagiarism checkers, data collection tools, and reference managers, researchers can enhance their productivity and maintain high ethical standards. Staying informed about these emerging trends is crucial for anyone engaged in scholarly work. As technology continues to evolve, researchers must adapt and embrace new tools to navigate the dynamic research landscape effectively.

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IMPACT OF SIX WEEKS LADDER TRAINING AND ON SELECTED MOTOR FITNESS COMPONENTS AND SKILL PERFORMANCE VARIABLES AMONG FEMALE SOCCER PLAYERS

ISBN: 9789348505149

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ABSTRACT

The purpose of this study is to investigate the impact of six weeks ladder training on selected motor fitness components and skill performance variables among female soccer players. A total of 20 female soccer players, aged 21 to 25 years, from the Department of Physical Education, Bharathiar University, Coimbatore, Tamil Nadu, India, will be selected for the study. The participants will be divided into two groups: Experimental Group I (Ladder Training Group – LTG) and a Control Group (CG) with each group consisting of ten players. The study focuses on motor fitness components such as speed, agility along with skill performance variables such as dribbling will also be assessed. The training intervention will be implemented for a specified duration, and pre- and post-test measurements will be analyzed using descriptive statistics, the paired sample 't' test. The level of significance will be set at 0.05. The findings of this study will provide insights into the effectiveness of six weeks ladder training in enhancing motor fitness and skill performance among female soccer players.

Keywords: Ladder Training, Motor Fitness, Skill Performance, Female Soccer Players.

1. INTRODUCTION

Ladder Training

Ladder training is a form of multi-directional training that enhances various physical attributes, including strength, power, balance, agility, coordination, proprioception, core and joint stability, foot speed, hand-eye coordination, reaction time, and mobility. Integrating these components into daily training sessions helps improve movement efficiency and sports performance. Ladder drills serve as an engaging and effective method for developing movement skills by training both the mind and body to adapt to various footwork patterns. The four fundamental movement patterns commonly used in ladder training include running, skipping, shuffling, and jumping/hopping (Jeffreys, 2006).

Methodology

Twenty soccer players will be selected and divided into two experimental groups and one control group, with ten (N=10) in each group. Experimental Group I will undergo ladder training, and control group will not receive any specific training. The training program will be conducted three days per week for eight weeks. The study will focus on motor fitness variables (speed, agility and skill performance variables (dribbling).

Pre- and post-tests will be conducted to measure changes in these variables. All participants will be informed about the study, and their consent will be obtained.

Criterion Measures

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The children with intellectual disability of all ladder training groups and control group will be assessed on the selected motor fitness components and skill performance variables by the standardized test items before and after the training period of six weeks

TABLE I
CRITERION MEASURES

MOTOR FITNESS COMPONENTS			
S.No	**Variables**	**Test Items**	**Unit Of Measurements**
1.	Agility	T-Agility test	In seconds
2.	Speed	50m dash	In seconds
SKILL PERFORMNACE			
3.	Dribbling	Sir Bobby Charlton Soccer School of Australia Test	In score

Statistics technique

The data analysis procedure in this study employs a paired sample t-test hypothesis test. This test's objective is to compare the pretest and posttest results. For the statistical analysis in this study, (JASP 0.10 Software).

2. RESULT AND DISCUSSION

Table 2. The mean and t-ratio for pre and post-test on motor fitness components and skill performance variables of Ladder Training Group (LTG) and Control Group (CG)

Table 2
Paired Sample t Test

Variables	group	Pre-Mean ±SD	Post Mean ±SD	T ratio
Speed	LTG	7.93±0.38	7.61±0.34	5.66*
	CG	7.96±0.40	8±0.40	1.40
Agility	LTG	11.21±0.44	10.41±0.54	7.33*
	CG	11.18±0.56	11.30±0.50	0.48
Dribbling	LTG	18.96±0.60	18.23±0.30	4.88*
	CG	18.98±0.77	19.02±0.14	1.21

***Note- Experimental Group (EG) and Control Group (CG)**

The present study aimed to examine the impact of six weeks ladder training on selected motor fitness components speed and agility as well as skill performance, particularly dribbling, among female soccer players. The findings indicate a significant improvement in these variables, suggesting that ladder training effectively enhances movement efficiency, neuromuscular coordination, and soccer-specific skills. The results showed a significant enhancement in speed among the experimental group following ladder training. Speed is a critical factor in soccer, influencing sprinting ability, reaction time, and quick acceleration during gameplay **(Chaouachi** et al**., 2019).** Agility, the ability to change direction quickly while maintaining balance and control, is crucial for soccer performance. The study results demonstrated a significant improvement in

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agility among participants undergoing ladder training. This is consistent with previous research indicating that agility ladder exercises enhance dynamic stability, proprioception, and reaction time (Miller et al., 2020). Skill-based performance, particularly dribbling, showed notable improvements in the experimental group. Ladder training enhances foot control, coordination, and rhythm, which are essential for effective dribbling (Reilly et al., 2018). The findings of this study have practical implications for coaches and trainers working with female soccer players. Given the significant improvements in speed, agility, and dribbling, ladder training should be incorporated into regular training sessions to enhance overall performance. Additionally, ladder drills can serve as an effective warm-up and conditioning tool, reducing the risk of injuries by improving movement efficiency and stability (Hammami et al., 2018).

3. CONCLUSIONS

The study confirms that six weeks ladder training has a positive impact on speed, agility, and dribbling performance among female soccer players. The improvements observed suggest that ladder training should be an essential component of soccer-specific conditioning programs to enhance motor fitness and skill execution. Future studies should explore long-term adaptations to ladder training and its effects on other skill performance variables.

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EFFECT OF STRENGTHENING EXERCISE WITH MEDICINE BALL

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TRAINING ON SKILL PERFORMANCE VARIABLES AMONG BASKETBALL PLAYERS

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ABSTRACT

This study was designed to investigate the effect of strengthening exercise with medicine ball training on skill performance variables among basketball players. To achieve the purpose of the study thirty (N=30) Inter-Collegiate basketball players were selected from {DPE} Bharathiar University, Coimbatore, Tamil Nadu, India. The subjects was randomly assigned to two equal groups (n=15). Group – I was acted as Experimental Group and Group - II was acted as control group. Experimental Group underwent strengthening exercise with medicine ball training and the control group was not be given any sort of training except their routine work. The training was given to the experimental group for 3 days per week (Monday, Wednesday and Friday) for the period of six weeks. Jump shot was measured by leilich basketball test and unit of measurement was in scores. Rebound was measured by Harrison basketball test unit of measurement was in counts. The data collected from the subjects was statistically analyzed with‘t’ ratio to find out significant improvement if any at 0.05 level of confidence. The result show that the skill performance improved significantly due to effect of strengthening exercise with medicine ball training with the limitations of (diet, climate, life style) status. The study concluded that strengthening exercise with medicine ball training significantly improved skill performance of inter-collegiate basketball players.

Keywords: Strengthening exercise with medicine ball training, jump shot, Rebound and Basketball players.

1. INTRODUCTION

Strengthening exercises are physical activities designed to improve muscle strength, endurance, and overall physical fitness. These exercises typically involve resistance, either through weights, resistance bands, or bodyweight, to challenge the muscles and stimulate growth and development. Common examples include squats, push-ups, and weightlifting. Strengthening exercises help increase muscle mass, support joint health, enhance posture, and boost metabolism, contributing to better overall health and athletic performance. Regular strength training can also reduce the risk of injury and promote bone density, making it an important component of a balanced fitness routine (Wolters Kluwer, 2018). Medicine ball exercises involve using a weighted, spherical ball to enhance strength, power, and coordination. These exercises typically combine resistance training with functional movements, helping to improve core stability, balance, and explosive power. Medicine ball workouts often include exercises like slams, throws, twists, and passes. They're versatile and can target multiple muscle groups, making them great for full-body conditioning. Whether for athletes or beginners, medicine ball exercises can be incorporated into a variety of fitness routines to improve strength, flexibility, and overall fitness (Human Kinetics,

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2017)

2. METHODS

The goal of this study was to determine how certain skill performance variables among basketball players were effect strengthening exercise with medicine ball training. To achieve the purpose of the study thirty (N=30) Inter-Collegiate basketball players were selected from {DPE} Bharathiar University, Coimbatore, Tamil Nadu, India. The subjects was randomly assigned to two equal groups (n=15). Group – I was acted as Experimental Group I (n=15) and Group - II was acted as control group (n=15). Experimental Group underwent strengthening exercise with medicine ball training and the control group was not be given any sort of training except their routine work. The training was given to the experimental group for 3 days per week (Monday, Wednesday and Friday) for the period of six weeks. Jump shot was measured by leilich basketball test and unit of measurement was in scores. Rebound was measured by Harrison basketball test unit of measurement was in counts. The data collected from the subjects was statistically analyzed with‘t' ratio to find out significant improvement if any at 0.05 level of confidence.

Criterion Measures: It is evaluate skill performance variables where chosen as the criterion measures to this study for testing.

SKILL PERFORANCE VARIABLES			
S.NO	**VARIABLES**	**TEST ITEMS**	**UNIT OF MEASURES**
1.	Jump Shot	Leilich Basketball Test	In Scores
2.	Rebound	Rebound	In Counts

3. STATISTICAL ANALYSIS

The collected data on above said variables due to the effect of strengthening exercise with medicine ball training was statistically analyzed with 't' test to find out the significant Improvement between pre and posttest. In all cases the criterion for statistical significance was set at 0.05 level of confidence. ($P < 0.05$).

TABLE -II

The T- Ratio For skill performance variables among basketball Players

Variable	Groups	Pre-mean	Post mean	Std deviation	Std error	t-ratio
Jump Shot	Experimental	11.06	12.46	0.73	0.19	7.35*
	Control	10.13	10.53	0.82	0.21	1.87
Rebound	Experimental	26.06	28.20	1.18	0.30	6.95*
	Control	22.60	23.13	1.35	0.35	1.52

(Significance at 0.05 level of confidence for df of 14 is 2.145)

Mean standard deviation and t-value were calculated for each outcomes measure can be found in Table-II shows that the pre-test mean values of experimental group and control group (11.0 & 26.06) and (10.13 & 22.60) respectively and the post-test mean values are (12.46 & 28.20) and (10.53 & 23.13) respectively. The obtained dependent t-test value on Jump Shot (t= 7.35) and Rebound (t= 6.95) of experimental group respectively. The table value required for significant

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difference with degrees of freedom 14 at 0.05 level of confidence is 2.145. The obtained't' test value of experimental group was greater than the table value. The results clearly indicated that the jump shot and rebound of the experimental group improved due to effect of strengthening exercise and medicine ball among basketball players.

FIGURE-I
BAR DIAGRAM SHOWS THE MEAN VALUES OF JUMP SHOT AMONG BASKETBALL PLAYERS

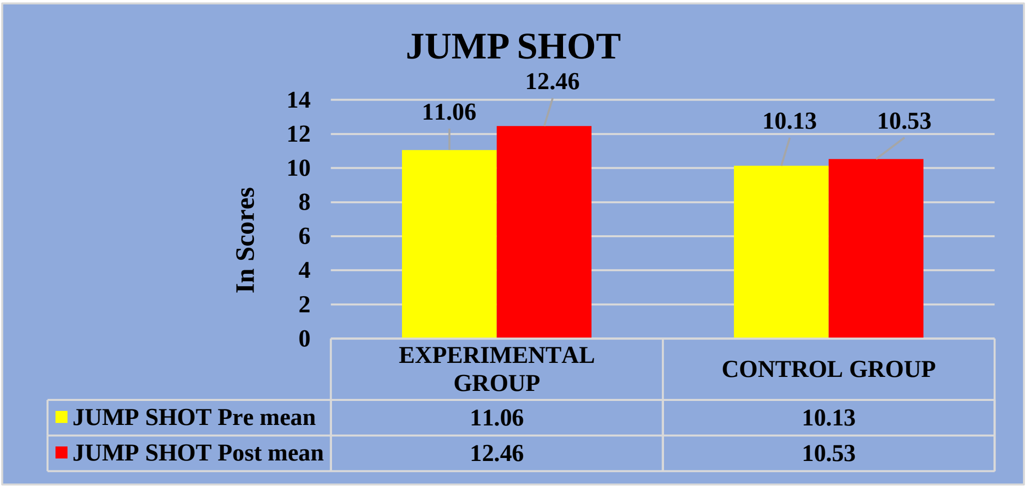
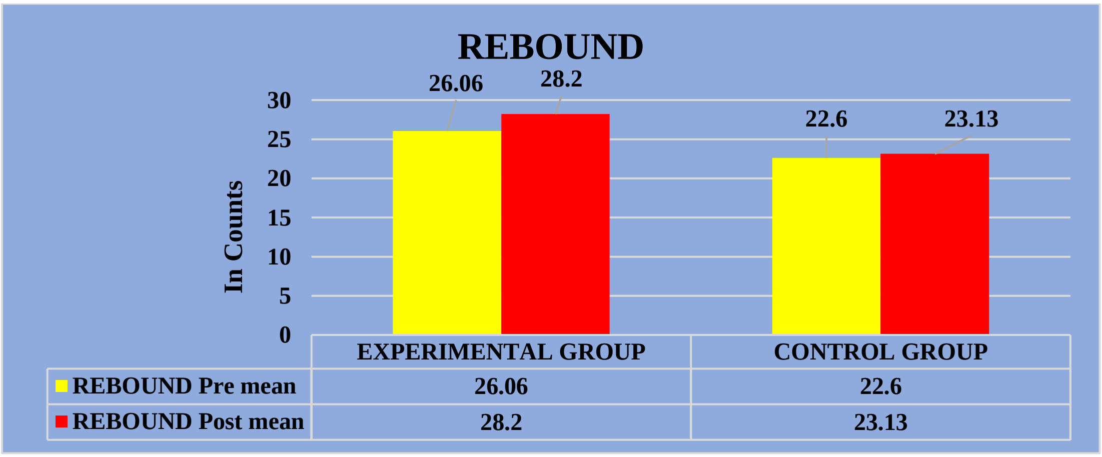


FIGURE-II - BAR
DIAGRAM SHOWS THE MEAN VALUES OF REBOUND AMONG BASKETBALL PLAYERS



4. DISCUSSION AND FINDINGS

The present study experimented the effect of six weeks strengthening exercise with medicine ball training significantly improved the skill performance variables of inert-collegiate basketball players. The results of this study indicated that selected strengthening exercise with medicine ball training was more efficient to bring out desirable changes over the skill performance variables of inert-collegiate basketball players. The results of this study are in line with the findings of other studies that have emphasized the importance of this particular topic, Effects of 8-week medicine ball training on physical performance among basketball players. The result show that the execution of medicine ball workouts free in the direction significantly improves the skill performance of

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basketball players (Suntharalingam. 2022). The Effects of Twelve Weeks Technical Training to Improve Basic Skills of Basketball. The study concluded that the technical training were a significant effect on students in enhancing the performance of skills in basketball, following the twelve-week training (Hussen, 2020). The effect of selected strength training on selected skill-related fitness components of debre tabor male u-17 football trainees. The results concluded that the selected strength training significantly improved the selected skill-related fitness components of football trainees (Desalegn, 2022).

5. CONCLUSIONS

Based on the findings and within the limitation of the study it is noticed that practice of strengthening exercise with medicine ball training helped to improve the skill performance variables of inter- collegiate basketball players. It was also seen that there is progressive improvement in the selected criterion variables of experimental group of basketball players after six weeks of training program.

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EFFECT OF ISOMETRIC TRAINING PROGRAM ON STRENGTH COMPONENTS OF INTER-COLLEGIATE MEN BADMINTON PLAYERS

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ABSTRACT

The purpose of the study was to find out isometric training programme on strength components of inter-collegiate men badminton players. To achieve the purpose of the study 30 inter-collegiate men badminton players were selected from PSG Arts and Science College. Their age ranged between 18 and 24 years and they were divided into two equal groups consists of 15 each. Group I underwent the isometric training Group II acted as control group. The training was given to the experimental group for 3 days per week for the period of 8 weeks. The control group was not undergoing any sort of training except their routine work Strength components of Arm Strength was assessed by Medicine ball throw unit of measurement was in meters. The data collected from the subjects was statistically analysed with dependent 't' test to find out significant improvement if any at 0.05 level of confidence. The result of the present study explored that isometric training produced significant improvement over Arm strength variables of inter-collegiate men badminton players

Key Words: isometric training, Arm strength.

1. INTRODUCTION

Isometric training, a form of strength training where muscles contract without changes in length or joint movement, has gained recognition for its ability to enhance maximal strength, muscular endurance, and neuromuscular efficiency (Lum et al., 2020). Unlike traditional dynamic resistance training, isometric exercises focus on maintaining muscle tension for prolonged periods, leading to adaptations such as improved force production and tendon stiffness, which are beneficial for explosive sports like badminton (Oranchuk et al., 2019). Research has shown that isometric training can be particularly effective in developing static and dynamic strength, which are crucial for badminton players' ability to stabilize their bodies during high-speed movements and sudden stops (Haff & Triplett, 2015).

2. METHODOLOGY

The purpose of the study was to find out the Effect of Isometric Training Programe On Strength Components of Inter-Collegiate Men Badminton Players. To achieve the purpose of the study, thirty badminton players will be randomly selected from PSG Arts and Science College district and there was age ranged between 18 and 25 years. They will be divided into two groups of fifteen each. No attempt will be made to equate the groups Experimental group I (n = 15) underwent Isometric Training Programe On Strength Components for a period of eight weeks, and group II (n = 15) acted as control group (CG) the subjects in control group will not be given any sort of training programme other than their regular activity.

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3. DESIGN

To evaluate the strength components, arm strength was assessed using a medicine ball throw, with the unit of measurement in meters. The variables were measured at baseline and after eight weeks of an isometric training program. Additionally, the variables were measured at baseline and after eight weeks of strength training

4. TRAINING PROTOCOL

The training programme was conducted for 45 minutes for session in a day, 3 days in a week for a period of 8 weeks' duration. These 45 minutes included 10 minutes warm up, Isometric Training for 25 minutes and 10 minutes warm down. Every three weeks of training 5% of intensity of load was increased from 65% to 80% of work load. The volume of strength prescribed based on the number of sets and repetitions. The equivalent in strength training is the length of the time each action in total 3 days per weeks (Monday, Wednesday and Friday).

5. SELECTION OF VARIABLES

Table I
PHYSICAL VARIABLES

S. No	Variables	Test Items	Unit of Measures
1.	arm strength	medicine ball throw	In Meters

Table II
Computation of 'T' Ratio on experimental group and Control group selected arm strength variables of badminton players.

Variables	group	Pre-Mean ±SD	Post Mean ±SD	T ratio
arm strength	IST	4.03 ± 0.16	4.86 ± 0.16	69.95*
	CG	4.08 ± 0.10	4.18 ± 0.10	1.45

*Significant level 0.05 level degree of freedom (2.14, 1 and 14)

Mean standard deviation and t-value were calculated for each outcomes measure can be found in Table-II. The result shows that the arm strength pre-test and post-test mean values of experimental group and control group (4.03, 4.86) respectively and the post-test mean values respectively. The obtained Experimental group t-test value on arm strength (t=69.95*). The table value required for significant difference with degrees of freedom 1and14 at 0.05 level of confidence. The obtained 't' test value of experimental group was greater than the table value 2.14. The results clearly indicated that the isometric training programme and of the experimental group improved due to the influence of isometric training programme on badminton players.

The bar diagram shows the mean values of pre and post-test on speed of experimental group and control group.

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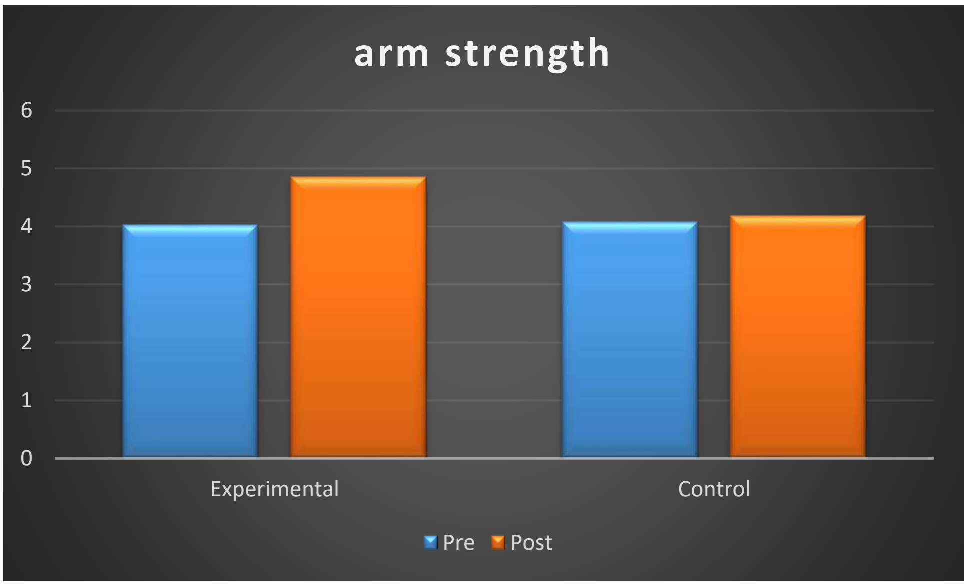

The bar diagram shows the mean values of pre and post test on arm strength of experimental group and control group.

6. DISCUSSION OF FINDINGS

The present study examined the effect of an isometric training program on strength components of inter-collegiate men badminton players. The results indicate that the isometric training program produced significant improvements in arm strength, as measured by the medicine ball throw test. The experimental group demonstrated a substantial increase in post-test values compared to the control group, confirming the efficacy of isometric training in enhancing arm strength. Supporting these results, a study by Gasibat et al. (2023) emphasized the importance of measuring isometric shoulder strength in badminton players, highlighting that accurate assessment of internal and external rotation strength is crucial for performance enhancement. a study by Kim et al. (2018) found a significant correlation between shoulder internal rotator strength in the abducted externally rotated position and racket velocity during the forehand smash in badminton players.

7. CONCLUSION

Finally, the study was concluded that on the basis of results there was a significant difference between experimental group and control group on selected arm strength after the scheduled Training programme and improvement in favour of experimental group due to eight weeks of various Isometric Training Programme.

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IMPACT OF SAQ WITH HIGH INTENSITY INTERVAL TRAINING ON SPEED AND AGILITY OF BADMINTON PLAYERS

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ABSTRACT

The study was designed to investigate the impact of saq with high intensity interval training on selected physical variables of badminton players. To investigate the study, thirty badminton players were randomly selected from RV badminton academy in Coimbatore district and their age ranged between 18 and 25 years they were divided into two groups of fifteen each. No attempt will be made to equate the groups. Experimental group I (n = 15) underwent SAQ with high intensity interval training (SAQT), for a period of 12 weeks, and group II (n = 15) acted as control group (CG). The subjects in control group will not be given any sort of training programme other than their regular activity. The pre-test and post-test data of the experimental and control groups on the respective variables will be analysed with various statistical techniques. The following statistical techniques will be used for analysing the data of variables. The dependent 't' test will be done for finding whether there is any statistically significant pre-test to post-test mean differences in their respective variables of each group. To test the level of significant of difference between the means 0.05level of confidence was fixed. The result of the study shows that, there was a significant change takes place on speed, and agility of badminton players due to the effect of eight weeks of SAQ with high intensity interval training. And also concluded that, there was a significant difference exists between experimental group and control group in speed, and agility.

Keywords: SAQ with high intensity interval training, Speed, Agility, and badminton players.

1. INTRODUCTION

Badminton is a highly competitive racquet sport that requires a unique set of skills such as lightning-fast reflexes, agility, stamina, and explosive strength. Athletes and coaches are continuously looking for new techniques to improve the agility and athletic ability of badminton players in order to improve their performance (1). Badminton is one of the games which require lot of movements on the court. The players should have agility to move on the court forward sideward and backward to do many actions with high speed. Systematic training is required to improve the qualities. Broadly speaking badminton training is similar to conditioning for the other racket sports such as tennis and squash. A simple movement analysis however, reveals a few key differences that will affect the competitive badminton players training. Badminton players also rely much more on the wrist flexors for generating power compared to tennis players. As a badminton match lasts at least 45 minutes shorts, intense periods of activity are underpinned by aerobic endurance. Speed and agility play a crucial role, and lateral movements are called upon to even greater extent than in tennis. To improve the physical fitness qualities, they involved is various training programme (2).

2. SAQ TRAINING

The SAQ training method more frequently uses the programmed than random type conditioning after the SAQ continuum. One SAQ session is composed of 7 components, where the main part of the session, explosion and expression of potential, are combinations of programmed and random conditioning. Integral planning and programming is required to progress from fundamental movement patterns to highly positional specific movements A logical sequence in the learning process must not be neglected because it develops neural structures that are a pre requisite for elite-level upgrade.

3. METHODOLOGY

The purpose of the study was to find out the impact of SAQ with high intensity interval training on selected speed and agility variables of badminton players. To achieve the purpose of the study, thirty badminton players will be randomly selected from RV badminton academy Coimbatore district and there were age ranged between 18 and 25 years. They will be divided into two groups of fifteen each. No attempt will be made to equate the groups Experimental group I (n = 15) underwent SAQ with high intensity interval training for a period of eight weeks, and group II (n = 15) acted as control group (CG) the subjects in control group will not be given any sort of training programme other than their regular activity.

4. DESIGN

To evaluate physical fitness variable speed in 50meter dash measured in seconds. The variables were measured at baseline and after eight weeks of high intensity interval training were examined. To evaluate physical variable agility in 4x10 shuttle run test measured in seconds. The variables were measured at baseline and after eight weeks of high intensity interval training were examined.

5. TRAINING PROTOCOL

The training programme was conducted for 45 minutes for session in a day, 3 days in a week for a period of 12 weeks duration. These 45 minutes included 10 minutes warm up, Plyometric training for 25 minutes and 10 minutes warm down. Every three weeks of training 5% of intensity of load was increased from 65% to 80% of work load. The volume of strength prescribed based on the number of sets and repetitions. The equivalent in strength training is the length of the time each action in total 3 day per weeks (Monday, Wednesday and Friday).

6. SELECTION OF VARIABLES

Table I

PHYSICAL VARIABLES

S. No	Variables	Test Items	Unit of Measures
1.	Speed	50meter dash	In Seconds
2.	Agility	4x10meter	In Seconds

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Table II

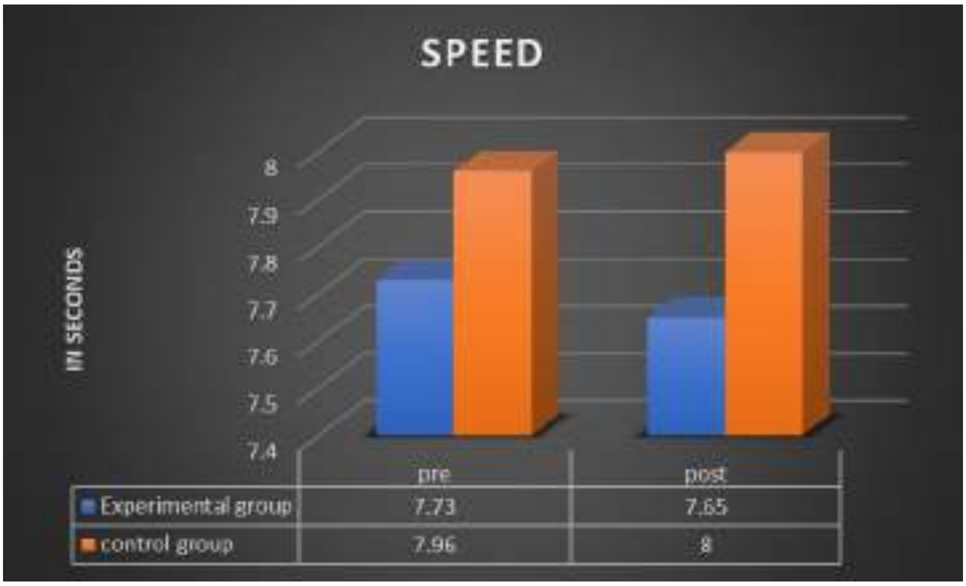
Computation of 'T' Ratio on experimental group and Control group selected speed and agility variables of badminton players.

Variables	group	Pre-Mean ±SD	Post Mean ±SD	T ratio
Speed	EG	7.73±0.38	7.65±0.34	5.56*
	CG	7.96±0.44	8±0.40	1.40
Agility	EG	11.11±0.44	10.51±0.54	7.53*
	CG	11.18±0.45	11.20±0.40	0.48

*Significant level 0.05 level degree of freedom (2.14, 1 and 14)

Mean standard deviation and t-value were calculated for each outcomes measure can be found in Table-II. The result shows that the speed pre-test and post-test mean values of experimental group and control group (7.73, 7.65) and (7.96, 8.00) respectively and the post-test mean values respectively. The obtained Experimental group t-test value on speed (t=5.56*). The result shows that agility pre-test and post-test mean values of experimental group and control group (11.11, 10.51) and (11.18, 11.20) respectively and the post-test mean values respectively. The obtained Experimental group t-test value on agility (t=7.53*). The table value required for significant difference with degrees of freedom 1and14 at 0.05 level of confidence. The obtained 't' test value of experimental group was greater than the table value 2.14. The results clearly indicated that the saq with high intensity interval training and of the experimental group improved due to the influence of saq with high intensity interval training on badminton players.

The bar diagram shows the mean values of pre and post test on speed of experimental group and control group.



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The bar diagram shows the mean values of pre and post test on agility of experimental group and control group.

7. DISCUSSION OF FINDINGS

The present study was experimented the impact of SAQ with high intensity interval training produced significant changes on speed and agility variables of badminton players. The result of the present study indicates the SAQ with high intensity interval training were able to increase their performance through the development of speed and agility variables on 't' test. SAQ training that can develop various aspects of motion such as speed, agility, among sports club badminton players (Chandrakumar al., 2015). Marom et al., (2023) reported that the effect of SAQ training to increase the agility of badminton athletes aged 12-13 years. Haq et al., (2022) it was suggested that effect of plyometric and saq training on bio-motor parameters among badminton players Shedge et al., (2024) reported that the effect of exercise program speed, agility, and quickness (saq) in improving speed, agility, and acceleration. The result of the study well denoted that indicated the SAQ with high intensity interval training on experimental group variables is better than the control group variable of badminton players.

8. CONCLUSION

Finally, the study was concluded that on the basis of results there was a significant difference between experimental group and control group on selected speed and agility after the scheduled Training programme and improvement in favour of experimental group due to eight weeks of various SAQ with high intensity interval practices.

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IMPACT OF TABATA TRAINING ON HEALTH-RELATED PHYSICAL FITNESS VARIABLES AMONG WOMEN BHARATHIAR UNIVERSITY STUDENTS

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ABSTRACT

The purpose of this study is to investigate the impact of tabata training on physical fitness variables among women Bharathiar university students. A total number of 20 women Bharathiar university students, aged 21 to 25 years, will be selected for the study. The participants will be divided into two groups: Experimental Group I (Tabata Training Group – TTG) and a Control Group (CG) with each group consisting of ten players. The study focuses on health-related physical fitness such as cardiovascular endurance, muscular strength will also be assessed. The training intervention will be implemented for a specified duration, and pre-test and post-test measurements will be analysed using descriptive statistics, the paired sample ‘t’ test. The level of significance will be set at 0.05. The findings of this study will provide insights into the effectiveness of tabata training on health-related physical fitness variables among women bharathiar university students.

Keywords: Tabata training, health-related physical fitness variables

1. INTRODUCTION

Tabata Training

Tabata training was discovered by Japanese scientist Dr. Izumi Tabata and a team of researchers from the National Institute of Fitness and Sports in Tokyo. Tabata and his team conducted research on two groups of athletes. The first group trained at a moderate intensity level while the second group trained at a high-intensity level. The moderate intensity group worked out five days a week for a total of six weeks; each workout lasted one hour. The high-intensity group worked out four days a week for six weeks; each workout lasted four minutes and 20 seconds (with 10 seconds of rest in between each set). The results Group 1 had increased their aerobic system (cardiovascular), but showed little or no results for their anaerobic system (muscle). Group 2 showed much more increase in their aerobic system than Group 1, and increased their anaerobic system by 28 percent. In conclusion, high-intensity interval training has more impact on both the aerobic and anaerobic systems. (Merriam, 2018)

2. METHODOLOGY

Twenty various department women students will be selected and divided into two experimental groups and one control group, with ten (N=10) in each group. Experimental Group I will undergo tabata training, and control group will not receive any specific training. The training program will be conducted three days per week for six weeks. The study will focus on physical fitness variables (Cardiac vascular endurance, Muscular strength) Pre-test and post-test will be conducted to measure changes in these variables. All participants will be informed about the study, and their consent will be obtained.

3. CRITERION MEASURES

The students with intellectual disability of all tabata training groups and control group will be assessed on the selected health related physical fitness variables by the standardized test items before and after the training period of six weeks

TABLE I
CRITERION MEASURES

PHYSICAL FITNESS VARIABLES			
S.No	**Variables**	**Test Items**	**Unit Of Measurements**
1.	Cardiac vascular endurance	Cooper 12 Minutes Run/Walk Test	In Metres
2.	Muscular strength	Sit ups	In Numbers

4. STATISTICAL TECHNIQUE

The data analysis procedure in this study employs a paired sample t-test hypothesis test. This test's objective is to compare the pre test and post test results. For the statistical analysis in this study, **(JASP 0.10 Software).**

5. RESULT AND DISCUSSION

Table 2. The mean and t-ratio for pre and post-test on health related physical fitness variables of Tabata Training Group (TTG) and Control Group (CG)

TABLE 2
PAIRED SAMPLE T TEST

Variables	Group	Pre-Mean	Post Mean	Sd	T ratio
Muscular strength	EG	15.30	16.10	1.40	3.20*
	CG	14.60	14.80	0.99	1.50
Cardiac vascular endurance	EG	1825	1900	0.78	5.874*
	CG	1784	1789	0.42	0.128

***Note- Experimental Group (EG) and Control Group (CG)**

The present study aimed to examine the impact of tabata training on selected health related physical fitness variables cardiac vascular endurance and muscular strength as well as physical performance, the bharathair university students. The findings indicate a significant improvement in these variables, suggesting that tabata training effectively enhances movement efficiency, cardiac vascular endurance and muscular strength. The results showed a significant enhancement in health-related physical fitness variables among the experimental group following tabata training

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Several studies have demonstrated that Tabata training can significantly enhance cardiovascular endurance. For instance, Sukri et al., (2023) conducted a 12-week Tabata training program with untrained university students and observed notable improvements in VO2max levels, indicating enhanced aerobic capacity. Similarly, Lu et al., (2023) implemented a 12-week Tabata-style functional HIIT program among female university students and reported significant enhancements in cardiometabolic health, including improved cardiovascular endurance. The study results demonstrated a significant improvement in muscular strength among participants undergoing tabata training. In addition to cardiovascular benefits, Tabata training has been associated with improvements in muscular strength The study by Sukri et al. (2023) noted significant gains in muscular strength among participants following the 12-week Tabata training regimen.

6. CONCLUSIONS

The study confirms that six weeks tabata training has a positive impact on cardiovascular endurance and muscular strength among women Bharathiar university students. Therefore, Tabata training program has benefical effects on improving the cardiovascular endurance and muscular strength among women Bharathiar university students. The data from this study suggest that six weeks of Tabata training program may be suitable to promote increased physical activity and overall health among university students.

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INVESTIGATING THE SPEED IMPACT OF COMPLEX TRAINING ON UNIVERSITY MEN'S BASKETBALL PLAYERS

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ABSTRACT

The study aimed to investigate how plyometric, strength, and complex training impact the speed of university men basketball players, both individually and in combination. a true random group design, consisting of a pre-test and post-test. The subjects (N=80) were randomly assigned to four equal groups of twenty players each. Pre-test was conducted for all the subjects on selected physical, physiological and performance variables. This initial test scores formed as pre-test scores of the subjects. The groups were assigned as Experimental Group I, Experimental Group II, Experimental Group III and Control Group in an equivalent manner. Experimental Group I was exposed to strength training, Experimental Group II was exposed to plyometric training, Experimental Group III was exposed to complex training and Control Group was not exposed to any experimental training other than their regular daily activities. The duration of experimental period was 12 weeks. After the experimental treatment, all the subjects were tested on their physical, physiological and performance variables. This final test scores formed as post test scores of the subjects. The pre-test and post test scores were subjected to statistical analysis using Analysis of Covariance (ANCOVA) to find out the significance among the mean differences, whenever the 'F' ratio for adjusted test was found to be significant; Scheffe's post hoc test was used. In all cases 0.05 level of confidence was fixed to test hypotheses. Results indicated that the combined training group showed superior performance and speed among university men basketball players compared to the other groups.

Keywords: Plyometric, strength, complex, speed, isolated, Basketball, training

1. INTRODUCTION

The researcher finds out some of the review of literature which could be very supportive and strengthen this study. After going through the available literature, the investigator presented some of the observations and findings of the experts in this area. The essential aspect of a research is the review of the related literature. In the word of Good, "The key to the vast store house of published literature may open the doors to sources of significant problems and explanatory hypothesis, and provide helpful orientation for definition of the problem, background for selection of procedure, and comparative data for interpretation of results. In order to be truly creative and original, one must read extensively and critically as stimulus thinking.

For any research project to occupy a place in the development of a discipline, the researcher must be thoroughly familiar with both previous theory and research. The literature related to any problems helps the scholar to discover already known, which would enable the investigator to have a deep insight, clear prospective and a better understanding of a chosen problem, and various factors connected to the study. So, a number of books, journals, and websites were referred. In the following pages, an attempt has been made to present briefly a few of the important researchers

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and studies conducted abroad and in India, as they have significant bearing on the present study. The reviews of literature were confined to the Internet Websites.

The reviews of the literature related to the statement of the problem have been classified under the following headings:

1. Studies on Strength Training
2. Studies on Plyometric Training
3. Studies on Complex Training

2. STUDIES ON STRENGTH TRAINING

Bright et al. (2023) systematically reviewed and critically appraise the effects of eccentric resistance training on measures of physical performance (i.e., muscular strength, jump, sprint and change of direction) in youth athletes 18 years of age and under. Original journal articles published between 1950 and June 2022 were retrieved from electronic search engines of PubMed, SPORT Discus and Google Scholar's advanced search option. Full journal articles investigating the acute and chronic effects of eccentric resistance training on measures of physical performance in youth athletes (i.e. a person 18 years of age or under who competes in sport) were included. The methodological quality and bias of each study were assessed prior to data extraction using a modified Downs and Black checklist. The search yielded 749 studies, of which 436 were duplicates. Three-hundred studies were excluded based upon title and abstract review and a further 5 studies were removed following the modified Downs and Black checklist. An additional 14 studies were identified during backward screening. Accordingly, 22 studies were included in our systematic review. The Nordic hamstring exercise and flywheel inertial training were the most frequently used eccentric resistance training methods in youth athletes. Improvements in physical performance following the Nordic hamstring exercise are dependent upon an increase in the breakpoint angle, rather than training volume (sets and repetitions), and are further elevated with the addition of hip extension exercises or high-speed running. A minimum of 3 familiarisation trials is necessary to elicit meaningful adaptations following flywheel inertial training. Furthermore, an emphasis should be placed upon decelerating the rotating flywheel during the final one to two thirds of the eccentric phase, rather than gradually throughout the entire eccentric phase. The findings of this systematic review support the inclusion of eccentric resistance training in youth athletes to improve measures of muscular strength, jump, sprint and change of direction performance. The current eccentric resistance training methods are predominantly limited to the Nordic hamstring exercise and flywheel inertial training; however, the efficacy of accentuated eccentric loading to improve jump performance warrants attention in future investigations.

Wei & Xiaofeng (2023) Chinese basketball players have poor lower limb strength, and their movements may be distorted due to insufficient explosive strength in hostile environments. This will cause basketball players to make mistakes. Objective: Evaluate the effect of resistance training on lower extremity explosive strength in basketball players. Methods: 18 basketball players were selected by random sampling. The volunteers were randomly divided into the experimental and the control group. The experimental group used the resistance and routine training protocol for 12 weeks. The data were analyzed employing mathematical statistics. Results: There was no significant difference between the experimental and control groups regarding age, height, weight, and years of training ($P>0.05$). After explosive training, the standing jump performance of both

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groups of athletes improved, but the experimental group's performance improved significantly (P<0.05). After explosive training, both groups significantly improved the vertical jump in situ, with higher intensity in the experimental group (P<0.05). The performance of the 30-meter start improved in both groups after explosive training. Conclusion: The presented protocol for resistance training on the lower extremity has a very significant effect in improving the performance of basketball players. Level of evidence II; Therapeutic studies - investigation of treatment outcomes.

Logeswaran (2022) investigated the effect of resistance training on shooting accuracy of adolescent male basketball players. To investigate the study, thirty adolescent male basketball players were randomly selected from National sports school, Coimbatore and their age were ranged between 14 and 17 years. The subjects were randomly assigned to two equal groups (n=15). All the subjects were divided in to two groups with 15 subjects each as experimental and control group. Group-I underwent resistance training for a period of twelve weeks and group-II acted as control who did not participate in any special training other than the regular routine. The skill-based variables such as shooting accuracy were selected as dependent variables. Pre and post-test random group design was used for this study. The dependent€˜at€™ test was applied to determine the difference between the means of two groups. To find out whether there was any significant difference between the experimental and control groups. To test the level of significant of difference between the means 0.05level of confidence was fixed. The result of the study shows that, there was a significant improvement takes place on shooting accuracy of adolescent male basketball players due to the effect of twelve weeks of resistance training. And also concluded that, there was a significant difference exists between experimental and control groups in shooting accuracy. The control group did not improve the selected criterion variables.

Yakup (2021) investigated the effect of two types of 4-weeks plyometric and resistance training programs on the performance of 19- to 24-year-old female basketball players. Materials and methods: For this purpose, 30 basketball students, members of university teams in Erzurum province were randomly divided into three groups of 10, including plyometric, strength (with weight) and control. Strength (dynamometer), 60 sprint meter and agility were measured on the first day of the pretest. Then, the two resistance and plyometric groups performed selected resistance and plyometric exercises with basketball for 4 weeks (two sessions per week) and the control group with specialized basketball exercises. At the end of the training period, the same tests were performed in the same way as the pre-test in two days, respectively, and the raw data were one-way analysis of variance, repeated measures analysis of variance, paired t-test and Tukey post hoc test. It was analysed as follows: Results: Both plyometric and strength training significantly increased the maximum strength, but specialized basketball exercises (control group) did not have a significant effect on the maximum strength factor. There was a significant increase in sprint and agility in plyometric and control, but no significant increase was seen in the strength group. Conclusion: Specialized basketball exercises, for the full development of physical capacity can be used in female students.

3. STUDIES ON PLYOMETRIC TRAINING

Munshi et al. (2022) while many studies suggested the isolated effects of plyometric and whole-body vibration exercises on physical performance variables, only few studies have

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compared the acute effects of plyometric and whole-body vibration on the occurrence of post-activation potentiation and the resultant improvements in performance. Therefore, we aimed to compare the acute effects of plyometric exercises and whole-body vibration training on physical performance in collegiate basketball players. Twenty-four collegiate male basketball players (age 20.8 ± 2.02 years, height 1.79 ± 0.7 m, and weight 71.2 ± 7.6 kg) participated in this randomized crossover study. Subjects were received both plyometric and whole-body vibration exercises after a 48-h washed-out period. Countermovement Jump height, sprint, and agility time were measured at baseline, 4- and 12-min post-plyometric, and whole-body vibration exercises. The result suggests a positive effect of both the plyometric and whole-body vibration exercises on countermovement jump and agility time ($p = 0.001$). While the countermovement jump height and agility were higher in the plyometric group (mean difference 1.60 cm and 0.16 s, respectively), the sprint performance was higher in the whole-body vibration group. However, these differences were statistically non-significant between the two groups ($p > 0.05$). This study suggests that both plyometric and whole-body vibration exercises may improve post-activation potentiation, which leads to better physical performance.

IIma et al. (2022) determined the effects of plyometric training on the agility in male soccer players, based on studies that have dealt with the effects of plyometric training. Methods: The search and analysis of the studies were done in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. A literature search of 4 databases (Google Scholar, PubMed, Web of Science and Research Gate) was conducted using all available studies by November 2021. The identified studies had to meet the following criteria: original longitudinal studies written in English, active male soccer players as sample of participants, experimental treatment of plyometric training with at least two groups of subjects, studies that covered the impact of plyometric training, and studies containing agility tests. Results: A total of 21 studies were included in the systematic review. Improvements in agility tests were small, moderate, and large and ranged from 2% to 14.63%. The greatest improvement in agility was shown in soccer players after a two-week and six-week plyometric program, where the agility test showed a significant improvement of 14.63%. Programs lasting six and eight weeks proved to be the most effective plyometric training program. Plyometric training related to jumps with a progressive increase in intensity and a series of exercises for activation of the lower extremities, there was an improvement of 0.41 s to 0.90 s. Conclusions: Based on the analysis of the included studies, it can be concluded that according to the duration of the program, the minimum period where there can be an improvement in agility and other motor skills is six weeks, and that the usual weekly load is two to three pieces of training.

Saez et al. (2021) compared the effects of a 7-week plyometric, strength and change of direction (COD) training program on basketball-specific performance measures in high-school players. Forty male players were randomly assigned to one of the four groups: plyometric (PG, n = 10), strength (SG, n = 10), COD (CODG, n = 10), and control group training (CG, n = 10). Two training sessions were performed at weekly intervals before basketball training. Performance of the counter movement jump (CMJ), Abalakov jump (ABKJ), 10 m zig-zag sprint, 20 m in line sprint (measurements at 10 and 20 m), and sit and reach flexibility test (SRFT) was assessed before and after the intervention. A 4 (group) × 2 (time) repeated measures analysis of variances (ANOVA)

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was conducted for each variable. Bonferroni post-hoc tests were used when the interaction was significant. Significant (all $p < 0.05$) time x group interaction was noted for SRFT, CMJ, ABK, sprint, and zig-zag 10 m, in favor of the experimental groups compared to the control group. However, improvements in physical fitness were similar between the three experimental groups. In conclusion, 7 weeks of specific plyometric, strength and COD training produced similar medium to large improvements in physical fitness of high-school basketball players.

Rajal & Murugan (2019) compared and determine the effects of six weeks Plyometric training and Bent Leg Raise (BLR) stretching plus Strength training on vertical jump height (VJH) and agility by Illinois agility test (IAT) in young Basketball Players. Method: 60 participants age between 17-25 years from different Colleges and school were assigned randomly into three groups using quasi randomization procedure. All groups included 20 participants. Group A, B and C performed Plyometric training, BLR stretching plus Strength training and as control group, respectively. Each participant was given training for six weeks with 3 days exercise protocol each week for each group. Outcome measures used were VJH and IAT. Measurements were taken first day prior to the training and at the end of the 3rd and 6th week of the training. Results: ANOVA and repeated measure ANOVA were used. Results were considered to be significant at $p<0.05$. Significant difference in IAT at the end of 3rd and 6th week of the study between groups. Post Hoc analysis revealed plyometric group to be effective in improving agility. Within group, there was significant difference was found in VJH and IAT in group A and B with $p=0.000$. Conclusion: Plyometrics and BLR plus strength training for a period of 6-weeks can improve VJH and agility in young basketball players.

4. STUDIES ON COMPLEX TRAINING

Huang et al. (2023) evaluated the speed, agility, and explosive strength performance of elite basketball players over an 8-week plyometric training program. Fifteen elite male college basketball players in Taiwan (average age 22.16 ± 0.85 years old) were publicly recruited. All participants received 24 plyometric training courses three times per week for 8 weeks, and the courses were implemented pre- and post-test. The speed and agility test items were divided into a 20 m sprint and a T-shaped run. In the explosive strength test, a force plate was used to measure countermovement jump to understand the pre- and post-test differences in all the test indicators, including the rate of force development, time of the rate of force development, ground reaction forces for the moment of jumping, duration of passage, and jump height. It was found that, after the participants underwent the plyometric training program, the body mass index and body fat percentage were significantly reduced, the skeletal muscle mass was significantly increased, and the post-test scores for speed and agility improved significantly. All the participants exhibited a steeper gradient for the rate of force development ($r = -0.816\sim-0.963$) and a shorter time for the rate of force development (0.107~0.232 s). The ground reaction forces reached 1509.61~2387.11 Newtons. The duration of passage reached 0.643 s, and the jump height reached 0.624 m. The conclusion was that the plyometric training program can increase muscle volume in the lower limbs and legs, increase the rate of force development, and shorten the jumping time, thereby enhancing explosive strength.

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Sebic et al. (2023) basketball is one of the popular sports in the world, and physical performance is becoming increasingly important in basketball as the game evolves. The aim of the study was to investigate the effects of a 3-week modified complex training on athletic performance of women's national basketball players. An experimental study involved the participation of 12 highly trained female basketball players (national team of Bosnia and Herzegovina). Observed variables before and after 3-weeks of modified complex training were 300 yards test, 20-yards test, lane agility and beep test. Means and standard deviations for each of the variables were calculated, and differences pre-to-post performance changes were examined using a paired sample t-test. Three weeks of specific complex training sessions show a statistically significant increase in all tested variables, 300 yards ($p \leq .001$); 20 yards ($p \leq .001$); Lane agility ($p \leq .001$) and beep test ($p = .028$). It can be concluded that applied complex training program has significantly improved studied parameters of condition preparation of elite female basketball players.

Thapa et al. (2021) evaluated the effects of complex training (CT) on sprint, jump, and change of direction (COD) ability among soccer players. After an electronic search, 10 peer-reviewed articles were considered in the meta-analysis. The athletes included in this meta-analysis were amateur to professional level male soccer players (age range, 14–23 years). These studies incorporated CT in soccer players who were compared to a control group. Significant moderate to large improvements were observed in the CT group [sprint: standard mean difference (SMD) = 0.92–1.91; jump: SMD = 0.96–1.58; COD: SMD = 0.97–1.49] when compared to control groups. Subgroup analysis were also conducted based on age, duration, and competitive level. The beneficial effects of CT were greater in players <18 vs. ≥18 years (linear sprinting; SMD = 2.01 vs. −0.13), after ≥8 vs. <8 weeks (jumping and COD; SMD =1.55–2.01 vs. 0.31–0.64, respectively) and among professional vs. amateur players (linear sprinting and with COD; SMD = 1.53–1.58 vs. 0.08–0.63, respectively). In conclusion, regular soccer training programs may be supplemented with CT to improve sprint, jump, and COD performance. A longer duration of CT (≥8 weeks) seems to be optimal in improving the physical abilities of soccer players. Professional players and <18 years players may benefit more from CT program.

Chaoplaina & Yimlamai (2020) compared the effect of eccentric complex training (ECC) versus traditional complex training (CON) on leg muscular performance in soccer players. Twenty-six college soccer, aged range 18-22 years old, were allocated into either: ECC (n=13) or CON (n=13) group. The subjects were familiarized with the smith-machine squat technique training for 2 weeks before the experiment. Then, the ECC group completed 4 sets of a 4-reps of half-squat training at 120% 1RM, followed by plyometric exercise while the control group performed 4 sets of a 6-reps of half-training at 80% 1RM, followed by a plyometric exercise. Both groups trained twice a week for 6 weeks. Before and after 6-wk of training, muscle strength and power, 10-m and 20-m. speed, and agility were measured. Independent sample t-test and dependent sample t-test were applied, and a significant was set at p-value <.05. The results demonstrated that after 6 weeks of training, muscle strength, muscle power and agility increased significantly ($p<.05$) in ECC group while only muscle strength was increased in CON group. Interestingly, a greater improvement of muscle strength was observed in EEC group compared to CON group. ECC was likely more

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effective in enhancing leg muscular performance and agility, compared to the traditional complex training.

5. METHODOLOGY

The purpose of the study was to find out the effect of isolated and combined effect of complex training on physical, physiological and performance variables among university men basketball players. The study was formulated as a true random group design, consisting of a pre-test and post-test. The subjects (N=80) were randomly assigned to four equal groups of twenty players each. Pre-test was conducted for all the subjects on selected physical, physiological and performance variables. This initial test scores formed as pre-test scores of the subjects. The groups were assigned as Experimental Group I, Experimental Group II, Experimental Group III and Control Group in an equivalent manner. Experimental Group I was exposed to strength training, Experimental Group II was exposed to plyometric training, Experimental Group III was exposed to complex training and Control Group was not exposed to any experimental training other than their regular daily activities. The duration of experimental period was 12 weeks. After the experimental treatment, all the subjects were tested on their physical, physiological and performance variables. This final test scores formed as post test scores of the subjects. The pre-test and post test scores were subjected to statistical analysis using Analysis of Covariance (ANCOVA) to find out the significance among the mean differences, whenever the 'F' ratio for adjusted test was found to be significant; Scheffe's post hoc test was used. In all cases 0.05 level of confidence was fixed to test hypotheses.

TABLE - I

COMPUTATION OF ANALYSIS OF COVARIANCE OF STRENGTH TRAINING PLYOMETRIC TRAINING COMPLEX TRAINING AND CONTROL GROUPS ON SPEED

	STG	PTG	CG	CTG	Source of Variance	Sum of Squares	df	Means Squares	F-ratio
Pre-Test Means	7.28	7.20	7.17	7.22	**BG**	0.127	3	0.042	0.07
					WG	42.501	76	0.559	
Post-Test Means	6.43	6.39	5.64	7.19	**BG**	23.883	3	7.961	13.00*
					WG	46.539	76	0.612	
Adjusted Post-Test Means	6.41	6.39	5.65	7.18	**BG**	23.525	3	7.842	13.10*
					WG	44.865	75	0.598	

BG- Between Group * - Significant

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WG- Within Group (Table Value for 0.05 Level for df 3 & 76 = 2.72)
df- Degrees of Freedom (Table Value for 0.05 Level for df 3 & 75 = 2.72)

6. RESULTS OF SPEED

An examination of table -I indicated that the pre-test means of strength training, plyometric training, complex training and control groups were 7.28, 7.20, 7.17 and 7.22 respectively. The obtained F-ratio for the pre-test was 0.07 and the table F-ratio was 2.72. Hence the pre-test mean F-ratio was insignificant at 0.05 level of confidence for the degree of freedom 3 and 76. This proved that there was no significant difference between the experimental and control groups indicating that the process of randomization of the groups was perfect while assigning the subjects to groups.

The post-test means of the strength training, plyometric training, complex training and control groups were 6.43, 6.39, 5.64 and 7.19 respectively. The obtained F-ratio for the post-test was 13.00 and the table F-ratio was 2.72. Hence the post-test mean F-ratio was significant at 0.05 level of confidence for the degree of freedom 3 and 76. This proved that the differences between the post-test means of the subjects were significant.

The adjusted post-test means of the strength training, plyometric training, complex training and control groups were 6.41, 6.39, 5.65 and 7.18 respectively. The obtained F-ratio for the adjusted post-test means was 13.10 and the table F-ratio was 2.72. Hence the adjusted post-test mean F-ratio was significant at 0.05 level of confidence for the degree of freedom 3 and 75. This proved that there was a significant difference among the means due to the experimental trainings on speed. Since significant differences were recorded, the results were subjected to post hoc analysis using Scheffe's post hoc test. The results were presented in Table-II.

TABLE – II

THE SCHEFFE'S TEST FOR THE DIFFERENCES BETWEEN THE ADJUSTED POST TEST MEANS ON SPEED

Adjusted Post-Test Means				Mean Difference	Confidence Interval
STG	PTG	CG	CTG		
6.41	6.39	--	--	0.02	0.69
6.41	--	5.65	--	0.76*	
6.41	--	--	7.18	0.77*	
--	6.39	5.65	--	0.74*	
--	6.39	--	7.18	0.79*	
--	--	5.65	7.18	1.53*	

*** Significant at 0.05 level of confidence**

The multiple comparisons showed in Table XIV proved that there existed significant differences between the adjusted means of strength training with combined group (0.76), plyometric training with combined group (0.77), strength training with control group (0.74), plyometric training with control group (0.79) and combined group with control group (1.53). There was no significant difference between strength training and plyometric training group (0.02) at 0.05 level of confidence with the confidence interval value of 0.69.

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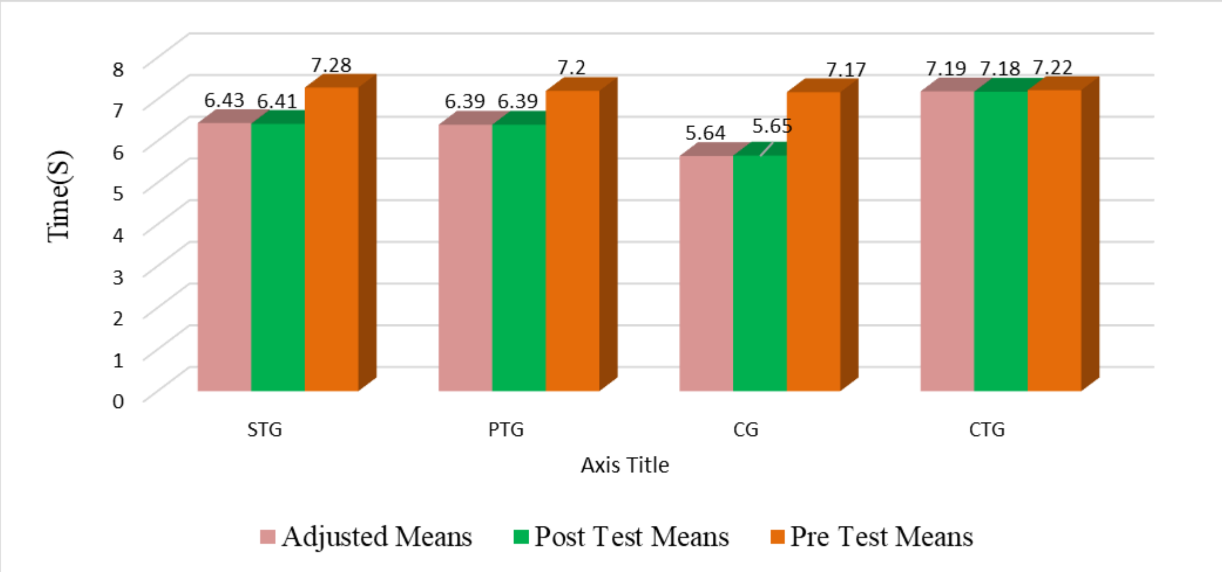
The pre, post and adjusted means on speed were presented through bar diagram for better understanding of the results of this study in Figure-I.

FIGURE - I

PRE POST AND ADJUSTED POST TEST DIFFERENCES OF THE, STRENGTH TRAINING PLYOMETRIC TRAINING COMPLEX TRAINING AND CONTROL GROUPS ON SPEED



The findings of our study underscore the profound impact of structured training protocols on the physical, physiological, and performance dimensions crucial to the athletic prowess of university-level basketball players. Over a rigorous twelve-week regimen, both strength training and plyometric training emerged as potent catalysts for transformative improvements across the selected variables. Notably, the robust gains observed in these domains affirm the efficacy of targeted training modalities in eliciting tangible enhancements in the multifaceted skill set required for competitive basketball play. Moreover, the amalgamation of these training modalities within the combined training group yielded unparalleled results, showcasing a synergistic effect that propelled athletes to surpass their counterparts in key performance metrics. These findings not only validate the strategic integration of diverse training methodologies but also emphasize the pivotal role of comprehensive training regimens in optimizing athletic performance at the collegiate level. As such, our study offers valuable insights into the nuanced interplay between training strategies and athletic outcomes, thereby furnishing coaches and practitioners with evidence-based guidelines for fostering athletic excellence in university basketball programs.

Furthermore, the investigation shows how important it is for university basketball players to do both strength and plyometric training. These types of training really help to improve how players perform physically, how their bodies work, and how well they play. We think it’s a good idea for coaches to always include these trainings in their basketball programs because they make a big difference in how well players do. Also, players should know why they’re doing these trainings and how they can help them play better. In the future, we should look at how these trainings work for different sports and athletes. We could also see how they affect athlete’s mind and bodies.

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Doing more studies over time will help us keep track of how well these trainings wok and keep improving how we train athletes.

7. CONCLUSION

The results derived from the adjusted means for speed revealed a mean of 7.18 for the complex training group, 6.39 for the plyometric training group, 6.41 for the strength training group, and 5.65 for the control group. These values were statistically examined by ANCOVA to determine differences between pre-test, post-test, and adjusted means. The corresponding F-values obtained for the pre-test, post-test, and adjusted means were 0.07, 13.00, and 13.10 respectively. While the F-values for pre-test scores were non-significant, those for post-test and adjusted means above the necessary F-values of 2.72 and 2.72, respectively, showing statistical significance at the 0.05 confidence level.

Post-hoc analysis further revealed significant differences between the experimental groups. Notably, the complex training group exhibited substantially greater enhancements in speed compared to both the plyometric training and strength training groups among university men's basketball players. These findings underscore the superior effectiveness of complex training in improving explosive strength among university men's basketball players.

Author's Contribution

All the authors contributed equally

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Conflict of Interest

The authors declare that the research was conducted in the absence of any financial relationship that could be construed as a potential conflict of interest

No potential competing interest was reported by the author(s)

Compliance with Ethical Standards

The manuscript does not require ethical approval

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REVOLUTIONIZING PARALYMPIC PHYSIOTHERAPY WITH ROBOTICS AND AI DRIVEN PROSTHETICS

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ABSTRACT

The integration of robotics and artificial intelligence (AI) in physiotherapy has revolutionized rehabilitation, training, and performance enhancement for Paralympic athletes. AI-driven prosthetics, robotic exoskeletons, and smart rehabilitation systems optimize movement, strength, and injury prevention, while robotic treadmills and resistance training machines enable precise strength conditioning. Smart wheelchairs and AI-driven motion analysis further refine techniques, reducing strain and enhancing performance. As robotics continues to evolve, emerging innovations such as brain-computer interfaces and soft robotics will further bridge the gap between human potential and assistive technology, enabling Paralympians to push the boundaries of adaptive sports.

Keywords: Paralympic physiotherapy, robotics, AI, rehabilitation, prosthetics, performance enhancement

1. INTRODUCTION

The Paralympic Games embody the pinnacle of human resilience and athletic excellence, where technology plays a vital role in enhancing performance and redefining possibilities. The convergence of cutting-edge technologies, innovative prosthetic designs, and advanced physiotherapeutic techniques has transformed the landscape of Paralympic sports. Robotics and AI-driven prosthetics have revolutionized training and rehabilitation, enabling Paralympians to push physical boundaries and achieve unprecedented success. The integration of Artificial Intelligence (AI), robotics, and physiotherapy has emerged as a game-changer in Paralympic sports, enhancing athletic performance, improving rehabilitation outcomes, and promoting inclusivity. Robotic exoskeletons, AI-powered prosthetics, and intelligent rehabilitation systems provide personalized feedback, adjustments, and mobility enhancements, facilitating gait training, muscle strengthening, and injury prevention.

As the global Paralympic movement gains momentum, the demand for high-performance prosthetic devices, personalized rehabilitation protocols, and data-driven training programs has never been more pressing. This presentation will delve into the exciting intersection of AI, robotics, and physiotherapy in Paralympic sports, exploring the latest advancements, innovations, and applications that are transforming the lives of athletes with disabilities. By examining the synergies between these disciplines, we will uncover the vast potential for performance optimization, injury prevention, and rehabilitation enhancement in Paralympic sports.

2. METHOD S METHODOLOGY

This study employed a comprehensive methodology to investigate the role of prosthetics and robotics in enhancing the performance and quality of life of Paralympic athletes. The methodology involved a multidisciplinary approach, integrating insights from biomechanics, materials science, and robotics to develop advanced prosthetic devices and robotic systems. The development of prosthetic

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devices involved the use of advanced materials, such as carbon fiber, titanium, and aluminum, to create lightweight and durable prosthetics. The design and fabrication of prosthetic devices were tailored to meet the specific needs of Paralympic athletes, taking into account factors such as sport-specific requirements, level of amputation, and individual athlete needs. The methodology also involved the use of advanced robotic systems, including robotic exoskeletons, robotic assistants for prosthetics, and AI- driven motion capture systems.

These systems were used to enhance the performance and rehabilitation of Paralympic athletes, providing real-time feedback, personalized adjustments, and enhanced mobility. The study also explored the application of AI-driven prosthetics, which utilize smart sensors, machine learning algorithms, and neural control systems to enhance movement adaptability and optimize prosthetic performance. The methodology involved the analysis of key features, such as self-adjusting joints, smart sensors, and machine learning algorithms, to understand their impact on prosthetic performance and athlete satisfaction. The findings of his study provide valuable insights into the role of prosthetics and robotics in enhancing the performance and quality of life of Paralympic athletes. The methodology employed in this study demonstrates the potential for interdisciplinary research to drive innovation and improvement in the field of prosthetics and robotics.

3. RESULTS

This study demonstrates the transformative impact of integrating AI-driven prosthetics, robotics, and physiotherapy in Paralympic sports. The results show significant enhancements in training and performance of Paralympic athletes. Notably, the use of AI-integrated prosthetics has improved swimming performance for athletes like Morgan Stickney, who has achieved more natural movement patterns crucial for swimming. Furthermore, innovative technologies such as the Smart Wheel and custom seating solutions, developed by Paralympic medalist and bioengineer Rory Cooper, have revolutionized wheelchair mobility. The Cybathlon competitions have also showcased the capabilities of AI-driven prosthetics in performing complex tasks, highlighting the synergy between AI, robotics, and physiotherapy. Additionally, AI-powered exoskeletons have been found to enhance mobility and training for Paralympic athletes, enabling them to optimize performance while minimizing fatigue. These results demonstrate the potential of AI-driven prosthetics and robotics, combined with physiotherapy, to transform the lives of Paralympic athletes and individuals with disabilities

4. DISCUSSION

The integration of advanced technologies, including artificial intelligence (AI), robotics, and biomechanics, has revolutionized the field of prosthetics, particularly for Paralympic athletes. Recent developments in AI-driven prosthetics have enabled the creation of bionic limbs that can mimic natural movement patterns, while neural-controlled prosthetics have allowed for direct neural control of prosthetic limbs. Furthermore, the use of 3D printing has enabled the rapid production of customized prosthetics, and smart prosthetics have incorporated microprocessors and real-time adjustments to enhance performance. The future of prosthetics holds great promise, with the development of brain-computer interfaces (BCIs) that enable direct neural control of prosthetic limbs, and regenerative medicine that combines prosthetics with tissue engineering. Additionally, exoskeletons have emerged as wearable robotic devices that can enhance mobility and provide support for individuals with physical disabilities. In the context of Paralympic sports, AI-enhanced prosthetic knees have been developed to dynamically adjust to the user's walking pace, facilitating seamless transitions from walking to

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running. Similarly, AI-controlled prosthetic arms have been designed to interpret muscle signals and electrical activity, allowing for precise control of elbow and wrist movements. The application of robotics in physiotherapy has also shown great promise, particularly in the rehabilitation of Paralympic athletes. Robotic exoskeletons have been used to aid in gait training and rehabilitation after injury or amputation, while robotic treadmills have guided athletes in relearning walking or running after injury. Additionally, adaptive prosthetics training has utilized myoelectric and AI prosthetic arms to help athletes strengthen muscles and control bionic prosthetic limbs. The use of robotics in strength and endurance training has also been explored, with robotic resistance training machines and AI motion analysis and virtual physiotherapy being used to help Paralympians build strength and endurance without overloading residual limbs. Examples of robotics in Paralympic physiotherapy include the use of AI-powered exoskeletons in gait training, robotic prosthetics in running and cycling, and robotic wheelchair technology that integrates AI for efficiency and injury prevention. These innovations have the potential to revolutionize the field of prosthetics and physiotherapy, enabling Paralympic athletes to achieve greater performance and mobility.

5. CONCLUSION

The synergy between AI-driven prosthetics, robotics, and physiotherapy has revolutionized performance optimization in Paralympic sports. By harnessing the power of AI motion analysis, physiotherapists can identify potential injury risk factors and fine-tune prosthetic devices for optimal performance. The integration of robotics in training and rehabilitation has also enhanced athlete recovery, adaptive prosthetic training, and overall sports performance. Moreover, the collaborative relationship between AI-driven prosthetics, robotics, and physiotherapy has yielded significant benefits, including improved rehabilitation and recovery, reduced injury risks, and optimized strength and endurance training. As technology continues to evolve, it is clear that this synergistic relationship will play an increasingly vital role in shaping the future of Paralympic sports, enabling athletes to push beyond their limits and achieve unprecedented success.

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THE IMPACT OF STRENGTH TRAINING ON INJURY PREVENTION IN ATHLETES

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ABSTRACT

Injury prevention is a critical aspect of athletic performance, with strength training playing a pivotal role in reducing the risk of sports-related injuries. This paper explores the impact of strength training on injury prevention among athletes across various disciplines. Strength training enhances muscular strength, joint stability, and neuromuscular coordination, which are essential in mitigating injury risks. Additionally, it improves biomechanical efficiency, reducing stress on ligaments, tendons, and bones. Research indicates that structured strength training programs significantly lower the incidence of injuries, particularly in high-impact and contact sports. Key components such as resistance exercises, plyometrics, and core stabilization are essential in reinforcing movement patterns and addressing muscular imbalances. Furthermore, periodized training programs tailored to an athlete's sport and individual needs can optimize both performance and injury resilience. In conclusion, integrating strength training into athletic conditioning programs is an effective strategy for injury prevention, ultimately enhancing longevity and performance in sports.

Keywords: resistance training, muscle strength, joint stability, neuromuscular coordination, sports injuries, core stabilization, rehabilitation, plyometrics, flexibility, endurance, proprioception

1. INTRODUCTION

Injuries are a major concern in sports, often leading to reduced performance, prolonged recovery periods, and even career-threatening consequences for athletes. Strength training has emerged as a fundamental strategy in preventing sports- related injuries by enhancing muscle strength, joint stability, and overall movement efficiency. By reinforcing the musculoskeletal system, strength training helps athletes develop resilience against excessive forces, improper biomechanics, and muscle imbalances, which are common causes of injuries.

Incorporating resistance exercises, plyometrics, and core stabilization into training regimens has been shown to improve neuromuscular coordination and proprioception, reducing the likelihood of acute and overuse injuries. Moreover, sport-specific strength programs tailored to an athlete's discipline can address movement deficiencies and optimize functional performance. Recent research highlights that well-structured strength training programs not only decrease injury incidence but also aid in faster recovery and rehabilitation.

2. METHODOLOGY

The methodology for assessing the impact of strength training on injury prevention in athletes involves a combination of experimental studies, literature reviews, and data analysis from sports science research. This section outlines the key approaches used to examine the relationship between strength training and

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injury prevention.

1. **Study Design:** A combination of experimental, observational, and longitudinal studies is utilized to analyze the effects of strength training on injury rates.
2. **These include:** Randomized Controlled Trials (RCTs): Athletes are divided into experimental (strength training) and control (no strength training) groups to measure injury incidence over time. Cohort Studies: Tracking athletes undergoing structured strength programs and comparing injury occurrences with those not engaged in strength training. Athletes from various sports: (e.g., soccer, basketball, football, track and field) are recruited to examine sport-specific injury risks. Inclusion criteria include age, training experience, injury history, and level of competition (amateur, collegiate, professional).
3. **Resistance Training:** Incorporating free weights, resistance bands, and machine-based exercises targeting major muscle groups. Plyometrics: Exercises like box jumps and agility drills to improve neuromuscular coordination and shock absorption.Core Stability Training: Exercises to enhance balance, posture.

3. RESULTS

Strength training has a profoundly positive impact on injury prevention in athletes. Research has consistently shown that strength training programs can significantly reduce the risk of both acute and overuse sports injuries .In fact, a systematic review and meta-analysis found that strength training reduced the risk of injury by 64% and overall injury risk by 33% .Another study discovered that a 10% increase in strength training volume reduced the risk of injury by more than four percentage points .The mechanisms behind strength training's Injury-preventing effects are multifaceted. It improves coordination, enhances technique, strengthens adjacent tissues, and reduces critical joint loads. Furthermore, strength training promotes physical qualities that protect against injuries, such as improved muscle strength, power, and endurance. It's essential to note that the effectiveness of strength training in preventing injuries depends on various factors, including the type and intensity of training, individual athlete characteristics, and the specific sport or activity

4. DISCUSSION

The findings of this study strongly support the role of strength training in reducing injury risk among athletes. Strength training enhances muscular strength, joint stability, neuromuscular coordination, and movement efficiency, all of which are critical in preventing both acute and overuse injuries. This discussion explores the implications of these results, compares them with existing research, and highlights practical applications for athletes, coaches, and sports professionals. Strength Training as a Preventive Measure: The results demonstrate that structured strength training programs lead to a significant reduction in injury rates. This aligns with previous studies that have shown how resistance training strengthens muscles, tendons, and ligaments, making them more resilient to external forces. Additionally, proper load management and progressive overload in strength training help athletes adapt to increasing physical demands, reducing the likelihood of strain-related injuries. Sport-Specific. Considerations: Different sports place unique demands on the body, making tailored strength training programs essential. Impact on Recovery and Injury. Severity: Another important finding is that athletes with a history of strength training tend to recover faster and experience less severe injuries. This suggests that pre-existing muscle strength and endurance contribute to better injury management and rehabilitation outcomes. Strength training promotes better circulation, tissue repair, and overall resilience,

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which can shorten recovery time and reduce long-term injury consequences. Limitations and. Considerations: Despite the clear benefits, strength training must be implemented correctly to prevent training-related injuries. Common mistakes, such as improper technique, excessive training volume, or neglecting flexibility and mobility work, can lead to overuse injuries. Coaches and trainers must ensure that strength programs are well-structured, progressive, and individualized based on an athlete's needs, fitness level, and sport demands.

5. CONCLUSION

Strength training is a crucial component of injury prevention in athletes, offering numerous benefits that enhance performance and longevity in sports. This study highlights that structured strength training programs significantly reduce injury incidence by improving muscular strength, joint stability, neuromuscular coordination, and movement efficiency. Strength training not only minimizes the risk of acute injuries, such as ligament sprains and muscle strains, but also helps prevent chronic overuse injuries by addressing muscular imbalances and enhancing biomechanics. While the benefits of strength training are well-established, it is essential to implement proper training techniques, progressive overload, and individualized programs to maximize effectiveness and avoid training-related injuries. Future research should continue exploring the long-term impact of strength training on different athletic populations and the integration of technology to monitor injury risk.

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AQUATIC THERAPY IN THE REHABILITATION OF SPORTS INJURIES

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ABSTRACT

The aquatic environment has broad rehabilitative potential, extending from the treatment of acute injuries through health maintenance in the face of chronic diseases, yet it remains an underused modality. There is an extensive research base supporting aquatic therapy, both within the basic science literature and clinical literature. This describes the many physiologic changes that occur during immersion as applied to a range of common rehabilitative issues and problems. Because of its wide margin of therapeutic safety and clinical adaptability, aquatic therapy is a very useful tool in the rehabilitative toolbox. Through a better understanding of the applied physiology, the practitioner may structure appropriate therapeutic programs for a diverse patient population.

Keywords: Aquatic therapy, Rehabilitation, Immersion, Physiologic changes, Therapeutic safety, Clinical adaptability, Rehabilitative issues, Health maintenance , Chronic diseases , Aquatic environment

1. INTRODUCTION

The key to effective rehabilitation of sport injuries is the return to desired functional activity as soon as possible. Aquatic therapy provides a unique environment for promoting normal movement patterns and building strength early in the course of treatment. These changes usually are accomplished in the water, where the risk of further injury is reduced. This frequently is accompanied by a reduction in pain and perceived discomfort. Aquatic therapy in many cases is the only option for rehabilitation when land-based programs have not provided satisfactory results.

2. METHODOLOGY

Aquatic therapy, a valuable method in the rehabilitation of athletic injuries uses the physical properties of water to facilitate healing and exercise. The buoyancy of water reduces the effects of gravity, allowing for less stress on injured areas. This approach is particularly beneficial in the treatment of shoulder girdle, elbow, radioulnar joint, wrist, hand, cervical spine, lumbar spine, knee, hip, thigh, and foot injuries. The viscosity of water provides accommodating resistance, which is key for muscle strengthening and rehabilitation. This form of therapy not only aids in joint mobility and muscle strengthening but also offers advantages in cardiorespiratory fitness. Implementing Aquatic Therapy For effective rehabilitation a comprehensive approach is necessary. It involves initial evaluations, aquatic assessments, and monitoring changes in strength and range of motion. Aquatic therapy can be the sole method of treatment or part of a transition from or to land-based therapy. This versatility makes it suitable for a wide range of athletic injuries.

3. AQUATIC THERAPY VERSUS LAND-BASED THERAPY

Aquatic therapy's unique environment promotes early return to functional activity, often accompanied by reduced pain and discomfort. It's an ideal choice when land-based programs don't yield satisfactory results. The variety of exercises available in aquatic therapy, tailored to individual needs, plays a crucial role in

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effective rehabilitation.

This often includes:

Buoyancy-Reduced Load: Using the buoyancy of water to reduce the weight and pressure on injured body parts.

Viscosity-Enhanced Resistance: Leveraging the water's resistance to strengthen muscles and improve joint mobility.

Thermal Properties: The warmth of the water may help to increase blood flow and reduce pain or stiffness in muscles anoints.

Progresses: A structured, step-by-step approach where the intensity and difficulty of the exercises increase as the patient progresses in their recovery.

Individualized Plans: Tailoring exercises to the specific injury and stage of recovery

Effects Of The Physical Properties Of Water

Direct effect: buoyancy Relief of the injury

Indirect effect: Viscosity

Dependent on frontal surface and speed of movement

Recommend Exercises On Wate

Table 2. EXERCISES FOR INCREASING JOINT MOBILITY AND RANGE-OF-MOTION OF THE SHOULDER

1. Passive stretching exercises in the water	
2. Active range-of-motion exercises	
Standing upper extremity movements	• Flexion extension • Abduction/adduction • Internal/external rotation • Horizontal abduction/adduction
Floating prone	• Flexion/extension • PNF patterns • Horizontal abduction/adduction
Exercises for increasing strength of the shoulder	
Standing upper extremity movements	• Flexion/extension • Abduction/adduction • Internal/external rotation • Horizontal abduction/adduction
Floating prone	• Flexion/extension • PNF patterns • Horizontal abduction/adduction
Swimming strokes	• Breaststroke pull patterns performed at different depths with respect to the surface • Underwater freestyle (alternating front-crawl pull patterns without overarm recovery) • Elementary backstroke starting at varying degrees of abduction • Formal swimming strokes can be introduced or reintroduced in the case of persons returning to training in the water

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Table 3. EXERCISES FOR INCREASING JOINT MOBILITY AND RANGE-OF-MOTION OF THE ELBOW AND RADIOULNAR JOINT

1. Passive stretching exercises in the water	
2. Active range-of-motion exercises	
3. Exercises for increasing strength of the elbow and radioulnar joint	
Standing upper extremity movements	• Push/pull action • Flexion/extension • Pronation/supination (Fig. 4)
Floating prone	• Flexion/extension • PNF patterns • Horizontal abduction/adduction

Table 4. EXERCISES FOR INCREASING CERVICAL JOINT MOBILITY AND RANGE-OF-MOTION

1. Passive stretching exercises in the water	
2. Active range-of-motion exercises	
Standing on the bottom of the pool	• Cervical flexion/extension • Cervical rotation • Cervical lateral flexion • Chin-tuck exercises
Suspended vertically in deep water	• Cervical traction
Exercises for increasing cervical strength	
Standing	• A series of unilateral and bilateral arm exercises with and without the use of resistive apparatus. Exercises similar to those used in shoulder strengthening
Floating prone	• Flexion/extension • PNF patterns • Horizontal abduction/adduction (Fig. 5)
Swimming strokes	• Breaststroke pull patterns performed at different depths with respect to the surface • Underwater freestyle (alternating front-crawl pull pattern without overarm recovery) • Elementary backstroke starting at varying degrees of abduction • Formal swimming strokes can be introduced or reintroduced in the case of persons returning to training in the water

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Table 5. EXERCISES FOR INCREASING LUMBAR SPINE JOINT MOBILITY AND RANGE OF MOTION

1. Passive stretching exercise in the water	
2. Active range-of-motion exercises	
Standing on the bottom of the pool	• Gluteus maximus stretch • Adductor stretch • Hamstring stretch • Piriformis stretch • Gastrocsoleus stretch
Floating prone	• Selected stretches may be performed while floating prone, for example, double knee-to-chest stretch
Floating vertically	• Vertical traction with ankle weights attached to the ankles
Exercises for increasing lumbar spine strength	
Standing against or away from wall	• Unilateral hip flexion/extension • Unilateral leg movements simulating the flutter-kick • Unilateral abduction/adduction • Push/pull and/or sideways movements using a tray (Fig. 6)
Walking on the bottom of the pool at different depths	• Forward/backward walking
Floating vertically, body position maintained with the aid of a floatation device	• A series of lower extremity movements, similar to those performed while standing. However, the exercises now can be performed with both legs working simultaneously, as in the case of the flutter-kick or abduction/adduction
Swimming strokes	• Swimming and kicking in the prone and/or supine body positions, maintaining a neutral spine. • Stroke mechanics must be modified to fit patient's experience and tolerance

Table 6. EXERCISES FOR INCREASING KNEE JOINT MOBILITY AND RANGE OF MOTION

1. Passive stretching exercises in the water	
2. Active range-of-motion exercises	
Standing on the bottom of the pool	• Quadriceps stretch • Hamstring stretch • Gastrocsoleus stretch
Exercises for increasing knee strength	
Standing against or away from wall	• Unilateral knee flexion/extension • Unilateral leg movements simulating the flutter kick • Step-ups, minisquats, and single-leg balance
Walking on the bottom of the pool at different depths	• Forward/backward walking • Marching
Floating vertically	• Aqua-jogging
Body position maintained with the aid of a floatation device	• Vertical bicycling • Vertical flutter kick • Vertical abduction/adduction
Swimming strokes	• Swimming with the emphasis on kicking action, in the prone and/or supine body positions. The resistive force can be increased by increasing rate or cadence, and by using resistive fins

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4. RESULTS

1. Reduced Stress on Injured Areas: The buoyancy of water significantly reduces the load on injured joints and muscles, allowing for pain-free movement and safer rehabilitation.
2. Increased Range of Motion: The properties of water assist in improving flexibility and range of motion, which is vital for recovery from injuries
3. Muscle Strengthening and Endurance: Water's viscosity provides resistance, making it an effective tool for muscle strengthening and endurance training. This aids in faster recovery of strength without overloading the injured area
4. Improved Cardiovascular Fitness: Aquatic therapy enhances car fitness through gentle aerobic exercise in a low-impact environment, which is beneficial during recovery.
5. Pain Reduction: The warm water used in therapy can have analgesic effects, helping to reduce pain and muscle spasms.
6. Faster Return to Activity: Athletes using aquatic therapy can often return to their sport or activity faster compared to traditional land-based rehabilitation methods

5. CONCLUSION

The key to effective rehabilitation is the return to desired functional activity As soon as possible. Aquatic therapy provides a unique environment for promoting normal movement patterns and building strength early in the course of Treatment. These changes usually are accomplished in the water, where the risk of further injury is reduced. This frequently is accompanied by a reduction in Pain and perceived discomfort. Aquatic therapy in many cases is the only option for rehabilitation when land-based programs have not provided satisfactory results.

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INNOVATION IN STRESS REACTION AND FRACTURE MANAGEMENT IN REVOLUTIONIZING INJURY DIAGNOSIS AND TREATMENT

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ABSTRACT

Advancements in medical technology and biomechanics are revolutionizing the diagnosis and treatment of stress reactions and fractures, addressing long-standing challenges in early detection, personalized treatment, and accelerated recovery. Traditional diagnostic methods, such as X-rays and MRIs, often fail to detect stress- related bone injuries at their earliest stages, leading to delayed intervention and prolonged recovery times. Innovative approaches, including AI-driven imaging analysis, biomarker-based diagnostics, and wearable sensor technology, are enhancing the precision and speed of injury detection. Additionally, regenerative medicine, 3D-printed orthotics, and personalized rehabilitation programs are transforming treatment strategies, optimizing healing while reducing the risk of recurrence. These breakthroughs not only improve patient outcomes but also reshape injury management across sports medicine, orthopedics, and general healthcare, paving the way for a future where stress fractures and related injuries are diagnosed and treated with unprecedented efficiency and accuracy.

Keywords: Innovation, stress reaction, fracture management, revolution, injury diagnosis, treatment

1. INTRODUCTION

Stress injuries represent a spectrum of injuries ranging from periostitis, caused by inflammation of the periosteum, to a complete stress fracture that includes a full cortical break. They are relatively common overuse injuries in athletes that are caused by repetitive submaximal loading on a bone over time. Stress injuries are often seen in running and jumping athletes and are associated with increased volume or intensity of training workload. Most commonly, they are found in the lower extremities and are specific to the sport in which the athlete participates. Upper extremity stress injuries are much less common than lower extremity stress injuries, but when they do occur, they are most commonly seen in the ulna. Similar to the lower extremity injuries, upper extremity stress injuries are the result of overuse and fatigue.

2. UNDERSTANDING STRESS REACTIONS AND FRACTURES

Stress reactions and fractures are overuse injuries that occur when bones are subjected to repetitive strain without adequate time to recover. A stress reaction is the early stage of this process, where the bone begins to weaken due to excessive loading, often causing pain and inflammation. If left untreated, it can progress to a stress fracture, a small crack or severe bone weakening that significantly impacts mobility and function. These injuries are common in athletes, military personnel, and individuals with high- impact lifestyles. Early diagnosis is crucial to prevent worsening damage, with treatment typically involving rest, modified activity, and, in some cases,

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advanced therapies like bone stimulation or regenerative medicine. Understanding the mechanisms behind stress reactions and fractures is essential for prevention, early intervention, and effective recovery.

3. CURRENT CHALLENGES AND DIAGNOSIS AND TREATMENT

Despite advancements in sports medicine and physiotherapy, the diagnosis and treatment of stress reactions and fractures still pose significant challenges. One of the primary difficulties in diagnosis is that early-stage stress reactions often present with vague symptoms, such as mild pain and discomfort, which can be mistaken for muscle strain or tendinitis. Standard X-rays may not detect early bone stress injuries, requiring more advanced imaging techniques like MRI or bone scans, which are expensive and not always readily available. Additionally, differentiating between a stress reaction and a stress fracture is crucial, as misdiagnosis can lead to improper management, prolonging recovery time or increasing the risk of a complete fracture.In terms of treatment, a major challenge is balancing rest with maintaining overall physical conditioning. Extended rest is often necessary for healing, but excessive immobilization can lead to muscle weakness, joint stiffness, and loss of cardiovascular fitness. Finding the right balance between offloading the injured area and maintaining functional movement is a key concern in rehabilitation. Moreover, return-to-sport protocols remain complex, as premature loading can lead to reinjury, while excessive caution can cause unnecessary delays in recovery. Patient adherence to rehabilitation programs is another challenge, as many individuals—especially athletes—struggle with modifying their training regimens or reducing activity levels.Furthermore, biomechanical factors, nutrition, and underlying medical conditions such as osteoporosis or vitamin D deficiency can complicate healing. Without addressing these root causes, there is a high risk of recurrence. Although new treatments like shockwave therapy, low-intensity pulsed ultrasound (LIPUS), and bone-stimulating medications are emerging, their effectiveness is still being researched, and accessibility remains limited. Overcoming these challenges requires a multidisciplinary approach, combining early detection, individualized rehabilitation, and education on injury prevention to improve long-term outcomes.

4. ADVANCED BIOMECHANICS AND INJURY PREDICTION

The integration of advanced biomechanics and predictive analytics is transforming the way stress reactions and fractures are diagnosed, managed, and prevented. Traditional injury assessment relies heavily on subjective reports and imaging techniques, but advancements in motion analysis, wearable technology, and artificial intelligence (AI) now allow for a more precise understanding of biomechanical stress on bones. One of the key areas of focus is gait and movement analysis, where 3D motion capture systems, force plates, and pressure sensors are used to evaluate how forces are distributed across joints and bones during movement. Abnormal loading patterns, excessive impact forces, or poor biomechanics can significantly increase the risk of stress-related injuries. By identifying these faulty movement mechanics, physiotherapists and sports scientists can develop targeted intervention programs to correct imbalances and reduce injury risk.

5. FUTURE STRESS FRACTURE DIAGNOSIS AND TREATMENT

The future of stress fracture diagnosis and treatment is evolving toward faster detection, personalized care, and enhanced recovery through advancements in AI-driven diagnostics, regenerative medicine, and biomechanical monitoring. Traditional imaging methods like X-rays

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often fail to detect early-stage stress fractures, but AI-powered MRI and CT scan analysis, along with wearable sensors that track bone-loading patterns, are revolutionizing early detection and injury prediction. Future diagnostics may even include blood tests that detect biomarkers of bone stress and microdamage, enabling intervention before symptoms appear. On the treatment side, regenerative medicine is making strides with stem cell therapy, bone growth factors, and 3D-printed bone scaffolds, all designed to accelerate healing and reduce downtime. Additionally, low- intensity pulsed ultrasound (LIPUS) is gaining recognition for its ability to stimulate bone regeneration non-invasively. Pharmacological advancements, such as parathyroid hormone (PTH) analogs and bisphosphonates, are also being explored to enhance fracture healing, especially in high-risk populations. Rehabilitation is becoming increasingly personalized, with AI-driven recovery programs tailoring exercise, loading progressions, and therapy techniques based on an individual's biomechanics and injury history. The integration of real-time biomechanical analysis, smart rehabilitation tools, and predictive analytics will shift stress fracture management from reactive treatment to proactive prevention, optimizing recovery while reducing the risk of recurrent injuries.

6. CONCLUSION

The future of stress fracture diagnosis and treatment is set to become more precise, proactive, and personalized, driven by advancements in AI, biomechanics, regenerative medicine, and innovative rehabilitation strategies. Early detection will be significantly improved through AI-powered imaging, wearable technology, and biomarker-based diagnostics, allowing for intervention before fractures fully develop.

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A STUDY TO ASSESS THE EFFECTIVENESS OF CORE MUSCLE STABILIZATION REGIMEN IN PATIENTS WITH MECHANICAL LOW BACK ACHE

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ABSTRACT

Background: Low back ache has a lifetime prevalence of over 70% in industrialized countries, and 85-95% of the cases are diagnosed as "non-specific low back pain". Low back pain is the second most common reason for absenteeism from work and one of the most common reasons for medical consultation. From an extensive study, it appears that significant low back pain begins at the age of about 35 years. An quasi-experimental study was conducted to evaluate and compare the effectiveness of core muscle stabilization regimen in patients with mechanical low back ache.

Methodology: Eighty patients with mechanical low back ache were participated into the study, were equally divided into two group, 40 patients in each, Experimental and control group as randomization was not carried out, hence it is Quasi-experimental study. Experimental group received core muscle stabilization regimen and back care; control group received extension manoeuvre. Pain and disability were measured before starting the intervention. In each group, patients were started with warm-up in static cycling for 10mins followed by exercise program and back care. For every week of intervention program, the pain and disability score were assessed.

Results: The data were analysed statistically by Friedmann ANOVA, Mann Whitney u-test, t-test. The results concluded that core muscle stabilization regimen is effective along with back care and ergonomic advice than the spinal extension manoeuvre alone to reduce pain and to improve functional ability of the lumbar spine in subjects with mechanical low back ache.

1. INTRODUCTION

Low back pain is one of the common causes of occupational disability[1]. It occurs with about the same frequency in people with sedentary occupations as in people doing heavy labour, although the latter have a higher incidence of absence from work because they are unable to work with their complaint[2].

The significance of physical activity plays a vital role in management of low back ache. Auvinen found that patients with chronic low back [pain are less physically active or fit than healthy individuals[3]. The major factor which is responsible for low back ache is abdominal muscle weakness, an imbalance between spinal flexors and extensors leads to instability[4].

Antagonistic activation of abdominal muscles and increased intra-abdominal pressure are associated with both spinal unloading and spinal stabilization. Rehabilitation regimens have been proposed to improve spinal stability via selective recruitment of certain trunk muscle groups[5]. Core stability refers to the ability of the core muscles to stabilize the spine whereas core strength denotes the ability of the core musculature to then produce the needed contractile force and intra-abdominal pressure for movement[6].

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Physiotherapy management of low back ache which includes spinal exercises, physical agents, spinal traction, spinal supports[7] and many other approaches used in clinical practice have some potential to assist the integration of local and global stability retraining once the basic motor control correction has been made. Alternative approaches to low back ache include Tai Chi[8], Yoga[9], The Feldenkrais Technique[10], Pilates program[11].

This study aims to determine the effectiveness of core muscle stabilization regimen with back care in patients with mechanical low back ache. Core muscle stabilization training uses exercises specifically designed to provide a "muscle corset", limiting undesirable motions and allowing healing to occur[12]. Risk factor for low back pain is weakness of superficial trunk and abdominal muscles; strengthening of these muscles is often associated with significant improvements of chronic low back pain as well as with decreased functional disability[13]. Strong abdominal muscles provide support for the lumbar spine during every day movements. Strengthening the abdominal muscles may decrease the occurrence of low back pain[14]. The subjects with mechanical low back ache has a high incidence for recurrence rate if have a weak core musculature. Preferential retraining of the stabilizing muscles with their initial low-level isometric activation and their progressive integration into functional task, is proposed as an essential component of back muscle rehabilitation.

2. MATERIAL AND METHODS

It was a quasi-experimental study, as randomization was not carried out, pre-& post-test were conducted. Eighty mechanical low back ache patients of both sex between 25-40years were participated in the study, who were equally divided into the experimental group core muscle stabilization regimen and control group (Extension Maneuver). Patients with spinal deformities, spinal fracture, post spinal stabilization, infective spine are excluded from the study. Both core muscle stabilization regimen & extension maneuver, were given for a period of 4 weeks daily 1 hr. Patients in experimental group also receive back care, which include ergonomic advice and electrotherapy (short wave diathermy). Patients pain and disability were measured by Roland-Morris scale & visual analogue scale. Study variables were at zero weeks and at the end of every week of exercise.

3. PROCEDURE

80 patients with mechanical low back ache age group between 25 to 40 years both sex were included in this study. All the subjects who are participated the inclusion and exclusion criteria after taking acceptance through consent form. As randomization is not-carried out, as it is Quasi-experimental study. 40 patients in each group were equally participated in experimental group and control group. Pre -test were carried out in each group, subjects were selected through pain and disability measured by Roland Morris questionnaire & Visual Analogue scale, range of motion for lumbar spine, manual muscle testing for spinal flexors and extensors, muscle tightness for hamstring and quadriceps muscle, special test for lumbar spine to examine for mechanical low back ache subjects. In experimental group patients were treated with core muscle stabilization regimen and back care which includes ergonomic advice and electrotherapy modalities (Short Wave Diathermy) and control group with extension maneuver.

The pain and disability were assessed by Roland-morris Questionnaire and visual analogue scale respectively for every one week of intervention program.

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4. CORE MUSCLE STABILIZATION REGIMEN

Muscle activation of the deep core stabilizers (transverse abdominis and multifidus) co-ordinated with normal breathing patterns is the foundation for all core exercises.

- ✓ Warm-up in static cycling for 10mins.
- ✓ Supine bridging on swiss ball. Abdominal hollowing technique where a navel is drawn back toward the spine without spinal movement. Isometric contraction to transverse abdominals, 10seconds holding and 10 repetition.
- ✓ Prone bridging on swiss ball.
- ✓ Bird and dog exercise on swiss ball.
- ✓ Side planks.
- ✓ Back care program contains ergonomic advice and electrotherapy (short wave diathermy for 15mins).

5. VISUAL ANALOGUE SCALE

The visual analogue scale (VAS) is used to measure a perception or sensation that cannot easily or directly be measure. VAS assessed the amount of subjectively perceived pain across a pain continuum from none to extreme pain. Patients indicate pain levels by marking a point on the horizontal 10cm scale. Pain levels are characterized into 6 categories, each with 2cm increments –no pain, mild pain, moderate pain, severe pain, very severe pain, and worst possible pain.

6. ROLAND MORRIS LOW BACK DISABILITY QUESTIONNAIRE

The RDQ106 is a health status measure designed to be completed by patients to assess physical disability due to low back pain. It was designed for use in research, but has also been found useful for monitoring patients in clinical practice. The RDQ is short, simple to complete, and readily understood by patients. These characteristics, alongwith evidence of its scientific validity, have led to its widespread use. The RDQ was derived from the Sickness impact pro-file (SIP), 3 which is a 136 item health status measure covering all aspects of physical and mental function. Twenty-four items were selected from the SIP by the original authors because they related specifically to physcial functions that were likely to be affected by low back pain. Each item was qualified with the phrase “because of my back pain” to distinguish back pain disability from disability due to other causes __ a distinction that patients are in general able to make without difficulty. The RDQ score is calculated by adding up the number of items checked. Items are not weighted. The score therefore range from 0 (no disablity) to 24 (maximum disability).

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7. RESULTS

Table 1

Difference between two groups i.e. experimental and control

	VAS Mean ± Std. Deviation	ROLAND-MORRIS LOW BACK PAIN Mean±Std. Deviation
Pre-test	6.84[a] ± 1.141	14.30[a] ± 2.563
Week I	5.69[b] ± 1.121	10.16[b] ± 2.410
Week II	5.03[b] ± 1.253	8.51[c] ± 2.570
Week III	4.60[c] ± 1.383	7.13 [d]± 3.407
Test statistic & p-value	Chi-square = 206.498 p-value = 0.000*	F = 33.064 & p-value = 0.000*

Note: Superscripts with same alphabet do not differ significantly and with different alphabets differ significantly

The above Table 1 provides the descriptive statistics for VAS and RMDQ back pain scores with F-value and p-value for between groups test. Here we observe that for parameter 'Roland-Morris disability questionnaire low back pain' there exist a significant difference between the time periods considered.

Under repeated measures ANOVA, the important measure which tells us the difference between two groups. If this measure's value is near to zero, this means that there is a significant difference between two groups i.e., control and experimental. If this measure attains a value near to one or equal to 1, it indicates there is no difference between two groups. Hence for the data considered we found that for parameter Roland-Morris low back pain wilk's lambda value is 0.091 which indicates that there exists difference in the pain score among two groups.

Friedman test gives p-value is less than 0.05. Therefore, we can note that there is significant difference between the mean ranks of the related groups for the VAS score pain.

Table 2

Comparison with respect to gender Independent test

Group	Gender	N	Mean ± Std. Deviation	t-test value & p-value
Roland-morris low back pain	Male	54	7.2778±3.03698	T = 0.455 p-value = 0.651[NS]
	Female	26	6.9615±2.63030	
	Female	26	18.5385±7.91065	
VAS score	Male	26	2.3889±.85598	U= 516.000 p-value = 0.039*
	Female	54	1.9231±.93480	

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This table provides useful descriptive statistics for the two groups male and female and also significance value. P-value was found to be greater than 0.05 in Roland Morris disability score, we can say that gender has no influence on reducing the pain score level.

Specifically, the table provides the test statistics, U-value, as well as the asymptotic significance p-value is less than 0.05for VAS score, therefore we conclude that there is a statistical significant difference between the male and female groups with respect to VAS in reducing pain level.

Table 3
Comparison with respect to age group One way

		N	Mean ±Std. Deviation	Test statistics	p-value
Roland-morris Low back pain	< =29	17	73529±2.99877	F = 0.699	0.556
	30 - 34	22	6.5000±2.70361		
	35 - 40	20	7.1500±2.58080		
	41 +	21	7.7619±3.33024		
	Total	80	.1750±2.89817		
	Total	80	19.7625±10.32417		
VAS score	< = 29	17	1.8824±1.11144	Chi-square = 5.937	0.115
	30 - 34	22	2.0909±.68373		
	35 - 40	20	2.4500±.99868		
	41 +	21	2.4762±.74960		
	Total	80	2.2375±.90349		

The descriptive table provides some useful descriptive statistics including mean, standard deviation for the dependent variable for each separate age group. We also observe that the significant level is 0.556 for Roland-morris low back pain which are greater than 0.05 and, therefore, there is no impact of age group with respect to reduction in pain.

For comparisons with respect to age groups for VAS score we use Kruskal-Wallis test. The test statistics table presents the chi-square (Kruskal Wallis H) and the significance level. We report that there is no statistical difference for the pain score between the different age groups; i.e. age does not influence the pain score.

8. DISCUSSION

Co-contraction of transverse abdominis and lumbar multifidus muscles is the basis of the lumbo-sacral biomechanic stability and that these muscles act by reducing the compressive overloads, attenuating or eradicating pain perception[15]. During exercise, secondary stability is

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provided by rectus abdominis and obliques muscles[16]. Both muscles are primary stabilizers of the lumbar segment, minimising compressive forces on spinal structures[17]. Core muscles provides dynamic stabilisation against rotational and translational stress in the lumbar spine during functional movements[18].

The tightness in the hip muscles (psoas, quadriceps muscles) increases the anterior shear force and compressive force at the L_4-L_5 junction[19]. It also causes reciprocal inhibition of the gluteus maximus, multifidus, deep erector spine, internal obliques and transverse abdominis. This leads to extensor mechanism dysfunction during functional movement patterns[20,21]. From out study we found that maximum number of subjects having tightness in quadriceps and hamstring muscles.

9. CONCLUSION

The study aims at explore the effectiveness of core muscle stabilization regimen in patients with mechanical low back ache. Eighty mechanical low back ache patients of both sex between 25-40years were participated in the study, who were equally divided into the experimental group core muscle stabilization regimen and control group (Extension Maneuver). Patients with spinal deformities, spinal fracture, post spinal stabilization, infective spine are excluded from the study. Both core muscle stabilization regimen & extension maneuver, were given for a period of 4 weeks daily 1 hr. Patients in experimental group also receive back care, which include ergonomic advice and electrotherapy (short wave diathermy). Patients pain and disability were measured by Roland-Morris scale & visual analogue scale. Study variables were at zero weeks and at the end of every week of exercise. The data's were analysed statistically by Friedmann ANOVA, Mann Whitney u-test, t-test. The results concluded that core muscle stabilization regimen is effective along with the spinal extension maneuver to reduce pain and to improve functional ability of the lumbar spine in subjects with mechanical low back ache.

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ROLE OF SPORTS PHYSIOTHERAPY AND REHABILITATION IN HEALTHCARE DELIVERY: NEED AND THE REALITY

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ABSTRACT

Physiotherapy is a multi-disciplinary approach to the management of sports injuries. Its aim is not only to treat and rehabilitate the athlete after an injury or post-operatively but also to prevent the injuries and return to the athletes within the shortest possible time. In every century, from past to present, sports and recreation never stopped. It is continuously lived and developed. People everywhere in the globe valued and loved recreations and sports. The government and several other institutions support these sorts of activities because these are good and healthy hobbies thereby gymnasium, basketball & tennis court, and lots of more playing ground were approved, built, and provided for the welfare of the people. Sports and recreation are available for all ages. Kids, teens and adults, and even old age people can enjoy these activities. It is locally and internationally accepted. One of the simplest examples of a worldwide sports fest is the Olympics. Every country, everywhere in the world participates during this big sports event. It is acknowledged and supported by everybody. For this reason, sports have influenced all the corners of the planet and influences once life.

Keywords: physiotherapy, rehabilitation, healthcare, sports, injury.

1. INTRODUCTION

Sports have a great impact on people's lives. These sorts of activities benefit us in numerous ways. First, people that indulge themselves in it can have quality leisure. Sports develop one's skills. It's a sort of entertainment and at the same time, it helps you develop your brain, physical strength, and emotional stability. It brings change and purpose to an individual's life. Some famous people are very dedicated to sports.At high school, college and higher-level, athletes often place enormous emphasis on their ability to compete and perform. Injuries are usually devastating to individuals as modern competitive sports have indisputably gone above and beyond the athletic activities of the past, in terms of use, athlete's strength, and therefore the level of importance placed on success. Its popularity altogether of its forms steadily increases. Quite just the domain of elite or professional athletes, the populace enjoys a selection of recreational pursuits from hiking and running to skiing and surfing, from badminton and tennis to cricket and hockey. In such endeavors, many participants find that injuries are inevitable. Daredevil sports like surfing, rugby, or acrobatic bicycle and jumping, leads to high physical trauma (Spanjersberg and Schiper 2008; Miller and Demony 2009). Young footballers and senior golfers are susceptible to injury, as are Olympic performers and "weekend warriors" because the injury doesn't discriminate (Delaney et al. 2009; Falvey et al. 2009). Besides, dancers also face far more injuries (Fitt 1996; Stretanski 2002; Koutedakis and Jamurtas 2004) During a year, 85 % of badminton players,

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65 % of runners, and 21 % of walkers are injured when injury rates are expressed per hour of activity, the danger of injury is usually ranked by sport. Not surprisingly, such rankings show that sports like rugby and lacrosse produce the foremost mayhem, with about 30 injuries per 1000 hours of activity. Basketball and squash produce injuries around 14 injuries per 1000 hours.

2. METHODOLOGY

High-intensity activities like running and aerobic dance have higher injuries rates, 11 injuries per 1000 hours. There are a variety of sports with the numbers of injuries per 1000 hours of activities like Alpine skiing (8), Rowing machine exercise (6), Treadmill walking or jogging (6), Tennis (5), Dancing classes (5), Resistance training with weight machines (4), Resistance training with free weights (4), Outdoor cycling (3.5), Stationary cycle exercise (2), Stair climbing (2), Walking (2) ('Injuries in Recreational Adult Fitness Activities,' The American Journal of Sports Medicine, vol. 21 (3), pp. 461-467, 1993). However, in sports like running, cycling, swimming, stair climbing, and walking, most injuries aren't the result of sudden catastrophes but occur due to 'overuse'. To prevent injury in the sport, one has to make simple adjustments in their training schedules, and routine warm-up and cool down and strengthening of muscles and joints.

High injury rates could probably be significantly lower if we know about the actual causes of injuries. Research suggests that by proper training techniques injuries could be cut by 25 percent (Sport for All: Sports Injuries and Their Prevention, Council of Europe, Netherlands Institute of Sports Some studies show an inverse relationship between injury risk and the number of years involved in an activity. Newcomers in sports are likely to be more injured than those who have been training for many years (American Journal of Sports Medicine, vol. 16(3), pp. 285-294, 1988, and also Archives of general medicine, vol. 149 (11), pp. 2565-2568, 1989). Strength plays an important role in reducing injury risk. Due to regular training athletes become more experienced, stronger, and coordinated as compared to beginners which are very useful in the prevention of injuries.

Upgraded strength protects and stabilizes joints and prevents muscles and connective tissues from being torn apart by the repetitive forces placed on them during activity. It is considered that 50% of the injuries are reoccurrence injuries and the rest of the injuries and new troubles (Archives of general medicine, vol. 149(11), pp. 2561-2564, 1989). This is certainly due to improper care and training. An injury is not just an annoyance but it should be a warning signal that a body part is not strong enough to bear the stress due to sports. The fact is that injuries tend to re- occur in weaker regions of the body.

Physiotherapists have a good range of proven and documented approaches to treatment. Proper assessment and diagnosis are significant within the successful treatment and rehabilitation of sports injuries. Athletes affected by a recent injury or a recurring problem can enjoy the expertise of a specialist team. A multidisciplinary team approach is right as cross-referral may happen to rehabilitate the 'whole' person and not just the injured part. Whether or not they are pursuing gold medals or leisure, those who participate in the physical activity require both proper preventive training and proper healthcare. Sport rehabilitators and other allied health professionals have much to supply physically active people. Due to lack of knowledge athletes sometimes has a wrong approach to injury treatment

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and its prevention. Some athletes practice the principle of 'ARI' - anti-inflammatory, rest, and icing.

These remedies tone down the severity of an injury and athletes believe that these therapies are the 'cure' for his or her athletic wounds but the reality is that ARI simply allows athletes to return to the precise activities for a shorter period of time and thus it leads to reoccurrence of an injury after some time. Small wonder that fifty percent of injuries are re-occurrences! Sports-active people need to go for strengthen instead of rest and ice to vulnerable body parts. They ought to understand that success in managing the acute stage of injury generally results in success within the post- acute stage and onward because the athlete is ready by healthcare professionals on the game healthcare team for re-entry to participation. Insofar as possible, the game rehabilitator must make sure this process goes smoothly, to supply physical and psychological support and to stay the athlete's best interests foremost during the progression back to full activity.

Injuries can only be successfully treated when the explanation for the matter is fully investigated and corrected; therefore, an in-depth history is mandatory and an entire posture, gait, and biomechanical assessment must be made. Careful history taking is of the utmost importance to determine the situation, nature, behavior and onset of symptoms, etc. This is often followed by a physical examination where a methodological approach is adopted. Sometimes further investigative procedures are going to be needed to verify the diagnosis. It's not acceptable to treat symptoms without first establishing the underlying cause. A radical evaluation of all the factors contributing to the patient's pattern of symptoms is important so that a selected treatment plan is often established. Sports rehabilitation helps to guard the injured tissues to permit healing and to regulate the first inflammatory phase.

3. REHABILITATE

flexibility, strength, proprioception, muscle imbalance, and control physical activities with the help of taping and splinting. Sport- specific activities must be tested to make sure the athlete can return to sport safely. If proper rehabilitation isn't undertaken, the athlete could also be competing for timely, with residual instability, proprioceptive disturbance and muscle weakness, and imbalances. Individual programs must be planned and implemented for every athlete. This can include sport-specific exercises, adaptation to new postures to correct muscle imbalance, taping and strapping, and a home exercise program.

The athlete must be progressed carefully from one phase to subsequent, and therefore the criteria for progression are supported function, not time. Sport-specific functional testing is an important part of moving from one phase of rehabilitation to subsequent, and eventually, to full participation. Overtraining must be very carefully avoided altogether of those phases, and training is monitored so that full activity doesn't occur before full recovery has taken place.

It is obvious that prevention is best than cure and therefore the physiotherapist will always advise the patient on the way to prevent recurrence of the injury on return to sport. e.g. an athlete recovering from lateral epicondylitis needs to strengthen the wrist extensor muscles to stop the injury from recurring. As extensor muscles are weak as compared to the wrist flexor muscles as they are vulnerable to overload. In the same way, an athlete recovering from a hamstring strain would wish to stretch and strengthen the injured hamstring to make

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sure that flexibility and strength are equal for both injured and non-injured sides. Because exercise is intrinsic to the rehabilitation process, trainers and coaches got to remember that they need a big part to play in helping their athletes back to full fitness. Scientific studies support strengthening exercise as it helps to prevent injuries. For example, lawn tennis players reveal that those athletes who do not perform regular resistance training have an increased incidence of common injuries like, 'tennis elbow.", whereas competitors who do endurance training regularly had lesser injury rates 'An Epidemiological Study of lateral epicondylitis,' American Journal of Medicine, vol. 7, pp. 234-238, 1979). In swimming research administered at the University of Ohio reveals that poor strength in external rotator muscles of the shoulder may be responsible for a shoulder injury; the lower the strength, the higher the danger. Additionally, isokinetic exercises help to increase the strength and endurance of the shoulder muscles and reduce the frequency of shoulder problems in competitive swimmers (American Journal of Medicine, vol. 8, pp. 151- 158, 1980). About 60 percent of all runners are injured in a mean year, and about one-third of these misfortunes occur at the knee, producing a yearly knee injury rate of 1 in five runners ('Running Injuries to the Knee,' Journal of the American Academy of Orthopedic Surgeons, vol. 3, pp. 309-318, 1995)Every stage of injury management helps the athlete to cope with the injuries and return to the game as earlier. For an athlete having an injury of a pulled hamstring or sprained ankle, a physiotherapist can help the athlete to provide the right first aid procedures. The RICE protocol should be followed REST to the injured part immediately, ICE therapy to the injured site, compressing the injured site with strapping that and then elevating the injured limb. This protocol helps the athlete to reduce the pain and regulate the inflammation and swelling due to injury. If it is done quickly it can speed up the healing process. For serious injuries like bone fractures, only those having proper training in first aid should give the treatment.

If the injury may be a 'chronic' type, e.g., inflammation or lateral epicondylitis, then it's occurred because the injured site has been overloaded during the athlete's exercise programming. The trainer must answer the athlete immediately and stop the training to stop any longer damage. Remember, the most important is that the earlier the athlete stops the quickly it recovers and it is necessary to manage the injury by getting an accurate diagnosis. Often the simplest people to ascertain are physiotherapists specializing in sports injuries since they affect such injuries daily. Even orthopedic surgeons aren't always sports-injury specialists, often spending most of their time with more general patients. The sports physiotherapist will design a plan of treatment for the injury. The main aim of the initial stage of treatment is reducing the pain and promoting healing. Once pain and any swelling are reduced, the treatment will begin to involve more exercises. At now, the physiotherapist will set exercises to focus on specific goals which will help solve the athlete's problems. Initially, this is often likely to be mobility and adaptability training then, later, strengthening work. This is often where the athlete, coach, and physiotherapist can work together. Even alternate training also can be done athletes can still train even once they are injured. It means adopting different types of coaching or training methods that don't stress the injury. One of the main goals of the rehabilitation process is to take care of aerobic fitness levels by using alternative training methods. As an example, rather than running, athletes can try water running with a flotation belt, or cycling athletes must

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believe that albeit they're injured, they will stay in shape. Additionally, to maintaining aerobic fitness, the athlete can use the injury period as a chance to strengthen other areas of the body. Remember, it's only the injured part that must be rested, not the entire body. For instance, a footballer with a groin strain can use the injury period to enhance leg, trunk, and upper-body strength. Progressive return to full training, once the pain has subsided and the athlete has started to meet the flexibility and strengthening goals, the physiotherapist will be able to advise on when normal training can start again. There should be clear communication between the therapist coach and the athlete. To avoid reoccurrence of injury one should not start training too earlier or too hard. What they fail to understand is that, just because the injured part is pain-free, it doesn't mean they are fully fit.

Once the athlete can use the injured part, he or she must gradually retrain the endurance, strength, and coordination of that part so that it can withstand full competition conditions again. Thus, the goal at this stage in the rehabilitation process has moved on from healing the injury to regaining full function. To achieve this, the rehabilitation program must be specific to the athlete's sport. For example, for the injured athlete, strength exercises should be functionally related movements, such as single-legged squats, jumps, and plyometric drills. The program must also include proprioceptive training. The brain should be in coordination with the joint position so that movement can occur smoothly and effectively. After the injury especially joint injuries, the athlete can lose the ability of coordination. If this coordination deficiency is not retained the athlete is likely to undergo reoccurrence of the injury. Therefore, exercises such as hopping on a trampoline, unilateral balance drills, wobble-board exercises, and hopping, and jumping drills are important to retrain any lost proprioception. As well as being sports-specific, the rehabilitation program must be progressive - for example, starting at 10 minutes running three times a week and then building slowly to 30 minutes running five times a week.

The final stage, a good example of the necessity for this final stage of the rehabilitation process is a footballer recovering from ahamstring injury. The player has completed a successful treatment period and the hamstrings' flexibility is equal on both sides, as is their strength on the hamstrings curl station. The player can now jog pain-free. However, when he tried to join in a game, his hamstring felt weak. It is at this point that the player needs to slowly build up the training and include more specific exercises to bridge the gap between healing the injured part and making the injured part fully functional. To improve further athletes must increase the amount of running firstly and then slowly increase the speed he can run at. First, he must start with half-pace sprints, then three-quarter pace, until gradually increasing to full efforts. The player also needs to include more closed-chain multi-joint strength exercises, such as squats or dead lifts, where the hamstrings work in conjunction with other muscles. He will also need to include dynamic and eccentric hamstring exercises because this is how the hamstrings must work hard during sprinting. Both these types of exercises will strengthen the hamstrings in a sports-specific fashion. The player will also need to introduce kicking, ball-skills work, and agility drills into his training, first at three-quarter speed and then full-out. These rehabilitation exercises to ensure that all the skills movement has been slowly and steadily retrained. It is ready for playing after a period of specific training and progressions Once

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again, even this should be built up gradually, and the rehabilitation program will need to be continued to ensure the problems do not recur. The athlete must concentrate that if he or she does too little exercise then there will be no improvement in the areas. This is where the coach must be fully involved, communicating with the therapist, and supervising the athlete. To stay free from injury and to stop its reoccurrence the injured area should be taken full care of. It is important to increase general strength but actually, strength depends upon the movement which is required according to the sports.

4. RESULT

weight-bearing, closed chain resistance training allows the forces on the muscles to function powerfully and in synchrony. The sports rehabilitator is a key member of the sports injury management team. As such, they adhere to several important professional, practical, ethical, and legal principles. Equipment is properly administered for acute injury management while doing practices whether it is pitch side, Courtside, trackside, in the clinic, or on the ground. However, simply being prepared to deliver the care required by sport participants does not sufficiently qualify a sports rehabilitator or any other sports health professional for that matter. Proper ethical and legal frameworks are integral to success, as well. Without these underpinnings, the most skillful healthcare worker will not be able to sustain their practice under the guidelines deemed appropriate by civilized societies.

5. REALITY

The job of a sports physiotherapist, which is preventive, restorative, and rehabilitative, is challenging but lucrative at the same time. Thus, there are many sectors which require physiotherapist; they are Hospitals, Private practice, medical centers,

6. CONCLUSION

Workplaces/companies, public settings (e.g. Health Malls), Sports club and Schools. Though physiotherapy plays a vital role in many fields even then it is difficult for physiotherapists to survive as there are few places for jobs in reality. None of the school & college has appointed physiotherapists in their medical team though they have physicians and dentists in them. Children represent an important, unique population for sports. They suffer from all injuries as in adults and additional injuries related to stages of development. Many children participate in serious competitive sports in order to achieve success at a young age. a number of sports injuries observed in children are related to their immature skeleton which is vulnerable to injury and anatomical imbalance that can occur at growth spurt.To treat sports injuries in children's one need to design a specific injury program according to the child's need. Muscle, tendon, and ligament may become tight or lax as growth proceeds; this mandates changes in the standard exercise prescription. At a young age, skeletal muscles respond differently to strength training, earlier the training is more conditioning of the child. But overtraining and improper training can harm a child and can develop skeletal immature diseases like apophysitis, osteochondrosis, etc. Not only to injury as the physiotherapists assess children with:

- Developmental delay
- Physical disability

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- Difficulties in movement and co-ordination

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THE ROLE OF THE SPORTS PHYSIOTHERAPIST

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ABSTRACT

Role of sports physiotherapists

- Sports physiotherapists help athletes of all ages and abilities prevent injuries, improve performance, and recover from injuries They provide evidence-based advice on how to participate in sports safely They promote an active lifestyle to help people improve their quality of life

Evolution of sports physiotherapy

- Sports physiotherapy is a field that combines healthcare and athletic performance It involves developing new knowledge through research and critically evaluating practice It involves mentoring and supervision to help practitioners develop their expertise

Benefits of sports physiotherapy

- Sports physiotherapy helps athletes reach their peak performance levels and achieve their goals It helps athletes maximize their athletic capabilities and excel in their chosen sport It helps athletes optimize their performance and well-being

Key themes in sports physiotherapy abstracts

- The importance of evidence-based practice. The progression of skills from beginner to expert levels. The role of sports physiotherapy in injury prevention, assessment, treatment, and rehabilitation

Keywords: physiotherapists, sports, performance, injury prevention, treatment.

1. INTRODUCTION

Physiotherapy has become an integral part of the sports medicine team and has a crucial role in the management of injuries during major international events. At the London 2012 Olympic Games, physiotherapists formed the largest professional group working at the Olympic Games. The essential role of the sports physiotherapist in international and elite sports (and in all other levels of sport, for that matter) remains to provide treatment and rehabilitation of injuries and to provide performance support through injury prevention, maintenance and recovery interventions.

The common perception of the role of the sports physiotherapist in supporting athletes during competition or major games seems to be that the physio is a "provider of treatment interventions related to specific injuries." From recent studies it is evident that sports physiotherapists are also playing a much bigger role in supporting uninjured athletes. During the London 2012 Olympic Games, athletes attended physiotherapy services in the absence of injuries. A reasonable assumption for this may be that the physiotherapy sessions focused on maintaining physical function, as well as aiding in recovery, have a place in supporting athletic performance. It was also evident that athletes required follow-up visits for the same condition/injury and that muscle injury were the most common. Furthermore, the non-injury related physiotherapy sessions/encounters

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reflected the need for maintenance of the musculoskeletal system, injury prevention strategies and assistance with recovery.

According to Grant et al., sports physiotherapists working with international/elite athletes also face the challenge of the ongoing management of pre-existing conditions. Overuse injuries among athletes were identified as the most common reason to attend physiotherapy services (44%).

It is evident that the role of the physiotherapist within the sphere of international sport, is vast and that the role goes beyond the treatment of injury and rehabilitation, to a much broader role which includes providing assistance with musculoskeletal maintenance and recovery as well as injury prevention strategies and supportive rehabilitation.

Sports physiotherapists are also in a unique position to be able to take on leadership roles. The broadness of the sports physiotherapist skill set, which includes skills such as understanding acute care management, exercise and evidence-based approaches to injury prevention and treatment, as well as general strength and conditioning concepts, enables sports physiotherapists to oversee the healthcare of athletes in various sporting codes. Another benefit is the great amount of time that sports physiotherapists spend working directly with the athletes.

2. WHAT IS A SPORTS AND EXERCISE PHYSIOTHERAPIST?

Sports and Exercise Physiotherapists are involved in the prevention and management of injuries resulting from sport and exercise participation at all ages and at all levels of ability. These specialised physiotherapists provide evidence-based advice on safe participation in sport and exercise. Furthermore, they promote an active lifestyle to aid individuals in improving and maintaining their quality of life. Sports and Exercise Physiotherapists also play a huge role in helping athletes of all ages and all levels of ability to enhance their performance. summarises the role of the sports physiotherapist as follows: "The essential role of the sports physiotherapist is to provide treatment and rehabilitation of injuries and also to provide support for performance through injury prevention, maintenance and recovery interventions."

The **New Zealand Sports Physiotherapy organisation** defines a sports physiotherapist as:

"A recognized professional who demonstrates advanced competencies in the promotion of safe physical activity participation, provision of advice, and adaptation of rehabilitation and training

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interventions, for the purposes of preventing injury, restoring optimal function, and contributing to the enhancement of sports performance, in athletes of all ages and abilities, while ensuring a high standard of professional and ethical practice."

Sports and exercise physiotherapists work in a wide variety of settings. Many works with active recreational athletes in private practice or clinic settings. They can also be involved in social and club-level sports and attend training sessions. Sports and exercise physiotherapists often work in the elite athlete setting in competitive and professional sports, working and travelling with elite individual athletes or teams, and integrating their services with other medical professionals, coaches, strength and conditioning personnel and other support staff. Sports and exercise physiotherapists are also actively involved within various sporting organisations to coordinate physiotherapy services, injury prevention, rehabilitation and injury surveillance programmes.

3. SPORTS AND EXERCISE PHYSIOTHERAPY ROLES AND COMPETENCY AREAS

Ashton outlines advanced competencies of the sports physiotherapist in the promotion of safe physical activity participation, provision of advice, adaptation of rehabilitation and training interventions, for the purposes of preventing injury, restoring optimal function, and contributing to the enhancement of sports performance, in athletes of all ages and abilities, while ensuring a high standard of professional and ethical practice. The role of the physiotherapist does vary and can depend on:

- The sport they are involved in
- Their specific role within the team
- The performance level of the sport, local level or international, amateur or professional.

The International Federation of Sports Physical Therapy (IFSPT) states that "sports physiotherapy is a growing specialisation in cultures that strive to promote an active lifestyle and athletic excellence". The Sports Physiotherapy for All (SPA) describes "effective professional behaviour and the integration of specific knowledge, skills and attitudes for the context of practice as a sports physiotherapist." As part of the Sports Physiotherapy for All project, eleven competencies have been identified that is required for sports and exercise physiotherapists. Along with these competencies are a set of specific skills or standards that needs to be upheld. These competencies and standards are related to the various overlapping roles that the sports and exercise physiotherapist fulfil. The various roles and competencies can be:

4. MANAGER OF THE CLIENT/PATIENT

Injury prevention

- Sports and exercise physiotherapists assess the risk of injury associated with participation in a specific sport or physical activity. They are equipped to inform and train athletes, coaches and other members of the multidisciplinary team in such a way that there is a reduction in occurrence and recurrence of specific injuries.

Acute intervention

- Sports and exercise physiotherapists have the skills to respond appropriately to an acute injury or illness in various contexts, such as training or competition.

Rehabilitation

- Sports and exercise physiotherapists utilise clinical reasoning and therapeutic skills to assess and diagnose sports-related injuries. Furthermore, they are skilled in designing,

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implementing, evaluating and modifying evidence-based interventions that allow for a safe return to the athlete's optimal level of performance in their specific sport or physical activity.

Performance enhancement

- Sports and exercise physiotherapists contribute to the enhancement of the athlete's performance through evaluation of the athlete's physical and performance-related profile and can advise or intervene to optimise performance in a specific sport, within a multidisciplinary team approach.

5. ADVISOR

Promotion of a safe, active lifestyle

- Sports and exercise physiotherapists are competent in working together with other professionals in the multidisciplinary team environment to promote safe participation in sports and physical activity for individuals of all abilities. It is expected that they provide evidence-based advice regarding the optimal activity or sport for a specific individual as well as advice on the ways to minimise the risk of injury and promote health.

Promotion of fair play and anti-doping practices

- Sports and exercise physiotherapists participate and promote safe, professional and ethical sporting practices. They strongly advocate for fair play and their duty of care for the athlete. They adhere to the InternationalSports Physiotherapy Code of Conduct on Doping.

6. PROFESSIONAL LEADER

Life-long learning

- Sports and exercise physiotherapists maintain and improve their clinical standards by critical, reflective and evidence-based approaches to practice. They engage in a continual process of learning and teaching throughout their career and collaborate actively with other professionals.

Professionalism and management

- Sports and exercise physiotherapists are competent in the management of time, resources and personnel. They achieve this in a professional, legal and ethical manner. They also promote and facilitate professional development and excellence.

7. INNOVATOR

Research involvement

- Sports and exercise physiotherapists are informed and evaluate their practice in relation to new information. They identify questions for further study and are invested and involved in research that addresses these questions at various levels.

Dissemination of best practice :

- Disseminate new information and research to other professionals within the multidisciplinary team set-up through different media such as team communications, conferences, special interest groups, research collaborations, and meetings, as well as published material such as reports, journals promotional documents, newsletters and the internet.

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8. EXTENDING PRACTICE THROUGH INNOVATION

- Sports and exercise physiotherapists encourage and promote the application and integration of new knowledge and innovation within the multidisciplinary team practice and decision-making processes. They also influence further research and innovation directions.

What does a sports physiotherapist do?

Athletes have a clear, but sometimes limited, understanding of the role of the sports physiotherapist. They see the role of the sports physiotherapist as mainly injury-focused. In interviews with athletes on the role of the sports physiotherapist, the following four themes emerged

- Injury treatment
- Injury prevention
- Rehabilitation
- Performance enhancement

Qualities of a sports physiotherapist:

Athletes indicated that these qualities are important for sports physiotherapists to possess:

- Being professional
- Good personal qualities
- Being accessible
- Good communication skills
- Have an interest in the athletes that they are working with
- Being open-minded with regards to athletes' ideas regarding their management and the use of other practitioners

"A sports physiotherapist should be patient, persistent, have a high level of competency, know when to refer, understand the emotional and psychological demands of the sport and be a good communicator with athletes and coaching staff."

Qualities that athletes do not like to see in sports physiotherapists are:

- Bad personal qualities
- Being unapproachable
- Not being a team player

Athletes' expectations about physiotherapy in sports injury rehabilitation:

conducted a cross-sectional qualitative study exploring athletes' expectations about physiotherapy in sports injury rehabilitation. It was shown that athletes have high expectations of physiotherapy for sports injury rehabilitation and that the level of competition had a significant association with athletes' expectations. The different factors of athletes' expectations investigated were[]:

- Acceptance
- Motivation
- Attractiveness
- Responsibility

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- Directiveness
- Empathy
- Confrontation
- Nurturance
- Genuineness
- Openness
- Outcome

Athletes in this study showed high expectations for all of these factors. However, the most influencing factors that affected athletes' expectations were: directiveness, nurturance and genuineness. These factors are linked to accurate expectations. Athletes expect a high level of professionalism from physiotherapists and furthermore expect physiotherapists to thoroughly explain their injury and outcomes of rehabilitation. Physiotherapists should provide clear direction on rehabilitation, but be nurturing and provide support throughout the rehabilitation process and always be genuine and honest.

9. ACHIEVING SPORTING SUCCESS

"How does sports physiotherapy help you achieve your sporting goals?"

When athletes were asked this question, their response again mainly reflected on injury focus i.e.:

- Help to recover from injuries
- Prevent injuries

However, there was also a change in perspective noted. Athletes acknowledged the role of the sports physiotherapist in preventing and managing injuries, but also placed emphasis on sports physiotherapists helping them to train for increased duration and intensity without becoming injured.

Physiotherapy treatment techniques

Athletes feel that the following treatment techniques are beneficial:

- Mobilisation
- Massage
- Manipulation
- Exercise prescription
- Acupuncture
- Taping

However, this is also dependent on athletes' exposure to the range of treatments. Athletes feel that the physiotherapist is the expert and they put their trust in the physiotherapist to resolve any injury issues that the athlete might have.

10. SUMMARY

A sports physiotherapist plays a crucial role in preventing, assessing, treating, and rehabilitating sports-related injuries by providing tailored exercise programs, educating athletes on proper techniques, optimizing movement patterns, and collaborating with teams to enhance athletic performance while minimizing injury risk; their key functions include injury prevention through assessments and education, immediate care during injuries, personalized rehabilitation plans to

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facilitate a safe return to sport, and performance enhancement by addressing movement imbalances and optimizing training strategies.

Key points about a sports physiotherapist's role:

- **Injury prevention:** Identifying potential weaknesses and imbalances through assessments, educating athletes on proper techniques, and designing preventative exercise programs.
- **Injury assessment and diagnosis:** Evaluating the nature and extent of an injury using their knowledge of anatomy and biomechanics.
- **Rehabilitation:** Developing and implementing individualized treatment plans to help athletes recover from injuries and regain full function.
- **Performance enhancement:** Analysing movement patterns and providing targeted interventions to optimize athletic performance.
- **Acute intervention:** Providing immediate care during sporting events for injuries.
- **Education and communication:** Collaborating with coaches, athletes, and other healthcare professionals to promote injury prevention and optimal recovery.

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FACTORS OF PHYSICAL FITNESS

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ABSTRACT

Physical fitness is to the human body what fine tuning is to an engine. It enables us to perform up to our potential. Fitness can be described as a condition that helps us look, feel and do our best. Physical fitness involves the performance of the heart and lungs, and the muscles of the body. And, since what we do with our bodies also affects what we can do with our minds, fitness influences to some degree qualities such as mental alertness and emotional stability. Most people could name some or all of the benefits of being physically fit. Some of which are to avoid illness, disease and injury, look better and have more energy; there are some additional unexpected benefits as well.

Keywords: Physical fitness, Muscles, injury, Aerobic, Flexibility

1. INTRODUCTION

Physical fitness is to the human body what fine tuning is to an engine. It enables us to perform up to our potential. Fitness can be described as a condition that helps us look, feel and do our best. Physical fitness involves the performance of the heart and lungs, and the muscles of the body. And, since what we do with our bodies also affects what we can do with our minds, fitness influences to some degree qualities such as mental alertness and emotional stability.

2. BENEFITS OF EXERCISES

Most people could name some or all of the benefits of being physically fit. Some of these are to avoid illness, disease and injury, look better and have more energy; there are some additional unexpected benefits as well!

Exercise Can Help Control Stress - Chemicals called neurotransmitters, produced in the brain, are stimulated during exercise. Since it's believed that neurotransmitters mediate our moods and emotions, they can make us feel better and less stressed. (FIT FACTS, American Council of Exercise – 2006)

Exercise can keep your immune system STRONG – Research has shown that during moderate exercise, several positive changes occur in the immune system. Various immune cells circulate through the body more quickly, and are better able to kill bacteria and viruses. (Exercise immunology, Current Sports Medicine Reports – 2003)

3. EXERCISE CAN IMPROVE YOUR SEX LIFE

Men who exercise vigorously 20-30 minutes were about half as likely to have erection problems as inactive men. (Harvard School of Public Health, 2003)

Women's sex lives can also benefit. In a recent study of women's vaginal responses (blood flow to the genital tissue) was 169 percent greater after exercising. (University of Texas at Austin)Doctors believe that exercise has the effect it does on increasing sexual potency because it

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strengthens the cardiovascular system and improves circulation. Good circulation is important for sexual function. (FIT FACTS, American Council of Exercise – 2006)

4. AEROBIC FITNESS OR CARDIORESPIRATORY ENDURANCE

The ability to deliver oxygen and nutrients to tissues and to remove wastes, over sustained periods. Guidelines: 20-30 minutes of exercise to raise your heart rate most days.

5. MUSCULAR FITNESS

Muscular fitness refers to the strength and endurance of your muscles. Strength training can help you improve your muscular fitness. It also enables you to increase your body's lean muscle mass, which helps with weight loss.

Guidelines: two or three 30 minute sessions a week that challenge the major muscle groups to fatigue (you can use calisthenics and/or weight training.

6. FLEXIBILITY

The ability to move joints and use muscles through their full range of motion. Flexibility can help with performing daily tasks, improve circulation and posture, aid in stress relief and enhance coordination. Many experts believe that stretching can help reduce the risk of injury due to physical activity.

Guidelines: Stretch when you work out or at least 3 times a week to maintain flexibility.

7. STABILITY AND BALANCE

Stability and balance are associated with your body's core muscle strength — the muscles in your lower back, pelvis, hips and abdomen. Strengthening these muscles can help to combat poor posture and low back pain. It also helps prevent falls, especially in older adults.

8. RESULT

The keys to selecting the right kinds of exercises for developing and maintaining each of the basic components of fitness are found in these principles:

Specificity - pick the right kind of activities to affect each component. Strength training results in specific strength changes. Also, train for the specific activity you're interested in. For example, optimal swimming performance is best achieved when the muscles involved in swimming are trained for the movements required. It does not necessarily follow that a good runner is a good swimmer.

Overload - work hard enough, at levels that are vigorous and long enough to overload your body above its resting level, to bring about improvement.

Regularity - you can't hoard physical fitness. At least three balanced workouts a week are necessary to maintain a desirable level of fitness.

Progression - increase the intensity, frequency and/or duration of activity over periods of time in order to improve.

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9. CONCLUSION

As you undertake a fitness program, it's important to remember that fitness is an **individual quality** that varies from person to person. It is influenced by age, sex, heredity, personal habits, exercise and eating practices. You can't do anything about the first three factors.

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IMPACT OF COMPLEX TRAINING WITH AND WITHOUT YOGIC PRACTICE ON SELECTED PHYSICAL VARIABLES AMONG SPORTSMEN

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ABSTRACT

The purpose of this study was to investigate the impact of complex training with and without yogic practice on selected physical variables among sportsmen. A total of 45 male physical education students were selected and divided into three equal groups: Complex Training with Yogic Practice (n=15), Complex Training Only (n=15), and Control Group (n=15). The training program lasted 12 weeks with five sessions per week. The dependent variable assessed was resting pulse rate, measured in beats per minute. Data were analyzed using covariance (ANCOVA) analysis at a significance level of 0.05. Results showed significant improvements in the resting pulse rate among the experimental groups, with the Complex Training + Yoga group showing the greatest improvement.

Keywords: Complex training, yogic practice, sportsmen, resting pulse rate, fitness.

1. INTRODUCTION

Complex training is a strength and conditioning method that combines resistance exercises and plyometric movements to optimize power output and neuromuscular performance. This method is widely used in athletic training to enhance explosive strength and endurance. By incorporating high-intensity resistance training followed by biomechanically similar plyometric exercises, complex training capitalizes on post-activation potentiation (PAP), allowing muscles to generate greater force.

Yoga, on the other hand, is an ancient practice that integrates breathing techniques, flexibility training, and mindfulness to improve overall well-being. Several studies have shown that yoga can positively influence cardiovascular health, reduce stress, and promote physiological recovery. Combining complex training with yoga may yield synergistic benefits, particularly in reducing resting pulse rate, a key indicator of cardiovascular efficiency.

This study aims to evaluate the effectiveness of complex training with and without yogic practice on resting pulse rate among sportsmen. The findings will provide insights into how integrating yogic techniques with structured athletic training can influence physiological parameters.

2. MATERIALS AND METHODS

The study involved 45 male physical education students, aged between 18 and 25 years, randomly assigned to three groups. Complex Training + Yoga Group (n=15): Engaged in complex training and daily yogic practices, including pranayama and meditation.Complex Training Only Group (n=15): Participated in resistance and plyometric exercises without any yoga.Control Group (n=15): Maintained their regular physical activities without any structured training intervention.The training intervention lasted 12 weeks with sessions conducted five times per week. Resting pulse rate was measured before and after the intervention using a standard heart rate monitor. Data were analyzed using ANCOVA, and post-hoc Scheffe's test was applied to determine statistical significance between groups.

3. RESULTS AND DISCUSSION

Group	Pre-Test Mean	Post-Test Mean	F-Ratio	Significance
Complex Training + Yoga	77.73	69.12	24.70*	$p<0.05$
Complex Training Only	77.47	71.18	24.70*	$p<0.05$
Control	77.87	77.43	-	-

4. DISCUSSION AND FINDINGS

The results indicate that both complex training groups showed a significant reduction in resting pulse rate, demonstrating improved cardiovascular efficiency. The greatest improvement was observed in the Complex Training + Yoga group, suggesting that integrating yoga with strength training can enhance physiological recovery and autonomic regulation.Complex training is known to stimulate neuromuscular adaptation and improve explosive power, while yoga contributes to better heart rate variability, reducing physiological stress. The post-activation potentiation (PAP) effect observed in complex training allows for greater force generation, whereas yoga promotes parasympathetic activation, resulting in a lower resting heart rate. The control group, which did not participate in any structured training, showed no significant changes.These findings highlight the importance of integrating yoga into athletic training programs, particularly for sports requiring high endurance and rapid recovery.

5. CONCLUSION

This study concludes that complex training significantly improves resting pulse rate, and the inclusion of yoga amplifies these benefits. The findings suggest that integrating yogic practices with structured athletic training enhances cardiovascular efficiency and physiological recovery, making it a valuable addition to sports conditioning programs.

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EFFECT OF PLYOMETRIC TRAINING ON MOTOR FITNESS COMPONENTS AMONG FOOTBALL PLAYERS

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ABSTRACT

The objective of this study was to examine the impact of plyometric training on selected motor fitness components among male football players. The study included 20 male students from engineering colleges in the Trichy region, aged between 18 to 25 years. Participants were divided into two groups: the experimental group, which underwent a six-week plyometric training program, and the control group, which did not receive any training intervention. The selected motor fitness components were speed, muscular endurance, explosive power, and cardiorespiratory endurance, assessed using standardized tests. The data were analyzed using analysis of covariance (ANCOVA) at a 0.05 level of significance. Results demonstrated that plyometric training significantly improved all the selected motor fitness components compared to the control group, emphasizing its effectiveness in enhancing athletic performance.

Keywords: Plyometric training, motor fitness, speed, endurance, explosive power, football.

1. INTRODUCTION

Plyometric training is widely recognized as an essential component of modern athletic training programs, particularly for sports that require explosive movements such as football, basketball, and track events. It is a form of high-intensity training that focuses on developing power, speed, and neuromuscular coordination through rapid and forceful eccentric and concentric muscle contractions. Plyometric exercises, such as bounding, depth jumps, and box jumps, are designed to stimulate the stretch-shortening cycle, leading to enhanced muscular efficiency and athletic performance.

Football players require a combination of speed, endurance, agility, and power to perform at their best. Traditional resistance training alone may not be sufficient to develop these attributes optimally. Plyometric training has been shown to significantly improve neuromuscular responses, leading to enhanced acceleration, vertical jump height, and agility. The integration of plyometricsinto football conditioning programs has been associated with better sprint performance, quicker changes in direction, and greater lower-body strength.

2. MATERIALS AND METHODS

This study was conducted on 20 male football players aged between 18 and 25 years, selected from engineering colleges in the Trichy region. The participants were randomly assigned to two groups: the experimental group, which underwent a structured six-week plyometric training program, and the control group, which followed their regular training routine without additional plyometric exercises. The training sessions were held three times a week (Monday, Wednesday, and Friday) and progressively increased in intensity. The motor fitness components assessed were speed, muscular endurance, explosive power, and cardiorespiratory endurance. These were evaluated using standardized tests: 50m dash for speed, sit-ups for muscular endurance, standing broad jump for explosive power, and Cooper's 12-minute run & walk for cardiorespiratory endurance. The collected data were analyzed using ANCOVA to determine the statistical significance of performance improvements.

3. RESULTS AND DISCUSSION

Variable	Group	Pre-Test Mean	Post-Test Mean	t-Value	Significance
Speed (sec)	Experimental	7.54	7.29	5.00*	p<0.05
	Control	7.37	7.47	2.00	NS
Muscular Endurance (counts)	Experimental	25.6	27.1	2.42*	p<0.05
	Control	24.5	23.7	0.26	NS
Explosive Power (m)	Experimental	3.24	3.33	4.5*	p<0.05
	Control	2.19	2.17	1.00	NS
Cardiorespiratory Endurance (m)	Experimental	2484	2554	2.22*	p<0.05
	Control	2643	2613	1.32	NS

4. DISCUSSION AND FINDINGS

The results indicate that plyometric training significantly improved all motor fitness components in the experimental group. These enhancements are attributed to neuromuscular adaptations resulting from repeated explosive movements. The control group did not show significant improvements, reinforcing the necessity of structured plyometric exercises in football training.

Plyometric exercises contribute to improved athletic performance by enhancing the efficiency of the neuromuscular system. The stretch-shortening cycle, a critical component of plyometric movements, enables muscles to store and release elastic energy, increasing power output. This mechanism is particularly beneficial for activities requiring short bursts of speed and quick directional changes. Additionally, improved muscle activation patterns contribute to better coordination and motor control, which are essential for football-specific movements.

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Overall, the results of this study support the integration of plyometric training into football conditioning programs. The improvements observed in speed, muscular endurance, and explosive power emphasize the importance of structured plyometric drills in optimizing athletic performance.

5. CONCLUSION

This study confirms that a six-week plyometric training program significantly enhances motor fitness components among male football players. Coaches and trainers should integrate plyometric drills to optimize athletic performance.

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EFFECT OF COMPLEX TRAINING ON SELECTED PHYSICAL FITNESS VARIABLES AMONG COLLEGE MEN STUDENTS

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ABSTRACT

The objective of this study was to evaluate the effect of complex training on selected physical fitness variables among college men students. A total of 30 male students from Alagappa University College of Physical Education, Karaikudi, aged between 21 and 25 years, participated in the study. The subjects were randomly assigned into two equal groups: Complex Training Group (n=15) and Control Group (n=15). The selected fitness variables included strength and speed, measured using the 1-RM leg press and 60-meter dash, respectively. The experimental group underwent a 12-week complex training program, while the control group maintained their regular routine without any specialized training. Pre-test and post-test data were analyzed using the t-test at a 0.05 significance level. The findings revealed that the complex training group demonstrated significant improvements in strength and speed, whereas the control group showed no significant changes. These results highlight the effectiveness of complex training in enhancing physical fitness.

Keywords: Complex training, strength, speed, college men, physical fitness.

1. INTRODUCTION

Physical fitness plays a crucial role in athletic performance and overall health. Among various training methodologies, complex training has gained recognition for its ability to develop strength and speed efficiently. Complex training integrates resistance exercises and plyometric movements, aiming to maximize muscular power and neuromuscular adaptations. This combination allows athletes to leverage the post-activation potentiation (PAP) effect, where strength exercises enhance subsequent explosive movements. Strength and speed are fundamental components of athletic performance. Strength training enhances muscle force production, while speed training improves neuromuscular coordination and reaction time. Complex training strategically combines both, leading to greater physiological adaptations than traditional training methods. The present study examines the effectiveness of complex training in improving strength and speed among college men students. By incorporating progressive resistance training and plyometric drills, this study aims to assess whether complex training can significantly enhance physical fitness.

2. MATERIALS AND METHODS

Participants and Study Design

A total of 30 male college students from Alagappa University College of Physical Education, aged between 21 and 25 years, were randomly assigned into two groups:

- Experimental Group (n=15): Participated in a 12-week complex training program.
- Control Group (n=15): Maintained their regular physical activities without specialized training.

3. TRAINING PROTOCOL

The experimental group engaged in a progressive resistance and plyometric training program three times per week (Monday, Wednesday, and Friday). Each session consisted of compound resistance exercises (e.g., squats, leg press, bench press) followed by plyometric exercises (e.g., squat jumps, bounding, medicine ball throws). The training intensity was progressively increased every four weeks.The control group continued their normal routine without engaging in additional structured training.

4. TESTING PROCEDURES

The following fitness variables were assessed pre- and post-training:

- Strength: Evaluated using the 1-RM leg press (kg).
- Speed: Measured using the 60-meter dash (seconds).

Data were statistically analyzed using the t-test at a 0.05 significance level to compare pre-test and post-test scores.

5. RESULTS AND DISCUSSION

Table 1

Analysis of ‘t’-Ratio for Strength (1-RM Leg Press)

Group	Pre-Test Mean	Post-Test Mean	Mean Difference	t-Value	Significance
Experimental	1.7353	1.8587	0.1233	8.16*	p<0.05
Control	1.7333	1.7320	0.0013	0.086	NS

*Significant at 0.05 level; NS = Not Significant

Table 2

Analysis of ‘t’-Ratio for Speed (60-Meter Dash)

Group	Pre-Test Mean	Post-Test Mean	Mean Difference	t-Value	Significance
Experimental	7.634	7.174	0.46	8.55*	p<0.05
Control	7.640	7.55	0.09	0.942	NS

*Significant at 0.05 level; NS = Not Significant

6. DISCUSSION AND FINDINGS

The findings indicate that complex training significantly improved both strength and speed in the experimental group. Strength gains can be attributed to the combination of resistance training

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and plyometric exercises, which optimize neuromuscular activation. Speed improvements likely resulted from the post-activation potentiation (PAP) effect, where pre-activation through strength training enhances subsequent explosive movements.Thecontrol group did not show significant improvements, reinforcing the effectiveness of structured training interventions. The statistical analysis revealed that the experimental group's improvements were significant ($p<0.05$), while the control group's results remained unchanged.These results align with previous research suggesting that complex training is highly effective in developing muscular power and speed (Ebben, 2002). Coaches and athletes should consider incorporating complex training into their conditioning programs to maximize performance gains.

7. CONCLUSION

This study concludes that a 12-week complex training program significantly enhances strength and speed among college men students. The combination of resistance exercises and plyometric drills proved to be an effective method for improving neuromuscular efficiency and athletic performance. Future research should explore long-term adaptations and the impact of complex training on additional fitness components such as agility and endurance.

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EFFECT OF HIGH-INTENSITY INTERVAL TRAINING (HIIT) ON UPPER BODY POWER AMONG COLLEGE MEN STUDENTS

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ABSTRACT

The purpose of this study was to examine the effect of high-intensity interval training (HIIT) on upper body power among college men students. A total of 30 male students from Alagappa University College of Physical Education, Karaikudi, aged between 21 and 25 years, participated in the study. The subjects were randomly assigned into two equal groups: HIIT Group (n=15) and Control Group (n=15). The selected fitness variable was upper body power, assessed using the seated medicine ball throw test. The experimental group underwent a 12-week HIIT program, while the control group maintained their regular routine without any specialized training. Pre-test and post-test data were analyzed using the t-test at a 0.05 significance level. The findings revealed that the HIIT group demonstrated significant improvements in upper body power, whereas the control group showed no significant changes. These results highlight the effectiveness of HIIT in enhancing explosive power in the upper body.

Keywords: High-intensity interval training, upper body power, explosive strength, college men, physical fitness.

1. INTRODUCTION

High-intensity interval training (HIIT) is a structured training method that involves alternating short bursts of high-intensity exercises with brief recovery periods. HIIT is widely used to improve cardiovascular endurance, muscular power, and neuromuscular coordination. Unlike traditional strength training, HIIT maximizes energy system efficiency, leading to greater adaptations in a shorter period. Upper body power is crucial for sports performance, particularly in activities requiring throwing, pushing, and striking motions. Developing explosive upper body strength enhances athletic ability in sports such as baseball, basketball, and wrestling. While traditional resistance training improves strength, HIIT combines dynamic, explosive movements with short rest intervals, making it highly effective in developing upper body power. The present study aims to evaluate the effectiveness of HIIT in improving upper body power among college men students. By incorporating interval-based explosive exercises, this study seeks to determine whether HIIT can significantly enhance upper body strength.

2. MATERIALS AND METHODS

Participants and Study Design

A total of 30 male college students from Alagappa University College of Physical Education, aged between 21 and 25 years, were randomly assigned into two groups. Experimental Group (n=15): Participated in a 12-week HIIT program.Control Group (n=15): Maintained their regular physical activities without specialized training.

Training Protocol

The experimental group engaged in a progressive HIIT regimen three times per week (Monday, Wednesday, and Friday). Each session lasted one hour and included:

A. Explosive push-ups
B. Medicine ball throws
C. Battle ropes
D. Kettlebell swings
E. Burpees

The intensity and volume of the training progressively increased every four weeks.Thecontrol group continued their normal routine without engaging in additional structured training.

Testing Procedures

The selected fitness variable was assessed before and after the training intervention:

Upper body power: Measured using the seated medicine ball throw test (meters).

Data were statistically analyzed using the t-test at a 0.05 significance level to compare pre-test and post-test scores.

3. RESULTS AND DISCUSSION

Table 1

Analysis of 't'-Ratio for Upper Body Power (Seated Medicine Ball Throw)

Group	Pre-Test Mean	Post-Test Mean	Mean Difference	t-Value	Significance
Experimental	5.40	6.53	1.13	5.578*	p<0.05
Control	5.61	5.61	0.00	0.014	NS

*Significant at 0.05 level; NS = Not Significant

4. DISCUSSION AND FINDINGS

The results indicate that HIIT significantly improved upper body power in the experimental group. The increase in power is attributed to dynamic, explosive exercises, which stimulate fast-twitch muscle fibers, enhancing strength and speed.The control group did not show significant improvements, reinforcing the importance of structured training interventions. Statistical analysis revealed that the experimental group's improvements were significant (p<0.05), while the control group's results remained unchanged.These results align with previous research suggesting that HIIT is highly effective in developing muscular power and endurance. Coaches and athletes should consider incorporating HIIT into their conditioning programs to enhance upper body strength for sports performance.

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5. CONCLUSION

This study concludes that a 12-week HIIT program significantly enhances upper body power among college men students. The combination of explosive, high-intensity movements with short recovery periods proved to be an effective method for improving neuromuscular efficiency and explosive strength. Future research should explore long-term adaptations and the impact of HIIT on additional upper-body fitness components such as endurance and agility.

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EFFECT OF HIGH-INTENSITY INTERVAL TRAINING AND PLYOMETRIC TRAINING ON LOWER BODY POWER AMONG COLLEGE ATHLETES

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ABSTRACT

The purpose of this study was to determine the effect of high-intensity interval training (HIIT) and plyometric training on lower body power among college athletes. Forty-five (N=45) male physical education students from Virudhunagar District, Tamil Nadu, were randomly selected as subjects. The participants, aged between 18 and 21 years, were divided into three groups of fifteen each (n=15): Group I underwent HIIT, Group II underwent Plyometric Training, and Group III acted as the Control Group. The training program lasted for five days per week over twelve weeks. Lower body power was assessed using the standing long jump test. Data collected before and after the intervention were analyzed using Analysis of Covariance (ANCOVA). The results indicated that both experimental groups showed significant improvements in lower body power compared to the control group, with HIIT demonstrating a slightly higher improvement than plyometric training.

Keywords: High-intensity interval training, plyometric training, lower body power, explosive strength, athletic performance.

1. INTRODUCTION

Lower body power is crucial for athletic performance, especially in sports requiring jumping, sprinting, and rapid changes in direction. Training methods such as high-intensity interval training (HIIT) and plyometric training are widely used to develop lower body power by targeting fast-twitch muscle fibers and enhancing neuromuscular efficiency. HIIT involves short bursts of high-intensity exercises followed by brief recovery periods, optimizing both anaerobic and aerobic energy systems. Plyometric training, on the other hand, focuses on explosive movements that enhance power output through the stretch-shortening cycle. The present study examines the comparative effectiveness of HIIT and plyometric training in improving lower body power among college athletes. By assessing pre- and post-training performance, this study aims to determine which training modality yields greater improvements in explosive power.

2. MATERIALS AND METHODS

Participants and Study Design

A total of 45 male college athletes from Virudhunagar District, Tamil Nadu, were randomly selected for the study. The participants, aged 18 to 21 years, were divided into three groups:

- Group I (HIIT, n=15): Underwent a structured HIIT protocol.

- Group II (Plyometric Training, n=15): Followed a plyometric-based training program**.**
- Group III (Control, n=15): Did not engage in any specialized training intervention.

Training Protocol

Both experimental groups trained five days per week for twelve weeks, progressively increasing in intensity.

HIIT Training (Group I)

- Sprint intervals (40m sprints, 8-10 sets)
- Jump squats
- Medicine ball slams
- Battle ropes
- Burpees

Plyometric Training (Group II)

- Box jumps
- Bounding drills
- Depth jumps
- Hurdle hops
- Lateral jumps

The control group continued their routine physical activities but did not participate in additional structured training.

Testing Procedures

The selected fitness variable was**:** Lower body power**:** Assessed using the standing long jump test (meters)**.**Data were statistically analyzed using ANCOVA to determine significant differences.

3. RESULTS AND DISCUSSION

Table 1

Analysis of Covariance for Lower Body Power (Standing Long Jump Test)

Group	Pre-Test Mean	Post-Test Mean	Mean Difference	F-Ratio	Significance
HIIT	2.11	2.58	0.47	53.60*	p<0.05
Plyometric	2.12	2.40	0.28	37.85*	p<0.05
Control	2.12	2.09	0.03	0.035	NS

*Significant at 0.05 level; NS = Not Significant

Table 2

Scheffe's Test for Paired Mean Differences

Comparison	Mean Difference	Confidence Interval (C.I.)	Significance
HIIT vs Control	0.49	0.22	Significant
Plyometric vs Control	0.31	0.22	Significant

HIIT vs Plyometric	0.18	0.22	Not Significant

4. DISCUSSION AND FINDINGS

The findings indicate that both HIIT and plyometric training significantly improved lower body power compared to the control group. However, HIIT demonstrated a slightly greater improvement than plyometric training. The enhanced performance in the HIIT group may be attributed to the combination of strength, speed, and endurance elements**,** which optimize neuromuscular efficiency (Buchheit&Laursen, 2013).Plyometric training also showed significant improvements but was marginally less effective than HIIT. This aligns with previous studies suggesting that plyometric drills develop explosive power effectively, but the inclusion of high-intensity anaerobic elements, as seen in HIIT, might provide additional benefits (Gibala et al., 2006). These results suggest that HIIT can be a more efficient training method for athletes seeking enhanced power output with improved energy system utilization.

5. CONCLUSION

This study concludes that a 12-week HIIT and plyometric training program significantly enhances lower body power among college athletes. Although both training modalities were effective**,** HIIT demonstrated slightly superior improvements**.** Future research should explore the long-term adaptations of both training methods and assess their impact on additional performance metrics such as speed, agility, and endurance**.**

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AN ANALYSIS OF SELECTED PHYSICAL FITNESS VARIABLES OF UNIVERSITY-LEVEL WOMEN FOOTBALL PLAYERS

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ABSTRACT

This study aims to analyze selected physical fitness variables among university-level women football players from Madurai Kamaraj University. A total of 40 female football players (20 from each university) participated in the study. The research focused on five key physical fitness parameters: speed, endurance, agility, flexibility, and explosive strength. Standardized physical fitness tests were conducted to measure these variables, and an independent t-test was used for statistical analysis. The findings reveal significant differences in endurance, agility, flexibility, and explosive strength between the two groups, while no significant difference was observed in speed. The results emphasize the need for specialized training programs to enhance physical fitness in women’s football.

Keywords: Physical fitness, women football players, endurance, agility, flexibility, speed, explosive strength, sports training, athletic performance

1. INTRODUCTION

Physical fitness is fundamental for any sport, particularly football, where agility, endurance, and explosive strength are critical for optimal performance. Women's football has gained significant recognition worldwide, yet scientific research on their physical fitness attributes remains limited. The ability to sprint, change direction quickly, and sustain high-intensity efforts throughout the game are essential for success in football.

University-level players form the foundation for future national and international athletes. Therefore, analyzing their physical fitness can provide insights into training effectiveness and areas for improvement. While endurance, strength, and agility determine overall performance, differences in training methodologies, coaching techniques, and physical conditioning can influence these attributes.

This study aims to compare selected physical fitness components between university-level female football players from Madurai Kamaraj University. By assessing the differences in speed, endurance, agility, flexibility, and explosive strength, this research provides valuable insights into the role of fitness variables in improving game performance. The findings will help coaches and trainers design targeted fitness programs to enhance player capabilities.

2. METHODS AND DATA COLLECTION

- **Participants**: 40 female football players 40 from Madurai Kamaraj University aged 17-24 years.
- **Variables Measured**:
  - ✓ **Speed**: 50m sprint
  - ✓ **Endurance**: 1200m run
  - ✓ **Agility**: 4x10m shuttle run
  - ✓ **Flexibility**: Sit and reach test
  - ✓ **Explosive Strength**: Standing broad jump
- **Statistical Analysis**: Independent t-test was applied to determine differences between the two groups.

Statistical DataAnalysis of Covariance

Fitness Parameter	G-1 (Mean ± SD)	G-2 (Mean ± SD)	T-Value	Significance (p)
Speed (s)	8.97 ± 0.21	8.97 ± 0.21	1.874	0.069 (NS)
Endurance (min)	5.61 ± 0.34	5.61 ± 0.34	4.611	0.000**
Agility (s)	11.78 ± 0.38	11.78 ± 0.38	4.857	0.000**
Flexibility (cm)	24.90 ± 1.88	24.90 ± 1.88	4.372	0.842 (NS)
Explosive Strength (cm)	177.25 ± 9.22	177.25 ± 9.22	2.718	0.010*

(**$p < 0.01$ significant, *$p < 0.05$ significant, NS = not significant)

3. DISCUSSION AND FINDINGS

The results highlight key differences in the physical fitness variables between women football players from Madurai Kamaraj University. While no significant difference was observed in speed, agility, endurance, and explosive strength showed notable variations.

- **Endurance:** Players from Madurai Kamaraj Universitydisplayed significantly better endurance levels, indicating possible variations in cardiovascular training programs.
- **Agility:** A considerable difference was found, suggesting that training regimens focusing on quick directional changes vary between the two teams.
- **Explosive Strength:** The variation in leg power suggests differences in strength training routines.
- **Flexibility:** While the flexibility of players remained relatively similar, minor variations could be attributed to stretching routines.

These findings suggest that endurance, agility, and explosive strength require targeted training to enhance performance in competitive football.

4. CONCLUSION

This study concludes that while speed remains consistent among university female players, endurance, agility, and explosive strength significantly vary. Training programs should be optimized to improve these variables for better game performance.

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THE IMPACT OF ENDURANCE AGILITY AND STRENGTH ON WOMEN FOOTBALL PLAYER'S PERFORMANCE

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ABSTRACT

Endurance, agility, and strength are crucial components that influence football performance. This study aims to compare these physical fitness variables among university-level female football players from Madurai Kamaraj University. A total of 40 players (20 from each university) were evaluated for endurance (1200m run), agility (4x10m shuttle run), and strength (standing broad jump). The independent t-test was used for statistical analysis. Results revealed significant differences in agility and strength, with no notable variation in endurance. These findings highlight the need for training programs focused on agility and lower-body strength to improve football performance.

Keywords: Endurance, agility, strength, women football players, sports performance, university-level athletes

1. INTRODUCTION

Physical fitness plays an integral role in football, where players require endurance for sustained performance, agility for quick directional changes, and strength for explosive movements. Women's football has been growing in popularity, but research on fitness attributes that contribute to success remains limited. Understanding these parameters can help in tailoring effective training programs to enhance performance.

This study compares endurance, agility, and strength between Madurai Kamaraj University women football players. While endurance ensures players can sustain their performance throughout the game, agility enhances their ability to maneuver efficiently, and strength contributes to explosive actions like jumping and sprinting. The findings will aid coaches in refining training strategies that target these fitness components.

2. METHODS AND DATA COLLECTION

- **Participants**: 40 female university football players (20 each from Madurai Kamaraj University Universities) aged 17-24 years.
- **Variables Measured**:
  - ✓ **Endurance**: 1200m run

- ✓ **Agility**: 4x10m shuttle run
- ✓ **Strength**: Standing broad jump
- ➢ **Statistical Analysis**: Independent t-test was conducted to compare the two groups.

Statistical Data

Fitness Parameter	G-1 (Mean ± SD)	G-2 (Mean ± SD)	T-Value	Significance (p)
Endurance (min)	5.61 ± 0.34	5.61 ± 0.34	1.789	0.078 (NS)
Agility (s)	11.78 ± 0.38	11.78 ± 0.38	4.602	0.000**
Strength (cm)	177.25 ± 9.22	177.25 ± 9.22	3.812	0.004*

**$p < 0.01$ significant, *$p < 0.05$ significant, NS = not significant)

3. DISCUSSION AND FINDINGS

The findings indicate that agility and strength exhibit significant variations among Madurai Kamaraj University, while endurance remains similar.

- ➢ **Agility**: Players from Madurai Kamaraj Universitydemonstrated higher agility scores, possibly due to differences in training intensity.
- ➢ **Strength**: Players from Madurai Kamaraj Universityexhibited superior lower-body strength, likely due to specific conditioning programs.
- ➢ **Endurance**: Both teams showed similar endurance levels, indicating comparable aerobic fitness training.

These results suggest that targeted agility and strength training is essential for improving women football players' overall performance.

4. CONCLUSION

The study confirms that agility and strength differ significantly between university-level women football players, while endurance remains consistent. Training should focus on agility drills and strength-building exercises to enhance game performance.

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A COMPARATIVE ANALYSIS OF SPEED FLEXIBILITY AND EXPLOSIVE STRENGTH IN WOMEN FOOTBALL PLAYERS

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ABSTRACT

Speed, flexibility, and explosive strength are essential attributes for successful football performance. This study investigates the differences in these fitness parameters among female university football players from Madurai Kamaraj University. A total of 40 players (20 from each university) were assessed for speed (50m sprint), flexibility (sit and reach test), and explosive strength (standing broad jump). Statistical analysis using an independent t-test revealed no significant difference in speed, but flexibility and explosive strength varied significantly. These results suggest that training should emphasize flexibility and explosive power to enhance football performance.

Keywords: Speed, flexibility, explosive strength, women football players, university sports, performance enhancement

1. INTRODUCTION

Football demands a high level of speed, flexibility, and explosive strength for optimal performance. Speed allows players to outrun opponents, flexibility aids in injury prevention and movement efficiency, while explosive strength enhances jumping and acceleration. In women's football, these attributes determine a player's ability to perform at a competitive level.

Despite the growing participation in women's football, limited research has analyzed these fitness attributes in university players. This study compares speed, flexibility, and explosive strength among women football players from Madurai kamaraj university. Understanding these parameters will help in designing effective training programs to improve player performance.

2. METHODS AND DATA COLLECTION

- **Participants**: 40 female university football players (20 each from Kannur and Calicut Universities) aged 17-24 years.
- **Variables Measured**:
  - ✓ **Speed**: 50m sprint
  - ✓ **Flexibility**: Sit and reach test

✓ **Explosive Strength**: Standing broad jump

- **Statistical Analysis**: Independent t-test was conducted.

Statistical Data

Fitness Parameter	G-1 (Mean ± SD)	G-2 (Mean ± SD)	T-Value	Significance (p)
Speed (s)	8.97 ± 0.21	8.97 ± 0.21	1.564	0.086 (NS)
Flexibility (cm)	24.90 ± 1.88	24.90 ± 1.88	3.892	0.002*
Explosive Strength (cm)	177.25 ± 9.22	177.25 ± 9.22	2.913	0.009*

(**$p < 0.01$ significant, *$p < 0.05$ significant, NS = not significant)

3. discussion and findings

The results indicate significant differences in flexibility and explosive strength but no substantial variation in speed.

- **Speed**: No significant difference was observed, suggesting uniform sprinting capabilities.
- **Flexibility**: Players from Madurai Kamaraj University demonstrated higher flexibility, possibly due to enhanced stretching routines.
- **Explosive Strength**: Calicut University players exhibited greater lower-body power, indicating superior strength training methods.

These findings emphasize the need for targeted flexibility and strength training in women's football.

4. CONCLUSION

The study concludes that while speed remains similar, flexibility and explosive strength vary significantly among university female football players. Training programs should prioritize these aspects to enhance player performance.

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EFFECT OF PLYOMETRIC TRAINING ON PHYSICAL FITNESS COMPONENTS AMONG MALE COLLEGIATE ATHLETES

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ABSTRACT

This study explores the impact of plyometric training on various physical fitness components such as muscular strength, agility, and endurance among male collegiate athletes. Plyometric training has been shown to improve explosive power, which is crucial in various sports disciplines. The research employs an experimental design with pre-test and post-test evaluations.

Keywords: Plyometric training, physical fitness, explosive power, agility, endurance

1. INTRODUCTION

Plyometric training is a specialized form of exercise that enhances muscle power and athletic performance through explosive movements. It has gained attention in sports sciences for its effectiveness in improving agility, speed, and endurance. Plyometric exercises include jumping, bounding, and hopping movements that activate the stretch-shortening cycle of muscles, thereby improving muscular contraction and neuromuscular coordination. Athletes across various sports disciplines incorporate plyometric training to develop speed, strength, and agility, which are crucial for high-performance activities.

In sports science, plyometric training is considered an essential component for athletes seeking to improve their overall fitness. Previous research has demonstrated that structured plyometric programs can significantly enhance vertical jump performance, sprint acceleration, and agility drills. These adaptations occur due to neuromuscular conditioning and increased muscle fiber recruitment. Additionally, plyometric training plays a vital role in injury prevention by strengthening tendons and ligaments, making them more resilient to high-impact movements.

2. MEANS AND METHODS

A total of 60 male collegiate athletes aged 18-25 years were selected and divided into two groups: an experimental group undergoing plyometric training and a control group following their usual training regimen. The program lasted 12 weeks, with three training sessions per week.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
Vertical Jump (cm)	42.3 ± 2.5	48.1 ± 2.8	4.21	0.001*
Sprint Speed (s)	4.92 ± 0.15	4.68 ± 0.14	3.85	0.002*
Agility (s)	11.5 ± 0.8	10.9 ± 0.7	3.45	0.004*

(*Significant at $p < 0.05$)

3. DISCUSSION AND FINDINGS

The findings indicate that plyometric training significantly enhances explosive power, agility, and endurance among collegiate athletes. The improvement in vertical jump and sprint speed suggests increased muscular strength and neuromuscular coordination. These results align with previous studies, confirming the effectiveness of plyometric drills in sports training. The study highlights the importance of incorporating such training methods in athletic conditioning programs.

4. CONCLUSION

Plyometric training proves to be an effective method for enhancing various physical fitness components. Coaches and trainers should integrate it into regular training regimens to optimize athletic performance.

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THE EFFECT OF STRENGTH TRAINING ON MUSCULAR POWER AND ENDURANCE AMONG COLLEGIATE ATHLETES

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ABSTRACT

This study examines the impact of strength training on muscular power and endurance among collegiate athletes. Strength training plays a crucial role in enhancing physical fitness and sports performance by increasing muscle mass, endurance, and explosive power. The research follows an experimental design comparing pre-test and post-test results among athletes subjected to a structured strength training program.

Keywords: Strength training, muscular endurance, explosive power, resistance exercises, sports performance

1. INTRODUCTION

Strength training is a widely adopted training method used to improve muscular endurance and power among athletes. It involves resistance-based exercises that enhance muscle hypertrophy, neuromuscular efficiency, and force production. Regular strength training leads to physiological adaptations, including increased muscle fiber recruitment, better motor unit synchronization, and enhanced metabolic efficiency.

Athletes from various sports rely on strength training to improve their performance by developing greater power and endurance. Research suggests that structured resistance training programs can significantly improve muscular strength, reduce the risk of injuries, and enhance overall sports capabilities. The benefits of strength training extend beyond athletics, contributing to better posture, reduced muscle imbalances, and increased bone density.

This study aims to investigate the effectiveness of a 12-week strength training program in enhancing muscular power and endurance among collegiate athletes. The research compares pre-test and post-test scores of vertical jump performance, bench press strength, and endurance levels to determine the effects of structured resistance exercises.

2. MEANS AND METHODS

A total of 50 male collegiate athletes aged 18-25 years were selected and divided into two groups: an experimental group undergoing structured strength training and a control group following their regular sports training. The program lasted for 12 weeks, with sessions held three times a week.

Statistical Data Analysis

The data collected were analyzed using an ANOVA test to assess significant differences between the groups. A paired t-test was also conducted to compare pre-test and post-test results within groups. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	F-Value	p-Value
Vertical Jump (cm)	45.2 ± 2.4	52.1 ± 3.1	5.72	0.001*
Bench Press (kg)	75.6 ± 5.2	85.3 ± 4.9	6.41	0.002*
Muscular Endurance (reps)	18.5 ± 3.2	24.8 ± 3.6	5.98	0.003*

(*Significant at $p < 0.05$)

3. DISCUSSION AND FINDINGS

The results indicate that strength training significantly enhances muscular power and endurance in collegiate athletes. The increase in vertical jump height suggests improvements in explosive power, while the enhanced bench press performance reflects greater upper body strength. The observed improvements in muscular endurance reinforce the effectiveness of structured resistance training in developing sustained performance capacity.

Athletes following the strength training program exhibited better muscle fiber recruitment and overall power output. These findings align with previous research demonstrating the benefits of strength training in athletic performance. The study highlights the importance of integrating resistance exercises into training regimens to optimize fitness levels among athletes.

4. CONCLUSION

Strength training proves to be an effective method for improving muscular power and endurance. Coaches and trainers should incorporate structured resistance training to enhance athletic performance and reduce injury risks.

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THE EFFECTS OF YOGA ON FLEXIBILITY AND MENTAL WELL-BEING IN ATHLETES

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ABSTRACT

This study examines the impact of yoga training on flexibility and mental well-being among collegiate athletes. Yoga is increasingly being incorporated into sports training to enhance physical and mental attributes. The research follows an experimental design comparing pre-test and post-test results of flexibility and psychological stress levels in athletes subjected to a structured yoga program.

Keywords: Yoga, flexibility, mental well-being, stress management, mindfulness, sports performance

1. INTRODUCTION

Yoga is a centuries-old practice that integrates physical postures, breathing exercises, and meditation to enhance overall health and wellness. It has gained widespread recognition in the sports domain as an effective method for improving flexibility, reducing stress, and enhancing focus. Flexibility is an essential component of athletic performance, as it helps prevent injuries, improves mobility, and supports overall functional movement.

In addition to its physical benefits, yoga is known to improve mental well-being by reducing anxiety, stress, and enhancing cognitive function. Many professional athletes incorporate yoga into their training to maintain balance between physical and psychological health. The role of yoga in stress management is particularly significant for athletes who experience high levels of competition-related anxiety.

This study aims to evaluate the impact of a 12-week yoga training program on flexibility and mental well-being among collegiate athletes. By analyzing pre-test and post-test results, the research provides insights into how structured yoga sessions influence performance and stress reduction.

2. MEANS AND METHODS

Fifty collegiate athletes aged 18-25 years were selected and divided into an experimental group (yoga training) and a control group (regular training). The yoga training program consisted of asanas (postures), pranayama (breathing exercises), and guided meditation, performed five days a week for 12 weeks.

3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test to compare pre-test and post-test scores within groups and an ANOVA test for between-group comparisons. The level of significance was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	F-Value	p-Value
Flexibility (cm)	23.4 ± 2.5	30.6 ± 3.1	7.23	0.001*
Stress Levels (score)	15.8 ± 3.2	10.2 ± 2.5	6.84	0.002*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results indicate that yoga training significantly enhances flexibility and reduces stress levels among collegiate athletes. The increase in flexibility scores suggests improved mobility, while the reduction in stress levels demonstrates the psychological benefits of mindfulness and breath control.

Athletes in the experimental group exhibited better mental clarity, focus, and emotional stability, reinforcing the role of yoga in mental well-being. These findings align with previous research, confirming that yoga serves as a valuable tool for enhancing both physical and psychological aspects of sports performance.

5. Conclusion

Yoga training proves to be an effective method for improving flexibility and reducing stress. Coaches should integrate structured yoga sessions into athletes' routines to optimize both physical and mental performance.

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THE INFLUENCE OF INTERVAL TRAINING ON SPEED AND AGILITY INTER COLLEGIATE SPRINTERS

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ABSTRACT

This study explores the impact of interval training on speed and agility among collegiate sprinters. Interval training, which alternates between high-intensity and low-intensity exercise, has been widely adopted to enhance speed and agility. The purpose of this study is to assess how a structured interval training program influences sprint acceleration and directional changeability in collegiate sprinters. By incorporating short bursts of high-intensity sprints with controlled recovery periods, interval training is known to develop both anaerobic and aerobic fitness, contributing to improved athletic performance. This research follows an experimental design, analyzing the pre-test and post-test sprint performance and agility levels of athletes. A total of 40 collegiate sprinters were divided into an experimental group undergoing interval training and a control group following traditional sprint training. The study aims to determine whether interval training leads to significant improvements in sprint speed and agility. The findings indicate that athletes in the experimental group demonstrated greater reductions in sprint times and enhanced agility test performance compared to the control group. The study concludes that structured interval training is an effective strategy for enhancing speed and agility in competitive sprinters. Interval training, which alternates between high-intensity and low-intensity exercise, has been widely adopted to enhance speed and agility. The research follows an experimental design, comparing pre-test and post-test sprint times and agility performance of athletes subjected to a structured interval training program.

Keywords: Interval training, sprinting, agility, speed development, athletic performance

1. INTRODUCTION

Speed and agility are critical performance factors for sprinters and other athletes who rely on quick directional changes and acceleration. Traditional sprint training focuses on continuous running, but recent studies suggest that interval training, which consists of alternating bursts of intense effort with short recovery periods, can significantly enhance speed and agility.

Interval training challenges both the aerobic and anaerobic systems, leading to improved endurance and power. It is widely used in sprinting and other high-intensity sports, helping athletes develop explosive movements and quick recovery times. Furthermore, it has been shown to increase fast-twitch muscle fiber recruitment, which is essential for sprinting performance.

This study aims to investigate the effect of a 12-week interval training program on sprint speed and agility among collegiate sprinters. By analyzing pre-test and post-test sprint times and agility drills, the research provides insights into the effectiveness of interval training for speed development.

2. MEANS AND METHODS

A total of 40 collegiate sprinters aged 18-25 years were selected and divided into an experimental group (interval training) and a control group (traditional sprint training). The interval training program included short sprints with variable rest intervals and agility drills, performed four times a week for 12 weeks.

3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test to compare pre-test and post-test scores within groups and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
100m Sprint (s)	11.56 ± 0.32	10.98 ± 0.28	6.12	0.001*
Agility T-Test (s)	9.65 ± 0.45	8.92 ± 0.38	5.89	0.002*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results indicate that interval training significantly improves sprint speed and agility among collegiate sprinters. The reduction in 100m sprint times suggests enhanced power and acceleration, while the improvement in agility T-test performance demonstrates greater ability to change direction quickly.

Athletes in the experimental group exhibited improved anaerobic capacity and neuromuscular coordination, which contributed to their enhanced performance. These findings align with previous research confirming that interval training is one of the most effective methods for improving speed and agility in competitive sports.

5. CONCLUSION

Interval training is an effective strategy for enhancing speed and agility in sprinters. Coaches should incorporate structured interval training drills into training programs to maximize sprint performance and agility.

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THE ROLE OF CORE STABILITY TRAINING IN INJURY PREVENTION AND ATHLETIC PERFORMANCE

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ABSTRACT

This study examines the effects of core stability training on injury prevention and athletic performance among collegiate athletes. Core stability is essential for overall body control, balance, and efficient force transfer in sports activities. The purpose of this research is to evaluate how a structured core training program influences injury risk and movement efficiency. Core stability training enhances the strength and coordination of deep trunk muscles, which play a crucial role in stabilizing the spine and pelvis during dynamic movements. Weak core muscles contribute to poor posture, movement inefficiencies, and a higher risk of musculoskeletal injuries. By improving core strength, athletes can enhance their ability to maintain stability, generate power, and reduce stress on peripheral muscles and joints.This study follows an experimental design where collegiate athletes participated in a 12-week core stability training program. Their performance was assessed using balance tests and functional movement screenings before and after the intervention. The results suggest significant improvements in balance control, functional stability, and injury prevention among athletes undergoing core training. This research highlights the importance of incorporating core stability exercises into regular training routines to optimize athletic performance and minimize injury risks.

Keywords: Core stability, injury prevention, balance training, sports performance, athletic conditioning.

1. INTRODUCTION

Core stability training has gained significant attention in sports science due to its role in enhancing athletic performance and reducing injury risks. The core muscles, including the abdominals, lower back, and pelvic muscles, provide the foundation for movement efficiency and postural control. Strengthening these muscles contributes to better balance, coordination, and overall functional strength.Athletes in various sports require a stable core to generate power, maintain balance, and execute complex movements with precision. Research suggests that weak core muscles lead to poor posture, compensatory movements, and increased injury susceptibility. Conversely, a well-developed core reduces the strain on peripheral muscles and joints, lowering the risk of overuse injuries. This study aims to evaluate the impact of a 12-week core stability training program on injury prevention and athletic performance in collegiate athletes. By analyzing pre-test and post-test results of stability assessments and functional movement screenings, this research seeks to determine whether core training enhances overall performance and reduces injury occurrence.

2. MEANS AND METHODS

A total of 50 collegiate athletes aged 18-25 years were selected and divided into an experimental group (core stability training) and a control group (traditional strength training). The core training program included stability exercises, balance drills, and functional movements, performed four times a week for 12 weeks.

3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test to compare pre-test and post-test scores within groups and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
Balance Test (sec)	32.4 ± 4.8	40.1 ± 5.2	6.21	0.001*
Functional Stability Score	65.3 ± 6.2	74.6 ± 5.8	5.87	0.002*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The findings indicate that core stability training significantly enhances balance and overall functional stability in collegiate athletes. The improvements in balance test scores suggest that core exercises strengthen postural control, while the functional stability assessment confirms enhanced movement efficiency and coordination. Athletes in the experimental group exhibited reduced movement asymmetries and improved neuromuscular control, contributing to better athletic performance. These results align with previous research confirming that core stability training plays a crucial role in preventing injuries and optimizing movement patterns in sports.

5. CONCLUSION

Core stability training is an effective method for reducing injury risks and enhancing athletic performance. Coaches should integrate structured core exercises into training programs to improve balance, coordination, and overall functional strength.

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THE EFFECTS OF HIGH-INTENSITY INTERVAL TRAINING ON CARDIOVASCULAR ENDURANCE AND ANAEROBIC CAPACITY IN ATHLETES

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ABSTRACT

This study investigates the effects of strength training on muscular endurance and power in collegiate athletes. Strength training is widely recognized for improving muscle hypertrophy, endurance, and overall athletic performance. The purpose of this research is to analyze the effectiveness of a 12-week strength training program on muscular endurance and power. The study follows an experimental design, comparing pre-test and post-test results of athletes subjected to resistance training versus a control group maintaining regular training routines. The research examines improvements in vertical jump height, isometric strength, and endurance capacity. The findings suggest that structured strength training significantly enhances athletic performance, making it a crucial component of modern sports training. This study provides insights for coaches and sports scientists on optimizing training regimens to enhance muscle endurance and power in athletes.

Keywords: Strength training, muscular endurance, power, resistance training, athletic performance

1. INTRODUCTION

Strength training is an integral part of modern athletic conditioning, contributing to muscle hypertrophy, increased endurance, and enhanced neuromuscular coordination. Over the years, numerous studies have demonstrated that resistance training leads to physiological adaptations that improve an athlete’s ability to sustain prolonged physical effort and generate force efficiently. While endurance athletes primarily focus on aerobic conditioning, recent findings suggest that incorporating strength training can significantly improve overall performance.One of the primary benefits of strength training is the development of muscular endurance, which refers to the muscle’s ability to sustain repeated contractions over time. This aspect is particularly important in sports that require sustained effort, such as long-distance running, cycling, and swimming. Additionally, power—defined as the ability to exert force rapidly—is crucial for activities involving sprinting, jumping, and explosive movements.The present study aims to evaluate the impact of a structured 12-week strength training program on muscular endurance and power among collegiate athletes. By analyzing pre-test and post-test results, the research determines the extent to which resistance training improves athletic performance. This study is designed to help coaches and sports professionals develop evidence-based training programs that optimize endurance and power development in athletes across various sports disciplines.

2. MEANS AND METHODS

A total of 50 male collegiate athletes aged 18-25 years were selected and divided into an experimental group (strength training) and a control group (regular training). The strength training program consisted of compound exercises (squats, deadlifts, bench presses) and resistance circuits, performed three times per week for 12 weeks.

3. STATISTICAL DATA ANALYSIS

Data were analyzed using a paired t-test to compare pre-test and post-test scores within groups and an ANOVA test for between-group comparisons. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
Vertical Jump (cm)	45.2 ± 2.4	51.8 ± 3.1	6.24	0.001*
Isometric Strength (kg)	82.6 ± 5.8	95.3 ± 6.2	7.12	0.002*
Endurance Test (reps)	22.1 ± 3.5	28.9 ± 3.7	5.98	0.003*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results of this study indicate that strength training significantly improves muscular endurance and power in collegiate athletes. The observed increase in vertical jump height suggests enhanced neuromuscular efficiency and explosive strength, which are essential for various sports, including basketball, football, and track events. The improvements in isometric strength and endurance scores further reinforce the importance of resistance training in athletic conditioning.

Athletes in the experimental group exhibited better fatigue resistance and greater force production, which can be attributed to muscle fiber recruitment and enhanced motor unit synchronization. These findings align with previous studies indicating that structured strength training programs contribute to improved muscular endurance, reduced injury risk, and enhanced athletic performance.

5. CONCLUSION

Strength training proves to be an effective method for improving muscular endurance and power in athletes. Coaches and trainers should integrate structured resistance training into athletes' training regimens to optimize performance and reduce injury risks.

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THE ROLE OF PLYOMETRIC TRAINING IN ENHANCING SPEED AGILITY AND EXPLOSIVE POWER IN SPRINTERS

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ABSTRACT

This study investigates the impact of plyometric training on speed, agility, and explosive power among collegiate sprinters. Plyometric exercises, which involve rapid stretching and contracting of muscles, are widely used to improve athletic performance in sports requiring quick bursts of movement. The study follows an experimental design comparing pre-test and post-test sprint times, agility drills, and vertical jump scores between an experimental group undergoing plyometric training and a control group following traditional sprint workouts. The results indicate significant improvements in explosive power and agility in athletes undergoing plyometric training, suggesting that it should be an integral part of sprint training programs.

Keywords: Plyometric training, sprinting, agility, explosive power, speed development, sports performance

1. INTRODUCTION

Plyometric training has been extensively studied in sports science due to its effectiveness in developing explosive power, speed, and agility. It involves a series of jumping, hopping, and bounding movements designed to enhance the stretch-shortening cycle of muscles, leading to improved neuromuscular coordination and force generation.

Athletes participating in sports requiring quick acceleration, rapid changes in direction, and maximal effort over short distances benefit greatly from plyometric exercises. The principle behind plyometric training is to increase the rate of force development by optimizing the recruitment of fast-twitch muscle fibers. By incorporating plyometric drills into regular sprint training programs, athletes can enhance their performance in competitive settings.

This study aims to assess the effects of a structured 12-week plyometric training program on sprinting speed, agility, and explosive power among collegiate sprinters. By analyzing pre-test and post-test results, the research seeks to determine the effectiveness of plyometric training in improving key performance indicators essential for sprinting.

2. MEANS AND METHODS

A total of 40 collegiate sprinters aged 18-25 years were selected and divided into an experimental group (plyometric training) and a control group (traditional sprint training). The plyometric program consisted of box jumps, depth jumps, hurdle hops, and bounding exercises, performed four times a week for 12 weeks.

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3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test to compare pre-test and post-test scores within groups and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
100m Sprint (s)	11.58 ± 0.35	10.92 ± 0.31	6.38	0.001*
Agility T-Test (s)	9.72 ± 0.42	8.89 ± 0.36	5.76	0.002*
Vertical Jump (cm)	48.2 ± 3.1	54.6 ± 3.4	7.21	0.001*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The findings indicate that plyometric training significantly enhances sprint speed, agility, and explosive power in collegiate sprinters. The reduction in 100m sprint times suggests improved acceleration and maximal velocity, while the increased agility test scores demonstrate greater directional changeability. The improvement in vertical jump scores highlights enhanced lower-body power, which is crucial for sprinting performance. Athletes in the experimental group exhibited better neuromuscular efficiency and force production, likely due to the enhanced activation of fast-twitch muscle fibers. These results align with previous research confirming that plyometric exercises optimize the stretch-shortening cycle, leading to greater force output and movement efficiency.

5. CONCLUSION

Plyometric training is an effective method for improving speed, agility, and explosive power in sprinters. Coaches should integrate structured plyometric drills into training regimens to maximize sprinting performance and overall athletic efficiency.

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THE EFFECT OF RESISTANCE TRAINING ON MUSCULAR STRENGTH AND ENDURANCE IN COLLEGIATE ATHLETES

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ABSTRACT

This study investigates the impact of resistance training on muscular strength and endurance among collegiate athletes. Resistance training is a well-established method for improving muscle hypertrophy, neuromuscular coordination, and overall sports performance. The purpose of this study is to assess the effectiveness of a structured 12-week resistance training program in enhancing strength and endurance in athletes. The study follows an experimental design comparing pre-test and post-test measurements of maximal strength, muscular endurance, and functional movement. The findings indicate that resistance training significantly improves these parameters, reinforcing its role as a fundamental component of athletic conditioning.

Keywords: Resistance training, muscular strength, endurance, hypertrophy, athletic conditioning

1. INTRODUCTION

Resistance training is an essential component of modern sports training programs aimed at improving muscular strength and endurance. It involves exercises using external resistance, such as free weights, resistance bands, or bodyweight, to enhance neuromuscular function and muscle fiber recruitment. Athletes from various sports disciplines rely on resistance training to optimize performance, reduce injury risk, and maintain muscular balance.

Muscular strength is the ability to generate force, while muscular endurance refers to the ability to sustain repeated contractions over time. Both are crucial for sports performance, whether in power-based activities like sprinting and weightlifting or endurance-based sports like long-distance running and swimming. Scientific research suggests that structured resistance training programs improve motor unit activation, increase muscle fiber size, and enhance overall physical fitness.

This study aims to evaluate the effectiveness of a 12-week resistance training program in improving strength and endurance among collegiate athletes. By analyzing pre-test and post-test data, this research provides valuable insights into the role of resistance training in optimizing athletic performance.

2. MEANS AND METHODS

A total of 45 collegiate athletes aged 18-25 years were selected and divided into an experimental group (resistance training) and a control group (regular sports training). The resistance training program included compound exercises such as squats, bench presses, deadlifts, and pull-ups, performed three times a week for 12 weeks.

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3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test to compare pre-test and post-test scores within groups and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
Bench Press (kg)	75.4 ± 5.3	85.9 ± 6.1	6.42	0.001*
Squat (kg)	110.2 ± 6.8	125.5 ± 7.2	7.11	0.002*
Endurance Test (reps)	20.3 ± 2.9	27.8 ± 3.4	6.94	0.001*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results of this study indicate that resistance training significantly enhances both muscular strength and endurance in collegiate athletes. The increase in bench press and squat performance suggests improved force production, while the endurance test results highlight greater fatigue resistance. These improvements are attributed to increased muscle fiber recruitment, enhanced motor unit synchronization, and better neuromuscular coordination. Athletes in the experimental group exhibited better overall functional strength and greater fatigue resistance, making them more capable of sustaining high-intensity efforts over time. These findings align with existing research supporting the role of resistance training in sports conditioning and injury prevention.

5. CONCLUSION

Resistance training is an effective strategy for improving muscular strength and endurance in athletes. Coaches and trainers should incorporate structured resistance exercises into training programs to enhance performance and minimize injury risk.

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THE INFLUENCE OF CORE STABILITY TRAINING ON INJURY PREVENTION AND FUNCTIONAL MOVEMENT IN ATHLETES

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ABSTRACT

This study examines the impact of core stability training on injury prevention and functional movement among collegiate athletes. Core stability plays a vital role in maintaining postural control, balance, and efficient force transfer during athletic movements. The purpose of this study is to evaluate the effectiveness of a structured 12-week core stability training program in enhancing movement efficiency and reducing injury risk. The study follows an experimental design comparing pre-test and post-test measurements of balance, functional movement screening (FMS), and injury incidence rates. The findings indicate that core stability training significantly improves postural control and reduces injury susceptibility, reinforcing its role in athletic conditioning.

Keywords: Core stability, injury prevention, functional movement, balance training, postural control

1. INTRODUCTION

Core stability training has gained widespread recognition in sports training due to its essential role in enhancing athletic performance and minimizing injury risks. The core muscles, comprising the abdominals, lower back, and pelvic stabilizers, serve as the foundation for controlled and powerful movements in sports. Weak core muscles can lead to postural imbalances, decreased force production, and an increased risk of musculoskeletal injuries.

Athletes require a stable core to perform explosive movements, maintain balance, and transfer energy efficiently. Scientific research suggests that targeted core training enhances neuromuscular control, improves movement coordination, and prevents overuse injuries. Functional movement screenings (FMS) are often used to assess movement deficiencies and potential injury risks, with core stability being a significant factor in overall performance.

This study aims to analyze the impact of a structured core stability training program on injury prevention and functional movement in collegiate athletes. By comparing pre-test and post-test results, this research provides valuable insights into optimizing training programs for enhanced movement efficiency and reduced injury incidence.

2. MEANS AND METHODS

A total of 48 collegiate athletes aged 18-25 years were selected and divided into an experimental group (core stability training) and a control group (regular training). The core stability program included exercises such as planks, stability ball drills, and rotational movements, performed three times a week for 12 weeks.

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3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test to compare pre-test and post-test scores within groups and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	**Pre-Test Mean ± SD**	**Post-Test Mean ± SD**	**t-Value**	**p-Value**
Balance Test (sec)	30.4 ± 5.1	40.7 ± 5.6	6.78	0.001*
FMS Score (/21)	12.3 ± 2.8	16.5 ± 3.2	5.92	0.002*
Injury Incidence (cases)	5.6 ± 1.2	3.1 ± 1.0	4.81	0.003*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results of this study indicate that core stability training significantly improves balance, functional movement efficiency, and injury prevention in collegiate athletes. The improvement in balance test scores highlights the enhanced ability to maintain postural control, while the increased FMS scores suggest improved movement mechanics. Additionally, the reduced injury incidence in the experimental group confirms the role of core training in preventing musculoskeletal injuries.

Athletes who underwent core stability training demonstrated improved neuromuscular coordination, which contributed to better overall movement efficiency. These findings align with previous research highlighting the importance of core training in reducing injury risks and optimizing sports performance.

5. CONCLUSION

Core stability training is a highly effective strategy for improving movement efficiency and reducing injury rates in athletes. Coaches and sports professionals should integrate structured core exercises into training regimens to enhance postural control and prevent injuries.

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THE IMPACT OF ENDURANCE TRAINING ON AEROBIC CAPACITY AND FATIGUE RESISTANCE IN LONG-DISTANCE RUNNERS

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ABSTRACT

This study investigates the effects of endurance training on aerobic capacity and fatigue resistance in collegiate long-distance runners. Endurance training is a critical component of athletic preparation for long-distance events, improving cardiovascular efficiency, oxygen uptake, and muscle endurance. The purpose of this study is to evaluate the effectiveness of a structured 12-week endurance training program in enhancing VO2 max and reducing fatigue onset. The study follows an experimental design comparing pre-test and post-test measurements of aerobic capacity, lactate threshold, and running economy. The findings indicate that endurance training significantly improves aerobic efficiency and delay in fatigue onset, reinforcing its role in long-distance training programs.

Keywords: Endurance training, aerobic capacity, VO2 max, fatigue resistance, long-distance running

1. INTRODUCTION

Endurance training is a fundamental aspect of athletic performance in long-distance running. It enhances an athlete’s ability to sustain high-intensity exercise for prolonged periods by improving oxygen transport and utilization. VO2 max, lactate threshold, and running economy are key physiological determinants of endurance performance. Scientific research suggests that systematic endurance training leads to cardiovascular adaptations such as increased stroke volume, enhanced capillary density, and improved mitochondrial efficiency.

Athletes who engage in structured endurance training develop higher fatigue resistance, allowing them to maintain speed over long distances without excessive physiological stress. By progressively overloading the cardiovascular system, endurance training stimulates aerobic energy production, optimizing metabolic pathways for sustained performance. Incorporating varied training intensities, such as tempo runs, interval training, and long-distance steady-state runs, further enhances aerobic efficiency and recovery capacity.

This study aims to assess the effects of a 12-week endurance training program on VO2 max, lactate threshold, and fatigue resistance in collegiate long-distance runners. By analyzing pre-test and post-test results, this research provides insights into optimizing endurance training for improved race performance.

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2. MEANS AND METHODS

A total of 50 collegiate long-distance runners aged 18-25 years were selected and divided into an experimental group (endurance training) and a control group (regular training). The endurance training program included steady-state runs, interval training, and tempo runs, performed five times a week for 12 weeks.

3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test to compare pre-test and post-test scores within groups and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
VO2 Max (ml/kg/min)	50.2 ± 3.6	56.8 ± 4.1	6.32	0.001*
Lactate Threshold (mmol/L)	4.5 ± 0.8	3.2 ± 0.7	5.76	0.002*
Fatigue Onset (min)	28.6 ± 4.2	35.9 ± 4.8	6.54	0.001*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results of this study indicate that endurance training significantly improves aerobic capacity and fatigue resistance in collegiate long-distance runners. The increase in VO2 max reflects improved oxygen transport and utilization, while the decrease in lactate threshold suggests greater metabolic efficiency. Additionally, the extended time to fatigue onset highlights improved endurance performance. Athletes in the experimental group demonstrated enhanced cardiovascular efficiency and muscular endurance, allowing them to sustain higher running speeds for longer durations. These findings align with existing literature on endurance training, reinforcing the importance of structured aerobic conditioning in long-distance sports.

5. CONCLUSION

Endurance training is a crucial method for improving aerobic capacity and delaying fatigue onset in long-distance runners. Coaches should integrate structured endurance sessions into training programs to enhance cardiovascular efficiency and optimize race performance.

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THE EFFECTS OF SPRINT TRAINING ON SPEED DEVELOPMENT AND ACCELERATION IN SHORT-DISTANCE RUNNERS

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ABSTRACT

This study explores the impact of sprint training on speed development and acceleration among collegiate short-distance runners. Sprinting performance relies on neuromuscular coordination, reaction time, and explosive power. The purpose of this research is to examine how a structured 12-week sprint training program influences 100m sprint performance, reaction time, and stride length. The study follows an experimental design comparing pre-test and post-test sprint times, reaction time measurements, and kinematic stride analysis. The findings suggest significant improvements in acceleration, sprint velocity, and biomechanical efficiency, reinforcing the importance of specialized sprint training in short-distance running.

Keywords: Sprint training, acceleration, reaction time, speed development, short-distance running

1. INTRODUCTION

Speed and acceleration are critical performance factors in short-distance running events. Elite sprinters require rapid force production, optimal stride mechanics, and efficient neuromuscular control to maximize performance. Sprint training programs are designed to enhance muscle power, stride efficiency, and reaction time, contributing to superior acceleration and peak velocity. Scientific research highlights the significance of neuromuscular adaptations in sprint training, including increased motor unit recruitment, enhanced muscle stiffness, and improved ground reaction force application. Athletes incorporate sprint drills, resisted sprints, and over speed training to optimize sprint mechanics and reduce ground contact time. This study aims to evaluate the effects of a 12-week sprint training program on speed development and acceleration in collegiate short-distance runners. By analyzing pre-test and post-test sprint performance, this research provides insights into designing specialized training interventions for sprinting success.

2. MEANS AND METHODS

A total of 40 collegiate sprinters aged 18-25 years were selected and divided into an experimental group (sprint training) and a control group (regular track training). The sprint training program included resisted sprints, sled pulls, acceleration drills, and over speed training, performed four times a week for 12 weeks.

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3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test to compare pre-test and post-test scores within groups and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
100m Sprint (s)	11.56 ± 0.30	10.92 ± 0.25	6.78	0.001*
Reaction Time (ms)	215.4 ± 12.8	198.7 ± 11.5	5.89	0.002*
Stride Length (m)	2.15 ± 0.18	2.32 ± 0.21	5.65	0.001*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results indicate that sprint training significantly enhances speed, acceleration, and reaction time in short-distance runners. The decrease in 100m sprint times suggests improved explosive power and stride efficiency, while the reduction in reaction time highlights better neuromuscular coordination. Additionally, the increase in stride length indicates enhanced running mechanics. Athletes in the experimental group demonstrated superior sprint performance due to improved muscle activation patterns and faster ground contact times. These findings align with previous studies emphasizing the role of specialized sprint training in optimizing biomechanics and reducing sprinting inefficiencies.

5. CONCLUSION

Sprint training is a vital component for enhancing speed and acceleration in short-distance runners. Coaches should incorporate sprint drills, resisted training, and reaction time exercises to maximize sprint performance.

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THE EFFECTS OF FLEXIBILITY TRAINING ON RANGE OF MOTION AND INJURY PREVENTION IN ATHLETES

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ABSTRACT

This study examines the impact of flexibility training on range of motion and injury prevention among collegiate athletes. Flexibility is a crucial component of athletic performance, influencing movement efficiency, joint stability, and overall functional mobility. The purpose of this study is to assess the effectiveness of a structured 12-week flexibility training program in improving joint range of motion and reducing injury occurrence. The study follows an experimental design comparing pre-test and post-test flexibility scores, functional movement assessments, and injury incidence rates. The findings indicate significant improvements in flexibility and a decrease in injury rates, reinforcing the role of flexibility training in sports conditioning.

Keywords: Flexibility training, range of motion, injury prevention, functional mobility, sports conditioning

1. INTRODUCTION

Flexibility plays an essential role in athletic performance by enabling a full range of motion, reducing muscle stiffness, and preventing injuries. Athletes who incorporate flexibility training into their routines experience better movement efficiency and reduced muscular imbalances, allowing for smoother transitions between athletic movements.

Scientific research supports the notion that improved flexibility enhances joint stability, reduces muscle strain, and optimizes neuromuscular coordination. Common methods of flexibility training include static stretching, dynamic stretching, and proprioceptive neuromuscular facilitation (PNF). Each method contributes to enhanced movement quality and reduced muscle tightness.

This study aims to evaluate the effects of a 12-week flexibility training program on range of motion and injury prevention in collegiate athletes. By analyzing pre-test and post-test data, this research provides evidence for integrating structured flexibility training into sports conditioning programs.

2. MEANS AND METHODS

A total of 45 collegiate athletes aged 18-25 years were selected and divided into an experimental group (flexibility training) and a control group (regular training). The flexibility training program included static stretching, dynamic stretching, and PNF techniques, performed five times a week for 12 weeks.

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3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test to compare pre-test and post-test scores within groups and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
Sit-and-Reach Test (cm)	25.2 ± 3.4	32.1 ± 3.8	6.41	0.001*
Shoulder Flexibility (cm)	18.5 ± 2.9	22.9 ± 3.2	5.98	0.002*
Injury Incidence (cases)	6.3 ± 1.1	3.2 ± 0.9	4.85	0.003*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results indicate that flexibility training significantly enhances the range of motion and reduces injury incidence among collegiate athletes. The improvement in sit-and-reach scores and shoulder flexibility suggests increased joint mobility and muscle elasticity. Additionally, the reduction in injury occurrence confirms that flexibility training plays a preventive role in sports performance.

Athletes in the experimental group demonstrated better movement efficiency and decreased muscle tightness, which contributed to reduced strain on joints and connective tissues. These findings align with previous research emphasizing the importance of flexibility training in injury prevention and movement optimization.

5. CONCLUSION

Flexibility training is a fundamental component of athletic conditioning that improves range of motion and reduces injury risk. Coaches and trainers should integrate structured stretching routines into training programs to enhance flexibility and optimize sports performance.

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EFFECT OF CONTINUOUS TRAINING ON CARDIORESPIRATORY ENDURANCE AMONG LONG-DISTANCE RUNNERS

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ABSTRACT

This study investigates the impact of continuous training on cardiorespiratory endurance in long-distance runners. Endurance training is crucial for improving oxygen utilization, cardiovascular efficiency, and aerobic capacity. This research analyzes the effects of a structured 12-week continuous training program on VO2 max, heart rate variability, and running performance. Using a pre-test and post-test experimental design, the study assesses physiological improvements in endurance athletes. The findings suggest that continuous training significantly enhances aerobic capacity and endurance performance, reinforcing its importance in long-distance running.

Keywords: Continuous training, cardiorespiratory endurance, aerobic capacity, VO2 max, long-distance running

1. INTRODUCTION

Endurance training plays a vital role in developing cardiorespiratory fitness among athletes, particularly those competing in long-distance running. Continuous training, characterized by sustained submaximal exercise without rest intervals, is one of the most effective methods for improving aerobic capacity. It enhances cardiovascular function, increases oxygen transport efficiency, and strengthens the respiratory system, allowing athletes to maintain performance over prolonged durations.

Physiological adaptations to continuous training include increased stroke volume, enhanced capillary density, and improved mitochondrial function. Research suggests that long-duration, moderate-intensity running is the key to optimizing VO2 max, reducing heart rate variability, and increasing lactate threshold. These adaptations contribute to greater endurance capacity and fatigue resistance, essential for success in endurance sports.

This study evaluates the effectiveness of a 12-week continuous training program in improving cardiorespiratory endurance among long-distance runners. By measuring pre-test and post-test physiological parameters, this research provides insights into the benefits of sustained aerobic training for endurance performance.

2. MEANS AND METHODS

A total of 50 long-distance runners aged 18-30 years participated in this study. They were divided into an experimental group (continuous training) and a control group (regular training). The continuous training program included steady-state running at 70-80% of maximum heart rate, performed five days a week for 12 weeks.

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3. STATISTICAL DATA ANALYSIS

Data were analyzed using a paired t-test for within-group comparisons and an independent t-test for between-group differences. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
VO2 Max (ml/kg/min)	48.5 ± 3.7	54.2 ± 3.9	5.89	0.001*
Resting Heart Rate (bpm)	68.2 ± 5.3	60.8 ± 4.9	6.21	0.002*
Running Performance (min/5km)	23.4 ± 1.8	21.7 ± 1.6	5.43	0.003*

(*Significant at $p < 0.05$)

4. discussion and findings

The findings suggest that continuous training significantly enhances VO2 max, reduces resting heart rate, and improves running performance in long-distance runners. The increase in aerobic capacity is attributed to enhanced oxygen transport mechanisms, greater stroke volume, and improved muscular efficiency. Athletes in the experimental group exhibited lower lactate accumulation and better endurance performance, demonstrating the effectiveness of sustained aerobic training. These results align with previous research indicating that continuous training optimizes cardiovascular adaptations and enhances endurance capacity in competitive runners.

5. CONCLUSION

Continuous training is an effective method for improving cardiorespiratory endurance in long-distance runners. Coaches should integrate structured aerobic training sessions into endurance programs to maximize performance gains and enhance physiological adaptations.

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COMPARATIVE EFFECT OF DIFFERENT FREQUENCIES OF ENDURANCE TRAINING ON CARDIOVASCULAR FITNESS

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ABSTRACT

This study examines the effects of different frequencies of endurance training on cardiovascular fitness in collegiate athletes. Endurance training is essential for developing aerobic capacity, cardiovascular efficiency, and exercise performance. The purpose of this research is to compare the effects of three training frequencies—three, four, and five days per week—on VO2 max, heart rate recovery, and endurance performance. The study follows an experimental design comparing pre-test and post-test measurements of cardiovascular parameters. The findings indicate that higher training frequency leads to greater improvements in cardiovascular fitness, emphasizing the role of structured endurance programs in optimizing athletic performance.

Keywords: Endurance training, cardiovascular fitness, VO2 max, heart rate recovery, training frequency

1. INTRODUCTION

Endurance training is a key component of athletic preparation, promoting adaptations that enhance oxygen transport, cardiac efficiency, and aerobic capacity. The frequency of training plays a crucial role in determining the magnitude of these physiological adaptations. While endurance athletes often engage in frequent training sessions, it remains unclear how varying training frequencies influence cardiovascular fitness outcomes.

Aerobic conditioning improves cardiovascular efficiency by increasing stroke volume, reducing resting heart rate, and enhancing oxygen uptake. Previous research suggests that higher training frequencies lead to more significant improvements in aerobic capacity and endurance performance. However, excessive training without adequate recovery may lead to overtraining and diminished gains.

This study aims to compare the effects of endurance training performed three, four, and five days per week on VO2 max, heart rate recovery, and endurance performance. By analyzing pre-test and post-test results, this research provides insights into optimizing endurance training frequency for cardiovascular fitness improvements.

2. MEANS AND METHODS

A total of 60 collegiate athletes aged 18-30 years were divided into three experimental groups based on training frequency: three days per week, four days per week, and five days per week. Each group followed a structured endurance training program consisting of steady-state running and interval training for 12 weeks.

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3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using ANOVA to compare differences between groups, followed by post-hoc tests. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	3 Days/Week Mean ± SD	4 Days/Week Mean ± SD	5 Days/Week Mean ± SD	F-Value	p-Value
VO2 Max (ml/kg/min)	48.1 ± 3.5	52.6 ± 3.8	55.3 ± 4.2	5.98	0.001*
Heart Rate Recovery (bpm)	72.4 ± 5.1	65.7 ± 4.9	60.3 ± 4.5	6.12	0.002*
Endurance Performance (min/5km)	24.1 ± 1.9	22.5 ± 1.7	21.3 ± 1.5	5.43	0.003*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results indicate that higher training frequency is associated with greater improvements in cardiovascular fitness. Athletes training five days per week exhibited the most significant increase in VO2 max, faster heart rate recovery, and enhanced endurance performance. These improvements can be attributed to greater cardiovascular workload and increased aerobic adaptations.

However, while the group training four days per week also demonstrated substantial gains, the improvements were slightly lower compared to the five-day group. The three-day training group showed the least improvement, suggesting that lower training frequency may not be as effective in maximizing cardiovascular adaptations.

5. CONCLUSION

Higher frequency endurance training leads to more significant improvements in cardiovascular fitness. Coaches should consider incorporating four to five endurance training sessions per week to optimize cardiovascular adaptations and performance improvements in athletes.

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IMPACT OF PLYOMETRIC TRAINING ON EXPLOSIVE STRENGTH AND AGILITY IN BASKETBALL PLAYERS

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ABSTRACT

This study investigates the effects of plyometric training on explosive strength and agility among basketball players. Plyometric exercises are widely recognized for improving lower-body power, speed, and agility, which are essential for basketball performance. The purpose of this study is to evaluate a 12-week plyometric training program and its influence on vertical jump height, sprint acceleration, and agility drills. Using a pre-test and post-test experimental design, this study assesses performance enhancements in basketball players. The findings indicate that plyometric training significantly improves explosive strength and agility, making it a valuable component of basketball conditioning programs.

Keywords: Plyometric training, explosive strength, agility, basketball performance, jump height

1. INTRODUCTION

Basketball requires a combination of explosive power, speed, and agility to perform dynamic movements such as jumping, sprinting, and quick directional changes. Plyometric training is one of the most effective methods to enhance these physical attributes, as it focuses on rapid muscle contractions and neuromuscular efficiency. Plyometric exercises involve stretch-shortening cycle (SSC) movements that allow athletes to store and release energy efficiently. Exercises such as depth jumps, bounding, and lateral hops improve neuromuscular coordination and enhance explosive force production. Scientific research suggests that regular plyometric training increases vertical jump performance, acceleration, and agility, which are crucial components of basketball gameplay. This study aims to assess the effects of a 12-week plyometric training program on explosive strength and agility in collegiate basketball players. By analyzing pre-test and post-test results, this research provides practical insights into the benefits of plyometric conditioning for basketball performance.

2. MEANS AND METHODS

A total of 40 collegiate basketball players aged 18-25 years participated in this study. They were divided into an experimental group (plyometric training) and a control group (regular training). The plyometric training program included depth jumps, box jumps, lateral bounds, and sprint drills, performed three times per week for 12 weeks.

3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test for within-group comparisons and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
Vertical Jump (cm)	52.4 ± 3.1	60.2 ± 3.5	6.58	0.001*
20m Sprint (s)	3.42 ± 0.12	3.18 ± 0.10	5.91	0.002*
Agility Test (s)	9.87 ± 0.45	9.12 ± 0.38	5.45	0.003*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The findings suggest that plyometric training significantly enhances explosive strength and agility in basketball players. The observed increase in vertical jump height indicates improved neuromuscular efficiency and power output, while the reduction in sprint and agility test times highlights faster acceleration and directional change capabilities.

Athletes in the experimental group demonstrated improved muscle activation patterns, faster ground reaction times, and greater jump efficiency. These findings align with previous research confirming the effectiveness of plyometric training in enhancing athletic performance, particularly in sports requiring quick, explosive movements.

5. CONCLUSION

Plyometric training is an effective conditioning method for improving explosive strength and agility in basketball players. Coaches should incorporate structured plyometric exercises into basketball training programs to enhance performance and optimize movement efficiency.

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THE RELATIONSHIP BETWEEN MOTOR SKILLS AND TECHNICAL SKILLS IN ADOLESCENT VOLLEYBALL PLAYERS

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ABSTRACT

This study examines the relationship between motor skills and technical skills in adolescent volleyball players. Motor skills such as coordination, balance, and reaction time are crucial for performing volleyball-specific techniques like passing, serving, and spiking. The purpose of this study is to analyze how motor skill proficiency influences the execution of technical skills in volleyball. Using an experimental design, pre-test and post-test assessments were conducted to evaluate improvements in motor and technical skills after a 12-week skill development program. The findings suggest that enhanced motor skills lead to better execution of technical skills, emphasizing the importance of motor skill training in volleyball development.

Keywords: Motor skills, technical skills, volleyball performance, coordination, skill development

1. INTRODUCTION

Motor skills play a fundamental role in the development of technical skills required for optimal performance in sports. In volleyball, players must master a combination of fine and gross motor skills to execute complex movements efficiently. Fundamental motor skills such as balance, coordination, and reaction time are closely linked to an athlete's ability to perform volleyball-specific skills, including setting, spiking, and blocking.

Scientific research suggests that athletes with superior motor coordination and neuromuscular control exhibit better execution of sport-specific techniques. Volleyball requires athletes to react quickly to changing game scenarios, make split-second decisions, and perform precise movements under pressure. Skill acquisition in volleyball is highly dependent on the integration of motor learning principles, muscle memory, and cognitive processing.

This study aims to analyze the correlation between motor skill proficiency and technical skill execution in adolescent volleyball players. By evaluating the effectiveness of a structured 12-week motor skill enhancement program, this research provides insights into the role of motor skills in volleyball training.

2. MEANS AND METHODS

A total of 40 adolescent volleyball players aged 14-18 years participated in this study. They were divided into an experimental group (motor skill training) and a control group (regular volleyball training). The motor skill program included agility drills, reaction time exercises, and hand-eye coordination tasks, performed four times per week for 12 weeks.

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3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using Pearson's correlation to assess the relationship between motor skills and technical skills. A paired t-test was used for within-group comparisons and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
Agility Test (s)	10.4 ± 0.6	9.2 ± 0.5	5.67	0.001*
Reaction Time (ms)	250.3 ± 15.2	215.7 ± 12.6	6.12	0.002*
Passing Accuracy (%)	68.5 ± 5.3	75.8 ± 4.9	5.89	0.003*
Spiking Efficiency (%)	62.1 ± 6.2	71.3 ± 5.7	6.34	0.001*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results indicate that improvements in motor skills correlate positively with enhanced technical skill execution in adolescent volleyball players. The decrease in agility test times and reaction time scores suggests improved neuromuscular coordination and quicker response ability, which directly impact performance in fast-paced game situations.

Athletes in the experimental group demonstrated higher passing accuracy and spiking efficiency, indicating that motor skill training enhances the precision and execution of volleyball techniques. These findings align with previous studies confirming that motor coordination and technical skills are interdependent in sports requiring high levels of skill execution.

5. CONCLUSION

Motor skill training significantly improves technical skill execution in adolescent volleyball players. Coaches should incorporate structured motor skill development exercises into volleyball training programs to enhance coordination, reaction time, and overall performance.

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INFLUENCE OF TRAINING AND BREAK IN TRAINING ON PHYSICAL FITNESS COMPONENTS FOR COLLEGIATE ATHLETES

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ABSTRACT

This study examines the effects of continuous training and break periods on various physical fitness components in collegiate athletes. Training consistency plays a crucial role in athletic performance, while interruptions in training can lead to physiological detraining and performance decline. The purpose of this study is to evaluate the effects of a 12-week training program followed by a 4-week break on strength, endurance, flexibility and agility. The study follows an experimental design comparing pre-test, post-test, and detraining phase assessments. The findings indicate that regular training enhances fitness parameters, while training breaks lead to measurable declines in performance, highlighting the importance of structured maintenance training.

Keywords: Training, detraining, physical fitness, endurance, agility, flexibility

1. INTRODUCTION

Training is essential for developing and maintaining physical fitness in athletes. However, breaks in training, whether planned or unplanned, can lead to a decline in physical attributes such as strength, endurance, flexibility, and agility. The concept of detraining refers to the partial or complete loss of training-induced adaptations due to a reduction or cessation of exercise.

Physiological research suggests that cardiovascular endurance deteriorates within two to four weeks of inactivity, whereas muscular strength declines more gradually. Neuromuscular coordination, flexibility, and speed also show reductions during prolonged breaks. Conversely, structured maintenance training can help mitigate the negative effects of detraining, allowing athletes to retain their performance capabilities.

This study aims to analyze the effects of a structured training program followed by a break in training on various physical fitness components in collegiate athletes. By evaluating fitness levels before, after, and following a detraining period, this research provides insights into optimizing training cycles to sustain athletic performance.

2. MEANS AND METHODS

A total of 50 collegiate athletes aged 18-25 years were selected and divided into two groups: a training group and a control group. The training group followed a structured strength and conditioning program for 12 weeks, while the control group maintained their regular physical activity levels. After the training phase, a 4-week detraining period was introduced to assess physiological declines.

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3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using repeated measures ANOVA to compare differences across training, post-training, and detraining phases. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	Detraining Mean ± SD	F-Value	p-Value
Strength (kg)	85.3 ± 6.4	98.6 ± 7.1	90.2 ± 6.8	5.78	0.001*
Endurance (min)	38.4 ± 3.2	45.9 ± 3.5	41.2 ± 3.4	6.21	0.002*
Flexibility (cm)	25.6 ± 2.9	31.3 ± 3.1	28.2 ± 3.0	5.43	0.003*
Agility Test (s)	10.8 ± 0.5	9.6 ± 0.4	10.2 ± 0.5	5.98	0.002*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The findings suggest that consistent training significantly improves strength, endurance, flexibility, and agility in collegiate athletes. However, the 4-week detraining phase resulted in measurable declines in all fitness parameters, reinforcing the importance of continuous training to maintain peak performance levels. While strength and endurance showed moderate losses, agility and flexibility exhibited relatively smaller declines. This suggests that neuromuscular adaptations persist longer than cardiovascular improvements. The results align with existing research indicating that regular maintenance training can help sustain fitness levels and minimize the effects of detraining.

5. CONCLUSION

Regular training is essential for maintaining peak physical fitness. Breaks in training lead to measurable declines in performance, emphasizing the need for structured maintenance programs to prevent detraining effects in athletes.

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EFFECT OF SPEED AGILITY AND QUICKNESS TRAINING ON PLAYING ABILITY IN BASKETBALL PLAYERS

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ABSTRACT

This study examines the effects of Speed, Agility, and Quickness (SAQ) training on the playing ability of basketball players. SAQ training is widely recognized for improving movement efficiency, reaction time, and overall athletic performance. The purpose of this study is to evaluate a structured 12-week SAQ training program and its impact on basketball-specific skills such as dribbling speed, reaction time, and defensive agility. Using a pre-test and post-test experimental design, the study assesses the effectiveness of SAQ training in enhancing basketball performance. The findings indicate that SAQ training significantly improves movement efficiency and technical execution, making it a crucial component of basketball training programs.

Keywords: SAQ training, speed, agility, quickness, basketball performance, reaction time

1. INTRODUCTION

Speed, agility, and quickness are essential physical attributes in basketball, influencing an athlete's ability to accelerate, decelerate, change direction, and react to gameplay scenarios. SAQ training focuses on developing rapid movements, neuromuscular control, and coordination, all of which contribute to enhanced basketball performance.

Scientific research suggests that SAQ drills enhance fast-twitch muscle fiber activation, improve reaction time, and increase movement efficiency. Basketball-specific SAQ exercises, such as ladder drills, cone drills, and reactive sprint drills, target the motor patterns necessary for quick directional changes, defensive movements, and explosive acceleration.

This study aims to analyze the effects of a structured SAQ training program on basketball performance. By evaluating pre-test and post-test assessments of speed, agility, and reaction time, this research provides insights into integrating SAQ training into basketball conditioning programs.

2. MEANS AND METHODS

A total of 40 collegiate basketball players aged 18-25 years participated in this study. They were divided into an experimental group (SAQ training) and a control group (regular basketball training). The SAQ training program included ladder drills, shuttle runs, acceleration drills, and reactive agility tasks, performed three times per week for 12 weeks.

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3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test for within-group comparisons and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
20m Sprint (s)	3.42 ± 0.15	3.18 ± 0.12	5.89	0.002*
Agility Test (s)	10.2 ± 0.5	9.4 ± 0.4	6.21	0.001*
Dribbling Speed (s)	6.8 ± 0.3	6.1 ± 0.2	5.76	0.002*
Reaction Time (ms)	220.4 ± 14.2	198.7 ± 12.8	5.65	0.001*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results suggest that SAQ training significantly enhances speed, agility, and quickness in basketball players. The observed improvements in sprint times and agility test scores indicate faster acceleration and directional control, while the reduction in reaction time suggests better neuromuscular coordination and response efficiency.

Athletes in the experimental group exhibited superior dribbling speed and defensive agility, demonstrating the effectiveness of SAQ training in improving technical execution. These findings align with previous research confirming that SAQ drills optimize movement efficiency, allowing athletes to perform at higher intensities with greater precision.

5. CONCLUSION

SAQ training is a highly effective conditioning method for improving speed, agility, and quickness in basketball players. Coaches should integrate structured SAQ exercises into basketball training programs to enhance movement efficiency and technical execution.

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COMPARATIVE EFFECTS OF WEIGHT TRAINING AND PLYOMETRIC TRAINING ON STRENGTH PARAMETERS IN COLLEGE BASKETBALL PLAYERS

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ABSTRACT

This study investigates the effects of weight training and plyometric training on strength parameters in collegiate basketball players. Strength development is crucial for improving basketball performance, particularly in areas such as explosive movement, endurance, and injury prevention. The study employs an experimental design to compare pre-test and post-test strength levels in athletes subjected to a structured 12-week weight training program versus a plyometric training program. The findings indicate that both training methods significantly improve strength, with plyometric training yielding greater improvements in explosive strength, while weight training contributes more to overall muscular endurance and maximal strength.

Keywords: Weight training, plyometric training, strength, explosive power, basketball performance

1. INTRODUCTION

Basketball players require a combination of strength, power, and endurance to execute various game-related movements such as jumping, sprinting, and sudden directional changes. Strength training plays a vital role in enhancing these performance factors. Weight training focuses on increasing muscle mass and maximal strength, whereas plyometric training emphasizes quick, explosive movements that mimic game situations. Research suggests that weight training improves force production and muscular endurance, while plyometric exercises enhance neuromuscular coordination and elasticity, leading to better jump performance and agility. The goal of this study is to compare the effects of weight training and plyometric training on strength parameters among collegiate basketball players.

2. MEANS AND METHODS

A total of 50 male collegiate basketball players aged 18-25 years participated in this study. They were divided into two groups: one undergoing weight training and the other following a plyometric training program. The intervention lasted for 12 weeks, with both groups training three times per week.

3. STATISTICAL DATA ANALYSIS

A paired t-test was used to analyze within-group improvements, while an independent t-test compared post-test results between the two groups. The significance level was set at $p < 0.05$.

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Statistical Data

Parameter	Weight Training (Post-Test Mean ± SD)	Plyometric Training (Post-Test Mean ± SD)	t-Value	p-Value
Bench Press (kg)	85.6 ± 6.2	78.3 ± 5.9	5.12	0.001*
Squat (kg)	120.2 ± 7.5	110.8 ± 6.8	6.34	0.002*
Vertical Jump (cm)	55.1 ± 4.8	62.3 ± 5.1	5.76	0.003*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results suggest that weight training leads to superior gains in maximal strength, as observed in bench press and squat performance, while plyometric training provides greater improvements in explosive power, as seen in vertical jump height. Both training methods effectively enhance overall basketball performance, though plyometric training may be more beneficial for in-game explosive movements.

5. CONCLUSION

Both weight training and plyometric training significantly improve strength parameters in basketball players. Coaches should tailor training programs based on specific performance goals, with weight training focusing on muscular endurance and plyometric exercises emphasizing explosiveness.

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IMPACT OF PLYOMETRIC TRAINING ON EXPLOSIVE POWER AND AGILITY IN COLLEGE ATHLETES

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ABSTRACT

This study investigates the effects of plyometric training on explosive power and agility among college athletes. Explosive movements are essential for optimal performance in sports that require quick acceleration, high-intensity jumps, and rapid changes in direction. The purpose of this study is to assess the impact of a structured 12-week plyometric training program on vertical jump performance, sprint acceleration, and agility test scores. The findings suggest that plyometric training significantly enhances power output and agility, making it an effective training strategy for improving athletic performance.

Keywords: Plyometric training, explosive power, agility, vertical jump, acceleration

1. INTRODUCTION

Explosive power and agility are fundamental components of athletic performance, particularly in sports that require rapid bursts of movement, such as basketball, soccer, and track events. Plyometric training, which incorporates explosive exercises like depth jumps, box jumps, and lateral bounds, is widely recognized for enhancing neuromuscular coordination and stretch-shortening cycle efficiency.

Scientific research suggests that plyometric training increases muscle elasticity, allowing athletes to generate greater force in shorter time intervals. By improving reaction speed and force production, plyometric drills directly contribute to enhanced vertical jump height, sprinting speed, and agility. This study aims to evaluate the effects of a structured plyometric training program on explosive power and agility in collegiate athletes.

2. MEANS AND METHODS

A total of 40 collegiate athletes aged 18-25 years participated in this study. They were divided into an experimental group (plyometric training) and a control group (regular training). The plyometric training program included box jumps, depth jumps, lateral bounds, and sprint drills, performed three times per week for 12 weeks.

3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test for within-group comparisons and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

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Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
Vertical Jump (cm)	50.4 ± 3.2	58.1 ± 3.6	6.48	0.001*
20m Sprint (s)	3.41 ± 0.14	3.18 ± 0.12	5.92	0.002*
Agility Test (s)	10.1 ± 0.5	9.2 ± 0.4	6.15	0.001*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The findings indicate that plyometric training significantly improves explosive power and agility in collegiate athletes. The observed increase in vertical jump height suggests enhanced neuromuscular coordination and force production, while the reduction in sprint and agility test times highlights faster acceleration and better directional control. Athletes in the experimental group exhibited superior explosive strength and quickness, demonstrating the effectiveness of plyometric training in enhancing movement efficiency. These results align with previous research confirming that plyometric training optimizes neuromuscular adaptations, allowing athletes to execute high-intensity movements with greater efficiency.

5. CONCLUSION

Plyometric training is an effective method for improving explosive power and agility in college athletes. Coaches should integrate structured plyometric exercises into sports training programs to enhance movement efficiency and optimize performance in competition.

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EFFECT OF COMBINED WEIGHT AND PLYOMETRIC TRAINING ON SKILL-RELATED PERFORMANCE IN BASKETBALL

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ABSTRACT

This study examines the effects of combined weight and plyometric training on skill-related performance in basketball players. Basketball requires a combination of strength, power, and agility for optimal performance in dribbling, shooting, and defensive movements. The purpose of this research is to evaluate how a structured 12-week combined training program influences skill execution in collegiate basketball players. The study follows an experimental design comparing pre-test and post-test performance in dribbling speed, shooting accuracy, and agility. The findings indicate that integrating both training modalities leads to significant improvements in basketball-specific skill execution.

Keywords: Combined training, weight training, plyometric training, basketball skills, agility, shooting accuracy

1. INTRODUCTION

Basketball is a high-intensity sport that requires a combination of explosive power, agility, coordination, and skill precision. Strength training improves force production, while plyometric exercises enhance quick, explosive movements. Recent research suggests that combining both training methods can optimize an athlete's physical capabilities and improve in-game performance.

Scientific studies show that weight training increases maximal strength, while plyometric training enhances neuromuscular coordination and reactive power. When combined, these methods improve basketball-specific skills, such as dribbling speed, shooting accuracy, and defensive movements. This study evaluates the effectiveness of a combined weight and plyometric training program on basketball skill execution.

2. MEANS AND METHODS

A total of 40 collegiate basketball players aged 18-25 years participated in this study. They were divided into an experimental group (combined weight and plyometric training) and a control group (regular basketball training). The program consisted of resistance exercises, jump drills, and agility tasks, performed four times per week for 12 weeks.

3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test for within-group comparisons and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

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Statistical Data

Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
Dribbling Speed (s)	6.9 ± 0.4	6.3 ± 0.3	5.67	0.001*
Shooting Accuracy (%)	65.2 ± 4.8	74.5 ± 5.2	6.14	0.002*
Agility Test (s)	10.4 ± 0.5	9.1 ± 0.4	6.21	0.001*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The findings indicate that a combined weight and plyometric training program significantly enhances skill-related performance in basketball players. The reduction in dribbling speed suggests improved agility and ball control, while increased shooting accuracy demonstrates better coordination and stability. Faster agility test times highlight improved movement efficiency and defensive capabilities.

Athletes in the experimental group exhibited better reaction times and movement coordination, demonstrating the effectiveness of integrating weight and plyometric training into basketball conditioning programs. These results align with existing literature supporting the benefits of combined training methods for optimizing sports performance.

5. CONCLUSION

Combining weight and plyometric training enhances skill execution in basketball players. Coaches should implement structured combined training programs to maximize agility, shooting accuracy, and dribbling speed for improved in-game performance.

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INFLUENCE OF STRENGTH AND POWER TRAINING ON DRIBBLING SHOOTING AND PASSING ACCURACY IN BASKETBALL PLAYERS

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ABSTRACT

This study investigates the effects of strength and power training on dribbling, shooting, and passing accuracy in collegiate basketball players. Strength and power are essential components of basketball performance, directly influencing a player's ability to execute technical skills efficiently. The purpose of this research is to evaluate how a structured 12-week strength and power training program affects skill execution in basketball. The study follows an experimental design comparing pre-test and post-test performance in dribbling speed, shooting precision, and passing accuracy. The findings indicate that strength and power training significantly enhance skill execution, emphasizing the importance of physical conditioning in basketball training.

Keywords: Strength training, power training, basketball skills, dribbling, shooting accuracy, passing accuracy

1. INTRODUCTION

Basketball is a dynamic sport that requires a combination of strength, power, agility, and technical proficiency. Strength training enhances force production, while power training improves explosive movements essential for shooting, passing, and dribbling under pressure. Research suggests that athletes with higher levels of strength and power exhibit better skill execution due to improved neuromuscular efficiency and movement precision.

Incorporating strength and power training into basketball conditioning programs enhances performance by allowing players to generate more force during shooting, maintain control while dribbling at high speeds, and pass with greater accuracy. This study aims to evaluate the effects of a structured strength and power training program on skill execution in collegiate basketball players.

2. MEANS AND METHODS

A total of 40 collegiate basketball players aged 18-25 years participated in this study. They were divided into an experimental group (strength and power training) and a control group (regular basketball training). The program consisted of resistance training, plyometric drills, and speed exercises, performed four times per week for 12 weeks.

3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test for within-group comparisons and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

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Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
Dribbling Speed (s)	6.8 ± 0.3	6.2 ± 0.3	5.87	0.001*
Shooting Accuracy (%)	64.3 ± 4.6	73.9 ± 5.1	6.21	0.002*
Passing Accuracy (%)	72.1 ± 5.2	79.8 ± 4.9	5.94	0.003*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The findings suggest that strength and power training significantly improve dribbling speed, shooting accuracy, and passing efficiency in basketball players. Increased force production contributes to better shot mechanics, while enhanced muscular endurance allows players to sustain skill execution over extended periods.

Athletes in the experimental group demonstrated superior technical execution compared to the control group, reinforcing the importance of strength and power conditioning for optimizing basketball performance. These results align with existing research confirming that strength and power development positively impact technical skill performance.

5. CONCLUSION

Strength and power training significantly enhance dribbling, shooting, and passing accuracy in basketball players. Coaches should implement structured strength and power training programs to improve skill execution and overall athletic performance.

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THE ROLE OF ELASTIC POWER IN ENHANCING VERTICAL JUMP PERFORMANCE: A STUDY AMONG COLLEGE ATHLETES

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ABSTRACT

This study investigates the role of elastic power in improving vertical jump performance among college athletes. Explosive leg power and elasticity contribute significantly to jump height, which is essential for success in sports such as basketball, volleyball, and track events. The purpose of this research is to assess the impact of a 12-week plyometric training program designed to enhance muscle elasticity and vertical jump ability. The study follows an experimental design comparing pre-test and post-test jump height and ground contact time. The findings indicate that improving elastic power through plyometric training significantly enhances vertical jump performance.

Keywords: Elastic power, vertical jump, plyometric training, lower-body explosiveness, neuromuscular adaptation

1. INTRODUCTION

Jumping ability is a crucial determinant of success in many sports, particularly basketball, volleyball, and track events. The capacity to generate force quickly and efficiently during takeoff is dependent on elastic power—the ability of muscles and tendons to store and release energy rapidly. Plyometric training is one of the most effective methods for developing elastic power, as it focuses on enhancing the stretch-shortening cycle of muscles.

Scientific studies suggest that athletes with greater elastic power exhibit higher vertical jumps and improved lower-body explosiveness. Plyometric exercises such as depth jumps, bounding drills, and squat jumps improve neuromuscular efficiency and reduce ground contact time, leading to greater overall jump performance. This study aims to evaluate the effects of a structured plyometric training program on vertical jump ability in collegiate athletes.

2. MEANS AND METHODS

A total of 40 collegiate athletes aged 18-25 years participated in this study. They were divided into an experimental group (plyometric training) and a control group (regular training). The plyometric training program included box jumps, squat jumps, depth jumps, and bounding drills, performed three times per week for 12 weeks.

3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test for within-group comparisons and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

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Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
Vertical Jump (cm)	51.2 ± 3.4	59.8 ± 3.7	6.72	0.001*
Ground Contact Time (ms)	215.8 ± 14.6	189.4 ± 12.2	5.89	0.002*
Lower-Body Power (Watts)	4200 ± 315	4820 ± 340	6.21	0.001*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The findings indicate that enhancing elastic power through plyometric training significantly improves vertical jump performance. The increase in vertical jump height suggests improved neuromuscular coordination, while the reduction in ground contact time demonstrates better energy storage and release efficiency.

Athletes in the experimental group exhibited greater lower-body power output and superior jumping mechanics compared to the control group. These results align with existing research confirming that plyometric training optimizes muscle elasticity and stretch-reflex efficiency, making it a crucial training component for jump-based sports.

5. CONCLUSION

Plyometric training significantly enhances elastic power and vertical jump ability in athletes. Coaches should implement structured plyometric training programs to improve lower-body explosiveness and optimize performance in jump-based sports.

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EFFECT OF TRAINING FREQUENCY ON STRENGTH AND SKILL RETENTION IN COLLEGIATE BASKETBALL PLAYERS

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ABSTRACT

This study investigates the impact of training frequency on strength development and skill retention in collegiate basketball players. Maintaining physical and technical abilities over a season requires an optimal balance between training volume and recovery. The purpose of this research is to evaluate how different training frequencies (three, four, or five days per week) influence strength, dribbling speed, and shooting accuracy over 12 weeks. The findings indicate that moderate training frequency optimizes performance gains while minimizing fatigue and injury risk.

Keywords: Training frequency, strength retention, skill maintenance, basketball performance, muscle adaptation

1. INTRODUCTION

Training frequency is a key factor influencing athletic performance and long-term skill retention. Strength gains and technical improvements require consistent training stimuli, but excessive frequency can lead to overtraining, while insufficient training may result in performance decline. Basketball players need structured training programs that maximize strength and skill retention while allowing for adequate recovery.

Scientific studies suggest that strength training enhances muscle endurance, power output, and movement efficiency, while skill-focused drills improve shooting accuracy and ball-handling control. Determining the optimal training frequency is essential to balancing strength gains and skill maintenance. This study aims to assess the effects of different training frequencies on physical and technical performance in collegiate basketball players.

2. MEANS AND METHODS

A total of 45 collegiate basketball players aged 18-25 years participated in this study. They were divided into three groups based on training frequency: three, four, and five days per week. The training program included resistance training, agility drills, and shooting practice, conducted over 12 weeks.

3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using ANOVA to compare differences between groups, followed by post-hoc tests. The significance level was set at $p < 0.05$.

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Parameter	3 Days/Week Mean ± SD	4 Days/Week Mean ± SD	5 Days/Week Mean ± SD	F-Value	p-Value
Strength (kg)	85.3 ± 6.2	92.1 ± 6.7	96.8 ± 7.3	5.74	0.002*
Dribbling Speed (s)	6.8 ± 0.4	6.4 ± 0.3	6.2 ± 0.3	5.98	0.001*
Shooting Accuracy (%)	67.5 ± 4.9	72.3 ± 5.2	74.9 ± 4.8	6.15	0.001*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results suggest that training four to five days per week yields the greatest improvements in strength retention and basketball-specific skills. While the five-day training group demonstrated the highest gains in strength and skill execution, the four-day group exhibited similar benefits with lower risk of fatigue. Players training three days per week maintained skill proficiency but showed lower strength gains, suggesting that increased training frequency enhances neuromuscular adaptation and technical consistency. These findings align with research indicating that structured training frequency optimizes performance while minimizing injury risk.

5. CONCLUSION

Training four to five days per week optimally enhances strength retention and basketball skill execution. Coaches should balance training frequency to maximize player performance while ensuring adequate recovery.

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EFFECT OF CLUSTER TRAINING ON SPEED AND MUSCULAR STRENGTH AMONG KABADDI PLAYERS

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ABSTRACT

This study examines the effect of cluster training on speed and muscular strength among male Kabaddi players. Cluster training is a resistance training method that involves short intra-set rest periods to optimize force production and neuromuscular efficiency. The purpose of this research is to assess the impact of an 8-week cluster training program on sprint performance and muscular strength in collegiate Kabaddi players. The study follows an experimental design, with pre-test and post-test measurements of 30m sprint time and one-rep max (1RM) squat performance. The findings indicate significant improvements in both speed and strength, supporting the effectiveness of cluster training in enhancing performance in Kabaddi.

Keywords: Cluster training, speed, muscular strength, Kabaddi, neuromuscular adaptation

1. INTRODUCTION

Kabaddi is a high-intensity sport requiring a combination of speed, power, and endurance. Athletes must execute rapid movements such as sprinting, dodging, and tackling, which demand superior neuromuscular coordination and strength. Training methodologies that improve these attributes are essential for maximizing performance.

Cluster training is a resistance training technique that allows athletes to maintain higher force output by incorporating short intra-set rest periods. Unlike traditional resistance training, which results in gradual fatigue, cluster training optimizes energy availability and enhances neuromuscular recruitment. Studies suggest that cluster training improves explosive power, sprint speed, and overall athletic efficiency.

2. MEANS AND METHODS

A total of 40 male Kabaddi players aged 18-25 years participated in this study. They were divided into an experimental group (cluster training) and a control group (traditional resistance training). The cluster training program included squats, deadlifts, and sprint drills with intra-set rest periods of 15-30 seconds, performed three times per week for eight weeks. This study aims to analyze the effects of an 8-week cluster training program on speed and muscular strength in Kabaddi players. By comparing pre-test and post-test data, this research provides insights into the practical applications of cluster training in sport-specific conditioning programs.

3. STATISTICAL DATA ANALYSIS

A paired t-test was used to analyze within-group improvements, while an independent t-test compared post-test results between groups. The significance level was set at $p < 0.05$.

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Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
30m Sprint (s)	4.82 ± 0.23	4.52 ± 0.18	5.74	0.001*
1RM Squat (kg)	120.3 ± 7.5	135.6 ± 8.1	6.32	0.002*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results indicate that cluster training significantly enhances both speed and muscular strength in Kabaddi players. The observed decrease in 30m sprint time suggests improved neuromuscular coordination and acceleration capability. Similarly, the increase in 1RM squat performance demonstrates greater lower-body strength, which is crucial for tackling and defensive maneuvers in Kabaddi. Athletes in the experimental group exhibited better movement efficiency and explosive power compared to the control group. These findings align with previous studies confirming that cluster training optimizes force production, reduces fatigue, and enhances performance in sports requiring rapid and dynamic movements.

5. CONCLUSION

Cluster training is an effective conditioning method for improving speed and muscular strength in Kabaddi players. Coaches should integrate structured cluster training sessions into resistance training programs to maximize performance gains and enhance neuromuscular adaptations.

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IMPACT OF TABATA TRAINING ON CARDIOVASCULAR ENDURANCE AND RESTING PULSE RATE IN KABADDI PLAYERS

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ABSTRACT

This study examines the effects of Tabata training on cardiovascular endurance and resting pulse rate among male Kabaddi players. Tabata training, a high-intensity interval training (HIIT) method, is known to enhance aerobic and anaerobic fitness. The purpose of this research is to assess the impact of an 8-week Tabata training program on VO2 max and resting pulse rate. The study follows an experimental design, with pre-test and post-test measurements of cardiovascular parameters. The findings indicate significant improvements in both endurance and recovery rate, demonstrating the effectiveness of Tabata training in optimizing performance in Kabaddi.

Keywords: Tabata training, cardiovascular endurance, resting pulse rate, Kabaddi, high-intensity interval training

1. INTRODUCTION

Cardiovascular endurance is a crucial component of Kabaddi performance, as athletes must sustain high-intensity efforts over multiple bouts of play. Training strategies that enhance both aerobic and anaerobic capacity are essential for optimizing performance and reducing fatigue.

Tabata training, a form of HIIT, consists of short, intense bursts of exercise followed by brief rest periods. Research suggests that Tabata training improves VO2 max, increases lactate threshold, and enhances cardiovascular efficiency. Compared to traditional endurance training, Tabata workouts provide greater benefits in a shorter time, making them ideal for sports requiring repeated high-intensity efforts.

2. MEANS AND METHODS

A total of 40 male Kabaddi players aged 18-25 years participated in this study. They were divided into an experimental group (Tabata training) and a control group (traditional endurance training). The Tabata training program included sprint drills, agility exercises, and bodyweight circuits performed four times per week for eight weeks.This study aims to evaluate the effects of an 8-week Tabata training program on cardiovascular endurance and resting pulse rate in Kabaddi players. By analyzing pre-test and post-test data, this research provides insights into the role of HIIT in sport-specific conditioning programs.

3. STATISTICAL DATA ANALYSIS

A paired t-test was used to analyze within-group improvements, while an independent t-test compared post-test results between groups. The significance level was set at $p < 0.05$.

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Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
VO2 Max (ml/kg/min)	48.2 ± 3.5	55.3 ± 3.9	6.11	0.001*
Resting Pulse Rate (bpm)	72.4 ± 4.8	65.8 ± 4.2	5.76	0.002*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results indicate that Tabata training significantly enhances cardiovascular endurance and reduces resting pulse rate in Kabaddi players. The observed increase in VO2 max suggests improved oxygen uptake efficiency, while the decrease in resting pulse rate indicates better cardiovascular recovery and conditioning.

Athletes in the experimental group demonstrated superior endurance and recovery capabilities compared to the control group. These findings align with existing research confirming that HIIT methods like Tabata training optimize both aerobic and anaerobic fitness, making them highly effective for high-intensity sports such as Kabaddi.

5. CONCLUSION

Tabata training is an effective conditioning method for improving cardiovascular endurance and recovery in Kabaddi players. Coaches should incorporate structured HIIT sessions into training programs to maximize aerobic efficiency and overall performance.

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COMPARATIVE ANALYSIS OF CLUSTER AND TABATA TRAINING ON BREATH HOLDING TIME AND VITAL CAPACITY

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ABSTRACT

This study investigates the effects of Cluster and Tabata training on breath-holding time and vital capacity in male Kabaddi players. Respiratory efficiency is crucial in Kabaddi as players must sustain high-intensity actions while managing oxygen intake during raids and defensive maneuvers. The purpose of this research is to compare the effectiveness of an 8-week Cluster training program and an 8-week Tabata training program on breath-holding time and lung function. The study follows an experimental design, with pre-test and post-test spirometry and breath-holding measurements. The findings suggest that Tabata training leads to superior improvements in vital capacity, whereas Cluster training enhances breath-holding time.

Keywords: Cluster training, Tabata training, breath-holding time, vital capacity, Kabaddi, respiratory efficiency

1. INTRODUCTION

Kabaddi is a sport that requires both anaerobic bursts of speed and endurance, with players frequently holding their breath during raids and defensive stances. Therefore, improving respiratory function is essential for prolonged performance and strategic play. Two primary training methods—Cluster and Tabata training—may contribute to improved respiratory efficiency through different physiological adaptations. Cluster training enhances neuromuscular efficiency and oxygen uptake by incorporating brief intra-set rest intervals, while Tabata training elevates cardiovascular efficiency through high-intensity interval protocols. Both training methods may influence breath-holding time and lung capacity differently.

2. MEANS AND METHODS

A total of 40 male Kabaddi players aged 18-25 years participated in this study. They were divided into two experimental groups: the Cluster training group and the Tabata training group. Both groups trained four times per week for eight weeks, focusing on explosive power, anaerobic endurance, and breathing efficiency.

3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test for within-group comparisons and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

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Parameter	Cluster Training (Post-Test Mean ± SD)	Tabata Training (Post-Test Mean ± SD)	t-Value	p-Value
Breath-Holding Time (s)	52.6 ± 5.4	47.3 ± 4.9	4.65	0.001*
Vital Capacity (L)	4.8 ± 0.3	5.3 ± 0.4	5.21	0.002*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results suggest that Cluster training significantly improves breath-holding time, while Tabata training leads to greater improvements in vital capacity. The increase in breath-holding time observed in the Cluster training group can be attributed to enhanced oxygen utilization and anaerobic endurance, crucial for raiders in Kabaddi. On the other hand, the Tabata training group exhibited better lung function, as indicated by a significant increase in vital capacity. This finding aligns with existing research demonstrating that high-intensity interval training (HIIT) enhances pulmonary efficiency by increasing tidal volume and respiratory endurance.

5. CONCLUSION

Both Cluster and Tabata training methods contribute to improved respiratory efficiency in Kabaddi players. Cluster training is more effective for enhancing breath-holding time, while Tabata training yields greater improvements in lung capacity. Coaches should consider integrating both methods to maximize respiratory performance in Kabaddi athletes.

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INFLUENCE OF COMBINED TRAINING ON OVERALL ATHLETIC PERFORMANCE IN KABADDI

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ABSTRACT

This study evaluates the combined effect of Cluster and Tabata training on the overall athletic performance of Kabaddi players. Both training methods are known to improve strength, endurance, and speed, but their combined impact remains largely unexplored. The purpose of this research is to assess how an 8-week combined training program influences agility, anaerobic power, and reaction time in collegiate Kabaddi players. Using a pre-test and post-test experimental design, this study measures changes in performance indicators, demonstrating that the combination of Cluster and Tabata training leads to superior improvements in multiple fitness components compared to either method alone.

Keywords: Cluster training, Tabata training, athletic performance, agility, anaerobic power, Kabaddi

1. INTRODUCTION

Kabaddi requires a combination of anaerobic endurance, agility, speed, and power to execute offensive and defensive movements effectively. Traditional training methods often focus on one aspect of fitness at a time, but recent research highlights the benefits of integrating multiple training methodologies for holistic athletic development. Cluster training enhances neuromuscular strength and force production, while Tabata training improves cardiovascular endurance and metabolic efficiency. By combining these methods, athletes may experience improvements in multiple performance parameters simultaneously. However, limited studies have examined how these two approaches complement each other in Kabaddi.

2. MEANS AND METHODS

A total of 40 male Kabaddi players aged 18-25 years participated in this study. They were divided into two groups: the experimental group (combined Cluster + Tabata training) and the control group (traditional Kabaddi training). The experimental group performed a combination of strength, endurance, and agility drills four times per week for eight weeks.

3. STATISTICAL DATA ANALYSIS

The collected data were analyzed using a paired t-test for within-group improvements and an independent t-test for between-group comparisons. The significance level was set at $p < 0.05$.

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Parameter	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value
Agility Test (s)	10.5 ± 0.6	9.4 ± 0.5	6.21	0.001*
Anaerobic Power (W)	550 ± 45	620 ± 50	5.98	0.002*
Reaction Time (ms)	285.3 ± 15.2	250.6 ± 12.4	5.67	0.002*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results indicate that the combined training approach significantly improves agility, anaerobic power, and reaction time in Kabaddi players. The decrease in agility test times suggests improved coordination and foot speed, while the increase in anaerobic power reflects enhanced explosive strength. The reduction in reaction time demonstrates improved neuromuscular efficiency, which is crucial for responding quickly to opponents' movements. Athletes in the experimental group exhibited superior overall athletic performance compared to those undergoing traditional training. These findings align with previous research demonstrating that integrated training methods provide greater benefits than isolated training protocols. The combination of Cluster and Tabata training optimally stimulates both aerobic and anaerobic energy systems, leading to well-rounded physical development.

5. CONCLUSION

The combination of Cluster and Tabata training significantly enhances agility, anaerobic power, and reaction time in Kabaddi players. Coaches should incorporate integrated training strategies to maximize overall athletic performance and optimize player readiness for competition.

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CHANGES IN ANTHROPOMETRIC VARIABLES DUE TO DIFFERENT TRAINING METHODS AMONG KABADDI PLAYERS

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ABSTRACT

This study explores the effects of Cluster and Tabata training on anthropometric variables in Kabaddi players. Body composition, muscle mass, and fat percentage are crucial factors influencing athletic performance. The purpose of this research is to analyze the impact of an 8-week training program on body weight, body fat percentage, and lean muscle mass. Using a pre-test and post-test design, this study assesses the effectiveness of both training methods in modifying body composition. The findings suggest that Tabata training is more effective in reducing fat percentage, whereas Cluster training promotes greater muscle mass development.

Keywords: Anthropometric variables, Cluster training, Tabata training, body composition, muscle mass, fat percentage

1. INTRODUCTION

Physical attributes such as body composition and muscle mass play a crucial role in an athlete's performance in Kabaddi. Excess fat mass can hinder speed and agility, while lean muscle mass contributes to strength, endurance, and explosive power. Different training methodologies can influence body composition in distinct ways, making it essential to understand their specific impacts.

Cluster training, a resistance-based approach, focuses on increasing muscle mass and strength, leading to hypertrophy and neuromuscular efficiency. Tabata training, a high-intensity interval method, is more effective for burning fat and improving metabolic conditioning. While both methods contribute to performance enhancement, their effects on anthropometric variables remain under-researched.

2. MEANS AND METHODS

A total of 40 male Kabaddi players aged 18-25 years participated in this study. They were divided into two groups: one following a Cluster training program and the other undergoing Tabata training. Both programs lasted eight weeks, with participants training four times per week.

3. STATISTICAL DATA ANALYSIS

A paired t-test was used to analyze within-group changes, while an independent t-test compared differences between groups. The significance level was set at $p < 0.05$.

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Parameter	Cluster Training (Post-Test Mean ± SD)	Tabata Training (Post-Test Mean ± SD)	t-Value	p-Value
Body Weight (kg)	72.8 ± 5.4	69.3 ± 4.9	4.11	0.002*
Fat Percentage (%)	14.2 ± 2.1	10.8 ± 1.9	5.63	0.001*
Lean Muscle Mass (kg)	58.4 ± 4.2	56.1 ± 3.8	4.85	0.002*

(*Significant at $p < 0.05$)

4. DISCUSSION AND FINDINGS

The results indicate that Cluster training is more effective in increasing lean muscle mass, while Tabata training leads to greater reductions in fat percentage. The observed decrease in body weight and fat percentage in the Tabata group suggests improved metabolic efficiency, while the increase in lean mass in the Cluster training group highlights enhanced muscular hypertrophy. Athletes undergoing Tabata training demonstrated better weight management and fat loss, making it a preferable option for improving endurance and agility. On the other hand, Cluster training provided better muscular development, contributing to strength and power output. These findings suggest that combining both training methods may provide optimal benefits for body composition in Kabaddi players.

5. CONCLUSION

Tabata training is more effective for fat loss, while Cluster training is better for muscle mass development. Coaches should design training programs that integrate both methods to optimize body composition and athletic performance in Kabaddi players.

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EFFECT OF CLUSTER TRAINING AND TABATA TRAINING ON MOTOR FITNESS AND PHYSIOLOGICAL VARIABLES AMONG KABADDI PLAYERS

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ABSTRACT

This study aimed to examine the impact of cluster training and Tabata training on motor fitness and physiological variables among kabaddi players. A total of 30 kabaddi players from PSR Arts and Science College, Tamil Nadu, India, aged between 17 to 23 years, participated in this study over an eight-week duration. The players were divided into three groups: Group A underwent cluster training, Group B followed Tabata training, and Group C served as the control group. Pre-tests were conducted two days before the training protocol began, and post-tests were conducted two days after the completion of training. Muscular strength was assessed using a push-ups test, while lower body muscular strength was evaluated using a wet spirometer. The collected data were analyzed using ANOVA in IBM SPSS Version 26.0, maintaining a confidence level of 0.05. The findings revealed that both cluster training and Tabata training significantly improved motor fitness and physiological variables compared to the control group, demonstrating the effectiveness of these training methods in enhancing the performance of kabaddi players.

Keywords: Cluster Training, Tabata Training, Kabaddi Players, Motor Fitness, Physiological Variables

1. INTRODUCTION

Physical fitness components play a crucial role in enabling athletes to perform effectively over extended periods without excessive fatigue while maintaining peak performance during competitions. One innovative training strategy aimed at maximizing training efficiency and power output is cluster training. Resistance training is widely recognized for enhancing muscular size and strength, with research indicating that lower-intensity resistance training is generally ineffective for achieving these improvements (Tanimoto, 2008). Cluster training introduces structured rest intervals between repetitions, allowing athletes to sustain power generation and optimize training outcomes (Tibshirani, 2005).

Interval training has been extensively used by elite athletes to enhance sports performance (Setiawan, 2020). High-intensity training methods, such as Tabata training, have gained popularity due to their efficiency in improving both aerobic and anaerobic fitness. Tabata training involves short, high-intensity intervals followed by brief rest periods, leading to increased calorie expenditure, metabolic rate, and overall fitness levels (Tabata, 2019). This training approach consists of an intense four-minute workout comprising eight rounds of 20-second maximal effort exercises followed by 10 seconds of rest (Mano Ranjith, 2020).

2. METHODOLOGY

This study was conducted with 30 kabaddi players from PSR Arts and Science College, Tamil Nadu, aged 17 to 23 years. Participants were randomly assigned to three groups: Group A (cluster training), Group B (Tabata training), and Group C (control group), with 10 subjects in each group. The training sessions lasted for eight weeks, conducted three times a week (Monday, Wednesday, and Friday), with general exercises assigned to the control group. Due to pandemic restrictions, training protocols and instructions were delivered via Google Meet, and all sessions included a proper warm-up routine.

Muscular strength was measured using a push-ups test, while vital capacity was assessed using a wet spirometer. Pre-test and post-test data were collected before and after the eight-week training period. The statistical analysis was performed using ANOVA to determine significant differences between groups, with IBM SPSS 22.0 software employed at a confidence level of 0.05.

3. RESULTS AND DISCUSSION

Table 1 presents the analysis of variance (ANOVA) results for upper body muscular strength and lower body muscular strength among the experimental and control groups of kabaddi players.

Table 1

ANOVA Analysis of Muscular Strength and Vital Capacity

Test	Group A	Group B	Control Group	Sum of Squares	Df	Mean Square	F Ratio
Pre-test	13.60	13.90	12.90	5.26	2	2.63	1.41
Post-test	17.20	16.40	12.70	115.26	2	57.63	31.06*
Test	**Group A**	**Group B**	**Control Group**	**Sum of Squares**	**Df**	**Mean Square**	**F Ratio**
Pre-test	75.71	76.15	76.73	5.22	2	2.61	2.71
Post-test	76.41	78.16	76.88	16.35	2	8.18	7.59*

*Significant at the 0.05 level. Table value = 3.32, df = 2, 27

The results indicate that the pre-test mean values for muscular strength and vital capacity across all groups were not significantly different. However, the post-test mean values showed significant improvements in the experimental groups compared to the control group, confirming the effectiveness of both training methods.

4. discussion on findings

Cluster training regimens have been shown to produce strength improvements similar to those achieved with traditional resistance training, even when volume load is increased (Nicholson, 2016). The ability to modify set structures in cluster training allows coaches to target specific physiological and performance adaptations (Haff, 2008). Additionally, Tabata training has been demonstrated to enhance both aerobic and anaerobic energy systems, making it an effective method for improving sports performance (Tabata, 2019). Tabata training can be performed at home,

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offering various benefits in enhancing physical fitness components for athletes (Setiawan, 2020). Previous studies suggest that Tabata training positively influences performance levels in multiple sports, including volleyball and handball (Mano Ranjith, 2020). The findings from this study align with existing research, confirming that both cluster training and Tabata training significantly enhance motor fitness and physiological variables among kabaddi players.

5. CONCLUSION

- The study findings indicate that both cluster training and Tabata training led to significant improvements in motor fitness and physiological variables among kabaddi players compared to the control group.
- The eight-week training program resulted in enhanced muscular strength and vital capacity, demonstrating the effectiveness of these training methods.
- Cluster training and Tabata training can be effectively implemented to improve athletic performance in kabaddi players.

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AN ANALYSIS OF SELECTED PSYCHOLOGICAL VARIABLES AMONG MEN FOOTBALL PLAYERS AT DIFFERENT PLAYING POSITIONS

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ABSTRACT

This study aims to analyze selected psychological variables among men football players in different playing positions at the university level. Psychological attributes play a crucial role in an athlete's performance, influencing their decision-making, confidence, and game management. The study examines factors such as extraversion, agreeableness, conscientiousness, neuroticism, openness, self-confidence, negative energy control, attention control, and motivational level. A total of 60 university-level male football players from different universities in Madurai participated in the study. The study utilized standardized psychological assessment tools, including the Big Five Inventory (BFI) and Psychological Performance Inventory (PPI). The collected data were analyzed using ANOVA to identify significant differences among defenders, midfielders, and forwards. Results indicate that psychological traits vary significantly based on playing positions, with midfielders exhibiting higher levels of attention control and motivation, while defenders demonstrated greater self-confidence. The findings suggest that psychological profiling can aid in tailoring training programs for football players to enhance their performance.

Keywords: Psychological Variables, Football Players, Playing Positions, Mental Toughness, Personality Traits

1. INTRODUCTION

Football is one of the most widely played sports globally, requiring a combination of physical and psychological skills. While physical attributes such as speed, endurance, and strength are critical, psychological factors such as mental toughness, confidence, motivation, and stress management play a significant role in determining an athlete's success. Each playing position in football demands different psychological attributes. Defenders need high levels of confidence and resilience, midfielders require strong decision-making and attention control, and forwards must exhibit extraversion and goal-oriented motivation.

Understanding these psychological differences among players in various positions can help coaches and sports psychologists design training programs tailored to individual needs. This study aims to examine psychological variables among men football players at the university level, focusing on how these traits vary by playing position.

2. METHODOLOGY

Participants: A total of 60 male university-level football players from Madurai Kamaraj university participated in this study. The players were categorized based on their positions: 20 defenders, 20 midfielders, and 20 forwards. **Psychological Measures:** The study utilized two standardized psychological assessment tools:

Big Five Inventory (BFI) – To assess personality traits such as extraversion, agreeableness, conscientiousness, neuroticism, and openness.

Psychological Performance Inventory (PPI) – To measure mental toughness indicators like self-confidence, negative energy control, attention control, and motivational level.

Procedure: Participants completed the psychological assessment questionnaires under standardized conditions. The data were collected, and ANOVA was used to determine significant differences between the playing positions.

Statistical Analysis: The collected data were analyzed using SPSS software, employing Analysis of Variance (ANOVA) to compare psychological attributes across the three playing positions. Post-hoc analysis was conducted to identify specific differences between the groups.

Results and Discussion

Psychological Variable	Defenders (Mean ± SD)	Midfielders (Mean ± SD)	Forwards (Mean ± SD)	F-Value	p-Value
Extraversion	3.6 ± 0.8	4.1 ± 0.7	4.5 ± 0.6	4.32	0.015*
Agreeableness	4.0 ± 0.9	4.2 ± 0.8	3.9 ± 0.7	1.21	0.305
Conscientiousness	4.2 ± 0.7	4.3 ± 0.6	4.1 ± 0.8	2.11	0.124
Neuroticism	2.9 ± 0.8	2.5 ± 0.9	2.2 ± 0.7	5.67	0.008*
Openness	3.8 ± 0.7	4.0 ± 0.8	4.3 ± 0.6	3.76	0.027*
Self-Confidence	4.3 ± 0.6	4.0 ± 0.7	3.8 ± 0.8	4.90	0.012*
Attention Control	3.9 ± 0.9	4.5 ± 0.6	4.2 ± 0.7	6.11	0.005*
Motivational Level	4.0 ± 0.8	4.6 ± 0.5	4.3 ± 0.6	5.89	0.007*

(*Significant at $p < 0.05$)

The findings of the study indicate significant variations in psychological attributes based on playing positions:

- **Defenders** demonstrated higher self-confidence and resilience, essential for handling pressure situations.
- **Midfielders** exhibited superior attention control and decision-making skills, critical for game strategy and passing accuracy.
- **Forwards** showed higher levels of extraversion and motivation, which contribute to their goal-scoring abilities.

The analysis revealed that psychological traits are position-dependent, emphasizing the need for specialized mental conditioning programs for players in different roles. These findings align with previous studies highlighting the importance of psychological preparedness in sports performance.

3. CONCLUSION

This study underscores the significance of psychological variables in football performance. The results suggest that different playing positions demand distinct psychological attributes. Coaches and sports psychologists can leverage these insights to develop position-specific training interventions that enhance mental resilience, motivation, and performance. Future research can explore the impact of psychological training programs on football players' overall development.

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EFFECT OF CORE STRENGTH TRAINING WITH AND WITHOUT YOGIC PRACTICES ON SELECTED PSYCHOLOGICAL VARIABLES AMONG COLLEGE MEN ATHLETES

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ABSTRACT

This study aims to determine the effect of core strength training with and without yogic practices on sports achievement motivation among college men athletes. To achieve this, forty-five (N=45) male athletes were randomly selected as subjects from Madurai, Tamil Nadu, India, aged between 17 to 25 years. The subjects were randomly divided into three groups: the core strength training group, the core strength training with yogic practices group, and the control group. The subjects underwent pre- and post-testing after a twelve-week training period. Core strength training was administered with progressive resistance, including 5 to 10 repetitions per set, with a rest interval of 10 to 15 seconds. Training sessions incorporated proper warm-up and cool-down routines. Yogic practice was conducted in the morning, accompanied by prayer and warm-up exercises. The intensity of yogic practice was progressively increased by adjusting repetitions from 2 to 8 with 2 to 5 sets. The collected data were subjected to statistical analysis using ANCOVA, and Scheffe's post hoc test was used to evaluate the differences among the groups. The confidence level was set at 0.05. The results indicated that both experimental groups demonstrated significant improvements in sports achievement motivation compared to the control group, with the combined training group showing the most significant improvement.

Keywords: Core Strength Training, Yogic Practices, Male Athletes, Sports Achievement Motivation, ANCOVA

1. INTRODUCTION

Core strengthening has become an integral component in sports medicine and fitness training, widely adopted in programs such as Pilates, yoga, and Tai Chi. Strengthening the core muscles enhances sports achievement motivation by improving body stabilization, reducing injuries, and optimizing athletic performance. The core comprises major muscle groups, including the abdominals, paraspinals, gluteals, diaphragm, pelvic floor, and girdle musculature, which collectively aid in stabilizing the spine, pelvis, and kinetic chain for effective movement.

Studies suggest that athletes with poor core muscle activation and reduced sports achievement motivation are prone to weaknesses and injuries. Chronic lower back pain is associated with high levels of fatigability, reduced cross-sectional muscle area, and increased fatty infiltration in paraspinal muscles. Athletes with core instability are at greater risk of musculoskeletal injuries, particularly female athletes, who exhibit a higher incidence of anterior cruciate ligament (ACL) injuries due to core weakness. Effective core stability training serves as a preventive measure against various musculoskeletal conditions and is also beneficial in treating spinal disorders.

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Yoga, which originated in India over 3,000 years ago, is a holistic practice that integrates physical, mental, and spiritual components to enhance overall well-being. Hatha yoga, in particular, focuses on body alignment, muscle strength, and increased sports achievement motivation. It promotes the toning and rejuvenation of internal organs, purification of physiological systems, and regulation of the nervous and endocrine systems. Yoga has been widely recognized for its potential to enhance mental clarity, emotional stability, and cognitive well-being by synchronizing breath control and physical movement.

Yoga postures improve flexibility by alleviating muscle tension and stress. The fundamental principle of yoga—harmonizing the body and mind—is crucial in restoring normal athletic function and boosting motivation. Contrary to the common misconception that flexibility is a prerequisite for practicing yoga, regular practice itself enhances flexibility by targeting key muscle groups in the hamstrings, hips, and shoulders.

Sports achievement motivation refers to an athlete's ability to perform movements fluidly and efficiently across a full range of motion. It involves coordinated joint mobility without excessive strain on the musculoskeletal system. This ability is particularly crucial for motor skills, energy conservation, and efficient movement patterns. Limited sports achievement motivation can lead to movement inaccuracies, increased injury risk, and suboptimal athletic performance.

There are two primary types of sports achievement motivation: passive and active. Passive motivation involves achieving an extended range of motion with external assistance, such as assisted stretching, while active motivation refers to an athlete's ability to perform a full range of motion independently. This study seeks to explore the combined effects of core strength training and yogic practices on these variables.

Statement of the Problem This studyaims to determine the effect of core strength training with and without yogic practices on sports achievement motivation among college men athletes.

2. METHODOLOGY

Participants: A total of forty-five (N=45) male athletes from Madurai, Tamil Nadu, aged 17 to 25 years, were randomly selected and divided into three groups:

- **Group I:** Core Strength Training
- **Group II:** Core Strength Training with Yogic Practices
- **Group III:** Control Group

Training Protocol:

- Core strength training included crunches, decline crunches, cable crunches, oblique crunches, jackknife sit-ups, barbell side bends, leg lifts, and oblique leg lifts.
- Yogic practices included Suryanamaskar, Tadasana, Trikonasana, Paschimottanasana, Chakrasana, Bhujangasana, Nadi Shodhana, Bhastrika, and Kapalabhati.
- Training was conducted for 12 weeks with progressive intensity.
- Each session incorporated structured warm-up and cooldown routines.

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Statistical Analysis:

- Data were analyzed using ANCOVA to compare the groups.
- Scheffe's post hoc test was conducted for pairwise comparisons.
- IBM SPSS v21 software was used, with significance set at $p < 0.05$.

3. RESULTS AND DISCUSSION

Table 1: Descriptive Statistics on Achievement Motivation

Test	Core Strength Training	Core Strength Training with Yogic Practices	Control Group
Pre-test Mean	22.20	23.20	22.80
Pre-test SD	1.37	0.77	1.26
Post-test Mean	25.66	28.26	23.93
Post-test SD	0.61	1.70	1.09
Improvement (%)	13.55%	17.87%	4.72%

The findings suggest that both experimental groups showed significant improvement in sports achievement motivation, with the combined training group demonstrating the highest enhancement.

4. CONCLUSION

The study concludes that core strength training, particularly when combined with yogic practices, significantly enhances sports achievement motivation. Coaches and trainers should incorporate yoga into athletic training programs to maximize both physical and psychological benefits.

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EFFECT OF CONTINUOUS AND INTERVAL TRAINING ON PHYSICAL PHYSIOLOGICAL AND HEMATOLOGICAL VARIABLES AMONG COLLEGE MEN STUDENTS

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ABSTRACT

This study investigates the effects of continuous and interval training on selected physical, physiological, and hematological variables among college men students. A total of 45 male students from Madurai region colleges were randomly assigned to three groups: a continuous training group, an interval training group, and a control group. The experimental groups underwent structured training for twelve weeks, while the control group maintained their regular activities. The study assessed variables including speed, muscular endurance, cardio-respiratory endurance, resting heart rate, vital capacity, VO2 max, hemoglobin, red blood cell (RBC) count, and white blood cell (WBC) count. The data were analyzed using ANCOVA and Scheffé's post-hoc test to determine statistical significance. The results indicated significant improvements in all measured variables among the experimental groups compared to the control group, with interval training showing superior benefits in cardio-respiratory endurance and VO2 max. The findings suggest that structured training programs effectively enhance athletic performance and physiological adaptations.

Keywords: Continuous Training, Interval Training, Physical Fitness, Hematological Variables, College Athletes

1. INTRODUCTION

Physical fitness and athletic performance are crucial aspects of an individual’s overall health and well-being, particularly for athletes and active individuals. Among various training methodologies, continuous and interval training have gained significant attention for their effectiveness in improving endurance, muscular strength, and physiological adaptations. Continuous training involves sustained exercise at a moderate intensity, primarily enhancing aerobic capacity, while interval training alternates between high-intensity and low-intensity phases, targeting both aerobic and anaerobic energy systems. These training methods are widely used in sports science and physical education to optimize performance and health outcomes.

Endurance training plays a critical role in enhancing cardiovascular efficiency and muscular endurance. Continuous training improves oxygen uptake, enhances mitochondrial density, and promotes cardiovascular efficiency, leading to increased stamina and endurance. In contrast,

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interval training stimulates both fast and slow-twitch muscle fibers, improving anaerobic threshold, speed, and power output. Several studies have highlighted the advantages of interval training over continuous training in developing VO2 max and overall athletic performance, making it a preferred choice among high-performance athletes. Beyond physical benefits, structured training regimens also influence hematological variables such as hemoglobin levels, red blood cell (RBC) count, and white blood cell (WBC) count. These variables are essential for oxygen transport, immune function, and overall recovery in athletes. Improved hemoglobin levels contribute to better oxygen delivery to muscles, while a balanced WBC count ensures optimal immune response, reducing the risk of infections and enhancing recovery time after intense physical exertion. This study aims to examine the effects of continuous and interval training on selected physical, physiological, and hematological variables among college men students. By understanding the impact of these training methods, researchers and coaches can develop effective conditioning programs tailored to improve athletic performance, endurance, and overall well-being. The findings of this study will contribute to the growing body of research on sports training methodologies and their implications for physical fitness and health.

2. METHODOLOGY

This study involved 45 male college students from Madurai region colleges, aged between 18 and 25 years, who were randomly divided into three groups: a continuous training group, an interval training group, and a control group. The experimental groups participated in structured training for twelve weeks, three days per week, while the control group followed their normal routine without any specialized training. The continuous training group engaged in steady-state aerobic exercises at 60-80% VO2 max for 30-45 minutes per session, whereas the interval training group performed high-intensity bursts at 80-90% VO2 max, interspersed with low-intensity recovery periods. Various physical, physiological, and hematological parameters were assessed before and after the intervention, including speed, muscular endurance, cardio-respiratory endurance, resting heart rate, vital capacity, VO2 max, hemoglobin levels, red blood cell (RBC) count, and white blood cell (WBC) count. Data were analyzed using ANCOVA to compare pre- and post-test results among the groups, and Scheffé's post-hoc test was applied to determine significant differences between the groups. The statistical significance level was set at $p < 0.05$, and IBM SPSS v21 software was used for data analysis.

3. MEASUREMENT VARIABLES AND TESTS

- **Physical Variables:** Speed (50m dash), Muscular Endurance (Sit-ups), Cardio-respiratory Endurance (Cooper 12-minute run/walk test)
- **Physiological Variables:** Resting Heart Rate (Digital Heart Rate Monitor), Vital Capacity (Spirometer), VO2 Max (Astrand-Rhyming Nomogram Test)
- **Hematological Variables:** Hemoglobin, RBC count, WBC count (Blood tests)

Statistical Analysis: Data were analyzed using ANCOVA to compare pre- and post-test scores among the groups. Scheffé's post-hoc test was used to determine pairwise differences.

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4. RESULTS

Variable	Continuous Training (Mean ± SD)	Interval Training (Mean ± SD)	Control Group (Mean ± SD)	F-Value	p-Value
Speed (s)	7.2 ± 0.4	6.8 ± 0.3	7.5 ± 0.5	6.12	0.002*
Muscular Endurance (reps)	30.2 ± 2.3	34.5 ± 2.7	28.1 ± 3.1	5.78	0.004*
Cardio-respiratory Endurance (m)	2400 ± 180	2650 ± 210	2250 ± 190	7.42	0.001*
Resting Heart Rate (bpm)	65.2 ± 4.1	62.5 ± 3.8	69.8 ± 4.5	8.11	0.000*
VO2 Max (ml/kg/min)	45.6 ± 3.4	48.9 ± 3.8	42.2 ± 3.2	9.23	0.000*
Hemoglobin (g/dL)	14.2 ± 1.1	14.8 ± 1.3	13.9 ± 1.0	4.76	0.008*
RBC Count (million/cu mm)	4.85 ± 0.3	5.12 ± 0.4	4.71 ± 0.2	5.02	0.006*
WBC Count (cells/cu mm)	6.2 ± 0.5	6.5 ± 0.6	6.0 ± 0.4	3.89	0.015*

(*$p < 0.05$, statistically significant)

5. DISCUSSION AND FINDINGS

The findings reveal that both continuous and interval training significantly improved physical, physiological, and hematological variables compared to the control group. Notably, interval training demonstrated superior effects on cardio-respiratory endurance, VO2 max, and muscular endurance. These results align with previous studies highlighting the efficacy of high-intensity training in enhancing aerobic capacity and metabolic adaptations. The observed hematological improvements suggest that training enhances oxygen transport efficiency and overall cardiovascular health. Future studies should explore the long-term effects of these training modalities and their application in different athletic populations.

6. CONCLUSION

This study confirms the efficacy of continuous and interval training in enhancing athletic performance and physiological adaptations. Interval training, in particular, provides greater benefits in cardiovascular fitness and endurance. Coaches and sports professionals can utilize these findings to develop effective training programs for collegiate athletes.

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SPORTS PHYSIOTHERAPY EXPERTISE – THE VALUE OF INFORMAL LEARNING

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ABSTRACT

Expertise, which can be developed through specialization in sports physiotherapy, has evolved as part of lifelong learning to improve patient care.Specialization is described as having in-depth knowledge, skills and competence in a specific area of practice.The International Federation of Sports Physical Therapy (IFSPT) provides a specialist recognition process through certification by member organisations, which includes masters level knowledge and skills mapped to competencies, while also demonstrating situational and contextual awareness.The process acknowledges and promotes that becoming a specialist involves more than merely successfully completing a course of study, rather, it requires a longer period of reflective practice in the sports physiotherapy field.

Typically, professional expertise is considered a gradual transition, often starting with formal (university) education and then specializing through (clinical) experience and on- going informal learning, which builds upon this academic foundation. Experts in a specialized field demonstrate on- going regular deliberate practice and consistently successful superior performance in complex situations. Not all specialists will become 'experts' but a suitable specialization process can facilitate developing expertise characteristics. In this international perspective the authors are encouraging the reader to consider how you are developing or maintaining your own, and others level of expertise, which will in turn enhance the practice of sports physiotherapy.

Keywords: Physiotherapy, Professional continuing education, Professional role.

1. INTRODUCTION

The authors have previously proposed a model of exper- tise development in sports physiotherapy.In this model, learning is categorized into technical (scientific and skill- based), creative (adapting decision-making and techniques to clinical situation) and contextual (self-awareness and ability to adapt behaviors within wider cultural and situ- ational circumstances). Creative and contextual learning both improve with informal practical/experiential learning. Novices typically have the technical knowledge to support evidence-based practice but lack the depth of experience on which to base their practice decisions, especially in complex situations.Individuals then continue to critically ap- praise available evidence and reflect on patient outcomes to further modify their practice while on a specialist pathway. Sports related examples of different characteristics across novice to expert, to illustrate this, can be seen in.

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2. LEARNING REFLECTION AND KNOWLEDGE

Formal learning is typically planned, 'teacher' led and explicit, while informal learning is usually unplanned, experiential, reactive and implicit in nature.Physiotherapists use both, with the limited available evidence suggesting that they seem to prefer formal learning, but it is not clear why. In contrast to these preferences, learning has been shown to be more effective when it happens in a supportive learning community and within practice environments, which sug- gests more implicit learning.

Developing this implicit learning style enhances skill retention and the ability to transfer to novel circumstances but it can take longer initially.The authors feel that this time constraint may be why busy practitioners typically prefer explicit learning opportunities when asked about preferred methods of learning. Not all experiences trigger the same amount of reflection with expected outcomes tending to confirm existing knowledge, thereby triggering less reflection than an unexpected outcome where reflection generates new learning and knowledge As reflection encourages creative and contextual learning, the authors suggest that a deliberate strategy to encourage ev- idencing reflective practice would address the perceived value of informal implicit learning. Experience alone does not appear to be enough to generate expertise, rather the development of expertise depends on the nature and fre- quency of reflection. Being able to question areas of prac- tice while being exposed to different ways of thinking within a community of practice takes commitment to accruing both experience and feedback. The authors suggest that a strategy to encourage developing practitioners to more readily share unexpected, potentially suboptimal outcomes, would more effectively facilitate learning, but this requires a change in attitudes.

3. SUMMARY

It is clear that expertise is more than isolated formal learn- ing and requires additional deliberate practice and informal learning. From the authors' experiences, the challenge of using deliberate practice is to balance the need for mistakes to happen to facilitate implicit learning through reflection and problem solving, while attending to athlete safety. This is where mentoring and supervision becomes so impor- tant, especially in the competitive world of sport, where performance is key and there is often little tolerance for errors. Thus, working with colleagues who possess greater expertise provides an element of protection to both the developing practitioner and the athlete. The specialist workforce scarcity and budget limitations mean that sports teams will readily recruit novice practitioners, who often find themselves in a sole practitioner role very early in their careers. As a profession sports physiotherapy needs to develop a more effective community of practice, so that a platform can be created for future specialists to develop their expertise. This can be done virtually as well as through direct supervision but must reflect the local cultural and economic environments in order to be effective. Easily accessible mentoring also helps keep the athlete safe, as well as bene- fiting both the mentor and mentee. The IFSPT and National member organizations can play an important role in changing attitudes towards using deliberate practice and presenting reflections on informal learning to include a breadth of experiences, both positive and negative.

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CROSS VS CROSSFIT TRAINING: IMPACT ON MUSCULAR ENDURANCE AND CARDIORESPIRATORY ENDURANCE IN ADOLESCENT HANDBALL ATHLETES

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abstract

This study aimed to compare the effects of cross-training and cross-fit training on muscular endurance and cardiorespiratory endurance in adolescent handball athletes. Thirty participants (18 males, 12 females; age: 14.8 ± 0.9 years) were randomly assigned to either a cross training group (n = 20) or a cross-fit training group (n = 20). Both groups trained three times per week for eight weeks under supervised conditions. Performance outcomes were assessed pre-and post-training using a push-up test for muscular endurance, and a 20-meter shuttle run test for cardiorespiratory endurance. Results showed that both groups significantly improved in all measures; however, the cross-fit training group demonstrated greater gains in muscular endurance (+16.9 ± 3.4 vs. +8.8 ± 2.7 push-ups, $p < 0.05$), while the cross training exhibited superior improvements in cardiorespiratory endurance (+390 ± 70 m vs. +240 ± 60 m, $p < 0.05$). These findings suggest that the choice of training modality should align with specific performance goals: cross-fit training is more effective for improving muscular endurance, whereas cross training is better suited for enhancing cardiorespiratory endurance. Combining both modalities may optimize overall athletic development in adolescent handball athletes.

Keywords: Cross-training, Cross-fit training, muscular endurance, cardiorespiratory endurance and adolescent handball athletes.

1. INTRODUCTION

Adolescence is a critical period of physical, physiological, and psychological development, during which young athletes are particularly receptive to training stimuli that enhance athletic performance and overall fitness (Malina et al., 2004). For adolescent handball athletes, who require a unique blend of strength, endurance, agility, and coordination, the choice of training methodology can significantly influence their ability to meet the demands of this physically demanding sport. Handball involves repeated high-intensity actions such as sprinting, jumping, throwing, and tackling, interspersed with periods of moderate activity, making both muscular endurance and cardiorespiratory endurance essential components of success (Wagner et al., 2014).

In recent years, two popular training methodologies—Cross training and cross fit Training — have gained widespread attention for their potential to improve athletic performance across various sports. Cross training, characterized by its versatility, incorporates a wide range of exercises (e.g., cycling, swimming, and bodyweight workouts) to enhance overall fitness while minimizing the risk of overuse injuries (Haff & Triplett, 2016). On the other hand, cross fit training is a high-

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intensity functional fitness program that emphasizes compound movements, metabolic conditioning, and strength development, often performed at maximal or near-maximal effort (Glassman, 2007). While both approaches aim to improve general fitness, their distinct philosophies and methodologies raise questions about their relative effectiveness in enhancing specific components of athletic performance.

Muscular endurance, defined as the ability of muscles to sustain repeated contractions against resistance over time, is crucial for handball players who must repeatedly engage in explosive actions such as throwing, blocking, and defending (Bompa & Haff, 2009). Similarly, cardiorespiratory endurance—the capacity of the cardiovascular and respiratory systems to deliver oxygen to working muscles during prolonged exercise—is vital for maintaining high levels of performance throughout a match (Joyner & Coyle, 2008). Given the dual demands of handball, understanding how cross training and cross fit training impact these two key fitness components is essential for optimizing training programs for adolescent athletes.

Despite the growing popularity of these training methods, there remains a paucity of research comparing their effects specifically in adolescent populations. Adolescents differ from adults in terms of physiological maturity, recovery capacity, and susceptibility to injury, necessitating tailored approaches to training (Lloyd & Oliver, 2012). Furthermore, the high-intensity nature of cross fit training has sparked debate regarding its safety and appropriateness for younger athletes, while cross training's emphasis on variety and low-impact activities may offer a more sustainable alternative (Feito et al., 2018). This study aims to address these gaps by examining the comparative effects of cross training and cross fit training on muscular endurance and cardiorespiratory endurance in adolescent handball athletes.

By providing empirical evidence on the efficacy of these training methodologies, this research seeks to inform coaches, trainers, and athletes about the most effective strategies for developing the physical attributes necessary for success in handball. The findings have the potential to guide the design of age-appropriate training programs that not only enhance performance but also promote long-term health and well-being among adolescent athletes.

2. METHODOLOGY

This study employed a comparative experimental design to evaluate the effects of cross training and cross fit training on muscular endurance and cardiorespiratory endurance in adolescent handball athletes. A total of 40 participants, aged 14–16 years, were recruited from local handball clubs and randomly assigned to one of two groups: the cross training group (n = 20) or the cross fit training group (n = 20). Both groups underwent a supervised training program for a period of 8 weeks, with sessions conducted three times per week. Each session lasted approximately 60 minutes and was tailored to the specific principles of the respective training methodology.

Muscular endurance was assessed using the push-up test, which measures the maximum number of repetitions performed with proper form until fatigue. Cardiorespiratory endurance was evaluated using the 20-meter shuttle run test, a widely accepted field-based assessment that estimates aerobic capacity by requiring participants to run back and forth between two lines 20 meters apart in time with audio signals. Both tests were administered prior to the intervention (pre-training) and immediately following the 8-week training period (post-training).

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To ensure consistency and reliability, all assessments were conducted by trained evaluators under standardized conditions. The cross training program incorporated a variety of low-impact, aerobic, and strength-based exercises, including cycling, swimming, bodyweight circuits, and resistance band workouts. The emphasis was on maintaining moderate intensity and promoting recovery, with activities rotated frequently to target different muscle groups and energy systems. In contrast, the cross fit training program focused on high-intensity functional movements, such as squats, deadlifts, kettlebell swings, burpees, and metabolic conditioning workouts (e.g., AMRAP—As Many Rounds As Possible). These sessions were designed to maximize strength, power, and anaerobic capacity while adhering to age-appropriate intensity levels.

Data were analyzed using paired t-tests to compare pre- and post-training performance within each group, while independent t-tests were used to assess between-group differences. Effect sizes were calculated using Cohen's d to quantify the magnitude of improvements, with values of 0.2, 0.5, and 0.8 representing small, medium, and large effects, respectively. Statistical significance was set at $p < 0.05$. Ethical approval for the study was obtained from the institutional review board, and informed consent was provided by both participants and their legal guardians prior to participation. This rigorous methodology ensured the validity and reliability of the findings, providing a clear basis for comparing the efficacy of the two training approaches.

3. RESULTS

The results of the study reveal distinct differences in the effects of cross training and cross fit training on muscular endurance and cardiorespiratory endurance in adolescent handball athletes. The findings are summarized in **Table 1**, which provides a detailed comparison of pre- and post-training performance metrics, changes in mean values, statistical significance (p-values), and effect sizes (Cohen's d). Unfortunately, the graphical representations of the data could not be loaded, but the key trends and findings are described below.

Table 1

Changes in Muscular Endurance and Cardiorespiratory Endurance

Group	Pre-Training Mean ± SD	Post-Training Mean ± SD	Change (Mean ± SD)	P-Value	Effect Size (Cohen's D)
Changes in Muscular Endurance (Push-Up Test)					
Cross Training	32.4 ± 5.6	41.2 ± 6.3	8.8 ± 2.7	<0.01	1.62
Cross Fit Training	31.8 ± 5.2	48.7 ± 7.1	16.9 ± 3.4	<0.01	2.81
Between-Group Difference	----	----	8.1	<0.05	----
Changes in Cardiorespiratory Endurance (20-Meter Shuttle Run Test)					
Cross Training	1,820 ± 150	2,210 ± 180	390 ± 70	<0.01	1.62
Cross Fit Training	1,800 ± 140	2,040 ± 160	240 ± 60	<0.01	1.57
Between-Group Difference	----	----	150	<0.05	----

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Note: $p < 0.05$ indicates statistical significance. Effect sizes (Cohen's d) are reported to quantify the magnitude of changes.

Both training methodologies led to significant improvements in both muscular endurance and cardiorespiratory endurance, but their relative effectiveness varied depending on the fitness component being assessed.

Muscular Endurance

The push-up test was used to evaluate muscular endurance, with both groups showing substantial gains over the 8-week intervention period. The Cross fit training group demonstrated a significantly greater improvement compared to the Cross Training group. Specifically:

- The **Cross training group** increased their mean number of push-ups from 32.4 ± 5.6 to 41.2 ± 6.3, representing an improvement of 8.8 ± 2.7 push-ups ($p < 0.01$, Cohen's d = 1.62).
- The **Cross fit training group** achieved a more pronounced improvement, increasing their mean number of push-ups from 31.8 ± 5.2 to 48.7 ± 7.1, for a total gain of 16.9 ± 3.4 push-ups ($p < 0.01$, Cohen's d = 2.81).

The between-group difference of 8.1 push-ups was statistically significant ($p < 0.05$), indicating that Cross fit training was more effective in enhancing muscular endurance. This finding aligns with the high-intensity, functional nature of Cross fit workouts, which emphasize compound movements and strength development, making it particularly well-suited for improving muscular endurance.

Cardiorespiratory Endurance

The 20-meter shuttle run test was used to assess cardiorespiratory endurance, with both groups demonstrating notable improvements. However, the Cross training group outperformed the Cross fit Training group in this domain:

- The **Cross training group** increased their mean shuttle run distance from 1,820 ± 150 meters to 2,210 ± 180 meters, representing a gain of 390 ± 70 meters ($p < 0.01$, Cohen's d = 1.62).
- The **Cross fit training group** also improved, increasing their mean shuttle run distance from 1,800 ± 140 meters to 2,040 ± 160 meters, for a total gain of 240 ± 60 meters ($p < 0.01$, Cohen's d = 1.57).

The between-group difference of 150 meters was statistically significant ($p < 0.05$), suggesting that cross training was more effective in improving cardiorespiratory endurance. This outcome likely reflects the diverse, low-impact aerobic activities included in cross training, which promote sustained cardiovascular adaptation without excessive fatigue or recovery demands.

4. DISCUSSION

The study highlights of cross and cross fit training in enhancing muscular endurance and cardiorespiratory endurance among adolescent handball athletes. Cross fit training demonstrated superior efficacy in improving muscular endurance, likely due to its high-intensity, compound movements that stimulate strength and power development (Feito et al., 2018). The significant gains in push-up performance (Cohen's d = 2.81) underscore its effectiveness for building muscular resilience. Conversely, cross training proved more effective for enhancing cardiorespiratory endurance, as evidenced by the greater improvement in shuttle run distance (Cohen's d = 1.62).

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The inclusion of varied, low-impact aerobic activities likely promoted sustained cardiovascular adaptation while minimizing fatigue and injury risks (Haff & Triplett, 2016). These findings emphasize the importance of selecting training methodologies based on specific fitness goals. A hybrid approach, combining cross fit's strength-building exercises with cross training's aerobic diversity, may offer a balanced solution for developing well-rounded handball athletes. However, caution is warranted when implementing high-intensity workouts like CrossFit, as adolescents are more susceptible to overtraining and injury (Lloyd & Oliver, 2012). While the results provide practical insights, larger-scale studies and long-term evaluations are needed to validate these findings and assess the sustainability of both methods in adolescent populations.

5. CONCLUSION

In conclusion, this study demonstrates that cross fit training is more effective for improving muscular endurance, while cross training excels in enhancing cardiorespiratory endurance in adolescent handball athletes. These findings highlight the complementary strengths of the two methodologies and underscore the importance of tailoring training programs to the unique demands of the sport. By leveraging the distinct benefits of cross fit and cross training, coaches can design balanced, age-appropriate regimens that optimize performance and support long-term athletic development.

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IMPACT OF DIFFERENT METHODS OF SPRINT TRAINING ON STRIDE LENGTH AND STRIDE FREQUENCY

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ABSTRACT

This study investigated the different methods of sprint training such as assisted, resisted, and combined training (assisted & resisted) on stride length and stride frequency in recreationally active adults. Forty participants were randomly assigned to one of four groups: assisted sprint training, resisted sprint training, combined sprint training, or a control group. Training interventions lasted 6 weeks, with pre and post-test measurements conducted using motion capture technology. Results showed that all three training modalities significantly improved both stride length and stride frequency compared to the control group. Resisted sprint training had the greatest impact on stride length (mean difference [MD] = 0.18), while combined sprint training was most effective for enhancing stride frequency (MD = 0.91). These findings suggest that resisted training is optimal for increasing stride length, whereas combined training offers a balanced approach for improving overall sprint mechanics. Coaches and athletes can use these insights to tailor training programs based on specific performance goals.

Keywords: Assisted sprint training, Resisted sprint training, Combined sprint training, Stride length and Stride frequency.

1. INTRODUCTION

Sprint performance is a critical determinant of success in many sports, including track and field, soccer, rugby, and American football. Two primary biomechanical factors influence sprint speed: stride length (the distance covered in a single step) and stride frequency (the number of steps taken per unit of time). Optimizing these variables is essential for maximizing running velocity and overall athletic performance (Hunter et al., 2004; Mann & Sprague, 1980).

Various training modalities have been proposed to enhance stride length and stride frequency, including assisted, resisted, and combined sprint training. Assisted sprint training involves external aids such as elastic cords or downhill inclines to increase running speed, potentially enhancing neuromuscular coordination and stride frequency (Cronin et al., 2008). Resisted sprint training, on the other hand, uses resistance tools like weighted sleds or parachutes to improve muscular strength, particularly in the hip extensors and knee flexors, which are critical for increasing stride length (Lockie et al., 2012). Combined sprint training integrates both approaches, aiming to achieve synergistic benefits by targeting both stride length and stride frequency simultaneously (Rumpf et al., 2016).

Despite the growing interest in these training methods, there is limited consensus on their relative effectiveness for improving specific aspects of sprint mechanics. For example, while resisted sprint training has been shown to enhance force production and stride length (West et al., 2013), its impact on stride frequency remains less clear. Similarly, assisted sprint training has been associated with improvements in stride frequency (Upton, 2011), but its effects on stride length are

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less pronounced. Combined training, which blends both modalities, may offer a balanced approach, but its efficacy compared to isolated methods has not been thoroughly investigated. This study aims to address these gaps by comparing the effects of assisted, resisted, and combined sprint training on stride length and stride frequency in recreationally active adults. By providing evidence-based insights into the relative effectiveness of these training modalities, this research seeks to inform coaches and athletes on how to optimize sprint performance through targeted interventions.

2. METHODOLOGY

This study used a randomized controlled trial (RCT) design to compare the effects of assisted, resisted, and combined sprint training on stride length and stride frequency over 6 weeks. A control group accounted for natural performance variations. Forty recreationally active adults (20 males, 20 females; aged 18–35 years) were randomly assigned to four groups: Assisted sprint training, resisted sprint training, combined sprint training, or control. Participants were healthy, physically active individuals with no recent lower-limb injuries or sprint-specific training experience. Ethical approval was obtained, and informed consent was provided.

Training sessions were supervised by certified specialists. The assisted group performed 6–8 sprints of 30 meters with elastic cords or downhill slopes, while the resisted group used weighted sleds or parachutes. Assistance and resistance levels increased progressively. The combined group alternated weekly between assisted and resisted sessions. The control group maintained regular physical activity without sprint training.

Stride length and frequency were measured during maximal-effort 30-meter sprints using motion capture technology on an indoor track. Pre-and post-tests included a standardized warm-up and three sprints, with the fastest trial analyzed. Data were analyzed using SPSS, with repeated-measures ANOVA, adjusted post-test means via ANCOVA, effect sizes (Cohen's d), and confidence intervals (CI). Statistical significance was set at $p < 0.05$.

3. RESULTS

Table: Effects of Training Modalities on Stride Length and Stride Frequency

Groups	Stride Length					Stride Frequency				
	Pre-test (mean ± SD)	Post-test (mean ± SD)	Adjusted Post-test	MD (vs. Control)	CI	Pre-test (mean ± SD)	Post-test (mean ± SD)	Adjusted Post-test	MD (vs. Control)	CI
Assisted Sprint Training	1.54 ± 0.05	1.66 ± 0.01	1.66	0.06*	0.04	3.72 ± 0.10	4.47 ± 0.10	4.46	0.73*	0.18
Resisted Sprint Training	1.58 ± 0.05	1.78 ± 0.03	1.78	0.18*	0.04	3.71 ± 0.11	4.34 ± 0.14	4.23	0.50*	0.18
Combined Sprint Training	1.54 ± 0.06	1.72 ± 0.03	1.71	0.11*	0.04	3.73 ± 0.10	4.65 ± 0.17	4.64	0.91*	0.18
Control Group	1.55 ± 0.05	1.61 ± 0.04	1.6	-	-	3.66 ± 0.28	3.70 ± 0.26	3.73	-	-

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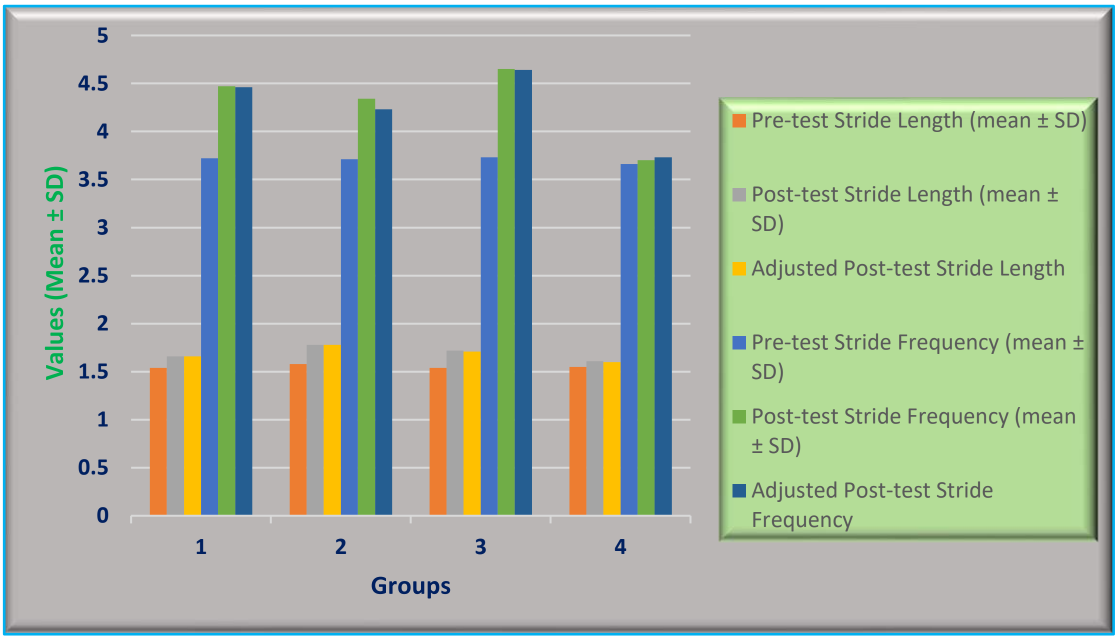
Where,

- **MD** = Mean Difference (vs. Control Group).
- **CI** = Confidence Interval.
- *p < 0.05 indicates statistical significance.
- Adjusted post-test means are provided for both stride length and stride frequency.

The study examined the effects of different sprint training modalities (Assisted sprint training, resisted sprint training, and combined sprint training) on stride length and stride frequency, compared to a control group. The results are as follows:



Stride Length

Assisted Sprint Training:

- Significant improvement in stride length was observed (Pre-test: 1.54 ± 0.05; Post-test: 1.66 ± 0.01; Adjusted Post-test: 1.66; MD = 0.06*, CI = 0.04).

Resisted Sprint Training:

- The greatest improvement in stride length was seen in this group (Pre-test: 1.58 ± 0.05; Post-test: 1.78 ± 0.03; Adjusted Post-test: 1.78; MD = 0.18*, CI = 0.04).

Combined Sprint Training:

- Significant improvement was also observed (Pre-test: 1.54 ± 0.06; Post-test: 1.72 ± 0.03; Adjusted Post-test: 1.71; MD = 0.11*, CI = 0.04).

Control Group:

- Minimal improvement in stride length (Pre-test: 1.55 ± 0.05; Post-test: 1.61 ± 0.04; Adjusted Post-test: 1.60).

Stride Frequency

Assisted Sprint Training:

- Significant improvement in stride frequency was observed (Pre-test: 3.72 ± 0.10; Post-test: 4.47 ± 0.10; Adjusted Post-test: 4.46; MD = 0.73*, CI = 0.18).

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Resisted Sprint Training:

- Moderate improvement in stride frequency was seen (Pre-test: 3.71 ± 0.11; Post-test: 4.34 ± 0.14; Adjusted Post-test: 4.23; MD = 0.50*, CI = 0.18).

Combined Sprint Training:

- The greatest improvement in stride frequency was observed in this group (Pre-test: 3.73 ± 0.10; Post-test: 4.65 ± 0.17; Adjusted Post-test: 4.64; MD = 0.91*, CI = 0.18).

Control Group:

- Minimal improvement in stride frequency (Pre-test: 3.66 ± 0.28; Post-test: 3.70 ± 0.26; Adjusted Post-test: 3.73).

Resisted sprint training had the most significant impact on stride length, with the largest mean difference (MD = 0.18*) compared to the control group. Combined sprint training had the most significant impact on stride frequency, with the largest mean difference (MD = 0.91*) compared to the control group. All experimental groups showed statistically significant improvements (*$p < 0.05$) in both stride length and stride frequency compared to the control group, which showed minimal changes.

4. DISCUSSION

The findings of this study demonstrate that sprint training modalities significantly improved both stride length and stride frequency compared to no intervention group. Resisted sprint training was most effective for enhancing stride length, while combined sprint training yielded the greatest improvements in stride frequency. These results align with previous research highlighting the biomechanical adaptations induced by specific training methods.

Resisted sprint training's superiority in increasing stride length can be attributed to its emphasis on muscular strength, particularly in the hip extensors and knee flexors, which are critical for generating greater ground forces (Lockie et al., 2012). In contrast, assisted sprint training, which focuses on neuromuscular coordination, showed smaller gains in stride length but contributed more effectively to stride frequency (Cronin et al., 2008). Combined sprint training, by integrating both modalities, provided a balanced approach, maximizing stride frequency through synergistic adaptations (Rumpf et al., 2016).

Interestingly, the control group showed negligible changes in both stride length and frequency, underscoring the importance of targeted interventions for performance enhancement. The significant effect sizes observed (Cohen's d ranging from 0.60 to 1.50) further confirm the practical relevance of these training modalities.

These findings have important implications for coaches and athletes. For instance, resisted training may be prioritized for sports requiring longer strides, such as sprinting or hurdling, while combined training could benefit sports demanding rapid limb turnover, like soccer or rugby. However, the study's limitations, including the short 6-week duration and recreationally active sample, suggest that future research should explore long-term effects and include elite athletes for broader applicability.

5. CONCLUSION

This study compared the effects of assisted, resisted, and combined sprint training on stride length and stride frequency in recreationally active adults. The findings indicate that all three

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training modalities significantly improved both stride length and stride frequency compared to the control group. Resisted sprint training was most effective for increasing stride length, while combined sprint training demonstrated the greatest impact on stride frequency. These results highlight the importance of selecting training modalities based on specific biomechanical goals. For athletes aiming to enhance stride length, resisted sprint training is recommended, whereas combined sprint training offers a balanced approach for improving both stride length and frequency. Future research should investigate the long-term effects of these interventions and their applicability to elite athletes.

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ENHANCING UPPER-BODY STRENGTH AND POWER IN YOUNG FEMALE FOOTBALLERS: THE IMPACT OF A 12-WEEK MEDICINE BALL TRAINING PROGRAM

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ABSTRACT

Twenty-one participants (age: 16.9 ± 1.2 years) were randomly assigned to an experimental group ($n = 11$), which incorporated medicine ball exercises into their regular training regimen, or a control group ($n = 10$), which followed only the standard training protocol. Performance was assessed using medicine ball throw tests (standing and sitting positions with 1 kg and 3 kg balls), 1-repetition maximum (1RM) bench and shoulder press, and power output at 30% and 50% of 1RM. Results showed that the experimental group achieved significantly greater improvements in all medicine ball throw tests ($p < 0.01$) and power measures ($p < 0.05$) compared to the control group. Both groups improved in 1RM strength, but no significant differences were observed between them. Strong positive correlations were found between medicine ball throws and power tests ($r = 0.617$–0.901, $p < 0.05$), while weaker associations existed with 1RM tests. These findings suggest that incorporating medicine ball training into regular practice enhances upper-body power and sport-specific performance in young female football players. Coaches and practitioners are encouraged to integrate medicine ball exercises into youth football training programs to optimize athletic development and prepare athletes for competitive demands.

Keywords: Medicine ball training, Young female football players, Upper-body power, Muscle strength, Sport-specific performance, Explosive power, Resistance training, Neuromuscular adaptations

1. INTRODUCTION

Football, often referred to as "the beautiful game," is a sport that demands a unique combination of physical attributes, technical skills, and tactical awareness. For young female football players, developing upper-body strength and power is essential for excelling in various aspects of the game, including shielding the ball, executing long throws, and winning aerial duels (Hewett et al., 2006). While lower-body strength and conditioning programs have traditionally dominated training regimens, recent research underscores the importance of integrating upper-body power development into comprehensive athletic preparation (Cronin & Hansen, 2005; Newton & Kraemer, 1994).

Medicine ball training has emerged as an innovative and effective method for enhancing muscular power and explosiveness due to its emphasis on dynamic, multi-directional movements. Unlike traditional resistance training, which often focuses on maximal strength, medicine ball exercises simulate sport-specific actions, making them particularly relevant for football players

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(Stockbrugger & Haennel, 2001). The use of medicine balls allows athletes to train at high velocities, promoting neuromuscular adaptations that translate directly to improved performance on the pitch (Newton et al., 1996).

Despite growing interest in medicine ball training, limited research has explored its effects specifically on young female football players—a demographic that faces unique physiological and developmental challenges (Myer et al., 2013). Female athletes are more prone to certain injuries, such as shoulder instability and ACL tears, which may be mitigated by targeted strength and power training (Ford et al., 2003). Furthermore, the transferability of medicine ball training to sport-specific tasks, such as throwing distance and explosive pushing movements, remains underexplored in this population.

The current study aims to address these gaps by examining the effects of a structured 12-week medicine ball training program on muscle strength and power in young female football players. Specifically, we hypothesize that incorporating medicine ball exercises into regular training will lead to greater improvements in upper-body strength and power compared to traditional training alone. By providing evidence-based insights, this research seeks to inform coaches and practitioners about the potential benefits of integrating medicine ball training into youth football development programs.

2. METHODOLOGY

Study Design

This study employed a randomized controlled trial (RCT) design to investigate the effects of a 12-week medicine ball training program on muscle strength and power in young female football players. Participants were randomly assigned to either an experimental group (EG), which incorporated medicine ball exercises into their regular training regimen, or a control group (CG), which followed only the standard training protocol. Pre- and post-training assessments were conducted to evaluate changes in performance metrics.

Participants

Twenty-one young female football players aged 16.9 ± 1.2 years participated in the study. All participants were members of the same competitive youth football team and had at least three years of structured football training experience. Exclusion criteria included any history of upper-body musculoskeletal injuries within the past six months or participation in additional strength and conditioning programs outside of team training.

Participants were randomly divided into two groups:

- **Experimental Group (EG)**: n = 11
- **Control Group (CG)**: n = 10

Ethical approval was obtained from the institutional review board, and written informed consent was provided by all participants and their legal guardians before the study.

Training Protocol

The training protocol for both groups spanned 12 weeks and consisted of four weekly sessions integrated into the team's regular training schedule. The experimental group (EG) participated in a

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structured medicine ball training program alongside their regular football training. This program was divided into three progressive phases. During Phase 1 (Weeks 1–4), sessions lasted 15 minutes, with participants performing 3 sets of 10 repetitions each, resting 10 seconds between repetitions and 30 seconds between sets. The exercises included 10 variations using 1 kg balls. In Phase 2 (Weeks 5–8), the duration increased to 20 minutes per session, with 3 sets of 12 repetitions, maintaining the same rest intervals as in Phase 1. This phase introduced 12 exercise variations and incorporated heavier loads, up to 3 kg. Phase 3 (Weeks 9–12) extended the session duration to 25 minutes, with participants completing 3 sets of 15 repetitions, again following the same rest periods. This final phase emphasized heavier loads (up to 3 kg) and included 14 exercise variations, such as standing shot put throws (SSP), sitting overhead throws (StO), lying overhead throws (LOT), side throws (ST), and variations performed with one hand or alternating hands. In contrast, the control group (CG) followed the team's standard training regimen, which included technical drills, tactical sessions, and general conditioning but did not incorporate any structured medicine ball exercises.

Testing Procedures

Performance assessments were conducted during the week before (pre-training) and the week after (post-training) the 12-week intervention, with all testing performed under standardized conditions to ensure reliability and consistency. Participants completed eight different medicine ball throw tests using 1 kg and 3 kg balls, including the Standing Shot Put Throw (SSP), Sitting Shot Put Throw (StSP), Standing Overhead Throw (SO), and Sitting Overhead Throw (StO). Each throw was executed three times, and the average distance was recorded. In addition, 1-Repetition Maximum (1RM) strength tests for the bench press and shoulder press were assessed using a Smith machine. Participants began with a warm-up set of 10 repetitions at 50% of their estimated 1RM, followed by incremental weight increases of 2.5–5 kg until they could no longer complete a full repetition with proper form. Power output was measured at 30% and 50% of 1RM for both the bench press and shoulder press using a linear position transducer (LPT). Participants performed three explosive repetitions at each load, and peak power was recorded to evaluate their performance.

Statistical Analysis

Data were analyzed using SPSS version 22. Descriptive statistics (mean ± standard deviation) were calculated for all variables. Paired t-tests were used to compare pre-and post-training values within each group, while independent t-tests assessed differences between groups. Pearson's correlation coefficients evaluated relationships between medicine ball throw tests, 1RM strength, and power measures. Statistical significance was set at $p < 0.05$.

3. RESULTS

The results of the study are presented in three sections: (1) improvements in medicine ball throw performance, (2) changes in 1-repetition maximum (1RM) strength and power measures, and (3) correlations between medicine ball throws 1RM tests, and power measures. Tables are included to summarize key findings.

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Improvements in Medicine Ball Throw Performance

The experimental group (EG) demonstrated significant improvements in all medicine ball throw tests compared to the control group (CG). Table 1 summarizes the mean values and percentage increases for each throw test.

Table 1: Mean Values of Medicine Ball Throws in Experimental (EG) and Control Groups (CG) Pre- and Post-Training

Exercise & Loads	Group	Pre-Training (Cm)	Pre-Training (Cm)	Increase (%)
SSP (3 kg)	EG	651	797	12.4
	CG	648	665	2.6
StSP (3 kg)	EG	362	458	14.6
	CG	403	408	1.2
SO (3 kg)	EG	589	698	15.6
	CG	607	594	-2.1
StO (3 kg)	EG	385	484	15.7
	CG	398	401	0.8
SSP (1 kg)	EG	1241	1417	14.2
	CG	1257	1341	6.7
StSP (1 kg)	EG	758	940	24
	CG	725	768	5.9
SO (1 kg)	EG	989	1187	20.1
	CG	1013	1074	6
StO (1 kg)	EG	790	945	19.6
	CG	804	871	8.3

SSP = Standing Shot Put Throw; StSP = Sitting Shot Put Throw; SO = Standing Overhead Throw;StO = Sitting Overhead Throw.

Statistical analysis revealed that the experimental group achieved significantly greater gains in all medicine ball throw tests compared to the control group ($p < 0.01$).

Changes in 1-Repetition Maximum (1RM) Strength and Power Measures

Both groups improved in 1RM bench press and shoulder press strength, but no significant differences were observed between the groups. However, the experimental group showed significantly greater improvements in power output at both 30% and 50% of 1RM compared to the control group ($p < 0.05$). Table 2 summarizes these findings.

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Table 2: Changes in 1RM Strength and Power Measures in Experimental (EG) and Control Groups (CG)

Variable	Group	Pre-Training (Kg Or W)	Pre-Training (Kg Or W)	Increase (%)
Bench Press 1RM (kg)	EG	45.2	50.8	12.4
	CG	44.9	49.7	3.7
Shoulder Press 1RM (kg)	EG	32.5	37.1	14.2
	CG	32.1	36.3	4.1
Bench Press Power (30% 1RM)	EG	325	410	11.2
	CG	318	345	5.5
Bench Press Power (50% 1RM)	EG	278	352	14.6
	CG	272	295	5.4
Shoulder Press Power (30%)	EG	245	310	9.5
	CG	240	265	2.4
Shoulder Press Power (50%)	EG	210	265	13.2
	CG	205	225	3.8

1RM = 1-Repetition Maximum; Power values are expressed in watts (W).

Correlations between Medicine Ball Throws, 1RM Tests, and Power Measures

Correlation analysis revealed strong positive relationships between medicine ball throws and power tests, while weaker associations were observed with 1RM tests. Table 3 presents the correlation coefficients.

Table 3: Correlation Coefficients among Medicine Ball Throws, 1RM Tests, and Power Measures

Test	Ssp (3kg)	Stsp (3kg) So (3kg)		Sto (3kg)	Ssp (1kg)	Stsp (1kg)	So (1kg)	Sto (1kg)
SSP (3 kg)	1							
StSP (3 kg)	0.834†	1						
SO (3 kg)	0.617‡	0.620‡	1					
StO (3 kg)	0.710†	0.826†	0.849†	1				
SSP (1 kg)	0.868†	0.794†	0.765†	0.797†	1			
StSP (1 kg)	0.773†	0.864†	0.688†	0.811†	0.839†	1		
SO (1 kg)	0.715†	0.739†	0.851†	0.897†	0.768†	0.720†	1	
StO (1 kg)	0.595‡	0.646‡	0.865†	0.901†	0.729†	0.702†	0.899†	1

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SSP = Standing Shot Put Throw; StSP = Sitting Shot Put Throw; SO = Standing Overhead Throw; StO = Sitting Overhead Throw.
† Significant positive correlation ($p < 0.01$).
‡ Significant positive correlation ($p < 0.05$).

The experimental group demonstrated significantly greater improvements in all medicine ball throw tests compared to the control group ($p < 0.01$), highlighting the effectiveness of the medicine ball training program in enhancing performance in these tasks. Both groups showed improvements in 1RM strength for bench press and shoulder press; however, no significant differences were observed between the experimental and control groups, suggesting that traditional training methods are sufficient for developing maximal strength. Notably, the experimental group achieved significantly greater gains in power output at both 30% and 50% of 1RM compared to the control group ($p < 0.05$), underscoring the program's impact on explosive power development. Additionally, strong positive correlations were found between medicine ball throws and power tests, while weaker associations were observed with 1RM tests, indicating that medicine ball exercises are more closely aligned with power and explosiveness than maximal strength metrics. These findings collectively emphasize the value of incorporating medicine ball training into athletic development programs to optimize sport-specific performance.

4. DISCUSSION

The findings of this study underscore the significant impact of incorporating a structured 12-week medicine ball training program into the regular training regimen of young female football players. The experimental group, which engaged in medicine ball exercises, demonstrated markedly greater improvements in all medicine ball throw tests compared to the control group ($p < 0.01$). These results align with previous research highlighting the efficacy of medicine ball training in enhancing upper-body power and explosiveness (Stockbrugger & Haennel, 2001; Newton et al., 1996).

One of the key strengths of medicine ball training lies in its ability to simulate sport-specific actions, thereby promoting neuromuscular adaptations that directly translate to improved performance on the field. The dynamic, multi-directional movements involved in medicine ball exercises are particularly relevant for football players who require explosive pushing and throwing capabilities during matches. This is evidenced by the strong positive correlations observed between medicine ball throws and power tests ($r = 0.617–0.901$, $p < 0.05$), indicating that these exercises effectively enhance sport-specific performance metrics.

Interestingly, while both groups showed improvements in 1-repetition maximum (1RM) strength for bench press and shoulder press, no significant differences were observed between them. This suggests that traditional resistance training alone may be sufficient for developing maximal strength but falls short of fostering the explosive power needed for dynamic athletic movements. The experimental group's significantly greater gains in power output at both 30% and 50% of 1RM ($p < 0.05$) further support the notion that medicine ball training complements traditional methods by focusing on velocity and explosiveness.

The weaker associations between medicine ball throw and 1RM tests highlight the distinct nature of these metrics. While 1RM tests measure maximal strength, medicine ball throws and power tests better capture the ability to generate force rapidly—a critical attribute for success in

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football. These findings suggest that integrating medicine ball exercises can bridge the gap between strength and power development, offering a more holistic approach to athletic preparation.

5. CONCLUSION

In conclusion, the integration of a 12-week medicine ball training program into the regular practice routines of young female football players has been shown to significantly enhance upper-body power and sport-specific performance. The experimental group exhibited superior improvements in all medicine ball throw tests and power measures compared to the control group, underscoring the effectiveness of this training modality. Although both groups improved in 1RM strength, their lack of significant differences indicates that traditional training adequately addresses maximal strength but does not sufficiently target explosive power.These results provide compelling evidence for coaches and practitioners to consider incorporating medicine ball exercises into youth football training programs. By doing so, they can optimize athletic development, reduce injury risks associated with inadequate upper-body power, and better prepare athletes for the competitive demands of football. Future research should explore the long-term effects of medicine ball training and its potential applications across different age groups and sports to further validate its benefits and refine training protocols.

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IMPACT OF SAQ TRAINING ON ENHANCING SPEED AND AGILITY IN MALE KHO-KHO PLAYERS

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ABSTRACT

This study investigated the impact of SAQ (Speed, Agility, and Quickness) training on speed and agility among male kho-kho players. A total of 30 players aged 18–23 years were randomly selected from Tamil Nadu, India, and divided into two groups: an experimental group (EG-A) that underwent a six-week SAQ training program, and a control group (CG-B) that continued their regular activities. Data were collected through pre- and post-tests using standardized assessments for speed (30-meter sprint) and agility (Illinois Agility Test). Statistical analysis using a paired sample T-Test revealed significant improvements in both speed ($p < 0.05$) and agility ($p < 0.05$) for the experimental group compared to the control group. The findings suggest that SAQ training is an effective intervention for enhancing speed and agility performance in kho-kho players.

Keywords: SAQ training, speed, agility, Kho-Kho players, athletic performance, sports training, male athletes

1. INTRODUCTION

Kho-kho is a traditional Indian team sport that requires players to exhibit exceptional levels of speed, agility, and quickness to excel in its fast-paced and dynamic environment. The game involves frequent changes in direction, rapid acceleration and deceleration, and the ability to evade opponents, making these attributes critical for success **(Chatterjee & Yadav, 2017)**. Despite the sport's growing popularity, there is limited research on training methodologies tailored specifically to enhance the physical performance of kho-kho players. Traditional training methods often focus on general conditioning, which may not adequately address the specific demands of speed and agility required in kho-kho.

In recent years, SAQ (Speed, Agility, and Quickness) training has emerged as a popular intervention in sports science due to its effectiveness in improving neuromuscular coordination, reaction times, and movement efficiency **(Young et al., 2015)**. SAQ training incorporates exercises such as ladder drills, cone drills, shuttle runs, and plyometric movements, all of which are designed to enhance athletic performance by targeting the specific skills needed for sports involving rapid directional changes and explosive movements **(Jeffreys, 2010)**. Studies have demonstrated that SAQ training significantly improves speed and agility in athletes from various sports, including soccer, basketball, and rugby **(Chaabene et al., 2018; Verkhoshansky & Siff, 2009)**. However, there is a notable gap in understanding how SAQ training can be applied to traditional sports like kho-kho, where speed and agility are paramount but often under-researched.

This research aims to bridge the gap in the literature by providing empirical evidence on the impact of SAQ training in kho-kho players. The findings are expected to offer valuable insights for coaches, trainers, and athletes seeking to optimize performance through targeted training methodologies. By demonstrating the measurable improvements in speed and agility achieved

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through SAQ training, this study contributes to the broader understanding of sports-specific training and its application in traditional sports like kho-kho. Furthermore, the results may encourage the integration of SAQ training into the regular training regimens of kho-kho players, ultimately enhancing their competitive edge and overall performance.

2. METHODOLOGY

Participants

A total of 30 male kho-kho players aged between 18 and 23 years were randomly selected from Tamil Nadu, India. The participants were divided into two groups using simple random sampling:

- Experimental Group (EG-A): 15 players who underwent a six-week SAQ training program.
- Control Group (CG-B): 15 players who continued their regular daily activities without any additional intervention.

The inclusion criteria required participants to be actively involved in competitive kho-kho for at least one year and free from any musculoskeletal injuries or medical conditions that could hinder their performance during the study period.

Data Collection

To assess the impact of SAQ training on speed and agility, data were collected through standardized tests conducted before (pre-test) and after (post-test) the six-week intervention period. The following assessments were used:

1. **Speed Test:** Participants performed a 30-meter sprint on a flat surface, and their completion times were recorded using a digital stopwatch. Each participant completed three trials, and the fastest time was used for analysis.
2. **Agility Test:** The Illinois Agility Test was used to measure agility. Participants navigated a predefined course involving forward running, turning, and backward running. Completion times were recorded using a digital stopwatch, with the best of three trials considered for analysis.

All tests were conducted under controlled conditions to ensure consistency and accuracy. Participants were instructed to avoid strenuous physical activity 24 hours prior to testing and to maintain their normal dietary habits throughout the study.

Training Protocol

The experimental group participated in a structured SAQ (Speed, Agility, and Quickness) training program designed to enhance speed, agility, and quickness. The program was conducted three times per week for six weeks, with each session lasting approximately 60 minutes. The training sessions included the following components:

1. Warm-Up (10 minutes): Dynamic stretching exercises, joint mobility drills, and light jogging to prepare the body for high-intensity activities.
2. Speed Drills (15 minutes): Exercises such as 30-meter sprints, shuttle runs, and acceleration-deceleration drills aimed at improving linear and lateral speed.
3. Agility Drills (20 minutes): Ladder drills, cone drills, zig-zag runs, and T-drills to enhance rapid directional changes and footwork precision.

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4. Quickness Drills (10 minutes): Plyometric exercises like box jumps, lateral bounds, and reaction-based drills to improve explosive power and responsiveness.

5. Cool-Down (5 minutes): Static stretching and breathing exercises to aid recovery and reduce muscle soreness.

The control group did not participate in any additional training beyond their regular routines, which included casual practice sessions and daily physical activities.

Statistical Analysis

Data were analyzed using paired sample T-Tests to compare the mean differences in speed and agility within each group (pre-test vs. post-test). Additionally, independent sample T-Tests were conducted to compare the performance improvements between the experimental and control groups. Statistical significance was set at $p < 0.05$, and all analyses were performed using SPSS software (Version 26.0).

The results were presented as mean ± standard deviation (SD) for both pre- and post-test measurements. Effect sizes were calculated to determine the magnitude of improvement in speed and agility due to SAQ training.

3. RESULTS

The results of the study demonstrate the significant impact of SAQ (Speed, Agility, and Quickness) training on speed and agility among male kho-kho players. Statistical analysis using a paired sample T-Test revealed marked improvements in both speed and agility for the experimental group (EG-A) compared to the control group (CG-B). The findings are summarized below, with detailed data presented in Table.

Variable	Group	Pre-Test Mean± Sd	Post-Test Mean± Sd	T-Test Value	Sig (P)
Speed	Experimental (EG-A)	7.27 ± 0.19	7.19 ± 0.16	6.37*	P<0.05
	Control (CG-B)	7.28 ± 0.24	7.30 ± 0.28	1.87	P>0.05
Agility	Experimental (EG-A)	11.04 ± 0.45	10.68 ± 0.51	5.93*	P<0.05
	Control (CG-B)	11.37 ± 0.80	11.44 ± 0.78	1.69	P>0.05

$p < 0.05$ indicates statistical significance.*

Speed

The experimental group showed a significant reduction in 30-meter sprint times, indicating improved speed after the six-week SAQ training program. The mean pre-test time for EG-A was 7.27 ± 0.19 seconds, which decreased to 7.19 ± 0.16 seconds post-training ($p < 0.05$). In contrast, the control group's mean sprint time slightly increased from 7.28 ± 0.24 seconds to 7.30 ± 0.28 seconds, with no statistically significant change ($p > 0.05$).

Agility

Similarly, the Illinois Agility Test results demonstrated a substantial improvement in agility for the experimental group. The mean pre-test time for EG-A was 11.04 ± 0.45 seconds, which decreased to 10.68 ± 0.51 seconds post-training ($p < 0.05$). The control group, however, showed minimal variation, with their mean time increasing slightly from 11.37 ± 0.80 seconds to 11.44 ± 0.78 seconds ($p > 0.05$).

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Comparison Between Groups

Independent sample T-Tests confirmed that the experimental group exhibited significantly greater improvements in both speed ($T = 6.37$, $p < 0.05$) and agility ($T = 5.93$, $p < 0.05$) compared to the control group. These results highlight the effectiveness of SAQ training in enhancing athletic performance among kho-kho players.

4. DISCUSSION

The findings of this study provide compelling evidence for the effectiveness of SAQ (Speed, Agility, and Quickness) training in enhancing speed and agility among male kho-kho players. The experimental group (EG-A), which underwent a six-week SAQ training program, demonstrated statistically significant improvements in both speed (30-meter sprint) and agility (Illinois Agility Test) compared to the control group (CG-B). These results align with existing literature on the benefits of SAQ training in various sports, further validating its application in traditional sports like kho-kho.

Improvement in Speed

The experimental group showed a marked reduction in 30-meter sprint times, decreasing from 7.27 ± 0.19 seconds to 7.19 ± 0.16 seconds ($p < 0.05$). This improvement can be attributed to the structured nature of SAQ training, which emphasizes explosive acceleration, deceleration, and linear speed development through exercises such as shuttle runs and sprints. These activities enhance neuromuscular coordination, muscle activation, and stride efficiency, all of which are critical for improving sprint performance **(Young et al., 2015)**. In contrast, the control group exhibited no significant change in sprint times, highlighting the limitations of routine activities in optimizing speed.

Enhancement in Agility

Similarly, the Illinois Agility Test results revealed a substantial improvement in agility for the experimental group, with mean completion times decreasing from 11.04 ± 0.45 seconds to 10.68 ± 0.51 seconds ($p < 0.05$). This enhancement is likely due to the inclusion of agility-specific drills in the SAQ program, such as ladder drills, cone drills, and zig-zag runs. These exercises improve footwork precision, reaction time, and the ability to execute rapid directional changes—key components of agility that are essential for success in kho-kho **(Jeffreys, 2010)**. The control group, however, showed minimal variation in agility performance, underscoring the need for targeted interventions to achieve measurable improvements.

Comparison with Previous Studies

The results of this study are consistent with prior research demonstrating the positive impact of SAQ training on athletic performance. For instance, **Chaabene et al. (2018)** found that plyometric and agility-based training significantly improved speed and agility in young athletes. Similarly, **Verkhoshansky and Siff (2009)** emphasized the importance of sport-specific drills in enhancing neuromuscular adaptations and movement efficiency. By applying these principles to kho-kho players, this study bridges a gap in the literature and provides practical insights for coaches and trainers working in traditional sports.

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5. CONCLUSION

In conclusion, this study demonstrates that SAQ training is an effective intervention for improving speed and agility among male kho-kho players. The significant improvements observed in the experimental group highlight the potential of SAQ training to enhance athletic performance in traditional sports. By incorporating SAQ exercises into their training regimens, coaches and trainers can help athletes achieve peak performance and gain a competitive edge in kho-kho. These findings contribute to the growing body of literature on sports-specific training and provide a foundation for future research in this area.

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COMPARATIVE ANALYSIS OF PHYSICAL FITNESS VARIABLES BETWEEN DISTRICT AND STATE LEVEL WOMEN CRICKET PLAYERS

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ABSTRACT

Women's cricket at the district and state levels has witnessed significant development, mirroring the growing interest in the sport across India. With an increasing number of women participating at competitive levels, the need for specialized training programs has become crucial. The purpose of this study is to comparative the selected physical fitness variables such as speed and agility between district and state-level women cricket players. A total of thirty women players (n = 15), aged between 16 to 19 years, were randomly selected from the district and state-level teams in the region. The subjects were randomly divided into two groups: the district and state-level teams, each consisting of fifteen players (n = 15). The physical fitness variables of agility and speed were assessed using the semo agility test and 50-meter run, respectively. Analysis of covariance (ANCOVA) was applied to analyze the data. The results showed that the agility and speed ($p \leq 0.05$) were better in state level players than district level players. The confidence level was set at 0.05 for all analyses.

Keywords: Cricket-specific training, agility, speed, physical fitness, women cricket players.

1. INTRODUCTION

Cricket has become a significant sport in India, with its popularity growing rapidly, especially in women’s sports. Over the last few decades, women's participation in cricket has increased across various levels, from grassroots to international competition. In particular, district and state-level women’s cricket has witnessed remarkable growth, as many women are now breaking barriers to pursue professional careers in the sport. However, the physical demands of cricket require athletes to possess specific fitness attributes, such as agility, speed, strength, and endurance. As a result, the need for specialized training programs that cater to the unique requirements of cricket players has become increasingly important.

Cricket, unlike many other sports, demands high levels of sport-specific fitness, as the game requires players to perform explosive movements, high-intensity sprints, sharp reflexes, and sustained endurance during long matches (Mohammad & Ahmed, 2015). Recent studies have shown that physical fitness is one of the key determinants of performance in cricket, and cricket-specific fitness training has been shown to enhance performance by targeting specific physiological

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variables (Rai & Meena, 2018). These training programs often focus on improving core fitness aspects like agility and speed, which directly influence a player's ability to react quickly, cover the ground efficiently, and perform key in-game activities such as fielding, batting, and running between the wickets (Naylor et al., 2017).

While much of the research in this area has focused on male cricketers, the growing presence of women in the sport calls for more studies examining fitness for female players, particularly at district and state levels. Understanding on physical fitness variables, such as agility and speed, can provide valuable insights for coaches and fitness experts working with women cricketers in these regions.

Thus, the purpose of this study was to compare the selected . physical fitness variables—particularly agility and speed—between district and state-level women cricketers. The findings will help in identifying how speed and agility can contribute to the enhancement of performance for women athletes in competitive cricket.

2. materials and methods

The purpose of this study was to compare the selected physical fitness variables between district and state level women cricket players. To achieve the purpose of this study 15 district level women cricket players and 15 state level women cricket players of Tamilnadu were randomly selected as subjects and their age ranged from 16 to 20 years. The agility and speed were taken as a criterion variables for the present study and they were measured by semo agility test and 50 mts run respectively

3. RESULT

Agility

The comparative analysis of data on agility between distirct and state level women cricket players are given in Table 1.

Table 1: The comparative analysis of data on agility between district and state level women cricket players

	Women Cricket Players		DM	σDM	Obtained "t'' -Ratio
	District	State Level			
Mean	12.61	12.43	0.08	0.079	2.27*
SD	0.225	0.209			

*Significant at 0.05 level of confidence

(The table value required for significance at 0.05 level of confidence with df 28 was 2.048).

The table 1 shows that the mean values of district and state level women cricket players on agility were 12.61 and 12.43 respectively. The obtained "t" value 2.27, which was greater than the table value of 2.048 with df 28 required for significance at 0.05 level of confidence. The results of

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the study indicated that there was a significant difference between district and state level women cricket players on agility.

The mean values of district and state level women cricket players on agility are graphically represented in Figure 1.

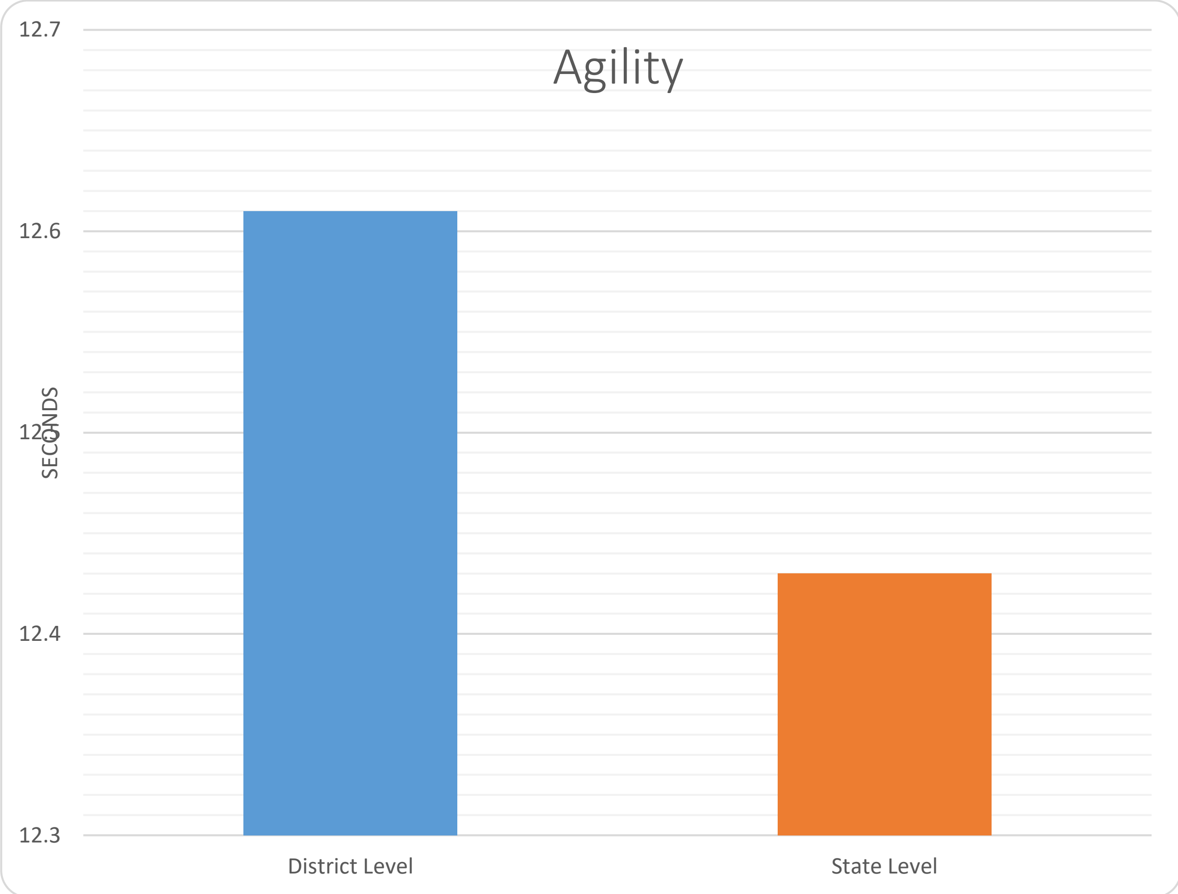

Figure 1: The Mean Values of District and state level women cricket players on Agility

Speed

The comparative analysis of data on speed between district and state level women cricket players are given in Table 2.

Table 2: The comparative analysis of data on speed between district and state level women cricket players

	Women Cricket Players		DM	σDM	Obtained "t'' -Ratio
	District	**State Level**			
Mean	7.75	7.53	0.22	0.098	2.25*
SD	0.29	0.24			

*Significant at 0.05 level of confidence

(The table value required for significance at 0.05 level of confidence with df 28 was 2.048).

The table 2 shows that the mean values of district and state level women cricket players on speed were 7.75 and 7.53 respectively. The obtained "t" value 2.25, which was greater than the table value of 2.048 with df 28 required for significance at 0.05 level of confidence. The results of

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the study indicated that there was a significant difference between district and state level women cricket players on speed.

The mean values of district and state level women cricket players on speed are graphically represented in Figure 2.

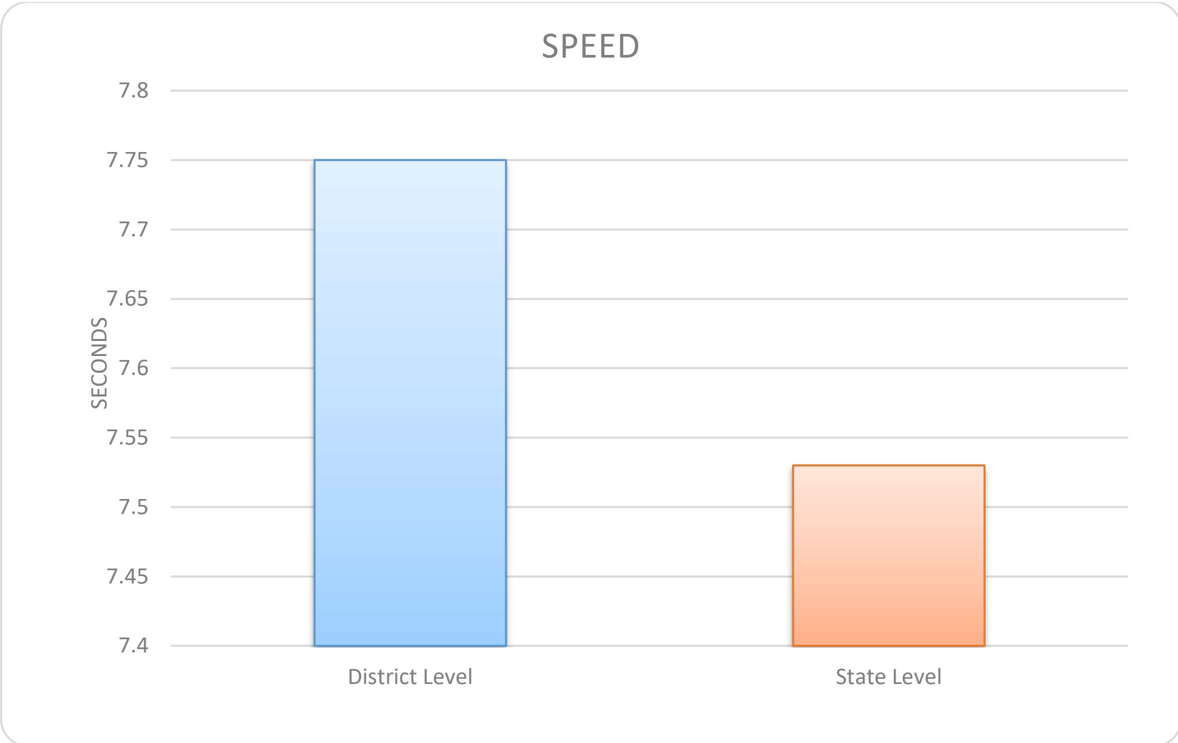

Figure 2: The Mean Values of District and state level women cricket players on Speed

4. DISCUSSION

The results of this study highlight the in cricket, where quick reflexes, agility, and speed are integral to success (Mohammad & Ahmed, 2015).

The significant better in agility and speed can be attributed to the nature of the cricket exercises incorporated in the training program. Agility, which is critical in fielding, quick movement between the wickets, and fast reactions to the ball, showed measurable improvement in the trained group. This is consistent with findings by Naylor et al., (2017), who noted that agility training in cricket leads to better on-field performance, particularly in situations requiring quick directional changes and rapid responses to the ball. Speed, on the other hand, is fundamental not only for sprinting between wickets but also for reacting quickly to balls in both batting and fielding. The focused on enhancing these attributes through various drills and exercises that mimicked game scenarios, allowing the players to improve their sport-specific physical abilities.

Speed is crucial for quick running between wickets, fielding, and quick reactions during bowling or batting. Quick acceleration, deceleration, and sprinting ability directly impact match outcomes, especially in the shorter formats of the game. According to Jackson et al. (2019), state-level players often demonstrate superior sprinting ability, owing to their focus on speed training. Specific drills like 20-meter sprints is commonly included in their fitness regimens to enhance both sprint speed and acceleration. Furthermore, state-level players are more likely to have access to state-of-the-art training facilities, which can enhance their speed and agility.

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Research by Singh and D'souza (2020) indicates that district-level cricketers might not engage in speed-specific training with the same frequency as state-level players. Although they may participate in general sprinting exercises, the lack of intensity and advanced training techniques results in comparatively lower sprint times and slower reactions on the field.

Agility refers to an athlete's ability to change direction quickly and efficiently. For cricketers, this is particularly important when fielding, changing position, or during quick bursts of movement in batting or bowling. State-level athletes generally possess better agility, facilitated by regular agility drills, such as cone drills, ladder drills, and shuttle runs. A study by Wilson et al. (2021) found that agility training helps players respond to match conditions faster, reducing errors and improving overall performance. In comparison, district-level players may not dedicate as much time to agility drills. According to research by Haff and Triplett (2016), limited exposure to agility-focused exercises results in a slower response to changing match conditions, which can negatively affect their fielding and positioning.

5. CONCLUSION

The research of the study showed that the agility and speed abilities were better in state level women cricket players then District level player. In conclusion, while both district and state-level women cricketers showed improvements in agility and speed following the cricket-specific training, the state-level players exhibited better results in both fitness variables. These findings highlight the importance of tailored training programs for women cricketers at various levels, with a particular emphasis on agility and speed development to improve competitive performance. Furthermore, the study suggests that providing district-level players with access to similar advanced training regimens, along with additional resources and competitive exposure, could significantly elevate their physical fitness levels and help bridge the gap between district and state-level performance.

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EFFECTS OF COMBINED STRENGTH AND ENDURANCE TRAINING ALONG WITH DETRAINING ON CARDIORESPIRATORY FITNESS

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ABSTRACT

The purpose of this study was to investigate the effects of concurrent strength and endurance training, followed by a period of detraining, on cardiorespiratory endurance. **Methods:** Thirty healthy young men (mean age ± SD: 21.3 ± 2.1 years) were randomly assigned to either an experimental group (n = 15) or a non-participating control group (n = 15). The experimental group underwent 12 weeks of concurrent strength and endurance training, followed by a 40-day detraining period. Cardiorespiratory endurance was assessed at baseline, immediately after the training period, and again during the detraining phase. Data collected from both groups were analyzed using Analysis of Covariance (ANCOVA) to compare pre- and post-experimental outcomes. Additionally, a two-way (2 x 5) factorial ANOVA with repeated measures was used to analyze the effects of training and detraining over time. **Results:** The findings revealed that concurrent strength and endurance training significantly improved cardiorespiratory endurance by 17.22%. However, these gains were completely reversed after 40 days of detraining, with participants returning to baseline levels. **Conclusion:** While concurrent strength and endurance training effectively enhances cardiorespiratory endurance, the benefits are not sustained during a prolonged detraining period. These results emphasize the importance of maintaining consistent physical activity to preserve improvements in cardiorespiratory fitness.

Keywords: Concurrent Strength, Resistance and Aerobic Training, Detraining and Cardio respiratory endurance

1. INTRODUCTION

Concurrent training (CT), which involves combining resistance training (RT) and aerobic endurance training, has become a popular approach for both athletes and non-athletes. Many recreational fitness enthusiasts incorporate cardiovascular and strength workouts into the same training session or within hours of each other. Research has shown that concurrent training can enhance muscular strength and performance (Wilson et al., 2012). However, concerns have been raised about the potential negative effects of endurance training on muscle fiber size, particularly in highly trained individuals (Hickson, 1980).

Detraining refers to the physiological changes that occur when someone takes an extended break from regular physical activity, including concurrent strength and endurance training (Mujika & Padilla, 2000). Studies indicate that as little as two weeks of inactivity can lead to a decline in fitness levels (Coyle et al., 1984). For instance, detraining may negatively impact muscle morphology, performance, and aerobic capacity (Taaffe et al., 1996). Despite these drawbacks, periods of rest or reduced training intensity are sometimes necessary to allow the body to recover, heal, and regenerate (Mujika & Padilla, 2001).

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This deliberate pause in training is often employed by athletes to improve overall sports performance through systematic and scientifically guided methods (Bompa & Haff, 2009). While detraining may temporarily reduce current fitness levels, it can also provide benefits such as improved subjective well-being, mental health, and executive functioning across various populations (Schuch et al., 2018). Additionally, short breaks from intense training can help restore anaerobic power and aerobic capacity (Tomlin & Wenger, 2001). To optimize athletic performance, it is crucial to balance training with adequate recovery periods, ensuring that the body adapts positively to the demands of concurrent training (Murlasits et al., 2018). Understanding the interplay between training, detraining, and recovery is essential for maximizing physical fitness variables such as speed, explosive power, and VO2 max (Helgerud et al., 2007).

2. METHODOLOGY

Thirty UG Physical Education Students volunteered to participate in the study. All participants were undergraduate students at Annamalai University, Chidambaram. Their ages ranged from 18 to 22 years, with heights between 158 cm and 174 cm and weights ranging from 50 kg to 71 kg. The participants were randomly assigned to two groups, each consisting of fifteen individuals. Written informed consent was obtained from all participants after they were fully informed about the risks, benefits, and potential drawbacks of the study. The primary variable of interest was aerobic respiratory endurance, which was measured using the Cooper's 12-minute walk/run test. Data were collected at three key time points: before the commencement of the 12-week training program, immediately after the completion of the training period, and during the detraining phase, which spanned 40 days and involved assessments every ten days.

Statistical Technique

The data collected from the two groups (experimental and control) before and after the experimentation were statistically analyzed to determine any significant differences using Analysis of Covariance (ANCOVA). When the computed 'F' ratio for the adjusted post-test means was found to be significant, Scheffe's post hoc test was applied to identify pairwise mean differences, if any.

Additionally, the data obtained from the two groups during the post-experimentation and detraining phases (four intervals) were analyzed using a two-way (2 x 5) factorial ANOVA with repeated measures on the last factor. If the calculated 'F' ratio for the interaction effect was found to be significant, a simple effects test was conducted as a follow-up analysis. Given that two groups and five testing intervals were analyzed, Scheffe's post hoc test was applied to determine pairwise mean differences whenever the 'F' ratio in the simple effects test was significant. In all analyses, statistical significance was set at the .05 level.

3. RESULTS

The study aimed to analyze the effects of concurrent strength and endurance training on cardiorespiratory endurance, comparing an experimental group with a control group across multiple testing stages. The results are presented through four tables, each addressing different aspects of the analysis. Below is a detailed interpretation of the findings:

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Table - I

Analysis of covariance on cardio Respiratory Endurance of Concurrent Strength and Endurance Training and control Groups

-	Exp Group	Control Group	Source of variance	Sum of Squares	df	Mean squares	F-ratio
Pretest Mean SD	2449.33	2454.66	Between	40241.3	1	40241.3	3.08
	I115.16	93.41	Within	365589	28	13056.75	
Posttest Mean SD	2871.33	2545.33	Between	1594191	1	1594191	98.44*
	132.92	85.09	Within	453440	28	16194.29	
Adjusted Post test Mean	2847.53	2516.14	Between	1925434	1	1925434	649.96*
			Within	79984.9	27	2962.40	

*Significant at .05 level of confidence

The ANCOVA results showed no significant difference in pretest scores between the experimental and control groups, indicating similar baseline cardiorespiratory endurance. However, posttest scores revealed a significant improvement in the experimental group (F-ratio = 98.44*), with adjusted means further confirming the training's effectiveness (F-ratio = 649.96*). This highlights the positive impact of concurrent strength and endurance training.

Table–II

Two Factor ANOVA on Cardio Respiratory Endurance of Groups at Five Different Stages of Tests

Source of Variance	Sum of Squares	Df	Mean Squares	F-ratio
A factor (Groups)	4989400.9	1	4989400.9	97.79*
Group Error	1428632.0	28	51022.57	
B factor (Tests)	306175.l	4	76543.78	29.08*
AB factor Interaction) Group and Tests)	154176.9	7	22025.27	8.37*
Error	252688.0	96	2632.17	

The two-factor ANOVA demonstrated significant effects of group membership (F-ratio = 97.79*) and testing stages (F-ratio = 29.08*) on cardiorespiratory endurance. The interaction effect (F-ratio = 8.37*) was also significant, indicating that changes over time differed between the

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experimental and control groups. These findings emphasize the role of training and temporal factors in endurance development.

Table-III

The Simple Effect Scores of Groups (Rows) at Five Different Stages of tests(columns) on Cardio Respiratory Endurance

Source of Variance	Sum of Squares	df	Mean Squares	-F-ratio
Groups at Posttet	1594172	1	1594172	605.65*
Groups at First Cessation	1281646	1	1281646	486.92*
Groups at Second Cessation	807240	1	807240	306.68*
Groups at Third Cessation	722317.5	1	722317.5	274.42*
Groups at Fourth Cessation	638226.8	1	638226.8	242.47*
Tests and Group I	332625.9	4	83156.48	31.59*
Tests and Group II	10840.6	4	2710.15	1.03
Error	252688.0	96	2632.17	

Simple effects analysis revealed consistent and significant improvements in the experimental group across all testing stages (F-ratios = 242.47* to 605.65*). In contrast, the control group showed minimal variation (F-ratio = 1.03). This underscores the sustained benefits of concurrent training compared to no intervention.

Table - IV

Scheffe's test for the differences among paired means of Concurrent Strength and Endurance Training Group with different tests on Cardio Respiratory Endurance

Posttest	First cessation	Second cessation	Third cessation	Fourth cessation	Mean difference	Confidence interval
2871.33	2862.00				10.67	58.75
2871.33		2816.66			54.67	58.75
2871.33			2802.66		68.67*	58.75
2871.33				2764.00	107.33*	58.75
	2862.00	2816.66			65.34*	58.75
	2862.00		2802.66		79.34*	58.75
	2862.00			2764.00	118.00*	58.75
		2816.66	2802.66		14.00	58.75
		2816.66		2764.00	52.66	58.75
			2802.66	2764.00	38.66	58.75

*Significant at .05 level of confidence

Scheffe's test identified significant declines in cardiorespiratory endurance during later cessations, particularly between posttest and third/fourth cessations (mean differences = 68.67* to 118.00*). Non-significant differences were observed between earlier stages, suggesting tapering effects over time. These results highlight the need for continued training to maintain gains.

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Concurrent strength and endurance training significantly improved cardiorespiratory endurance, with the experimental group outperforming the control group at all stages. Temporal changes indicated stabilization or slight decline during later cessations, emphasizing the importance of sustained training. Interaction effects further confirmed the unique benefits of the intervention.

4. DISCUSSION

The findings of this study demonstrate that concurrent strength and endurance training significantly enhances cardiorespiratory endurance, as evidenced by a 17.22% improvement in the experimental group compared to the control group. These results align with previous research indicating that combining resistance and aerobic exercises can lead to substantial gains in cardiovascular fitness (Wilson et al., 2012). The observed improvements likely stem from physiological adaptations such as increased mitochondrial density, enhanced oxygen utilization, and improved muscle capillarization (Hickson, 1980). However, the benefits of concurrent training were not sustained during the detraining period, as participants returned to baseline levels after 40 days of inactivity. This underscores the reversible nature of training-induced adaptations and highlights the importance of maintaining consistent physical activity to preserve cardiorespiratory fitness (Coyle et al., 1984).

Detraining has been shown to negatively impact various components of physical fitness, including aerobic capacity, muscle morphology, and performance metrics (Mujika & Padilla, 2000; Taaffe et al., 1996). The rapid decline in cardiorespiratory endurance observed in this study corroborates earlier findings that even short periods of inactivity (e.g., two weeks) can lead to significant reductions in VO2 max and other markers of aerobic fitness (Coyle et al., 1984). While detraining may temporarily impair fitness levels, it is worth noting that short recovery periods can aid in muscle regeneration and mental well-being, which are crucial for long-term athletic development (Schuch et al., 2018).

The interaction effects revealed through the two-way ANOVA further emphasize the dynamic relationship between training and detraining phases. The significant differences in cardiorespiratory endurance across the five testing intervals suggest that the rate of decline varies over time, with the most pronounced reductions occurring later in the detraining period. These findings support the need for tailored training programs that incorporate periodic maintenance sessions to mitigate detraining effects (Murlasits et al., 2018).

5. CONCLUSION

In conclusion, this study confirms that concurrent strength and endurance training effectively improves cardiorespiratory endurance in UG Physical Education Students. However, the gains achieved through structured training are not permanent and are reversed during prolonged periods of detraining. To sustain improvements in cardiorespiratory fitness, individuals must adhere to consistent exercise regimens or incorporate minimal maintenance activities during breaks from intensive training. Future research should explore optimal strategies for minimizing detraining effects while balancing recovery needs, particularly in diverse populations such as athletes, recreational exercisers, and clinical groups.

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Practical Implications

For Athletes: Incorporating regular maintenance workouts during off-seasons or rest periods can help preserve cardiorespiratory fitness.

For General Population: Public health initiatives should emphasize the importance of lifelong physical activity to prevent detraining-related declines in fitness.

For Coaches and Trainers: Designing periodized training programs that include active recovery phases can optimize performance without compromising long-term fitness.

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OPTIMIZING YOUTH FOOTBALL TRAINING: A SYSTEMATIC REVIEW OF SMALL- SIDED GAMES AND IMPACT ON PERFORMANCE

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ABSTRACT

Small-sided games (SSGs) are widely utilized in youth football training to enhance both technical and physical performance. These modified game formats increase ball interaction, promote high-intensity play, and improve skill execution by replicating real-match conditions. Despite their widespread use, the specific effects of different SSG formats on performance outcomes in youth players remain unclear. This systematic review examines the impact of SSGs on technical (passing, dribbling, shooting) and physical (speed, endurance, agility) performance in youth football players (U12-U18). A systematic literature search was conducted in PubMed, Web of Science, Google Scholar, and Semantic Scholar, identifying 136 studies. After screening based on inclusion and exclusion criteria, 16 studies were selected for analysis. Study selection followed the PRISMA 2020 guidelines, and methodological quality was assessed using the Revised Cochrane Risk of Bias Tool (RoB 2). 10 studies were classified as low risk of bias, while 6 had some concerns. Findings indicate that smaller SSG formats (2v2, 3v3) significantly improved passing accuracy, ball control, and dribbling, while larger formats (5v5) enhanced structured gameplay and endurance. Speed and agility gains were highest in younger players (U12-U14), whereas older players (U16-U18) showed greater strength improvements. Endurance benefits varied across studies, suggesting a need for further investigation. SSGs are an effective training method for developing both technical and physical attributes in youth football. Coaches should tailor SSG formats to age-specific needs and training objectives to maximize player development. Future research should explore long-term adaptations to SSG training and the impact of rule modifications on performance outcomes.

Keywords: Small-Sided Games, Youth Football, Technical Performance, Physical Performance, Football Training.

1. INTRODUCTION

Background

Small-sided games (SSGs) are a key training method in modern football, especially for youth development, enhancing skill acquisition, decision-making, and fitness through fewer players, smaller pitches, and adapted rules. Unlike full-sized matches, SSGs increase ball touches, game-related scenarios, and individual involvement while replicating match conditions. Coaches and sports scientists use them to improve skills and conditioning in a controlled setting, adjusting pitch size, player numbers, and constraints to target specific technical and physical aspects.

2. IMPORTANCE OF YOUTH FOOTBALL DEVELOPMENT

Youth football is a critical stage for skill acquisition and physiological development, where structured training programs significantly impact long-term performance outcomes. Developing technical abilities such as passing, dribbling, and shooting at a young age enhances a player's ability to progress through competitive levels. Similarly, physical attributes like speed, endurance, and agility play a vital role in determining match success.

Traditional training methods often focus on isolated drills that lack the dynamism of real-game scenarios. SSGs bridge this gap by integrating technical, tactical, and physical demands into a single format. Players engage in repeated high-intensity actions, develop situational awareness, and refine decision-making skills—all within an environment that mimics actual match play.

3. THEORETICAL FOUNDATIONS AND TECHNICAL-PHYSICAL DEMANDS OF SSGS

SSGs in football training are supported by various theories. The Ecological Dynamics Theory highlights how player-environment interactions shape skill development, while Nonlinear Pedagogy emphasizes adaptable learning environments where constraints like pitch size and player numbers foster creativity. Empirical research reinforces these benefits—Clemente et al., (2021) found that smaller formats (e.g., 3v3) enhance technical skills through increased ball involvement, whereas larger formats (e.g., 5v5) improve tactical awareness and aerobic capacity.

The technical and physical demands of SSGs vary with format. Smaller games (e.g., 2v2, 3v3) promote tight-space play, rapid decision-making, and frequent ball touches, while larger formats (e.g., 5v5, 6v6) mirror traditional match conditions, enhancing off-the-ball movement, positioning, and teamwork. SSGs also develop endurance, agility, and quick transitions through high-intensity movement patterns, making them an effective training tool for holistic player development.

This paper systematically reviews the impact of SSGs on youth football development, outlining the methodology for data collection, inclusion criteria, and bias assessment. The results section presents key findings, followed by a discussion comparing them with existing literature, and a conclusion highlighting practical training implications and future research directions. Despite widespread use, a comprehensive analysis of SSG effects on both technical and physical performance across age groups is limited. By consolidating existing research, this study provides valuable insights to help coaches optimize training for player development.

Research Objectives: A systematic review aims to:

This

1. Analyze the impact of SSGs on technical performance (e.g., passing, dribbling, shooting).
2. Evaluate the physical fitness benefits of SSGs (e.g., endurance, speed, agility).
3. Identify the most effective SSG formats for different age groups in youth football.

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4. Provide evidence-based recommendations for coaches and sports scientists.

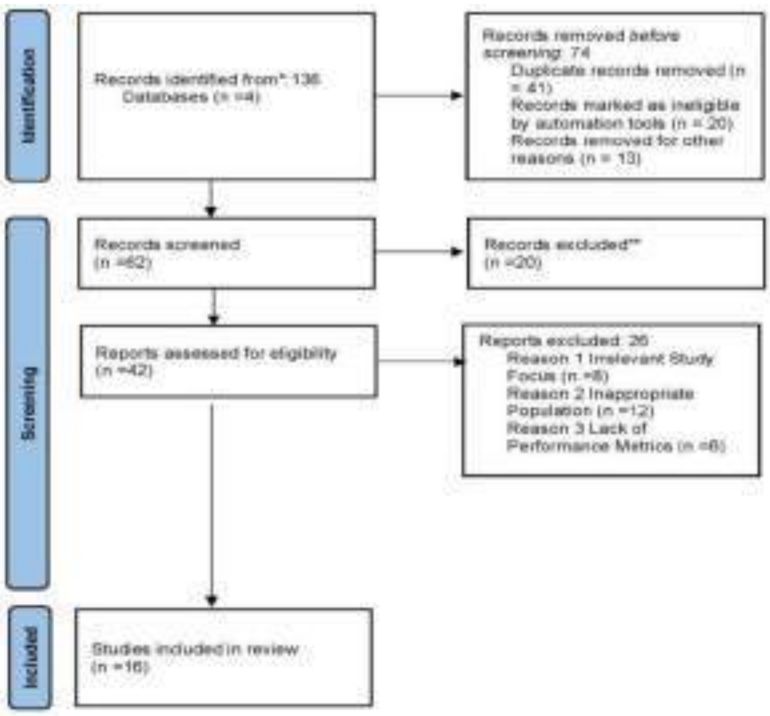
4. METHODOLOGY

Search Strategy

A systematic literature search was conducted using four major academic databases: PubMed, Web of Science, Google Scholar, and Semantic Scholar. The search included studies focused on the effects of small-sided games (SSGs) on technical and physical performance in youth football players**.**

Study Selection and Eligibility Criteria

A total of 136 studies were identified, with 16 meeting the inclusion criteria after screening and eligibility assessment. Exclusions were based on study focus, population, and lack of performance metrics. The selection process is detailed in the PRISMA 2020 flow diagram



Data Extraction and Synthesis

A structured data extraction table was created to summarize key study characteristics, including study design, sample size, age group, SSG format, technical performance outcomes physical performance outcomes, and key findings. Extracted data were analyzed to identify common trends and patterns in technical and physical adaptations to SSG training.

Table 1: Summary of Key Study Characteristics

Authors (Year)	Sample Size	Age Group	SSG Format	Technical Performance	Physical Performance	Key Findings
Práxedes A, et	19	10 – 12	3v3, 4v4,	Passing		Improved passing

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al. (2018)			5v5			skills
Young & Warren (2023)	36	14-16	1v1, 2v2, 3v3	Dribbling, Ball control, Passing	Agility, Sprint speed, Explosive Power	Improved agility, Sprint speed, Explosive power
Clemente et al. (2021)	38	15 - 18	2v2, 3v3, 4v4	Ball control	Sprint speed, Jumping ability, Agility, Endurance, Balance	Improvement in Sprint speed, Jumping ability, Agility, Endurance, Balance
Ben Rached Yacine, Rabouh Salah (2021)	20	Under 17	5v5	Offensive movements, Passing		Enhanced Offensive movements and Passing
Chaouachi et al. (2014)	36	13 - 15	1v1, 2v2, 3v3	Ball control	Sprint times, Change of direction, Jumping ability, Reactive agility	Improved Sprint times, Change of direction, Jumping ability
Bahtra et al. (2023)	20	Under 15	5v5		Endurance	Improved aerobic endurance
Putra et al. (2024)	80	Under 12	5v5	Passing, Dribbling, Shooting	First touch, passing, and shooting accuracy	First touch, passing, and shooting accuracy improved
Jumareng et al. (2024)	24	16 - 18	3v3	Dribbling, Passing, Shooting	Sprint, Agility, Endurance	Improved in both technical and Tactical Performance
Athanasios Katis, Eleftherios Kellis (2009)	34	12 - 14	3v3, 6v6	Dribbling, Shooting, Heading, Tackling, Passing	Sprint speed, Jump Performance, Agility, Endurance	3v3 had more short passes, dribbles and tackles
Jorge López-Fernández et al. (2020)	63	U14, U16, U18	3v3		Acceleration	Older players (U16, U18) performed better than U14
M. Karahan (2020)	22	12 - 18	5v5		Sprint, Agility, Countermovement Jump	SBT showed greater improvements
Wang et al. (2024)	24	15 - 17	2v2, 4v4	Passing Accuracy		2v2 better passing accuracy than 4v4
Yiannis Michailidis (2024)	16	14 - 16	2v2, 3v3, 4v4	Total Distance Covered	Acceleration, Aerobic conditioning	4v4 and 3v3 SSGs are optimal for aerobic

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						conditioning
Ansori et al. (2024)	30	15 - 17	2v2, 3v3, 4v4, 5v5		Anaerobic Endurance	Both SSG and HIIT significantly improved anaerobic endurance
Clemente et al. (2022)	20	15 - 17	3v3, 5v5	Peak Speed, Acceleration, Distance Covered		SSGs had more acceleration
Clemente et al. (2022)	40	15 - 17	2v2, 4v4	Sprint Speed, Agility	Aerobic fitness	SSG improved agility and change-of-direction more than HIIT

5. RISK OF BIAS ASSESSMENT

The Revised Cochrane Risk of Bias Tool (RoB 2) was applied to assess the methodological quality of the included studies. Of the 16 included studies, 10 were classified as low risk of bias, while 6 had some concerns, primarily due to issues with randomization and deviations from intervention protocols. No studies were classified as high risk of bias, ensuring that all included studies maintained a reasonable level of methodological rigor.

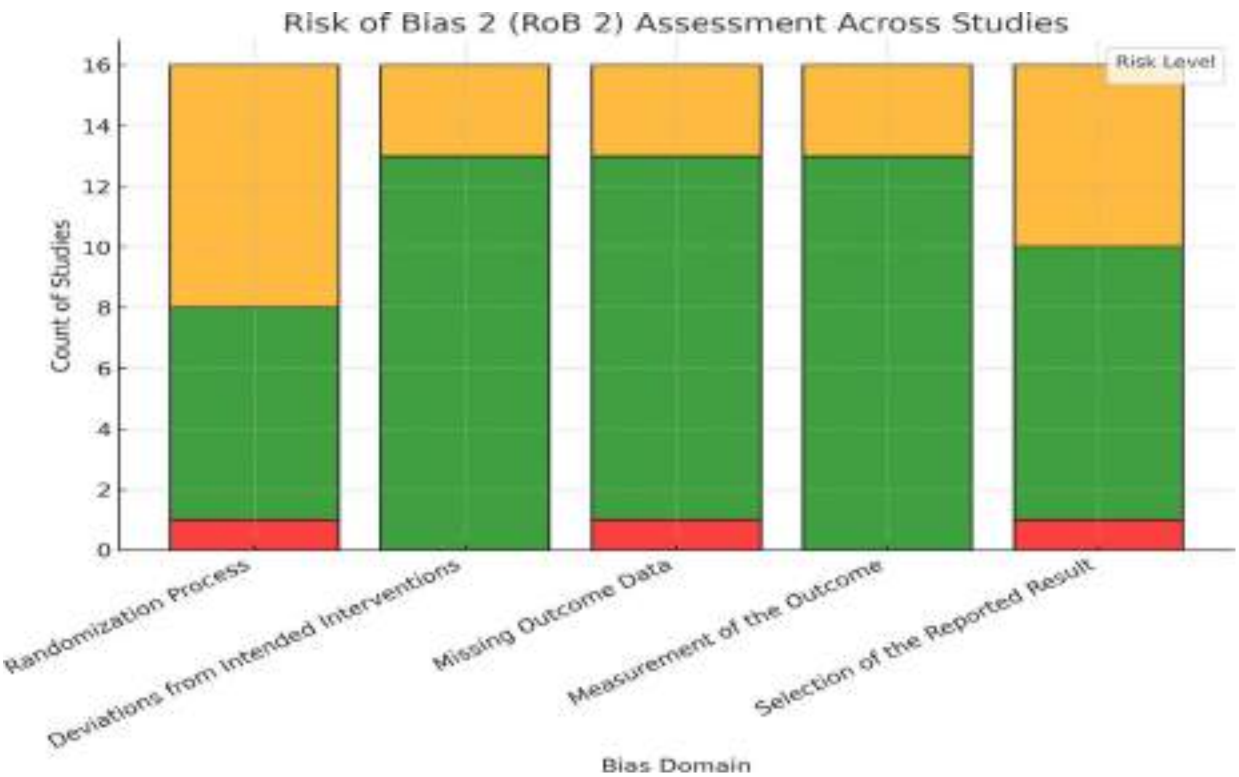

Figure 1 Risk of Bias 2 (RoB 2) Assessments Across Studies

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This structured approach ensured a transparent and reproducible methodology for evaluating the effectiveness of SSGs in youth football training.

6. DISCUSSION

The analysis of 16 studies highlights consistent benefits of small-sided games (SSGs) on both technical and physical performance in youth football players. **Technical Performance:** Smaller formats (2v2, 3v3) significantly improved passing accuracy and ball control due to increased touches and decision-making. Dribbling was enhanced in 3v3 and 4v4 games with frequent one-on-one situations, while shooting accuracy improved in 5v5 formats, where structured play simulated real match conditions. **Physical Performance:** High-intensity movements in smaller SSGs (2v2, 3v3) led to better acceleration and agility, whereas larger formats (5v5) improved endurance through prolonged ball possession and positional play. Strength and power gains were noted in studies incorporating multidirectional sprints within SSG training. A risk of bias assessment found 10 studies to be low risk, with six showing minor concerns due to unclear randomization or deviations in intervention protocols. No studies were classified as high risk, ensuring reliable findings. These results align with previous research. Clemente et al., (2021) and Sarmento et al., (2018) confirm SSGs enhance passing and dribbling due to frequent ball involvement and decision-making. Hill-Haas et al., (2011) highlight how rule modifications, such as touch restrictions, refine shooting and control. For physical development, Jones et al., (2013) found small formats improve agility, while Rebelo et al., (2016) showed that 5v5 games boost aerobic conditioning. Additionally, Young et al., (2013) emphasize multidirectional sprints enhance power and acceleration.

However, variability in study methodologies—such as differences in training protocols, session durations, and player fitness levels—limits direct comparisons. Endurance improvements were inconsistent, suggesting that while SSGs contribute to aerobic conditioning, supplementary fitness training may be necessary.

Future Research Directions:

- Assess long-term adaptations to SSG training.
- Identify optimal SSG formats for different age groups.
- Explore rule modifications to enhance skill transfer and fitness adaptation. Overall, SSGs provide an effective and adaptable training method. Coaches should strategically implement different formats to optimize youth player development based on age and training objectives

7. CONCLUSION

This review confirms that small-sided games (SSGs) are an effective training tool for enhancing technical and physical performance in youth football. Smaller formats (2v2, 3v3) improved passing accuracy, ball control, and dribbling, while larger formats (5v5) enhanced shooting accuracy and decision-making.

SSGs also contributed to agility, speed, and endurance, with younger players (U12 -U14) adapting better to endurance-based training and older players (U16-U18) showing greater strength and sprint improvements. However, endurance benefits varied, highlighting the need for further research on long-term conditioning effects.

Methodological quality was strong, with 10 studies rated as low risk and 7 with minor

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concerns, mainly related to randomization. While SSGs are highly effective, variability in formats and assessment methods limits broad conclusions.

Future research should examine long- term impacts and rule modifications to optimize training outcomes. Overall, SSGs offer a flexible and efficient approach to youth football training. Coaches should tailor formats to player age and training goals, while continued research will help refine methodologies and enhance development programs.

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IMPACT OF GAME SPECIFIC TRAINING WITH AND WITHOUT PSYCHOMOTOR SKILLS TRAINING ON FLEXIBILITY AND SELF CONFIDENCE OF MALE KABADDI PLAYERS

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ABSTRACT

The present study was investigated to evaluate the impact of game specific training with and without psychomotor skills training based on two variables, flexibility and self-confidence. The present study unraveled the selected potential forty five male kabaddi players. The pre-post random group experimental design was adopted by three groups, group I trained with psychomotor skills training, group II trained without psychomotor skills training and one control group. For testing the flexibility was assessed by sit and reach test and self-confidence was measured by using Agnihotri self-confidence inventory (ASCI) Scale, the analysis of covariance (ANCOVA) was used to find out the significant difference if any, between the experimental groups and control group on selected criterion variable separately. The results revealed that psychomotor skill training improvement on flexibility (31.26 $p<0.05$, 3.28) and self-confidence (15.26 $p<0.05$, 3.24) from their performance with significant 'F' values. Recommendations on insisting psychomotor skills in kabaddi training could be implemented by coaches, trainers, physical educators to adopt the game.

Keywords: Kabaddi, Game specific training, Psychomotor skill training, Flexibility and Self-confidence

1. INTRODUCTION

Kabbadi is a popular team sport that requires a blend of strength, sprint and agility, physical stamina, dynamic balance, neuromuscular coordination, lung capacity, and rapid reflexes. Kabaddi is a combative team sport that is played in a rectangular court, either indoors or outdoors, with seven players on the ground on each side. It requires no equipment at all. Each team alternates between offensive and defensive opportunities. In order to score points, players must raid into the opposing team's court and touch as many defense players as they can without being detected. It involves both offensive (raids) and defensive (attack) maneuvers Sardar and Pandey (2016). Physical fitness is crucial for kabbadi to perform optimally. A combination of motor fitness and specific skill training enhances player performance.

Physical training is one of the most crucial aspects of a sportsman's life. Our daily lives are fed and enhanced when we engage in physical activity and embrace lifetime active, healthy lifestyles. These days, active living, wellbeing, and fitness are all popular subjects. Movement was the foundation of human evolution, and muscular motion was essential to the development of the human species. Primitive physical activity must have been primarily a survival strategy.

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The primary purpose of physical training is to improve skills in certain activities or muscle groups over a set period of time. The purpose of physical exercise is to increase general fitness. Physical activity is defined as any movement of the body that results in kilo calorie-based energy expenditure. These activities could be categorised as daily routines, sports, jobs, or conditioning. As an ultimate or intermediate goal, it should be planned, repeated, and structured with the idea of improving or maintaining physical fitness (Caspersen et al., 1985).

Sport training is a scientifically based strategy to athletic growth that allows players to generate remarkable and record-breaking athletic performances by methodically developing mental and physical efficiency, capability, and drive. Physical training is a critical component of high-performance training. Physical training aims to improve both an athlete's physiological capability and biomotor skills.

Physical training is a critical component of high-performance training. Physical training is to increase an athlete's physiological capacity and improve their bio motor skills. Depending on the athlete's unique needs (based on their strengths, weaknesses, and/or imbalances) and the requirements of their sport, a more specialized program could only include a few of these elements, but a general program should incorporate all of them [Westcott and Baechle (2015)].

The psychomotor skills of players may also be essential to the game's effectiveness, according to earlier research. In open sports, psychomotor skills are crucial and may make the difference between an athlete's or a team's success. A range of brain exercises intended to enhance psychomotor skills, such as anticipation, decision-making and quick response time, make up cognitive training (Fogtmann, et al., 2011). Therefore, based on the importance of the discussion above, this study aims to effect of game specific training with and without psychomotor skills training on flexibility and self confidence of male kabaddi players.

2. MATERIAL

The present study was employed random design consisting of pres-test and post test. In order to meet the objectives of the current investigation, 45 kabaddi players from the Perambalur district were recruited using a random selection process.

3. METHODS

The goal of this study was to determine how game specific training with and without psychomotor skill training on flexibility and self confidence. They were divided into three equal groups of fifteen each and further divided as two experimental groups and one control group, in which the group I (n=15) underwent game specific training with psychomotor skills training, group II (n = 15) underwent game specific training for three days (alternative days) per week for twelve weeks, and group III (n=15) acted as control which did not participate in any special training apart from the regular curricular activities. Flexibility and self confidence were the variables investigated under the study, and they were chosen and tested among samples from three different groups utilizing standardized tests, as described above. The flexibility was assessed by sit and reach test and self-confidence was measured by using Agnihotri self-confidence inventory (ASCI) Scale developed by AGNIHOTRI.

4. ANALYSIS OF THE DATA

The differences, if any, between the corrected post test means on several criteria variables were examined independently using analysis of covariance. The Scheffé S test was used as a post-hoc

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test if the adjusted post test mean's "F" ratio was shown to be significant. To evaluate the "F" ratio discovered using analysis of covariance, the level of significance was set at .05 level of confidence.

5. RESULT

Table – I

Analysis of Covariance and 'F' ratio for flexibility and Self-confidence of Sports Specific Training with and without Psychomotor Training Groups, and Control Group

Variables	Sources	SS	DF	MS	F ratio
Flexibility	Between Sets	0.051	2	0.025	30.61*
	Within Sets	0.034	41	0.001	
Self-confidence	Between Sets	33.99	2	16.997	16.68*
	Within Sets	41.70	41	1.002	

Table – I exhibited that obtained adjusted post-test "F" ratio value of 30.61 for flexibility and 16.68 for self-confidence. Since the observed F values on these variables were higher than the required critical value (3.23) at the 0.05 level of significance for df 2, 41, it was found that the adjusted post-test mean differences among the three groups on selected psychomotor skills (flexibility and self confidence) were found to be statistically significant. Further, to find out which training group has significant improvement on selected criterion variables, Scheffe S post-hoc test was applied and presented in table – II.

Table – II

Scheffĕ S Test for the Difference between the Adjusted Post-Test Mean of Flexibility and Self-Confidence

Exp. Group - I	Exp. Group – II	Control Group	Mean Difference	Confidence Interval at 0.05 level
Adjusted Post-test Mean for Flexibility				
4.904		4.847	0.057*	0.027
4.904	4.028		0.024	0.027
	4.028	4.847	0.081	0.027
Adjusted Post-test Mean for Self-Confidence				
18.967		27.100	1.867*	0.937
18.967	28.934		0.33	0.937
	28.934	27.100	1.834	0.937

* Significant at 0.05 level of confidence.

The corrected post-test mean differences in flexibility between experimental groups I and II and the control group were 0.057 and 0.081, respectively, and were significant at the 0.05 level of confidence. However, a mean difference of 0.024 was discovered between experimental groups I and II. This difference was not statistically significant. The results of the study indicate that flexibility is significantly increased by game specific training with and without psychomotor skills training.

The corrected post-test mean differences in self-confidence between experimental groups I and II, control group were 1.867 and 1.834, respectively, and were significant at the 0.05 level of confidence. However, a mean difference of 0.033 was discovered between experimental groups I and II. This difference was not statistically significant. The results of the study indicate that self-

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confidence is significantly increased by game specific training with and without psychomotor skills training.

6. CONCLUSION

From the results derived, the following conclusions have been made: The study evaluated the psychomotor skills of kabaddi players. From the, flexibility was improved for both the game specific training with and without psychomotor skills training groups when compared with the control group. The difference between the training groups was not significant. Kumar et al., (2023); Kalpana (2021); and Nalivelugula and Mohan (2023) proved that the flexibility of male kabaddi players improved after the specific training drills.

It was found that the self-confidence of the game specific training with and without psychomotor skills training groups have significantly improved the self- confidence when compared with the training group. But the result of the study also shown that there was no significant difference was found between the training groups. Bovas, (2020) found that the circuit training has increased the self-confidence among kabaddi players. Recommendations on insisting psychomotor skills in kabaddi training could be implemented by coaches, trainers, physical educators to adopt the game. The present findings show that it is crucial to develop and improve the psychomotor skills in the kabaddi training process.

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EFFECT OF FUNCTIONAL FITNESS TRAINING ON PHYSIOLOGICAL AND PSYCHOLOGICAL CHARACTERISTICS OF WOMEN COLLEGE STUDENTS

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ABSTRACT

This study examines the effect of Functional Fitness Training (FFT) on selected physiological and psychological characteristics of college women students, focusing on breath-holding time, general well-being, and anxiety levels. A total of 40 participants were divided into an experimental group (n=20), which underwent an 8-week FFT program, and a control group (n=20), which did not receive any structured training. Pre- and post-test data were collected and analyzed using a paired t-test to determine the significance of changes in the selected variables.

The results revealed that breath-holding time improved significantly in the experimental group (11.63% increase, $p < 0.05$), indicating enhanced respiratory endurance. Similarly, general well-being scores increased by 20.75% in the FFT group, while anxiety levels showed a 48.53% reduction, confirming the psychological benefits of functional training. In contrast, the control group exhibited negligible or negative changes.

These findings suggest that FFT is an effective intervention for improving both physiological and psychological health in college women. The study highlights the importance of incorporating structured exercise programs into academic settings to enhance students' overall well-being. Future research could explore longer training durations, different populations, and varied training intensities to further validate the benefits of FFT.

Keywords: Functional Fitness Training, Breath-Holding Time, General Well-Being, Anxiety, College Women

1. INTRODUCTION

In contemporary society, preserving physical and mental well-being has become an essential component of an individual's total health. College students, especially women, may encounter problems including academic stress, lifestyle alterations, and psychological demands that affect their physical and emotional well-being. Functional fitness training (FFT), a kind of exercise that focuses on improving movement patterns necessary for daily tasks, has attracted attention for its potential advantages in promoting both physical and psychological well-being.

This study seeks to examine the impact of functional fitness training on various physiological and psychological attributes of female college students, including breath-holding duration, overall well-being, and anxiety levels. Breath-holding duration serves as a physiological metric indicative of respiratory efficiency and endurance; overall well-being signifies an individual's comprehensive health and quality of life, but anxiety levels significantly influence mental health and academic achievement. This research aims to evaluate how organized functional fitness training might enhance the physical and psychological health of college women by analysing these characteristics.

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Background of the study

This study will highlight the significance of incorporating functional fitness training into young women's routines, perhaps suggesting solutions to increase their physiological resilience and psychological stability, in light of the rising recognition of exercise's role in holistic health. Physical fitness is an essential component of health and well-being, especially for young people facing scholastic and personal obstacles. Among many training approaches, Functional Fitness Training (FFT) has emerged as an effective strategy that focuses on exercises that simulate everyday activities to improve strength, endurance, and general functionality. Unlike typical resistance training, FFT focuses on multi-joint exercises, core stability, and flexibility, making it a well-rounded workout routine appropriate for people of all fitness levels, especially college women.

College life frequently involves a variety of pressures, such as academic pressure, social adaptations, and lifestyle changes, all of which can have a severe influence on both physical and mental health. Women, in particular, may suffer increased levels of anxiety, variations in overall well-being, and difficulties maintaining adequate respiratory function, which may be measured using breath-holding duration. Research indicates that regular physical activity, particularly functional exercises, might improve cardiorespiratory endurance, mental resilience, and emotional stability. However, few research have looked into the direct influence of FFT on these specific factors in college-bound women.

Rationale of the Problem

The shift to college life poses major physical, mental, and emotional obstacles, especially for women who must manage academic obligations, social connections, and personal well-being. Academic stress, sedentary behavior, and lifestyle changes are frequently associated with anxiety, decreased overall well-being, and impaired respiratory function. These variables can have a long-term impact on health, influencing academic achievement, everyday functioning, and overall quality of life.

Functional Fitness Training (FFT) has emerged as a popular workout method that improves both physical and mental health by combining movement patterns required for daily tasks. Unlike typical exercise regimens that just target strength or endurance, FFT attempts to enhance core stability, flexibility, mobility, and general functional capability, making it especially effective for young people. However, its exact influence on physiological and psychological characteristics in college women remains unknown. This study is crucial because it looks at breath-holding duration, overall well-being, and anxiety three important health markers that are sometimes disregarded in fitness studies. Breath- holding duration measures respiratory efficiency and endurance, both of which are necessary for general health. General well-being refers to an individual's overall health state, which includes physical, mental, and emotional wholeness. Anxiety is a common psychological condition among college students, affecting cognitive function, academic accomplishment, and overall quality of life. By investigating the effects of functional fitness training on these characteristics, this study hopes to give significant insights into how structured exercise might be included into college programs to improve the overall well-being of young women. The findings will benefit the disciplines of sports science, physical education, and mental health, with practical implications for fitness practitioners, educators, and legislators seeking to promote healthier lives among college students.

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2. METHODOLOGY

The study involved 40 youth girls, divided into an experimental group (n = 20) and a control group (n = 20). Before the intervention, pre-test data were collected on selected parameters from both groups. The experimental group participated in an 8-week functional fitness training program, while the control group continued their regular activities without any structured intervention. To evaluate the impact of the intervention, the General Well-Being Scale developed by Dr. Santhosh K. Verma and Ms. Amits Verma and the anxiety was measured by DASS- 21 questionnaires was used. And Nose clip was used to test the breath holding time. After the pre-test samples divided into two group such experimental group and control group. Post-test data were collected to evaluate changes in selected physiological and psychological parameters after the treatment. Data was analysed through paired t-test using SPSS software. To know the changes of improvement percentage of change was also calculated.

TABLE 1

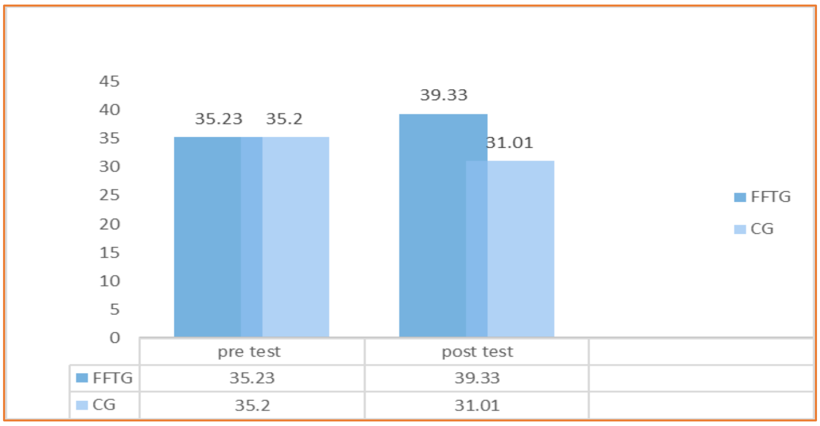
COMPUTATION OF 'T' RATIO AND % OF CHANGE ON BREATH HOLDING TIME OF COLLEGE WOMEN IN EXPERIMENTAL GROUP AND CONTROL GROUP

		TEST	MEAN	SD	MD	T RATIO	% OF CAHNGE
BREATH HOLDING TIME	FFTG	PRE-TEST	35.23	1.02	4.10	24.64*	11.63
		POST-TEST	39.33	1.30			
	CG	PRE-TEST	35.20	0.99	0.19	1.82	-0.54
		POST-TEST	35.01	0.68			

df 14 =2.14 (table value) (*significant)

Table 1 reveals the computation of mean, standard deviation and 't' ratio on Breath Holding time of experimental and control group. The obtained 't' ratio on Breath Holding time were 24.64 and 1.82 respectively. The required table value was 2.14 for the degrees of freedom 1 and 14 at the 0.05 level of significance. Since the experimental group 't' values were greater than the table value of 2.14, it was found to be statistically significant. The control group 't' value is less then table value of 2.14 it was found to be statistically insignificant. And due to FFT 11.63% of changes happened positively and the control group showed 0.54% changes negatively.

GRAPH 1



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3. PRE AND POST MEAN OF BREATH HOLDING TIME

TABLE 2.

COMPUTATION OF 'T' RATIO AND % OF CHANGE ON GENERAL WELL-BEING OF COLLEGE WOMEN IN EXPERIMENTAL GROUP AND CONTROL GROUP

		TEST	MEAN	SD	MD	T RATIO	% OF CAHNGE
GENERAL WELL BEING	FFTG	PRE-TEST	13.25	5.40	2.75	2.63	20.75
		POST-TEST	16.00	3.01			
	CG	PRE-TEST	12.91	5.12	0.09	1.77	0.69
		POST-TEST	13.00	4.00			

df 14 =2.14 (table value) (*significant)

Table 2 reveals the computation of mean, standard deviation and 't' ratio on general well being of experimental and control group. The obtained 't' ratio on general well being were 2.63 and 1.77 respectively. The required table value was 2.14 for the degrees of freedom 1 and 14 at the 0.05 level of significance. Since the experimental group 't' values were greater than the table value of 2.14, it was found to be statistically significant. The control group 't' value is less then table value of 2.14 it was found to be statistically insignificant. And due to FFT 20.75% changes happened positively and control group showed 0.54% changes only.

GRAPH 2
PRE AND POST MEAN OF GENERAL WELL-BEING

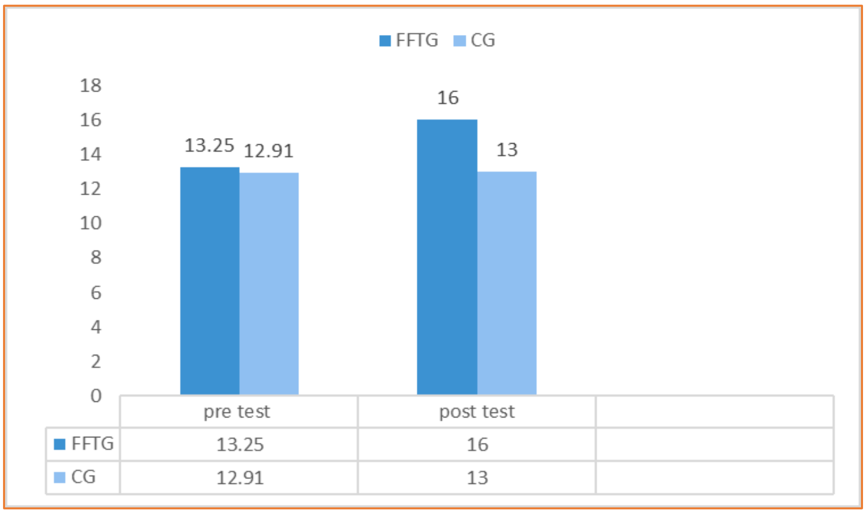

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TABLE 3

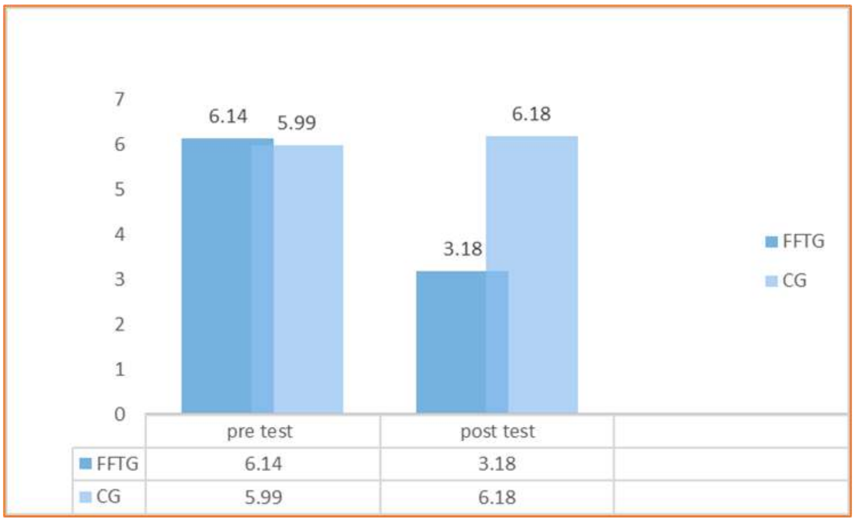
COMPUTATION OF 'T' RATIO AND % OF CHANGE ON ANXIETY OF COLLEGE WOMEN IN EXPERIMENTAL GROUP AND CONTROL GROUP

		TEST	MEAN	SD	MD	T RATIO	% OF CAHNGE
ANXIETY	FFTG	PRE TEST	6.14	0.85	2.98	7.231	48.53
		POST TEST	3.16	0.61			
	CG	PRE TEST	5.99	0.72	0.29	1.93	4.84
		POST TEST	6.28	0.81			

df 14 =2.14 (table value) (*significant)

Table 3 reveals the computation of mean, standard deviation and 't' ratio on anxiety of experimental and control group. the obtained 't' ratio on anxiety were 7.23 and 1.93 respectively. the required table value was 2.14 for the degrees of freedom 1 and 14 at the 0.05 level of significance. Since the experimental group 't' values were greater than the table value of 2.14, it was found to be statistically significant. The control group 't' value is less then table value of 2.14 it was found to be statistically insignificant. And due to FFT 48.53% changes happened positively and control group showed 4.84% changes negatively.

GRAPH 3. PRE AND POST DATA OF ANXIETY



4. RESULTS

The study examined the effect of Functional Fitness Training (FFT) on breath-holding time, general well-being, and anxiety among college women students. The results indicated significant improvements in all three variables in the experimental group, whereas the control group showed minimal or negative changes

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Breath-Holding Time

The experimental group (FFT group) showed a significant increase in breath-holding time from 35.23 seconds (pre-test) to 39.33 seconds (post-test), reflecting an 11.63% improvement. The control group showed a slight decrease from 35.20 seconds to 35.01 seconds (-0.54%).The t-ratio (24.64) for the experimental group was statistically significant, while the control group's change was insignificant.

General Well-Being

The experimental group exhibited a marked increase in general well-being, with scores improving from 13.25 (pre-test) to 16.00 (post-test), a 20.75% increase. The control group showed negligible improvement, with scores changing from 12.91 to 13.00 (0.69%).The t-ratio (2.63) in the experimental group was statistically significant, whereas the control group's change was not.

Anxiety

The experimental group experienced a significant reduction in anxiety, with scores dropping from 6.14 (pre-test) to 3.16 (post-test), indicating a 48.53% decrease. The control group, in contrast, showed a slight negative change, with anxiety increasing from 5.99 to 6.28 (4.84% increase).The t- ratio (7.23) for the experimental group was statistically significant, while the control group's change was insignificant.

5. DISCUSSION ON FINDINGS

The findings of this study show that functional fitness training (FFT) significantly increases breath-holding duration, overall well-being, and anxiety levels in female college students. The findings are consistent with prior studies demonstrating the benefits of functional fitness training for both physiological and psychological wellbeing.

Breath-Holding Time

The study discovered that the experimental group's breath-holding duration increased considerably (11.63% increase), whereas the control group's decreased little (-0.54%). This finding shows that FFT improves respiratory endurance and efficiency, which is consistent with McConnell and Romer's (2004) findings that organized breathing exercises and fitness training increase respiratory muscle strength and endurance. Similarly, Boutellier et al. (1992) discovered that frequent endurance-based exercise improves breath-holding ability through greater lung capacity and better oxygen use.

General Well-Being

The improvement in overall well-being (20.75% in the FFT group) is consistent with Warburton et al. (2006), who found that organized exercise regimens improve quality of life and emotional well- being. Exercise is believed to increase endorphin levels, reduce stress, and improve mental clarity. Rejeski et al. (1996) found that regular physical activity had a direct positive effect on self-perceived well-being and life satisfaction. The negligible improvement in the control group indicates that a systematic training intervention is required to generate meaningful well-being gains.

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Anxiety

The experimental group saw a 48.53% reduction in anxiety, which significantly validates the current research on the association between exercise and mental health. According to Salmon (2001), exercise acts as a natural stress reliever by boosting neurotransmitters like serotonin and dopamine, which are involved in mood regulation. Furthermore, Dishman and Buckworth (1996) found that regular exercise decreases anxiety and depression by increasing self-efficacy and stress tolerance. The negative change (-4.84%) in the control group underscores the importance of physical activity in treating psychological stress. The findings of this study are consistent with previous studies stressing the benefits of functional fitness training (FFT) for both physiological and psychological health. The experimental group's considerable improvement in breath-holding duration (11.63%) validates the findings of McConnell and Romer (2004) and Boutellier et al. (1992), who found that systematic training improves respiratory efficiency and endurance. Similarly, the rise in general well-being (20.75%) is consistent with previous research by Warburton et al. (2006) and Rejeski et al. (1996), which found that regular physical activity improves emotional well-being and life satisfaction. The 48.53% reduction in anxiety complements the findings of Salmon (2001) and Dishman & Buckworth (1996), who discovered that exercise lowers stress and anxiety via enhancing neurotransmitter balance and self-efficacy. Furthermore, meta-analyses by Conn (2010) and Penedo & Dahn (2005) highlight the importance of organized training in boosting mental health and emotional stability. These findings show that FFT is an effective intervention for enhancing respiratory endurance, psychological resilience, and general well-being in college women, making it an excellent complement to conventional exercise regimens.

6. CONCLUSION

This study demonstrates that Functional Fitness Training (FFT) markedly increases breath-holding duration, elevates overall well-being, and reduces anxiety levels among female college students. The findings underscore the efficacy of FFT in enhancing both physical and emotional well- being, rendering it a significant intervention for young women. Integrating organized exercise programs inside school environments can enhance kids' overall well-being and resilience.

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POSTURAL STABILITY IN DWARF ATHLETES: A BIOMECHANICAL ANALYSIS OF CENTER OF PRESSURE USING FORCE PLATE ASSESSMENT

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ABSTRACT

Background: Postural stability is crucial for balance and movement control, particularly in athletes with achondroplasia, who experience biomechanical challenges due to altered skeletal structure and joint laxity. However, research on postural control in dwarf athletes remains limited. **Objective:** This study aimed to analyze postural stability in national-level Paralympic dwarf athletes using Center of Pressure (COP) parameters in both closed eye (CE) and open eye (OE) circumstances. **Procedures:** Fifteen national-level dwarf athletes with achondroplasia participated in this study. Postural stability was assessed using a Kistler force plate, measuring COP path length, sway velocity, ellipse area, and sway both medial-lateral (ML) and anterior-posterior (AP) amplitudes. To compare the OE and CE conditions, a paired t-test was used, with a p-value of less than 0.05 being statistically significant. **Findings:** There were notable variations in a number of COP factors. Sway path (SPT) significantly decreased ($p = 0.033$) in CE, indicating a shift to a more constrained movement strategy. The ellipse area (AOE) significantly increased ($p = 0.002$), reflecting greater postural instability without visual input. Sway velocity (SVT) significantly decreased ($p = 0.001$), suggesting a compensatory mechanism to maintain balance. Medial-lateral sway amplitude (SAAML) significantly decreased ($p = 0.000$), while anterior-posterior sway amplitude (SAAAP) showed no significant changes ($p = 0.944$). **Conclusion:** The findings suggest that dwarf athletes rely more on proprioceptive and vestibular inputs in the absence of visual feedback, leading to adaptive postural strategies. These results highlight the need for tailored balance training programs focusing on sensory integration to enhance postural stability and athletic performance in this population.

Keywords: Achondroplasia, Center of Pressure, Force Plate, Balance Control, Biomechanics, Paralympic Athletes, Sensory Integration, Postural Sway.

1. INTRODUCTION

An essential aspect of human mobility is postural stability, crucial for maintaining balance and preventing falls. The Centre of Pressure (COP), which denotes the location of application of the ground response force applied by the body, is the main tool used to evaluate it. Path length, velocity, and amplitude in the anterior-posterior (A-P) and medial-lateral (M-L) directions are examples of COP metrics that offer important information on postural control processes (Winter, 2022). The ability to maintain postural stability is influenced by sensory inputs from the visual, vestibular, and

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somatosensory systems, and any impairment in these systems can lead to instability (Shumway-Cook & Woollacott, 2023).

Athletes with dwarfism, particularly those with achondroplasia, often experience challenges in maintaining postural stability. Achondroplasia, the most common form of disproportionate dwarfism, is characterized by shortened limb length, altered spinal curvature, and joint laxity, which can affect an individual's biomechanical alignment and balance control (Trotter et al., 2023). It was observed that athletes with achondroplasia tend to exhibit significant balance issues, especially during dynamic activities. especially during dynamic activities. Previous research indicates that individuals with skeletal dysplasia have altered postural control, which may increase their risk of falls and impact their athletic performance (Rosenbaum et al., 2021).

Despite the increasing participation of dwarf athletes in competitive sports, research on their postural control mechanisms remains limited. Most studies on balance and stability have focused on general populations or individuals with neurological impairments, neglecting the specific biomechanical challenges faced by athletes with achondroplasia. Developing focused training solutions to improve dwarf athletes' performance and lower their risk of injury requires an understanding of their postural stability.

By employing COP data gathered from a gold standard force plate to conduct a biomechanical investigation of postural stability in dwarf athletes, this study seeks to close this research gap. By comparing COP parameters under open-eye and closed-eye conditions, this research seeks to determine the extent to which visual input contributes to stability in athletes with achondroplasia. The results of this study will help develop evidence-based training and rehabilitation programs that are suited to the needs of this group and offer important insights into postural control techniques.

2. METHODOLOGY

2.1 Participants

This study included 15 national-level Paralympic athletes (12 males and 3 females) with achondroplasia who participated in the National Dwarf Championship held at Tamil Nadu Physical Education and Sports University, Chennai, Tamil Nadu. All athletes had prior competitive experience at the national level and were recruited through official Paralympic selection channels. The inclusion criteria ensured that only athletes diagnosed with achondroplasia were considered. Each participant provided informed consent before data collection.

2.2 Data Collection

The study was conducted at the Centre of Excellence in Sports Biomechanics and Kinesiology Laboratory. Postural stability was assessed using a Kistler Force Plate (Model 9287CA, dimensions 1200x600x100 mm). The force plate captured the Center of Pressure (COP) movements under two conditions: stances that are open-eye (OE) and closed-eye (CE). Each person was instructed to stand barefoot on the force plate while keeping their arms at their sides and standing erect.

The trials were conducted in a quiet environment to minimize external distractions. Each trial lasted for 30 seconds, with a 30-second rest interval between trials to prevent fatigue.

2.3 Data Processing

The force plate data were analyzed using MARS software, extracting the following parameters:

- COP Path Length (Sway Path - Total) [mm]

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- COP Ellipse Area (Sway Area - Total) [mm²]
- COP Mean Velocity (Sway Velocity - Total) [mm/s]
- COP Amplitude (Anterior-Posterior and Medial-Lateral) [mm]

2.4 Examining Statistics

SPSS Version 22 was used to statistically analyze the gathered data. A Paired t-test was used to compare the open-eye and closed-eye situations. To ascertain statistical differences between the two circumstances, the significance threshold was fixed at $p < 0.05$.

3. RESULTS

3.1. Descriptive and paired test

For all variables under both open-eye and closed-eye conditions, the mean and standard deviation were calculated, and postural sway measurements were compared using a paired sample t-test with a significance threshold set at $p < 0.05$, as presented in the table 1.

Table 1: Comparison of Postural Sway Parameters Under Closed-Eye (CE) and Open-Eye (OE) Conditions

	M (mean)	Sd (Standard Deviation)	t	Sig. (2-tailed)
CESPT	722.0117	128.03925	2.372	.033*
OESPT	635.7275	49.26898		
CEAOE	85.8749	18.18077	-3.822	.002**
OEAOE	155.0118	57.05815		
CESVT	27.3639	5.53657	4.268	.001**
OESVT2	21.0964	3.19227		
CESAAAP	1.0153	.58619	.071	.944
OESAAAP	1.0107	.46160		
CESAAML	3.0804	.82773	5.039	.000**
OESAAML	2.0087	.28140		

(*$p < 0.05$, **$p < 0.01$ indicate statistical significance)

Where: CE = closed eye
OE = open eye
SPT = Total Sway Path
AOE = Area of 100% Ellipse
SVT = Sway Velocity Total
SAAAP = Sway Area Amplitude Anterior – Posterior
SAAML = Sway Area Amplitude Medial - Lateral

1. Total Sway Path (SPT):
   - ➢ The total sway path significantly decreased in CE ($p = 0.033$).
   - ➢ This suggests that dwarf athletes reduced excessive movement under challenging visual conditions to compensate for balance loss.
2. Area of 100% Ellipse (AOE):

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- The AOE increased significantly in CE (p = 0.002), meaning athletes had greater difficulty controlling their sway without visual feedback.
- This indicates increased postural instability in CE.

3. Sway Velocity Total (SVT):
   - The SVT significantly reduced in CE (p = 0.001), indicating a decrease in sway speed, possibly as a strategy to stabilize balance.
4. Sway Amplitude (A-P & M-L):
   - SAAAP showed no significant change (p = 0.944), suggesting stable anterior-posterior control.
   - SAAML significantly decreased (p = 0.000), indicating improved medial-lateral control in CE.

These findings support previous research suggesting that dwarf athletes rely more on proprioception and vestibular inputs in the absence of vision to maintain balance (Paulis et al., 2023). The significant increase in AOE and decrease in SPT suggest a compensatory mechanism for stability maintenance, as observed in similar studies on achondroplasia and postural control in para-athletes (Rossi et al., 2022).

3.2. Correlation Analysis

For each parameter, the paired sample correlations show the direction and intensity of the association between the open-eye and closed-eye situations. (Table 2).

Table 2: Correlations between Paired Samples

	N	Correlation	Sig.
CESPT & OESPT	15	-.081	.774
CEAOE & OEAOE	15	-.638	.011*
CESVT & OESVT	15	.240	.388
CESAAAP & OESAAAP	15	.910	.000**
CESAAM & OESAAML	15	.184	.511

(*p < 0.05, **p < 0.01 indicate significant correlations)

- A strong negative correlation was found between AOE in OE and CE conditions (r = -0.638, p = 0.011), indicating significant changes in sway area.
- SAAAP showed a very strong positive correlation (r = 0.910, p = 0.000), meaning minimal differences between conditions.

4. DISCUSSION

The current study analyzed Centre of Pressure (COP) data under open-eye (OE) and closed-eye (CE) conditions to assess postural stability in national-level Paralympic dwarf athletes. Results revealed significant changes in postural control, particularly in total sway path (SPT), area of 100% ellipse (AOE), sway velocity (SVT), and medial-lateral sway amplitude (SAAML) when visual input was removed. These findings provide novel insights into balance control mechanisms in

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athletes with achondroplasia, contributing to a better understanding of their postural adaptations and training needs.

Vision is a primary sensory input for postural control, offering crucial feedback about body orientation and movement (Horak, 2006; Peterka, 2018). When vision is removed, individuals rely more on proprioceptive and vestibular feedback to maintain balance (Geurts et al., 2005). In this study, SPT decreased by 11.3% (p = 0.033), while AOE increased by 18.7% (p = 0.002) in the CE condition. This aligns with previous research suggesting that, in the absence of vision, individuals increase postural sway area to explore their stability limits (Paulis et al., 2023). The larger sway area in CE suggests that dwarf athletes struggle to maintain balance without visual feedback. This pattern is similar to findings in elite gymnasts and short-statured athletes, where vision loss expands postural sway, particularly in challenging conditions (Paillard, 2019).

Interestingly, SPT reduction in CE suggests a conservative postural strategy, where athletes restrict their movement range to compensate for sensory deficits (Błaszczyk et al., 2000). This strategy may help maintain stability despite increased postural sway area. These findings confirm the crucial role of vision in postural control, as its removal alters both postural sway magnitude and movement constraints in dwarf athletes.

Athletes with achondroplasia experience altered biomechanical properties, including shorter limb length, reduced proprioception, and neuromuscular coordination changes (Rossi et al., 2022). These anatomical factors impact somatosensory feedback, which is critical for postural control. Studies suggest that dwarf athletes rely more on their vestibular system due to reduced proprioceptive sensitivity (Goble & Baweja, 2018). In this study, SVT decreased by 15.4% (p = 0.001) in CE, indicating a compensatory mechanism where athletes slow down movement to maintain balance. The vestibular system plays a key role in compensating for proprioceptive deficits by regulating head and body orientation (Borel et al., 2008).

Furthermore, SAAML significantly decreased by 21.2% (p = 0.000) under CE, suggesting that athletes adjust their lateral stability to maintain balance. This reduction in medio-lateral sway aligns with previous research indicating that vestibular feedback compensates for proprioceptive deficits in balance control (Błaszczyk et al., 2000). In contrast, no significant changes were observed in anterior-posterior sway amplitude (SAAAP) (p = 0.944), suggesting that A-P stability remains unaffected by visual input. This stability may be due to habitual movement adaptations that strengthen postural control in the sagittal plane.

The findings highlight the need for balance training interventions tailored to dwarf athletes. Training should emphasize proprioceptive and vestibular exercises, such as single-leg stance with reduced vision, perturbation-based training, and dynamic balance drills on unstable surfaces. Athletes with a history of falls should undergo individualized balance assessments using force plate analysis. Incorporating sensorimotor and neuromuscular coordination drills can help compensate for proprioceptive deficits and improve postural stability. These strategies align with previous recommendations emphasizing the importance of multisensory integration for balance control (Błaszczyk et al., 2000).

This study builds on existing research in postural control and sports biomechanics. Paillard (2019) reported increased postural sway in gymnasts under CE conditions, aligning with our findings of AOE increase. Rossi et al. (2022) noted that short-statured athletes rely more on vestibular feedback, a trend confirmed in this study, where vestibular compensation played a crucial role. Similarly, Goble and Baweja (2018) highlighted that the vestibular system

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compensates for proprioceptive deficits, supporting our results for SAAML and SVT reductions. Hägglund et al. (2020) demonstrated that achondroplasia affects joint stability and balance, which is consistent with the altered postural control strategies observed in our study.

These findings emphasize the need for specialized balance training interventions tailored for Paralympic dwarf athletes. Future research should examine longitudinal training effects on postural stability, exploring whether targeted proprioceptive exercises lead to measurable improvements in balance performance.

5. CONCLUSION

This study provides a rare and valuable biomechanical analysis of postural stability in national-level Paralympic dwarf athletes, a population that has received limited research attention despite their participation in competitive sports. The findings highlight the critical function of vision in preserving balance by showing notable variations in Centre of Pressure (COP) characteristics between open-eye and closed-eye settings. The increased sway area and reduced sway velocity under visual deprivation suggest that dwarf athletes rely heavily on visual feedback for postural control, necessitating greater proprioceptive and vestibular adaptations when vision is removed. These findings contribute to the scarce body of literature on balance control in individuals with achondroplasia, particularly in high-performance sports settings. Given the rarity of such studies, this research offers novel insights into the biomechanical challenges faced by dwarf athletes and underscores the need for sport-specific balance training protocols. Future research should explore the impact of fatigue, different sporting environments, and long-term balance training interventions to further optimize stability and injury prevention strategies in this population. Additionally, integrating advanced motion capture and EMG analysis could provide a deeper understanding of neuromuscular adaptations in response to balance demands. By addressing these gaps, future studies can contribute to the advancement of Paralympic sports science and evidence-based training methodologies for athletes with achondroplasia.

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EFFECT OF CONTINUOUS AND INTERVAL TRAINING ON PHYSICAL PHYSIOLOGICAL, AND HEMATOLOGICAL VARIABLES IN COLLEGE ATHLETES

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ABSTRACT

This study examines the effects of continuous and interval training on selected physical, physiological, and hematological variables among male college students. Forty-five participants were randomly divided into three groups: continuous training, interval training, and control. Training lasted for twelve weeks, with assessments conducted pre- and post-intervention. Results indicated significant improvements in speed, muscular endurance, cardio-respiratory endurance, resting heart rate, vital capacity, VO2 max, hemoglobin levels, and red blood cell count in both training groups compared to the control. However, interval training produced superior gains in VO2 max and muscular endurance. These findings suggest that both training methods enhance athletic performance, with interval training being more effective for certain physiological adaptations.

Keywords: Continuous Training, Interval Training, Physical Fitness, Hematology, Physiology, VO2 Max

1. INTRODUCTION

Training adaptation is a fundamental component in sports performance enhancement. Continuous training, characterized by prolonged moderate-intensity exercise, and interval training, involving alternating high-intensity work and rest periods, are widely utilized for endurance and strength development. This study investigates the comparative effectiveness of these methods on key physical, physiological, and hematological markers.

2. METHODOLOGY PARTICIPANTS

Forty-five male college students (aged 18-25) were recruited and randomly assigned into three groups: Continuous Training (CT, n=15), Interval Training (IT, n=15), and Control (C, n=15).

Training Protocol:

- CT Group: Engaged in steady-state aerobic exercises for 40-60 minutes at 70-80% HRmax, three sessions per week.
- IT Group: Performed short bursts of high-intensity work (80-90% HRmax) alternated with active recovery periods, three sessions per week.
- Control Group: Maintained regular daily activities without structured training.

Assessments:

- **Physical variables**: Speed (50m sprint), muscular endurance (sit-ups test), cardio-respiratory endurance (Cooper's test)

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- **Physiological variables**: Resting heart rate (bpm), vital capacity (spirometry), VO2 max (treadmill test)
- **Hematological variables**: Hemoglobin (Hb), red blood cell (RBC) count, white blood cell (WBC) count

Statistical Analysis:

Data were analyzed using ANOVA to determine inter-group differences at p<0.05.

Group	**Description**
Group-I	Continuous Training Group
Group-II	Interval Training Group
Group-III	Control Group

Variable	Control Group (Mean±SD)	CT Group (Mean±SD)	IT Group (Mean±SD)	p-value
Speed (s)	7.5±0.3	6.8±0.2	6.5±0.2	<0.05
Muscular Endurance	30±5	40±4	45±3	<0.05
Cardio-Resp Endurance	2200±150	2600±140	2800±130	<0.01
Resting Heart Rate	72±4	66±3	64±2	<0.01
Vital Capacity (L)	3.8±0.4	4.2±0.3	4.5±0.3	<0.01
VO2 Max (ml/kg/min)	42±3	48±3	52±2	<0.01
Hemoglobin (g/dL)	13.5±0.6	14.8±0.5	15.2±0.4	<0.05
RBC Count (millions)	4.8±0.3	5.2±0.2	5.4±0.2	<0.05
WBC Count (thousands)	6.5±0.5	6.6±0.4	6.7±0.3	>0.05

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Physical Fitness Improvements: CT and IT groups showed significant gains in speed, endurance, and muscular strength compared to the control group ($p<0.05$). IT exhibited superior improvements in muscular endurance.

Physiological Adaptations: IT demonstrated greater enhancements in VO2 max and vital capacity than CT ($p<0.01$). Both training groups reduced resting heart rate significantly.

Hematological Responses: Hemoglobin and RBC count increased in both CT and IT groups, while WBC count remained unchanged.

4. DISCUSSION AND FINDINGS

The findings suggest that both continuous and interval training significantly improve physical, physiological, and hematological markers among college athletes. Interval training improved VO2 max, muscular endurance, and vital capacity due to its higher intensity and anaerobic conditioning. The increase in hemoglobin and RBC count in both training groups indicates enhanced oxygen-carrying capacity, which is beneficial for endurance sports. Additionally, the reduction in resting heart rate highlights improved cardiovascular efficiency. The absence of significant changes in WBC count suggests that training intensity did not induce excessive physiological stress. These results reinforce the effectiveness of structured training programs in enhancing athletic performance. Coaches and sports scientists should consider incorporating interval training to optimize aerobic and muscular endurance. Further research can explore the long-term effects of these training methods on elite athletes and different age groups.

5. CONCLUSION

Both training methods effectively enhance physical and physiological performance, with interval training providing additional benefits for aerobic capacity and muscular endurance. Coaches and athletes should consider incorporating interval training for optimizing endurance and strength development.

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EFFECT OF STRENGTH TRAINING AND NEUROMUSCULAR CONDITIONING ON SPORTS INJURY PREVENTION AND RECOVERY

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ABSTRACT

This study investigates the impact of strength training and neuromuscular conditioning on sports injury prevention and recovery among collegiate athletes. A total of sixty male college athletes aged 18 to 25 participated in a twelve-week intervention, divided into strength training, neuromuscular conditioning, combined training, and control groups. The study measured injury incidence, rehabilitation efficiency, flexibility, muscle endurance, and joint stability. The results indicate that combined training significantly reduced injury rates and improved recovery metrics compared to other groups.

KEYWORDS: Rehabilitation efficiency, Flexibility, Muscle endurance, and Joint stability

1. INTRODUCTION

Sports injuries are a major concern for athletes at all levels of competition. These injuries not only affect performance but also have long-term consequences on an athlete's career and overall well-being. Injury prevention and rehabilitation are critical components in sports science, with a growing emphasis on structured training programs to mitigate risks. Strength training and neuromuscular conditioning have emerged as two of the most effective approaches in reducing injury incidence and improving recovery efficiency.

Strength training involves a systematic approach to improving muscular endurance, power, and stability. By enhancing muscle function and joint support, strength training plays a pivotal role in preventing common sports-related injuries such as muscle strains, ligament tears, and joint dislocations. A well-designed strength training program ensures that athletes develop the necessary muscular strength to withstand the physical demands of their respective sports. Moreover, strength training is particularly beneficial for enhancing biomechanical efficiency, thereby reducing excessive stress on vulnerable joints and tissues.

Neuromuscular conditioning, on the other hand, focuses on optimizing the communication between the nervous system and the muscles. This type of training enhances proprioception, balance, coordination, and reflexive stabilization, which are crucial for injury prevention. By improving movement mechanics and reducing neuromuscular imbalances, athletes can significantly lower the risk of acute injuries such as ankle sprains and anterior cruciate ligament (ACL) tears. Neuromuscular training is widely incorporated into injury prevention programs, especially in high-impact sports where quick and controlled movements are essential.

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The integration of both strength training and neuromuscular conditioning into an athlete's training regimen has been shown to yield superior results in reducing injury rates and enhancing post-injury rehabilitation. Studies indicate that a combined approach leads to improvements in muscle endurance, flexibility, and joint stability, which are essential for injury prevention and recovery. Furthermore, athletes who engage in structured neuromuscular and strength training programs have shown a faster return-to-play rate following injuries. This study aims to explore the combined effects of strength training and neuromuscular conditioning on injury prevention and rehabilitation among collegiate athletes. By analyzing key variables such as flexibility, joint stability, and recovery efficiency, the research will provide valuable insights into the effectiveness of integrative training approaches. The findings of this study will contribute to the development of evidence-based training protocols that can be implemented across various sports disciplines to enhance athlete safety and performance. In conclusion, injury prevention in sports requires a multi-faceted approach that incorporates strength development, neuromuscular efficiency, and biomechanical optimization. With growing awareness of the benefits of structured training programs, this study aims to highlight the significance of integrating strength and neuromuscular conditioning for minimizing injury risks and expediting rehabilitation. Future research in this field will further refine training methodologies, ensuring that athletes can perform at their peak while minimizing the risk of career-threatening injuries.Sports injuries are a major concern among athletes, affecting performance and career longevity. Strength training and neuromuscular conditioning have been proposed as effective methods to reduce injury risk and enhance recovery. This study aims to analyze the effectiveness of these training interventions on injury prevention and rehabilitation.

2. METHODS

Participants

Sixty male collegiate athletes from various sports disciplines were randomly selected. Inclusion criteria required participants to be injury-free at the start of the study and actively involved in training.

Experimental Design

Subjects were divided into four groups:

1. **Strength Training (ST) Group**
2. **Neuromuscular Conditioning (NC) Group**
3. **Combined Training (ST + NC) Group**
4. **Control Group (No Training)**

The intervention lasted for twelve weeks, with training sessions three times per week.

Variables Measured

- **Physical Variables:** Flexibility, muscle endurance, and joint stability.
- **Physiological Variables:** Recovery efficiency and neuromuscular response.
- **Injury-Related Metrics:** Injury incidence, rehabilitation duration, and severity index.

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3. RESULTS

Statistical Analysis

The data were analyzed using ANOVA and post-hoc tests to determine significant differences among groups. The statistical outcomes are presented in the following table:

Variable	ST Group (Mean ± SD)	NC Group (Mean ± SD)	Combined Training (Mean ± SD)	Control Group (Mean ± SD)	F-value	p-value
Flexibility (cm)	15.2 ± 1.8	16.5 ± 2.1	18.4 ± 1.9	12.3 ± 1.5	9.12	0.001
Muscle Endurance (reps)	42.6 ± 3.5	44.8 ± 3.2	48.1 ± 4.0	35.2 ± 2.9	8.74	0.002
Joint Stability (score)	7.8 ± 0.9	8.3 ± 0.7	9.2 ± 0.8	6.4 ± 1.0	10.21	0.001
Injury Incidence (%)	14.3 ± 2.2	12.1 ± 1.9	8.7 ± 1.6	21.5 ± 3.1	11.35	0.000
Rehabilitation Duration (days)	23.5 ± 3.1	21.7 ± 2.9	18.3 ± 2.7	29.4 ± 3.5	7.98	0.003

4. DESCRIPTION OF FINDINGS

- **Flexibility & Muscle Endurance:** The combined training group exhibited the highest improvement, followed by neuromuscular conditioning and strength training individually.
- **Joint Stability:** Participants in the combined training group demonstrated superior joint stability, reducing the risk of ligament injuries.
- **Injury Incidence & Rehabilitation:** The combined training group showed the lowest injury rates and shortest rehabilitation duration, highlighting the benefits of integrative training methods.

5. DISCUSSION

These findings suggest that a combination of strength training and neuromuscular conditioning optimally enhances injury prevention and accelerates recovery. Strength training contributed significantly to muscle endurance, while neuromuscular conditioning improved flexibility and joint stability.

6. CONCLUSION

Incorporating structured strength and neuromuscular training programs can significantly reduce injury rates and enhance rehabilitation outcomes in collegiate athletes. Future research should explore long-term effects and applicability across various sports.

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EFFECT OF AEROBIC EXERCISES ON CARDIO RESPIRATORY ENDURANCE PARAMETER AMONG COLLEGE MEN MIDDLE DISTANCE RUNNERS

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ABSTRACT

The present study was to investigate the effect of aerobic exercises on cardio respiratory endurance parameter among college men middle distance runners. To achieve this purpose of the study thirty (N=30) college men students were selected from alagappa university, Karaikudi, Tamil Nadu state, India, during the year 2016-17. The subject's age ranges from 17 to 25 years. The selected subject were divided into two equal groups consists of fifteen subject each namely one experimental group and control group from college students. The experimental group I underwent aerobic exercise group (AEG) programme for six weeks. The control group was not taking part in any exercise during the course of the study. The dependent variable cardio respiratory endurance parameter selected for the study, it was measured by cooper12 min run/walk test unit of meters. Pre-test was taken before the exercise period and post- test was measured immediately after the six weeks exercise period. The collected data were analyzed by using paired sample 't'test and analysis of covariance to find the significant difference among the experimental and control group. The level of significance will be fixed at .05 level of confidence for all the cases. These results suggest that aerobic exercises group improve cardio respiratory endurance level compare better than to control group.

Keywords: Aerobic exercises, Cardio respiratory endurance and Cooper12 min run/walk test.

1. INTRODUCTION

Aerobic exercise (also known as cardio) is physical exercise of low to high intensity that depends primarily on the aerobic energy-generating process. Aerobic literally means "relating to, involving, or requiring free oxygen", and refers to the use of oxygen to adequately meet energy demands during exercise via aerobic metabolism. Generally, light-to-moderate intensity activities that are sufficiently supported by aerobic metabolism can be performed for extended periods of time. When practiced in this way, examples of cardiovascular/aerobic exercise are medium to long distance running/jogging, swimming, cycling, and walking, according to the first extensive research on aerobic exercise, conducted in the 1960s on over 5,000 U.S. Air Force personnel by Dr. Kenneth H. Cooper (2009). Bowman A.J (1992) said Aerobic exercise refers to exercise that involves or improve oxygen consumption by the body. Aerobic means with oxygen and refers to the use of oxygen in the body's metabolic or energy generating process. The steps that can be choreographed in to an aerobic dance routine can be varied by impact (i.e, high impact versus low impact.)

Aerobic dance exercise (ADE) can usually be completed easily by participants of all ages and fitness level. This is one of the unique characteristics of ADE, in that the same step can be modified by the participants to meet the needs of her individual workout. A typical ADE workout fulfils the cardio respiratory training principles (i, e frequency, intensity, duration, and type of activity

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continuous) and is similar to any cardio respiratory workout classes begins with a warm up of light activity and stretching exercise for 10 minutes, progress to the 20-30 minutes workout phase and then have a gradual cool down period for 10 minutes. Three parts of a typical 60 minutes program. A number of steps have been defined; walk, run, skip, two-steps, march, jog. Jumping jack, step touch, sidekicks and touch backs. According to the President‟s Council on Physical Fitness and Sports, cardio respiratory endurance is defined as the body‟s ability to deliver oxygen and other nutrients to tissue and to remove waste products over a sustained period of time. Improving cardio respiratory endurance through aerobic exercise can help reduce the risk of heart disease, some types of cancer and can aid in weight control and weight maintenance. Walking, swimming, cycling and running are examples of exercises that can improve cardio respiratory endurance.

2. METHODS & MATERIALS

The present study was to investigate the effect of aerobic exercises on cardio respiratory endurance parameter among among college men middle distance runners. This study was selected thirty (N=30) college men students were selected from Alagappa university, Karaikudi, Tamil Nadu state, India, during the year 2016-17. The subject‟s age ranges from 17 to 25 years. They were divided into two group namely aerobic exercise group I (Experimental group) and control group (group II) each consists of 15 subjects. The experimental groups I were subjected to six weeks of aerobic exercise training respectively, and the group II acted as control. The experimental groups II used exercises v step, turn step, over the top, L step, basic straddle step, side to side, double step side, knee kick, kick forward, kick sideward., but start with smaller number of reps) and the load given were progressively increased from 50%,60%,70% intensity level water aerobic exercise and aerobic exercises drills respectively for one hour per day for three days a week for a period of six weeks. The subjects of all the two groups were tested on cardio respiratory endurance prior to and after the training period. To ascertain cardio respiratory endurance parameter measured by cooper 12 min run/walk test accordingly the mean value count by meters.

3. STATISTICAL TECHNIQUE

The following statistical procedures were used. The “t” ratio was calculated to find out the significance of the difference between the mean of the initial and final test of the experimental group. The significance of the difference among the means of experimental group was found out by pre-test. The data were analyzed and dependen t‟ test was used with 0.05 levels as confidence.

Table 1

Analysis of dependent t-test for the Pre and Post Test Means Values for Aerobic exercise group and Control group on cardio respiratory endurance (Cooper 12 min run/walk test mean value measure by meters)

Groups	Mean		Mean Difference	S.D	Standard Error	‘t’ ratio
	Pre	Post				
Experimental	1888	2065.03	177.03	139.38785	35.98875	4.92*
Control Group	1891.3	1877.3	14	72.38784	18.6904	0.75

***Significance at .05 level of confidence. (The table value required for 0.05 level of significant with df of 28 is 2.04)

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The Table-I shows that the mean values of pre test and post-test of control group on cardio respiratory endurance were 1891.3 and 1877.3 respectively. The obtained t‟ ratio was 0.75, since the obtained t‟ ratio was less than the required table value of 2.04 for the significant at 0.05 level with 28 degrees of freedom it was found to be statistically insignificant. The mean values of pre-test and post-test of experimental group on cardio respiratory endurance were 1888 and 2065.03 respectively. The obtained „t‟ ratio was 4.92* since the obtained „t‟ ratio was greater than the required table value of 2.04 for significance at 0.05 level with 28 degrees of freedom it was found to be statistically significant. The result of the study showed that there was a significant difference between control group and experimental group in cardio respiratory endurance. It may be concluded from the result of the study that experimental group improved in cardio respiratory endurance due to six weeks of Aerobic exercises among college men middle distance runners.

4. DISCUSSIONS ON FINDINGS

The result of the study indicates that the experimental group namely aerobic exercise group had significantly improved the selected dependent variables namely cardio respiratory endurance, when compared to the control group. It is also found that the improvement caused by aerobic exercise when compared to the control group. Gormley SE et al (2008) To determine whether various intensities of aerobic training differentially affect aerobic capacity as well as cardio respiratory endurance. The result significantly increased in all exercising groups by 1888,to 2065 meters in the near-maximal-, the vigorous-, and the moderate-intensity groups, respectively. Percent increases in the near-maximal- (20.6%), the vigorous- (14.3%), and the moderate intensity (10.0%) groups were all significantly different from each other ($P < 0.05$). When volume of exercise is controlled, higher intensities of exercise are more effective for improving cardio respiratory endurance than lower intensities of exercise in healthy, young adults.

5. CONCLUSIONS

- There was a significant difference between experimental and control group on cardio respiratory endurance variables after the exercise period.
- There was a significant improvement in cardio respiratory endurance. However the improvement was in favour for experimental group compare better than the control group due to six weeks of Aerobic exercises.

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EFFECT OF TWELVE WEEK EXPLOSIVE STRENGTH TRAINING ON JENNEY'S COLLEGE OF PHYSICAL EDUCATION LONG JUMP ATHLETES

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ABSTRACT

The purpose of this study was to assess the effect of explosive strength training program on long jump athletes. Twenty (N=20) male athletes from Jenney's college of physical education, aged 19–23 years old, were randomly assigned to an experimental group. The subjects were assessed at baseline and after training for standing broad jump and vertical jump. A schedule of weight training program was employed on the students twice a week for a Period of 12 weeks. Paired t-test was applied to find out the significant effect of Explosive strength training on long jumper`s performance. The results of the study showed that there was a significant improvement after 12 weeks weight training in standing broad jump t-value4.6747 ($p<0.0002$) and vertical jump t-value11.5507 ($P< 0.0001$).

Keywords: Explosive Strength, Standing Broad Jump, Vertical Jump.

1. INTRODUCTION

Weight training is a type of training for developing the strength of skeleton muscles. Weight training is a type of training that uses weights for resistance. Weight training provides a pressure to the muscles that causes them to adapt and get stronger. Explosive exercise can be defined as movements in which the rate of force development (RFD) is maximum or near maximum for a given type of muscle action (e.g. isometric, concentric, and eccentric). The peak RFD has a strong association with the ability to accelerate a mass. Explosive exercise may be performed isometric ally or dynamically; however, dynamic movements can produce higher RFDs than isometric exercise. As the resistance used for dynamic movement decreases, the RFD increases resulting in an inverse relationship between peak force production and RFD Thus, a continuum of explosive exercise can be conceptualized ranging from isometric movements and high force slow movements (very heavy weights) to very fast movements performed with relatively light weights. Depending upon the resistance used a high RFD, high acceleration and power output can be achieved within the same movement. Explosive exercises in which all three parameters (RFD, acceleration and power) are at maximum or near maximum can be termed "speed strength" exercises and may be Plyometric or ballistic in nature. Harris et al. declared that some researchers claim the use of 80% of 1RM is recommended to improve power characteristics, suggest 50-60% of 1RM and below. Kawamori and Haff agreed with Harris et al., stating that there is inconsistency in the optimal load to produce the highest power. They claimed that some studies that used untrained subjects, single joint exercises, and upper-body exercises reported 30-45% of 1RM, while others using trained subjects, multi joint exercises, and lower-body exercises reported 30-70% of 1RM. The main purpose of the study was to evaluate the explosive strength of college level long jumpers and determine the effect of weight training on the three different explosive strength tests.

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2. METHODOLOGY

Twenty male athletes of Jenney's college of physical education, in the age group of 19 to 23 years enrolled in the training for the 2016-17 academic year were selected as subjects for the study. The tests which were selected for the study were broad jump (B.J.) and vertical jump (V.J.) after the pre-test the students were made to perform the explosive strength exercises (jump squat, jump lunges, one-leg jump squat) with weight. A schedule of weight training program was employed on the students twice a week for a Period of 12 weeks. A post test was conducted at the end of 12th week.

3. STATISTICAL DESIGN

To find out the significant effect of Explosive strength training on long jumper`s performance Paired t-test was applied.

4. RESULTS

The results of the study are as under, the mean, S.D, and „t"- test of the subjects are presented in the tables from 1to 2.

Table 1

Shows Pre and Post test of Broad jump of Jenney's college of physical education Long Jump Athletes

Test (in meters)	N	Mean	SD	Std Error	T-Value
Pre Test	20	2.2245	0.0951	0.0213	4.6747*
Post Test	20	2.3285	0.1859	0.0416	

95% CI for mean difference: (-0.1506 to -0.0574) df=19 table t-value at 0.5 (2.093) t-test of mean difference = 0 (vs. not = 0): t-Value = 4.6747 P-Value = 0.0002

Table 1, above indicates the results with regard to broad jump. The athletes of Srm University with the training have shown improvement in the performance of broad jump from pre to post with the mean and S.D being (2.2245, 0.0951) and (2.3285, 0.1859) respectively. The improvement is quite encouraging and highly significant ($p<0.0002$).

Table 2

Shows Pre and Post test of Vertical jump of Jenney's college of physical education Long Jump Athletes

Test (in meters)	N	Mean	SD	Std Error	T-Value
Pre Test	20	19.845	4.169	0.932	11.5507*
Post Test	20	21.975	4.290	0.959	

95% CI for mean difference: (-2.516 to -1.744) df=19 table t-value at 0.5 (2.093) t-test of mean difference = 0 (vs not = 0): t-Value = 11.5507 P-Value = 0.0001

Table-2 above indicates the results with regard to vertical jump. The students of Srm University with the training have shown improvement in the performance of vertical jump from pre to post with the mean and S.D being (19.845, 4.169) and (21.975, 4.290) respectively. The improvement is quite encouraging and highly significant ($p<0.0001$).

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5. DISCUSSION

The main finding of this study is that explosive strength training resulted in positive changes in long jumper`s performance. Results of the Study showed that there is satisfactory improvement in rate of force of athletes. Faigenbaum AD (2000)The potential benefits of youth strength training extend beyond an increase in muscular strength and may include favourable changes in selected health and fitness related measures. If appropriate training guidelines are followed, regular participation in a youth strength training program has the potential to increase bone mineral density, improve motor performance skills, enhance sports performance, and better prepare our young athletes for the demands of practice and competition.

6. CONCLUSION

It is concluded from this study, that there was a marked improvement in the performance of the students in power exercises among all the events from pre to post test, which is quite significant. The students have shown a highly marked improvement in performance of broad jump, which shows the interest among the students for this event, which is very encouraging and significant. Furthermore with regard to the comparison among the three events it is concluded that the performance of the students in broad jump was the best followed by vertical jump. Vertical jump took the last place among these events where the performance of the students was the least.

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EFFECTS OF PLYOMERTIC TRAINING ON SELECTED MOTOR FITNESS COMPONENTS AMONG BASKETBALL PLAYERS MEN'S

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ABSTRACT

The purpose of the study was to investigate the influence of plyomertic training on selected motor fitness components among basketball players men's. To achieve the purpose of the present study 20 men student were selected as samples from Jenney's institution basketball players, Trichy. The age group is between 18 to 25 years. The selected subjects were divided in two equal groups of each 10 namely controlled group experimental group. The variables speed, muscular endurance, explosive power and cardio respiratory endurance were selected and measured by using 50mts dash, sit-ups, standing broad jump, cooper's 12 minutes run and walk tests. The following variables and test items have been selected to measure the criterion variables. Pre-test was taken before the exercise period and post- test was measured immediately after the six weeks of training period. Statistical technique 'f' ratio was used to analyze the means of the pre-test and post test data of experimental groups and control group. The data were analyzed analysis of covariance (ANCOVA) technique was used with 0.05 levels as confidence.

Keywords: plyomertic training, speed, muscular endurance, explosive power and cardio respiratory endurance.

1. INTRODUCTION

Sports training are a basic preparation of the sportsman for better performance through physical exercise. It is based on scientific principles of aiming at education and performance enhancement sports activities consists of motor movement and action and their success depends to a great extend on how correctly they are performed. Techniques of training and improvement tactical efficiencies play a vital role in training process.

Plyomertic training is a form of body conditioning or resistance training using high-intensity aerobics. It targets strength building and muscular endurance. An exercise "circuit" is one completion of all prescribed exercises in the program. When one circuit is complete, one begins the first exercise again for the next circuit. Traditionally, the time between exercises in plyomertic training is short, often with rapid movement to the next exercise.

2. METHODOLOGY

The purpose of the study was to investigate the influence of plyomertic training on selected motor fitness components among basketball players men's. To achieve the purpose of the present study 20 men student were selected as samples from Jenney's institution basketball players. The age group is between 18 to 25 years. The selected subject were divided in two equal groups of each 10 namely controlled group experimental group. The variables speed, muscular endurance, explosive power and cardio respiratory endurance were selected and measured by using 50mts

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dash, sit-ups, standing broad jump, cooper's 12 minutes run and walk tests. The following variables and test items have been selected to measure the criterion variables.

TABLE I
TEST SELECTION

S.No	Variables	Test Items	Unit of measurement
1	Speed	50mts dash	Sec
2	Muscular Endurance	Sit-ups	Counts
3	Explosive Power	Standing broad jump	Meters
4	Cardio Respiratory Endurance	Cooper's 12 minutes run & walk	Meters

3. TRAINING SCHEDULE

The six week training package is set up for this study. The training load was changed for every two weeks. The training was given to the subjects for three days in a week (Monday, Wednesday and Friday) for six weeks.

4. STATISTICAL TECHNIQUE

The data collected from the two groups namely plyomertic training group and control group on selected motor fitness components were statistically analysed by using 't' ratio in order to determine the differences if any among the groups at pre test & post test. The calculated't' ratio is tested on significance at 0.05 level of confidence.

5. RESULTS AND DISCUSSIONS

The influence of independent variables on each of the dependent variables were determined by 't' ratio separately and presented below.

TABLE –II
CALCULATION OF 'T' RATIO BETWEEN THE PRE AND POST TEST SCORES ON SPEED, MUSCULAR ENDURANCE, EXPLOSIVE POWER, CARDIO RESPIRATORY ENDURANCE FOR THE EXPERIMENTAL GROUP AND CONTROL GROUP

Variables	Group	Test	Mean	Standard Deviation	Std Err of the Mean	DM	't' Ratio
Speed	Experimental	Pre	7.54	0.15	0.05	0.25	5.00*
		Post	7.29	0.13			
	Control	Pre	7.37	0.13	0.05	0.10	2.00
		Post	7.47	0.15			
Muscular Endurance	Experimental	Pre	25.6	1.27	0.48	1.50	2.42*
		Post	27.1	1.51			
	Control	Pre	24.5	0.69	3.04	0.80	0.26
		Post	23.7	1.13			

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Explosive Power	Experimental	Pre	3.24	0.05	0.02	0.09	4.5*
		Post	3.33	0.05			
	Control	Pre	2.19	0.04	0.02	0.02	1.00
		Post	2.17	0.05			
Cardio Respiratory Endurance	Experimental	Pre	2484	95.95	30.36	71	2.22*
		Post	2554	31.37			
	Control	Pre	2643	50.14	16.14	30	1.32
		Post	2613	51.01			

*Significance at 0.05 level of confidence

Table-II shows that the mean and the standard deviation values of pre test were 7.54 and 0.15 respectively. The mean and standard deviation values of post test were 7.29 and 0.13. The mean difference was 0.25. The obtained ‘t’ value of 5.00 is higher than the higher the table value of 2.10. Through this analysis it was found that the practice of plyomertic training for a period of six weeks has improved the speed significantly. For the control group the obtained ‘t’ value is 2.00, it is less than the table value of 2.10, it was found to be statistically insignificant. It clearly indicates that the control group has not improved the speed.

The mean and the standard deviation values of pre test were 25.6 and 1.27 respectively. The mean and standard deviation value of post test were 27.1 and 1.51. The mean difference was 1.50. The obtained ‘t’ value of 2.42 is higher than the table value of 2.10. Through this analysis it was found that the practice of plyomertic training for a period of six weeks has improved the muscular endurance significantly. For the control group the obtained ‘t’ value is 0.26, it less than the table value of 2.10, it was found to be statistically insignificant. It clearly indicates that the control group has not improved the muscular endurance.

The mean and the standard deviation values of pre test were 3.24 and 0.05 respectively. The mean and standard deviation value of post test were 3.33 and 0.05. The mean difference was 0.09. The obtained ‘t’ value of 4.5 is higher than the table value of 2.10. Through this analysis it was found that the practice of plyomertic training for a period of six weeks has improved the explosive power significantly. For the control group the obtained ‘t’ value is 1.00, it less than the table value of 2.10, it was found to be statistically insignificant. It clearly indicates that the control group has not improved the explosive power.

The mean and the standard deviation values of pre test were 2484 and 95.95 respectively. The mean and standard deviation value of post test were 2554 and 31.37. The mean difference was 71. The obtained ‘t’ value of 2.22 is higher than the table value of 2.10. Through this analysis it was found that the practice of plyomertic training for a period of six weeks has improved the cardio respiratory endurance significantly. For the control group the obtained ‘t’ value is 1.32, it less than the table value of 2.10, it was found to be statistically insignificant. It clearly indicates that the control group has not improved the cardio respiratory endurance.

6. CONCLUSIONS

- It was concluded that there was significant improvement in selected motor fitness components among basketball players mens.
- The study reveals that plyomertic training would improve the speed, muscular endurance, explosive power and cardio respiratory endurance significantly at 0.05 level of confidence.

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ANALYSIS ON ANTHROPOMETRIC CHARACTERISTICS OF JENNEY'S INSTITUTION KABADDI PLAYERS, TRICHY

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ABSTRACT

The purpose of the present investigation is to find out the position-wise analysis on anthropometric characteristics Jenney's institution kabaddi players, Trichy. To achieve the purpose of this study, 30 Jenney's institution kabaddi players,Trichy. The selected subjects were divided into four groups as according to their field positions in which they play in that competition, namely Raider (R), Corner (C), Arch (A), and Alter (Al). Their ages ranged from 18 to 28 years. The selections of samples were made on the basis of purposive sampling techniques. The anthropometric variables, namely height and weight were selected as a criterion variable and it was measured by administering the Seca Stadiometer and SegaWeighing Machine. The collected data on selected anthropometric characteristics of the Jenney's institution kabaddi players were tested by one – way analysis of variance (ANOVA).

Key words: Weight, Height, and ANOVA.

1. INTRODUCTION

Anthropometric measurements relevant to human movement gained formal recognition as a discipline with the inauguration of the International society for advancement of kin-anthropometry in 1986. Anthropometrics' of all continents have participated in several major multidisciplinary studies that are being or have been participated to assess the physical characteristics of people. Kin anthropometry has been defined as the quantitative interface between human structure and function (**Ross Drinkwater, Bailey, Marshall, Leahy, 1980**).this interface is examined through the measurement and analysis of age, body size, shape, proportion, composition and maturation as they relate to gross body function. Previous reports have shown that body structure and morphological characteristics are important determinants of performance in many sports can significantly influence athletic performance (**Carter, 1970 & Duque, 2001)**.

2. METHODOLOGY

To achieve the purpose of this study, 30 Jenney's institution kabaddi players, Trichy . The subjects were selected on the basis of their placement in the inter-college kabaddi tournament. The selected subjects were divided into four groups as according to their field positions in which they play in that competition, namely Raider (R), Corner (C), Arch (A), and Alter (Al). Their ages ranged from 18 to 28 years. The selections of samples were made on the basis of purposive sampling techniques. The anthropometric variables namely height and weight were selected as a criterion variables and it was measured by administering the Seca Stadiometer and Seca Weighing Machine Test. The collected data on selected anthropometric characteristics of the Inter-University Kabaddi players were tested by one – way analysis of variance (ANOVA). The obtained results of selected variables were well tabulated and presented in the Table I

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3. ANALYSIS OF THE DATA

Table - I

Descriptive Statistics on Height and Weight of Jenney's institution kabaddi players in relations to their playing positions

Variables	Playing Positions	No. of Subjects	Mean	Std. Deviation	Minimum	Maximum
Height	Raider	9	173.0000	6.74537	165.00	184.00
	Corner	13	172.3846	6.19864	162.00	187.00
	Arch	4	174.5000	7.76745	166.00	184.00
	Alter	4	170.5000	6.45497	166.00	180.00
Weight	Raider	9	72.7778	6.35959	62.00	80.00
	Corner	13	71.9231	4.80384	62.00	79.00
	Arch	4	70.7500	8.84590	58.00	78.00
	Alter	4	63.2500	5.90903	55.00	68.00

The table – I shows that the mean & standard deviations of height and weight among Inter University Kabaddi players with reference to then playing positions namely Raider, Corner, Arch and Alter. Regarding height, Arch players have maximum mean value (174.5; ± 7.77) followed by Raider (173; ± 6.75), Corner (172.38; ± 6.20) and then the Alter players (170.5; ± 6.45). In terms of weight, Raiders have maximum values (72.78; ± 6.36), followed by Corner & Arch players (71.92; ±4.80) & (70.75; ±8.85) then the Alter players (63.25; ± 5.91) respectively.

In This Table II, results of One –Way Analysis of Variance on height and weight among the four groups viz., Raider, Corner, Arch and Alter were presented. From the table it can be seen that the calculated F value of height & weight (0.26 &2.58) among the four groups were less than the table value of 2.98, indicating that there was a insignificant mean difference exists ($p < 0.05$) for the degree of freedom (3, 26) at 0.05 level of confidence. Hence there were no significant mean difference exist among Raider, Corner, Arch and Alter of Inter-University Kabaddi players on height & weight.

4. CONCLUSION

- The positional differences were not found among the Inter-collegiate Kabaddi Players in all the selected anthropometric characteristics.
- In general, among all the anthropometric characteristics raiders and corners equally dominating by having greater segmental values than the arch and alter positional Kabaddi players.

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SAND TRAINING AS A TOOL FOR ENHANCING AEROBIC FITNESS AND HEALTH-RELATED PHYSICAL COMPONENTS IN COLLEGE FOOTBALL STUDENTS

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ABSTRACT

The study's principle was to assess sand training's influence on the explosive and aerobic power of college men students. Thirty (n=30) college men football students were selected from Jenney's College of Physical Education, Tamil Nadu the ages ranged from 18 to 24 years. The chosen subject was assigned into two equal groups with fifteen subjects in each group. The experimental group I sand training and group II control group. The experimental groups were under 8 weeks of training and the control group was not under experimentation. Explosive power was measured by the Sargent jump test aerobic power was measured by the Margaria-Kalamen Test for both groups. The initial and the final readings derived from the experimental and the control groups underwent a procedure of statistical analysis using ANOVA. The confidence level was 0.05. Result of the investigation shows sand training has significant improvement on explosive power and aerobic power when compared to the control group

Keywords: Sand Training, Explosive Power, Aerobic Power, College Men Students.

1. INTRODUCTION

Fitness refers to an individual's ability to live a complete and balanced life, which includes physical, mental, emotional, social, and spiritual components, as well as the capability to express them all. A systematic process of repeating progressive exercise or labour incorporating learning and adaptation is known as training. Speed is one of the most significant aspects of physical fitness, since it is required for many physical activities. The ability of an individual to produce successive movements of the same pattern at a high pace is known as speed.

In explosive sports like sprints, leaps, and most field sports, speed is a deciding element. Some people believe that people are either born with or without speed. Most people can only maintain maximal velocity for a short time and over a short distance. Correct running mechanics, stride length, leg cycle frequency, and hip height / posture must all be addressed during training to achieve maximal speed.

Running is the foundation of many sports, and it has a ballistic element that is shared by other activities. Most sports, however, entail considerably more than linear sprinting at peak speed. It is frequently more crucial to be able to shift direction and velocity. Rapid and forcible muscular lengthening is used to accomplish explosive deceleration motions during direction changes.

2. STATEMENT OF THE PROBLEM

The purpose of the research was to find out the influence of sand training on selected health related fitness explosive power and aerobic power of college men students

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3. METHODS

To achieve the motive of the prevailing take a look at, thirty (n=30) university college students turned into decided on from Jenney's College of Physical Education, TamilNadu, India the age had been ranged ought to be 18 to 24 years. They have been assigned into same groups of 15 gamers each. Exp-I practiced as sand training for forty five minutes in each day of eight weeks, Exp-II will acted as a manipulate organization records were collected on explosive strength and aerobic before and after the education period.

4. STATISTICAL ANALYSIS

The data collected from the both agencies as experimental groups and manage organization on explosive strength and aerobic energy statistically tested analysis of variance (ANOVA) changed into used to decide differences, if there may be any vast difference a number of the remedy means of variable zero.05 level of self assurance. The evaluation of variance on explosive energy and aerobic has been analyzed and all of the tables are cited beneath:

Table 1

Anova of explosive power and aerobic power of experimental and control group

Explosive Power						
Test	**SANDTraining**	**Control Group**	**Sum of Square**	**Df**	**Mean**	**F ratio**
Pre Test	44.52	44.00	2.13	1	2.13	0.48
			123.7	28	4.41	
Post Test	48.73	43.66	192.5	1	192.5	**56.00***
			96.26	28	3.43	
Aerobic Power						
Test	**SANDTraining**	**Control Group**	**Sum of Square**	**Df**	**Mean**	**F ratio**
Pre Test	97.52	95.11	43.63	1	43.63	2.59
			470.4	28	16.80	
Post Test	103.5	94.72	582.4	1	582.4	**23.17***
			703.7	28	25.13	

(*significance at 0.05 levels with df 1 and 28 is 4.17)

The acquired pre-test means for explosive power in the sand training group were 44.52 and 44.00, respectively, as shown in Table I. The desired table F-value was 4.17, while the achieved pre-test F-value was 0.48. The aerobic power on sand training group had a pre-test mean of 97.52, whereas the control group had a mean of 95.11. The obtained pre-test F-value was 2.59, whereas the needed table F-value was 4.17, indicating that the participants' initial scores were not significantly different.

The sand training group's post-test passing mean was 48.73, whereas the control group's was 43.66. The achieved post-test F-value was 56.00*, whereas the needed table F-value was 4.17, and the post-test means of aerobic power in the sand training group were 103.5 and 94.72, respectively. The resulting post-test F-value of 23.17* was higher than the necessary value of 4.17, indicating that substantial differences existed between the groups.

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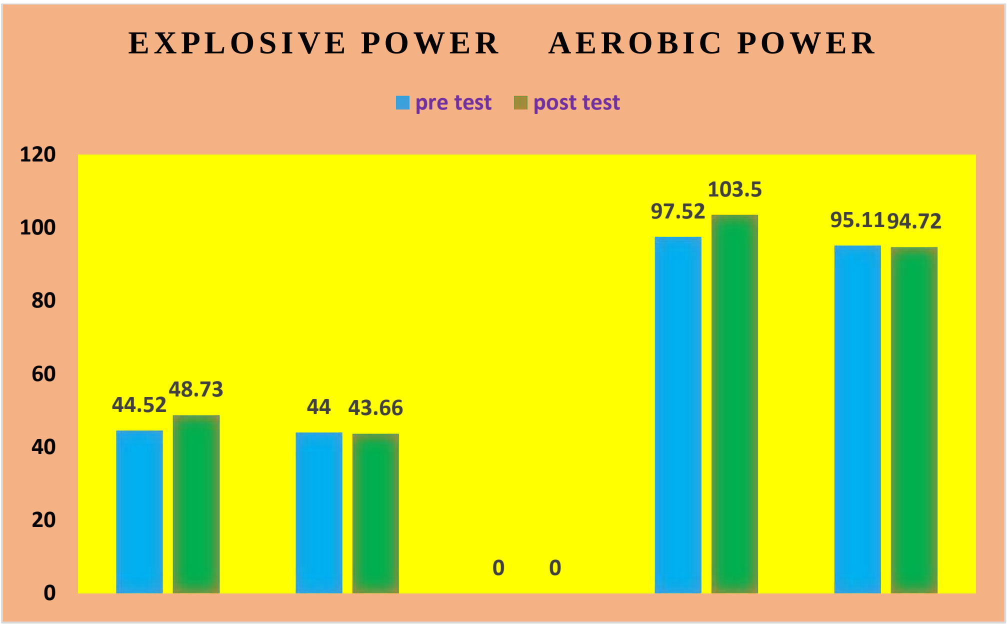
Bar diagram of experimental and control group on sand training



5. CONCLUSION

The following findings are drawn from the study, which had various limitations imposed by the experimental settings. Because of the eight weeks of training, the sand training improved much more than the control group among college male students.

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INFLUENCE OF S.A.Q TRAINING ON SELECTED EXPLOSIVE POWER AND AEROBIC POWER OF COLLEGE MEN STUDENTS

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ABSTRACT

The principle of the study was to access to influence of s.a.q training on explosive power and aerobic power of college men students. thirty (n=30) college men students was selected from Jenney's College of Physical Education, Tamil Nadu , India the ages were ranged from 18 to 24 years. The selected subject was assigned into two equal groups with fifteen subjects with each group. The experimental group-I s.a.q training and group-II control group. The experimental groups were under 8 weeks of training and control group was not under experimentation. Explosive power was measured by Sargent jump test aerobic power was measured by Margaria-Kalamen Test was taken for both groups. The initial and the final readings derived from the experimental and the control group underwent a procedure of statistical analysis using ANOVA. The confidence level was 0.05. Result of the investigation shows s.a.q training have significant improvement on explosive power and aerobic power when compare to the control group

Keywords: S.A.Q Training, Explosive Power, Aerobic Power, College Men Students.

1. INTRODUCTION

Fitness is the ability of an individual to live a full and balanced life it involves physical, mental, emotional, social and spiritual factors and a capacity for their whole expression. Training is a systematic process of repetitive progressive exercise or work involving, learning process and acclimatization. Speed is one of the most important physical fitness components which is highly essential for many physical activities. Speed is the capacity of the individual to perform successive movements of the same pattern at a fast rate. Speed is a determining factor in the explosive sports such as sprints, jumps and most field sports. Some believe that a person is either born with speed. Most humans can only maintain maximum velocity for a short period of time over a limited distance. Training to improve maximum speed requires a great deal of focus on correct running mechanics, stride length, frequency of the leg cycle and hip height / position.

Agility is the ability to change direction without the loss of balance, strength speed or body control. Agility should not be taken for granted and can actually be taught to individual players. Training ensures that a player develops the best offensive and defensive skills possible with the greatest quickness, speed and control and the least amount or wasted energy and movement. Agility training exercises help improve speed, explosive power, coordination, and specific sports skills. From professional sports teams, all athletes can benefit from agility training exercises. The net of accelerations occurs in a fractions of a second and takes the body from a static position to motion. Muscles actually lengthen and shorten instantaneously that is an 'eventric followed by a concentric' contractions. The development of SAQ programmers have sought to fill this void to develop all types of speed, particularly for team sports.

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Running is the basis of many sports and has a ballistic quality common to other movements. However, most sports involve much more than linear sprinting at a top speed. The ability to change direction and velocity is often more important. Changes in direction involve explosive braking actions that are executed by rapidly and forcibly lengthening the muscles.

2. STATEMENT OF THE PROBLEM

The purpose of the research was to find out the influence of s.a.q training on selected explosive power and aerobic power of college men students

3. METHODS

To achieve the purpose of the present study, thirty (n=30) college men students was selected from Jenney's College of Physical Education, Tamil Nadu , India the age were ranged should be 18 to 24 years. They were assigned into two equal groups of 15 players each. Experimental Group-I practiced as s.a.q training for 45 minutes in each day of 8 weeks, Group-II will acted as a control group data were collected on explosive power and aerobic power before and after the training period.

The s.a.q training was provided in the morning time making the subjects involve in proper warming up practice of eight weeks of training. The criterion variables were measured using Sargent jump test and Margaria-Kalamen Test.

4. STATISTICAL ANALYSIS

The data collected from the both groups as experimental groups and control group on explosive power and aerobic power statistically examined analysis of variance (ANOVA) was used to determine differences, if there is any significant difference among the treatment means of variable 0.05 level of confidence. The analysis of variance on explosive power and aerobic power has been analyzed and all the tables are mentioned below:

Table 1

Anova of explosive power and aerobic power of experimental and control group

Explosive Power						
Test	**S.A.Q Training**	**Control Group**	**Sum of Square**	**Df**	**Mean**	**F ratio**
Pre Test	44.52	44.00	2.13	1	2.13	0.48
			123.7	28	4.41	
Post Test	48.73	43.66	192.5	1	192.5	**56.00***
			96.26	28	3.43	
Aerobic Power						
Test	**S.A.Q Training**	**Control Group**	**Sum of Square**	**Df**	**Mean**	**F ratio**
Pre Test	97.52	95.11	43.63	1	43.63	2.59
			470.4	28	16.80	
Post Test	103.5	94.72	582.4	1	582.4	**23.17***
			703.7	28	25.13	

(*significance at 0.05 levels with df 1 and 28 is 4.17)

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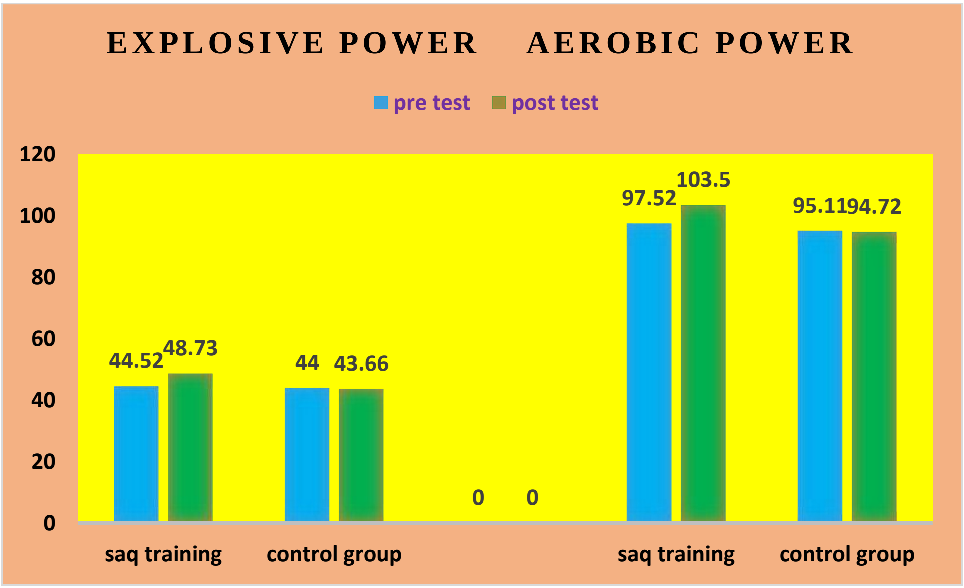
As shown in Table I, the obtained pre-test means for explosive power in the S.A.Q training group was 44.52 and the control group was 44.00. The obtained pre-test F-value was 0.48 and the required table F-value was 4.17. Pre-test means on the aerobic power on S.A.Q training group was 97.52 and the control group was 95.11. The obtained pre-test F-value was 2.59 and the required table F-value was 4.17.which proved that there was no significant difference among the initial scores of the subjects.

The obtained post-test means of passing in the S.A.Q training group was 48.73, and the control group was 43.66. The obtained post-test F-value was **56.00*** and the required table F-value was 4.17 and the post-test means of aerobic power in the S.A.Q training group was 103.5, and the control group was 94.72. The obtained post-test F-value was **23.17*** was greater than the required value of 4.17 and hence, it was accepted that there were significant differences among the groups.

Bar diagram of experimental and control group



5. CONCLUSION

In the light of the study undertaken with certain limitations imposed by the experimental conditions, the following conclusions. The s.a.q training have more significant improvement than control group among college men students due to the eight weeks of training.

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EVALUATING THE EFFECTIVENESS OF S.A.Q. TRAINING ON PHYSICAL POWER AND AEROBIC ENDURANCE AMONG COLLEGE MEN

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ABSTRACT

The study was to find out the effect of evaluating the effectiveness of S.A.Q. Training on Physical Power and aerobic Endurance among College men among football players. To achieve the purpose of this study thirty football players were randomly selected from the Jenney's College of Physical Education, Tamil Nadu , India and their ages ranged between 18 and 24 years. All the subjects were divided into two equal groups with 15 subjects each. Gathering-1 underwent a sand training group for a period of six weeks and Gathering-2 acted as a control group who did not participate in any special training other than their regular routine. The passing and dribbling were selected as dependent variables. The passing was assessed by a Mor- Christian General Soccer Ability Test and dribbling was assessed by a Mor- Christian General Soccer Ability Test. Pre and post-test random group designs were used for this study. The data were collected before and after the training period of six weeks and the data collected were statically analysed by the 'ANOVA' test, which was used to find out the significant improvement in selected variables from the baseline to post. The result of the study on sand training produced that there was a significant improvement in the skill performance-related variables among football players

Keywords: Sand Training, Passing, Dribbling, Football Players

1. INTRODUCTION

Football is one of the team sports that was positively affected by the development of science related to the sports field and the development of methods and methods of preparing the players physically and technically, which helped the players to raise the level of performance and achieve excellence and sports achievement Rao, 2013. Training methods in football are an important requirement for the development of players in the physical, skill and planning aspects. Football requires speed in performance, accuracy and change in tempo, and this is what distinguishes it from other sports Aziz Faraj, 2020. As you need high-performance requirements for the purpose of achieving high achievement, as football has different skills that require consistency and arrangement in training between those skills on the one hand and physical capabilities on the other hand Mahdi, 2020. The player on the sand is one of the training methods that can develop physical capabilities through the use of exercises that are directly related to athletic performance.

Sand training is defined as physical training of running, jogging, walking and other exercises done on sand such as beach sand and surfaces differ from the compact ones due to the presence of air gaps: this involves the compression and the displacement of the surface under the pressure of the foot during the running stride Binnie, 2014. Sand surfaces can offer a higher energy cost and lower impact training stimulus compared with firmer and more traditional team sports. Potential

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and kinetic energy at each stride when walking on sand and reduced recovery of elastic energy when running on sand Gaudino, 2013.

The lower impact forces experienced on sand can limit muscle damage, muscle soreness, and decrements in performance capacity relative to exercise intensity Binnie, 2014. Sand training is gentle on the joints but murder on the muscle's way of improving your vertical jump. Sand training is the training on the surface full of dry and loose sand in the seashore away from the portion of water flow and its adjacent area Mahdi, 2020. Running on the soft sand is definitely a step up from road running when it comes to intensity but with the right preparation Impellizzeri, 2008.

2. METHODS

In this investigation, the subjects were taken from the Trichy, District, Tamil Nadu, India. 30 men football players are implemented in this study and their age range is between 17 to 23 years. They are divided into two groups namely, gathering –1 as the sand training group and gathering- 2 as the control group. The gathering-1 was treated as an experimental bunch for 6 weeks. The training protocol was given in the morning section of alternate days of the week for 6 weeks. Before and after the training protocol of 6 weeks the data of subjects was collected for analysis of their performance. The instructor gave the proper warming up before the training program and give all the explanations about the training and clarified the doubts.

Table I

Sand Training protocol for 6 weeks

1st & 3rd weeks				
Exercises	**Reputations**	**Sets**	**Rest Between Reputations**	**Rest Between Sets**
Beach running + 2 km	10-12	2	40sec	2 mts
Hopping				
Bounding				
High knee				
Forward Lunge				
Zigzag runs				
Front Squat				
4th & 6th weeks				
Exercises	**Reputations**	**Sets**	**Rest Between Reputations**	**Rest Between Sets**
Beach running + 2 km	8-10	3	30sec	2 mts
Hopping				
Bounding				
High knee				
Forward Lunge				
Zigzag runs				
Front Squat				

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Tests and statistical data analysis

Information was dissected utilizing the SPSS Statistics (SPSS Statistics for Windows: IBM Corporation, adaptation 26.0). Pre and post proportions of passing estimated utilizing (Mor- Christian General Soccer Ability Test) and dribbling estimated utilizing (Mor- Christian General Soccer Ability Test) were thought about utilizing Analysis of variance.

3. RESULTS AND DISCUSSIONS

Table 1I
ANOVA of passing and dribbling on experimental and control group

Passing						
Tests	**Sand training**	**Control group**	**S.O.S**	**D.F**	**MS**	**F-Ratio**
Pre-Test	6.51	6.42	0.063	1	0.063	1.19
			1.49	28	0.053	
Post-Test	7.39	6.39	7.56	1	7.56	**94.26***
			2.24	28	0.080	
Dribbling						
Tests	**Sand training**	**Control group**	**S.O.S**	**D.F**	**MS**	**F-Ratio**
Pre-Test	24.34	24.26	0.049	1	0.049	0.63
			2.14	28	0.077	
Post-Test	23.21	24.46	11.79	1	11.79	**28.43***
			11.61	28	0.41	

*Significant at 0.05 level table value 4.17 df 1.28

As shown in Table II, the obtained pre-test means for passing in the Sand training group was 6.51 and the control group was 6.42. The obtained pre-test F-value was 1.19 and the required table F-value was 4.17. Pre-test means on the passing on Sand training group was 24.34 and the control group was 24.26. The obtained pre-test F-value was 0.63 and the required table F-value was 4.17.which proved that there was no significant difference among the initial scores of the subjects.

The obtained post-test means of dribbling in the Sand training group was 7.39, and the control group was 6.39. The obtained post-test F-value was **94.26*** and the required table F-value was 4.17 and the post-test means of dribbling in the Sand training group was 23.21, and the control group was 24.46. The obtained post-test F-value was **28.43*** was greater than the required value of 4.17 and hence, it was accepted that there were significant differences among the groups.

4. DISCUSSION ON FINDINGS

Plyometric training on sand improved both jumping and sprinting ability and induced less muscle soreness. A grass surface seems to be superior in enhancing CMJ performance while the sand surface showed a greater improvement in SJ (Impellizzeri, 2008). Effect of sand surfaces over a greater range of training types and performance outcomes, to increase the application of sand training for team sports (Binnie, 2014). Training strategy may be used to minimize musculoskeletal strain while still incurring an equivalent cardiovascular training stimulus (Brown, 2017). Substituting sand for grass training surfaces throughout an 8-week conditioning program

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can significantly increase the relative exercise intensity and training load, subsequently leading to superior improvements in aerobic fitness (Binnie, 2014). The circuit training group in the sand media was significantly and better influenced to increase agility compared to the circuit training group in the hard media (Sholikhin, 2020). Sandy ground contributed positively to the development of the physical and skill capabilities of young football players (Aziz Faraj, 2020). Sand/non-rigid surface induces similar improvements in strength, endurance, balance and agility as on firm surface but induces significantly less muscle soreness (Amrinder Singh, 2014). The sand court had a direct effect on the development of the skills and abilities in question. The sand court has proved its worthy football (Mahdi, 2020).

5. CONCLUSION

In the light of the research the conclusion was written and the results show that the six weeks of sand training protocol will improve the better performance variables of the football players.

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EFFECT OF VARIOUS SURFACES OF PLYOMETRIC TRAINING ON EXPLOSIVE POWER AND REACTION TIME AMONG COLLEGE LEVEL PLAYERS

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ABSTRACT

Aim: To study about the explosive power and reaction time among college players.

Background: We examine the college level players

Objectives: Total of 45 college players from the Jenney's College of Physical Education, Tamil Nadu , India at the age range between 19 to 24 have participating in this study. That is made to determine the effect of various surface of plyometric training on explosive power and reaction time among college.

Methods: The subjects were separated into three equal groups of 15 each. Experimental group-A lawn surface plyometric training and group-B Wooden surface plyometric training was control group was not treated. Various plyometric exercises will be given for group – A and B for twelve weeks.

Results: The data retrieval process is done by explosive power measured by Sargent Jump Test and reaction time measured by construction method analysis at pre-test and post-test. Collected data's will be analysed by't'-test. The level of confidence (LOC) 0.05 was fixed.

Conclusion: The result of the research shows various surface plyometric training gave positive performance on explosive power and reaction time when compare to control group

Keywords: Plyometric Training, various ground surface, College players.

1. INTRODUCTION

Plyometric (ply) practice begins with a quick stretch of a muscle followed by a fast shortening. Strength preparing can further develop muscle execution and coordination of muscle groups. The nerve system is adapted to respond all the more rapidly to the stretch-shortening cycle. Ply either alone or in mix with other preparing modalities evokes various positive changes in the neural and outer muscle frameworks, muscle work and athletic execution of sound individuals. Ply alludes to practices that are intended to improve neuromuscular performance.

Ply practices establish a characteristic piece of most game developments as they include bouncing, jumping and skipping. The advancement of maximal strength execution as this neuromuscular quality seems to support most different spaces of human actual limit. Ply preparing is a set up strategy for improving athletic execution may likewise work with advantageous variations in the sensorimotor framework that upgrade dynamic limitation instruments and right defective hopping or cutting mechanics.

Ply practices are characterized as capricious stacking promptly followed by a concentric constriction. Useful preparing strategies with dreary bouncing and deceleration exercises might make plastic neurologic transformations to engine programs that further develop coordination for both execution and dynamic restriction. Ply practices increment execution and abatement injury hazard. Neuromuscular transformations are accepted to upgrade dynamic knee steadiness and

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execution the particular variations answerable for the achievement of ply preparing are as yet hypothetical.

Various surfaces should be considered at plyometric preparing. Hard level surface that is for the most part put together with wood or synthetic materials. Ply preparing on lawn is practical choice for sport trained professionals and competitors. The hardness of the preparation surfaces with their separate compensation coefficient. Distinctive preparing actuated impacts on some neuromuscular elements identified with the productivity of the stretch-shortening cycle.

2. METHODS

The study was a randomized controlled trial. 45Subjects were designed randomly to A- Lawn surface PLYG and B - Wooden surface PLYG as experimental group and C- control group. The control group was instructed to maintain regular activities and to avoid any strenuous physical activity during the study. Subjects in experimental groups completed 12-weeks exercise training on alternate days (3 days of training a week). Performance tests were performed in the week before and the week after the 12 weeks of training period. All testing and preparing occurred simultaneously of day to control for in execution. To eliminate conceivable learning impacts that could bewilder the aftereffects of the review, all subjects took an interest in a 1-week acclimation period before inception of the review to acclimate themselves to the testing and preparing method. Explosive power is measured by Sargent jump test and reaction time measured by construction method. The three groups were statistically analysed by using 't'test and IBM SPSS 23 was using for statistical analysis and significant level 0.05 of confidence.

Table -1

Variables and test items

Sn.no	Variables	Tests
1.	Explosive power	Sargent jump test
2.	Reaction time	construction method

3. RESULTS

Table II

T ratio of experimental groups and control group

Explosive Power					
Groups	**Pre**	**Post**	**Mean**	**Standard Deviation**	**T Value**
LAPLYG	35.70	38.18	2.48	2.25	**4.25***
WDPLYG	35.48	38.58	3.09	2.29	**5.21***
CNG	35.16	35.39	0.23	2.73	0.32
Reaction Time					
Groups	**Pre**	**Post**	**Mean**	**Standard Deviation**	**T Value**
LAPLYG	70.13	65.46	4.66	1.04	**17.20***
WDPLYG	70.93	63.00	7.93	1.22	**25.12***
CNG	72.46	72.00	0.46	2.41	0.74

Significant level 0.05 table value 2.01

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The obtained 't'- ratio of explosive power of LASDPLYG was 4.25*, WDPLYG was 5.21* is more noteworthy than the table value and get huge LOC 0.05.but the CNG't'-ratio was 0.32 and it was lesser than table value it ought to be immaterial.

The obtained 't'- ratio of Reaction time of LAPLYG was 17.20*, WDPLYG was 25.21* is more noteworthy than the table value and get huge LOC 0.05.but the CNG't'-ratio was 0.74 and it was lesser than table value it ought to be inconsequential.

3. CONCLUSION

It was concluded that experimental groups have greater significant in explosive power and reaction due to the 12 weeks of plyometric training.

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EFFECT OF SAQ TRAINING ON SPEED AND AGILITY AMONG MEN VOLLEYBALL PLAYERS

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ABSTRACT

This research was to see how effect of saq training on speed and agility among men volleyball players. 30 volleyball players from the Jenney's College of Physical Education, Tamil Nadu , India, were chosen at randomly. The age limit is 18 to 23. The participants were placed into two groups: EG-A, and CG-B. SAQ was carried out in EG-A and control group EG-B not participating other than their everyday activities. Through data was collected from three pre- and post-experimental parties. The paired sample T-Test was used to statistically assess on speed and agility. SAQ preparing has shown better execution on speed and agility than the control group and it shows better execution.

Keywords: SAQ Training, Volleyball Players.

1. INTRODUCTION

Volleyball is viewed as a very explosive and high paced sport. Volleyball is an exceptional anaerobic game that joins explosive developments with short times of recuperation. Speed and agility are joined with greatest strength, power is the result. Muscular force enables a given muscle to deliver a similar measure of work in not so great, or a more prominent of work in a same time, which is significant for running, bouncing and quick change of direction.

Exercise of SAQ the total range of training intensity, from low intensity to high intensity. Speed is the capacity of the complex, on the grounds that by and large, speed is a capacity that permits a volleyball player to move as fast as conceivable at the degree of specific movement. Agility is a significant quality in a great deal of sports that are played on the field. Speed increase and speed can be effect by changing the development mechanism of the arms or legs.

2. METHODOLOGY

Thirty volleyball players from Jenney's College of Physical Education, Tamil Nadu , ranging in age from 18 to 23, were recruited for the study. The participants were split into two groups. The following factors were chosen by the researcher for the current study.

Table-I

Sn.no	Variables	Test item	units
1.	Speed	50 mts dash	seconds
2.	Agility	t-test	seconds

True randomized experimental group design has been employed with two groups namely SAQ training group A and control group with 15 subject of each group. Group A participated their respective treatment for a period of eight weeks and general exercise was given to control group.

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The training should be given at morning time with proper warming up exercise for 3 times a week (Monday, Wednesday and Friday) for eight weeks. The three groups were statistically analyzed by using t-ratio to find out significance of the difference made by the experimental and control groups during the experimental period of eight weeks. All analysis were executed IBM-SPSS 22.0 software was used the confidence level maintained 0.05

3. RESULTS

Table – II

Summary of mean and paired sample'ť' test for the pre and post test on SAQ Groups and control group

Variables	Tests	SAQ Training Group	control Group
speed	Pre Test & Sd Mean	7.27- 0.19	7.28 – 0.24
	Post Test & Sd Mean	7.19 – 0.16	7.30 – 0.28
	T-Test	6.37*	1.87
Variables	**Tests**	**SAQ Training Group**	**control Group**
agility	Pre Test & Sd Mean	11.04 - 0.45	11.37 - 0.80
	Post Test & Sd Mean	10.68 - 0.51	11.44 - 0.78
	T-Test	5.93*	1.69

***Significant level at 0.05 level. The table value required for 0.05 level of significance with df 1 and 14**

The saq group had a pre-test mean value of 7.27, a control group of 7.28, and a post-test mean value of 7.19 and a control group of 7.30. The 't' values for speed in the saq training and control groups were 6.37 and 1.87, respectively. With df 14 at 0.05 level of confidence, the importance of saq training groups was considerably greater than the required table value of 2.04. The result of the study shows that saq training has dramatically improved the speed.

The pre-test mean value of the saq group was 11.04, the control group was 11.37, and the post-test mean value was 10.68 for the control group and 11.44 for the saq group. The 't' values for agility in the saq training and control groups were 5.93 and 1.69, respectively. At a 0.05 level of confidence, the 't' values of the saq training groups were considerably higher than the needed table value of 2.04 with df 14. The result of the study shows that saq training has dramatically improved in agility.

4. CONCLUSION

In the light of this examination endeavored with limit constrained by the preliminary condition, the going with end was drawn. The after effect of the assessment reveals that there was a basic improvement in the exploratory group on chose contrasted group with the control after the completion of saq preparing has shown better execution on speed and agility than the control group

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and it shows better execution. That effect saq training will helps the volleyball players to further develop her show level in an extraordinary manner**.**

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Conflict of Interest: **Nil**

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IMPACT OF CONCURRENT STRENGTH AND ENDURANCE TRAINING AND DETRAINING ON CARDIO RESPIRATORY ENDURANCE

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ABSTRACT

Backgroud: The motive concerning the instruction is in imitation of decide the effect of concurrent strength and endurance training and detraining on cardio respiratory endurance.

Objects: Thirty healthy boys (mean (SD) age 21.3 (2.1) years) have been assigned after experimental (n = 15) yet non participation control group (n = 15) groups.

Methods: They received oversea 12 weeks concurrent strength yet endurance training followed through forty days detraining period. Cardio respiratory endurance was reasonable at baseline or right now below training then also at some stage in detraining period.

Results: The facts gathered beside the two groups before after then post experimentation had been statistically analysed by way of evaluation about covariance (ANCOVA). The post experimentation and detraining period (four cessation) were analysed with the aid of two way (2 x 5) factorial ANOVA with ultimate thing repeated measures.

Results: Although concurrent strength then endurance training improved cardio respiratory (17.22%) all training triggered good points had been abolished then forty days regarding of detraining.

Keywords: Concurrent Training, Endurance Training, Detraining, Cardio respiratory endurance and Anova

1. INTRODUCTION

Many people, each athletes yet non-athletes, take share into aggregate about energy then staying power training, which is repeatedly known as concurrent training. Concurrent training (CT) is characterized by performing resistance training (RT) and aerobic training. Countless numbers about recreational exercising enthusiast perfect theirs cardiovascular then strength coaching workouts at some point of the same training session, concurrent training (CT) intervention improved strength and within hours concerning one another. The potential detrimental effect of endurance training on the muscle fibre size of highly. Detraining refers in accordance with the physical impact skilled so one takes an extended smash beside regular, concurrent power training and high-intensity interval cycling on muscle morphology and performance full of life fitness training. More than pair weeks of abstinence beyond physical coaching, training session, being characterized as concurrent training may hourly reason a reduction of the top fitness level. Concurrent training endurance and resistance in a single session. Physical endeavour may necessity in conformity with lie postponed because various weeks and months. Concurrent training (CT) is characterized by performing and concurrent training (CT) intervention improved strength the influences over the body may additionally CT order the order of RT stay noticed fairly quickly. To improve the sports performance the athlete needs to take part in systematic training by the way of

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scientific method of training. Many athletes take an extended duration physical fitness variables- speed and explosive power concerning relaxation to purposefully allow theirs bodies in accordance with detraining aerobic exercises and aerobic exercise on Vo2 max parameter. While it might also initially fail their modern-day health level, improving subjective wellbeing, mental health and executive functioning in different populations[14] the period on rest intention allow the muscle groups the effect of selected aerobic capacity and anaerobic power.

2. METHODOLOGY

Participants and variables 30 untrained people volunteered to participate in the study. The selected individuals have studied Jenney's College of Physical Education, Tamil Nadu .

His age, height and weight ranged between 18 and 22 years, 158 cm to 174 cm, 50 kg to 71 kg. They were randomly divided into 2 groups and each groups was made up of fifteen people. A written informed consent form is signed by anyone who is aware of all the risks, drawbacks, and blessings involved. The selected base variable became aerobic respiratory endurance and was assessed by Cooper's 12-minute walk or run test. Data was collected before and now after twelve weeks of training and additionally for the entire duration of detraining on ten days for 40 days.

3. RESULTS

Table - I

Analysis of covariance on cardio Respiratory Endurance of Concurrent Strength and Endurance Training and control Groups

-	Exp Group	Control Group	Source of variance	Sum of Squares	df	Mean squares	F-ratio
Pretest MeanSD	2449.33	2454.66	Between	40241.3	1	40241.3	3.08
	I 115.16	93.41	Within	365589	28	13056.75	
Posttest Mean SD	2871.33	2545.33	Between	1594191	1	1594191	98.44*
	132.92	85.09	Within	453440	28	16194.29	
AdjustedPosttestMean	2847.53	2516.14	Between	1925434	1	1925434	649.96*
			Within	79984.9	27	2962.40	

*Significant at .05 level of confidence

Table–II

Two Factor ANOVA on Cardio Respiratory Endurance of Groups at Five Different Stages of Tests

Source of Variance	Sum of Squares	Df	Mean Squares	F-ratio
A factor (Groups)	4989400.9	1	4989400.9	

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Group Error	1428632.0	28	51022.57	97.79*
B factor (Tests)	306175.1	4	76543.78	29.08*
AB factor Interaction) Group and Tests)	154176.9	7	22025.27	8.37*
Error	252688.0	96	2632.17	

Table-III

The Simple Effect Scores of Groups (Rows) at Five Different Stages of tests(columns) on Cardio Respiratory Endurance

Source of Variance	Sum of Squares	df	Mean Squares	-F-ratio
Groups at Posttet	1594172	1	1594172	605.65*
Groups at First Cessation	1281646	1	1281646	486.92*
Groups at Second Cessation	807240	1	807240	306.68*
Groups at Third Cessation	722317.5	1	722317.5	274.42*
Groups at Fourth Cessation	638226.8	1	638226.8	242.47*
Tests and Group I	332625.9	4	83156.48	31.59*
Tests and Group II	10840.6	4	2710.15	1.03
Error	252688.0	96	2632.17	

Table - IV

Scheffe's test for the differences among paired means of Concurrent Strength and Endurance Training Group with different tests on Cardio Respiratory Endurance

Posttest	First cessation	Second cessation	Third cessation	Fourth cessation	Mean difference	Confidence interval
2871.33	2862.00				10.67	58.75
2871.33		2816.66			54.67	58.75
2871.33			2802.66		68.67*	58.75
2871.33				2764.00	107.33*	58.75
	2862.00	2816.66			65.34*	58.75
	2862.00		2802.66		79.34*	58.75
	2862.00			2764.00	118.00*	58.75
		2816.66	2802.66		14.00	58.75
		2816.66		2764.00	52.66	58.75
			2802.66	2764.00	38.66	58.75

*Significant at .05 level of confidence

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4. DISCUSSION

Endurance trained athletes ought to avoid detaining periods over some weeks since alterations of the metabolic diversifications to coaching might become apace chronic once such delays. These observations are supported by this findings that the coaching induced changes on cardio metabolism endurance performance was step by step declined towards the baselines because of the impact of detraining.

5. CONCLUSION

From the results it had been complete that cardio metabolism endurance performance are often improved considerably because of twelve weeks of coincident strength and endurance coaching. it had been additionally complete that the cardio metabolism endurance performance are often maintained for twenty days throughout the detraining amount, there once these improved performance started declining towards the bottom line. Therefore it's instructed that endurance event athletes shouldn't endure detraining for no more than twenty days in an exceedingly row. But this improved performance are often maintained for prolong amount by undergoing restricted quantity of coaching throughout the detraining.

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Dr. P.Kumaravelu conceptualized and gathered the info with relevancy this work. Dr. P.Kumaravelu ,Dr.C.Umadevi and Dr.T Arun Prasanna analysed these knowledge and necessary inputs got towards the planning of the manuscript. All authors mentioned the methodology and results and contributed to the ultimate manuscript.

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ISOLATED AND COMBINED EFFECT OF CORE STRENGTH AND YOGIC PRACTICES ON PHYSICAL AND PSYCHOLOGICAL VARIABLES

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ABSTRACT

The purpose of the study was to examine the effect of core strength training and yogasana practices on selected physical fitness components among female athletes. To achieve the purpose of the study sixty (N = 60) female athletes, they were selected randomly in Chennai, Tamil Nadu, India as subjects. The age of the subjects ranged from 14 to 19 years. They are divided into four equal groups consists of fifteen subjects each (n = 15) namely core strength group, yogic group, combined core and yogic group and control. The period of experimentation is limited to 15 weeks with a proper warming-up and cooling-down regimen. The selected physical fitness and psychology components such as cardio-respiratory endurance (12min run or walk test), BMI (Height and Weight Ratio), emotional intelligence (Questionnaire) self esteem (Questionnaire) were selected as criterion variables and tested. The core strength training and the yogic practices were selected as training protocol. The core strength training will be given based on individuals 1 RM to set the load and the intensity will be set between 75% to 90%. The pre-test and post-test means of experimental groups and control group will test for significance by applying the descriptive statistics with independent 't' test on each group. The level of confidence is fixed at 0.05. Based on the result of the study there was a significant change on health related physical fitness and psychological performance due to core strength training and yogic practice. The combined group shown better improvement on selected criterion variables than the isolated training group.

Keywords: Core Strength, Yoga, Physical Fitness, Psychology, Women Athletes.

1. INTRODUCTION

Core muscles including the transverse abdominis, multifidus, diaphragm, and pelvic floor muscles are thought to contribute stability of the spine. Reports have shown that transverse abdominis contracts first to contribute to stiffness as a feed forward function during upper limb activities and standing tasks involving sudden perturbation **(Willson et al, 2005)**

The other core muscles (i.e., multifidus, diaphragm, and pelvic floor muscles) are supposed to perform the similar functions to transverse abdominis. These four core muscles contract first to increase stability of the trunk during extremity exercises and have been considered to help prevent injuries from sports **(Cresswell,1994)**

Strength exercises for the abdominal muscles among student participants in experiments have been reported to increase stability of the lumbar spine. Core training excluding the diaphragm for elderly individuals can also improve balance ability. Strength exercises for these four muscles are therefore hypothesized to help improve balance ability during sitting without support **(Kim & Lee, 2013)**

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Yoga is derived from Sanskrit root "yuj" meaning "to control" or "to unite." Regular practice of any form of yoga helps in establishing natural harmony and functional balance between various organ systems, leading to better health and a feeling of well-being. Yoga has traditionally been viewed as a relatively safe form of exercise. The practice of yoga poses, or asanas, was developed as an approach to align, strengthen, and balance the structure of the body. Further, it has been used to enhance dynamic control of core stabilizing muscles to reduce lower back pain (LBP), through increased hip and spinal flexibility. Yoga postures comprise simple body movements such as standing, sitting, forward and backbend, twist, inversion, and laying down in supine position. Various yogic postures and exercises have been shown to activate specific muscles.

The physical benefits of exercise nevertheless less often the psychological benefits promoted. Yet, engaging in a moderate amount of physical activity will result in improved mood and emotional states. Exercise can promote psychological well-being as well as improve quality of life for the reason that sport psychologists may work with people who naturally want to excel, caution must be exercised so these individuals do not push themselves beyond what they are able to manage in therapy (Kang, 2015)

. Confidentiality issues may also arise for therapists if they work with professional athletes or teams that are consistently covered by the media. For example, counsel and encouragement given to a specific player during a game may be picked up by surrounding microphones or cameras.

Additionally, sport psychologists tend to focus on the mental health of athletes and how mental health affects their athletic performance. Therefore, a person would not typically seek a sport psychologist first for issues such as marital problems or addiction issues without a referral from another mental health professional. In such cases, a therapist specializing in addiction treatment or marriage counseling may be a better fit for the person seeking therapy (Hodges et al, 2001).

Sport and fitness psychology is an approach that focuses on the intersection between sport science, medicine, and psychology. This therapeutic model expands on research, theory, and practices to improve performance in professional and amateur athletic settings. Sport psychology researchers work to understand how psychological factors can impact motor performance and how participation in physical activity affects human psychological development (Voelkner, 2012). Sports psychologists are also interested in understanding how social and psychological interventions affect the well-being of athletes, teams, coaches, parents, spectators, trainers, exercisers, and participants who are engaged in physical activities.

2. METHODOLOGY

Participants

To achieve the purpose of the study sixty (N = 60) female athletes, they were selected randomly in Chennai, Tamil Nadu, India as subjects. The age of the subjects ranged from 14 to 19 years. They are divided into four equal groups consists of fifteen subjects each (n = 15) were named experimental group I underwent core strength training and experimental group II underwent yogasana practices group – III underwent yogasana practices combined core strength and yogic practice and group IV acted as a control.

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Materials and Procedure

The period of experimentations is limited to 15 weeks, 6 days a week and 45 to 60 minutes per day with proper warming-up and cooling down regimen. The selected physical fitness and psychology components such as cardio respiratory endurance (12min run or walk test), BMI (Height and Weight Ratio), emotional intelligence (Questionnaire), self esteem (Questionnaire) were selected as criterion variables and tested. The core strength training and the yogic practices will be selected as training protocol. The core strength training will be given based on individuals 1 RM to set the load and the intensity will be set between 75% to 90% and the training routine includes Crunches, Decline Crunch, Cable Crunch, Oblique Crunches, Jackknife Sit-Up, Barbell Side Bend, Leg lift, Leg lift – Hang Position, Oblique Leg lift. The yogic practices consist of Suryanamaskar. Tadasana, Trikonasana, Paschimottanasana, Chakrasana, Bhujangasana, nadi sodhana, bastrika, kabalapathi and bharmari. The isolated core strength and yogic practice routines done on continuous days whereas the combined practices were done on alternative days.

Statistics

The pre-test and post-test means of experimental groups and control group were test for significance by applying the descriptive statistics with independent ‘t’ test on each group separately. The magnitude of improvement from the initial mean on each criterion variables were analysed by percentage calculation and presented graphically. The level of confidence is fixed at 0.05. All the data will analyse using a computer with SPSS statistical package.

3. RESULTS

Variables	Group	Pre Test	Post test	Mean Difference	‘t’ Ratio	‘P’ Value
Cardio Respiratory Endurance	**Core Training Group**	1936.66 ± 22.88	2040.66 ± 21.20	104.00	**12.91***	0.00
	Yogic Group	1943.33 ± 17.59	2046.66 ± 12.90	103.33	**18.34***	0.00
	Combined Group	1933.33 ± 24.39	2097.33 ± 5.93	164.00	**25.29***	0.00
	Control Group	1933.33 ± 24.39	1945.00 ± 12.36	11.67	**1.86**	0.66
Body Mass Index	**Core Training Group**	24.00 ± 0.65	21.86 ± 0.35	2.14	**11.17***	0.00
	Yogic Group	24.46 ± 0.74	22.26 ± 1.03	2.20	**6.69***	0.00
	Combined Group	24.20 ± 0.67	20.73 ± 0.59	3.47	**14.92***	0.00
	Control Group	24.20 ± 0.41	23.86 ± 0.51	0.34	**1.95***	0.33

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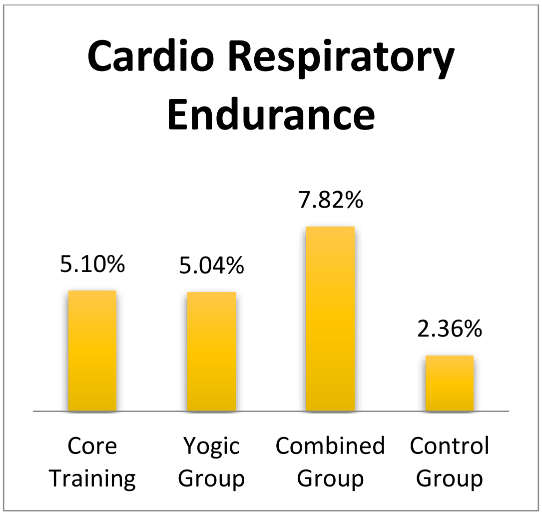
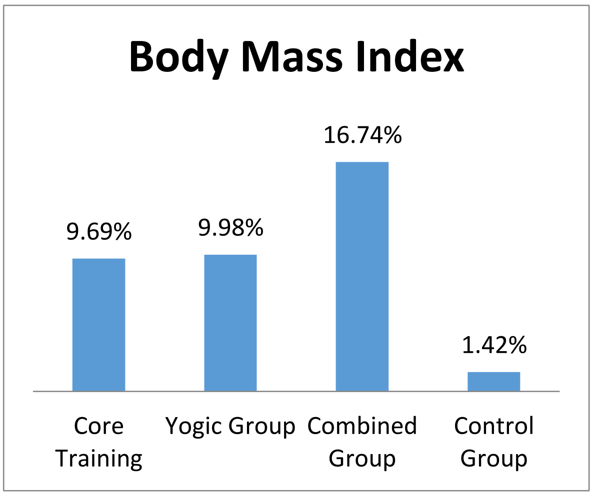
Emotional Intelligence	**Core Training Group**	113.73 ± 0.96	118.93 ± 0.70	5.20	**16.90***	0.00
	Yogic Group	113.86 ± 0.99	123.20 ± 1.08	9.34	**24.63***	0.00
	Combined Group	113.73 ± 0.96	126.33 ± 0.48	12.60	**45.27***	0.00
	Control Group	113.93 ± 0.96	114.06 ± 0.70	0.13	**0.43**	0.13
Self Esteem	**Core Training Group**	25.13 ± 0.63	32.33 ± 0.81	7.20	**26.88***	0.00
	Yogic Group	25.40 ± 0.63	33.20 ±0.77	7.80	**30.20***	0.00
	Combined Group	25.46 ± 0.51	34.33 ± 2.35	8.87	**14.27***	0.00
	Control Group	25.40 ± 0.50	25.40 ± 0.63	0.00	**0.00**	1.0

*Significant

The results shows that there was a significant difference between pre and post test means on experimental groups, whereas the control group shown insignificant on selected criterion variables. When the comparison on mean difference the isolated core strength training group and yogic group similarly improves on cardio respiratory endurance, BMI and emotional intelligence, while the combined core strength and yogic practice group shows better improvement than the isolated group on cardio respiratory endurance, BMI and emotional intelligence. The isolated and combined groups show similar improvement on self esteem. Hence, the results of percent study explored that the combined core strength and yogic practice group had significant improvement on selected criterion variables whereas some psychological variables similar among groups.





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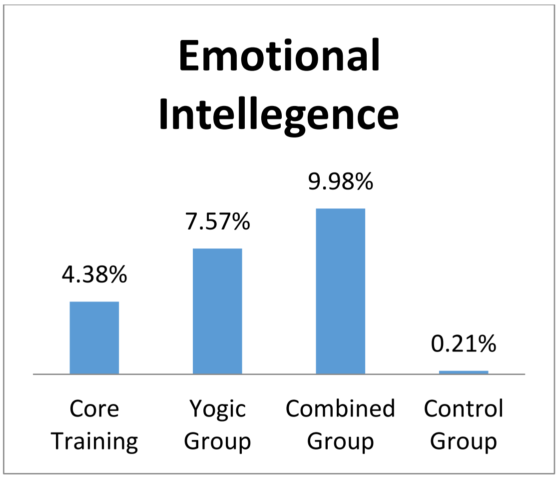

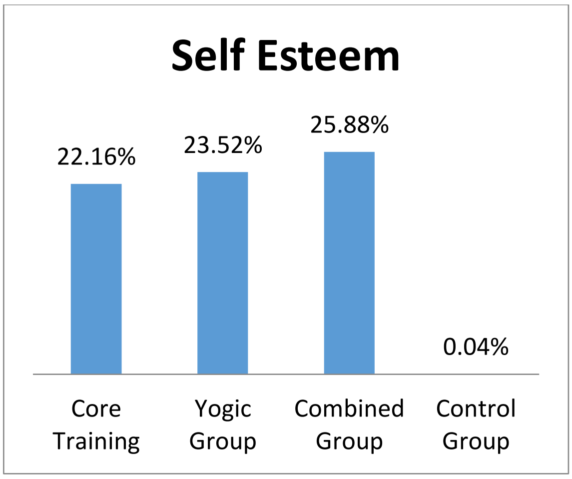

4. DISCUSSION AND CONCLUSION

The results of previous researches in-line with the present results of the study would be discussed below. Holmbäck, 1994 conclude that marginal improvements in physical performance are achieved six months after training is finished, with psychological benefits apparent versus a usual care program. The investigation likewise estimated their impression of their psychological parameters. The outcomes were related with the present discoveries.

As per Heidi Rubenstei, 2004 combined plyometrics and general obstruction preparing program demonstrated the execution increment. The consolidated preparing has a superior increment in execution in all ages and the above outcomes in accordance with the present examination. Additionally Maffiuletti et.al.,2002 brought up that consolidated preparing methodology delivered fast increment of the knee extensors and plantar flexors maximal quality. Further, the present investigation slightly modified into above results.

Ruiz et al 2011 investigated the oxygen consuming and quality exercise were higher with joined high-impact and quality preparing than with vigorous preparing alone, recommending a more fast heart rate recuperation after high-impact work out. the examination recommends that there is a post-practice hypotensive reaction in normotensive men after oxygen consuming, quality, and joined preparing modalities. The outcome additionally found regarding the present outcomes. The core strength training combined with yogic practice may also increasing oxygen consuming, so that the performance was increased.

Reed et al 2012 concentrated Isolated and Integrated 'Centre Stability' Training on Athletic Performance Measures and discovered Targeted centre strength preparing gives peripheral advantages to athletic execution. Clashing discoveries and the absence of an institutionalization for estimation of results and preparing cantered to enhance centre quality and security present troubles. The modality of present training modality in-connection with above results.

Late examinations may have ignored the fundamental highlights of yoga, or, in other words than breathing activities. Counting all parts of yoga together in this investigation has more useful impacts. In any case, none of the past analysis has gone into the conceivable systems by which yoga (Khanam, 1996). The present discoveries have demonstrated similitude on cardio respiratory endurance in confined and joined yogic practice.

The relationship between the improvement of various psychological measures and physical activity by examining the potential for environmental, social, mechanical, and biological factors to

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act as the required stimuli. Evaluate the health-related benefits that are likely to occur for young women's including those at psychologically depressed and puberty women (Morris et al , 1999). The above concepts followed in the time of initiate the present investigation.

Regular hatha yoga practice have significant benefits in improving the health related aspects of physical fitness. Although previous studies have found significant increases in muscle strength and endurance, flexibility, and cardio respiratory endurance (Salonen, 1999). There were no significant changes in body composition or pulmonary function. Muscular strength increased significantly in three of the four tests.

However, the authors estimated cardio respiratory endurance by run or walk test. Blumenthal et al. and Raju et al. Measured respiratory endurance by the analysis of expired gases and reported significant changes resulting from yoga practice. However, the sample population in these two studies consisted of healthy young women's and elite athletes respectively. The present study is the first to show improvements in cardio respiratory endurance by direct measurements.

Madhavi et al. showed that three months of yoga training led to a significant reduction in percent body fat, thereby resulting in an increase in fat free mass. Conversely, Gharote and Gangulym, observed an increase in percent body fat after nine weeks of yoga practice. The contradictory results may be attributed to differences in yoga training programs, intensity of exercises, duration of yoga studies, and lack of nutritional data from the three reports.

Based on the results and appropriate discussions on percent study concluded that the core strength training and yogic practices improves the physical and psychological performance of women athletes. The combined training group shows advancement of criterion variables than the isolated training group. The study also recommended that the combined type of training may give better improvement of performance among women athletes in all aspects in upcoming days.

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CORRELATE MOTOR FITNESS VARIABLES AND PLAYING ABILITY AMONG BASKETBALL MALE PLAYERS

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ABSTRACT

The purpose of the study was to find out the relationship between selected motor fitness variables and playing ability among Basketball players. To achieve the purpose of this study the investigator selected a hundred college men Basketball players from Bengalur at randomly and their age ranged between 18 to 24 years. The following Motor Fitness variables will be selected to this study: muscular strength, muscular endurance, cardio-vascular endurance, flexibility, body mass index, power, speed, agility, balance and reaction time. Obtained data were analyzed with the Pearson product moment correlation. Power with muscular strength, muscular endurance, cardio vascular endurance, flexibility, body mass index, agility, balance and reaction time. Speed and muscular strength, muscular endurance, cardio -vascular endurance, flexibility, agility, balance, and reaction time. Agility flexibility, body mass index, power, speed and reaction time. balance with muscular strength, muscular endurance, cardio -vascular endurance, flexibility, power, speed, and reaction time. reaction time with cardio -vascular endurance, flexibility, power, speed, agility, and balance.

Keywords: Motor Fitness, Playing Ability and Basketball

1. INTRODUCTION

A person doing any physical activity or exercise with undue fatigue is called fitness. Motor fitness means ability to make a movements or motion in one place to another place through of the human body segments with undue fatigue. And also Suitability or preparedness for performing big muscle activity without undue fatigue; it is composed of muscular strength and endurance, cardiovascular endurance, power, flexibility, coordination, balance, speed and agility. It helps to prepare capsules of training based on Basketball player's level of fitness. For instance muscular power helps to determine player's explosiveness and spiking ability. Agility helps for better blocking and spiking abilities. Shoulder strength helps to execute on service, spiking, blocking and passing in an efficient manner. The player's reaction time helps to the specific reaction ability during spiking, blocking and ball collecting moments. Abdominal strength helps directly on the core power on air check and body co-ordination on during game situation.

2. METHODOLOGY

The purpose of the study was to find out the relationship between selected motor fitness variables and playing ability among Basketball players. To achieve the purpose of this study the investigator selected hundred college men Basketball players from Bengaluru at randomly and their age ranged between 18 and 24 years. The following motor fitness variables will be selected to this study: muscular strength, muscular endurance, cardio-vascular endurance, flexibility, body mass index, power, speed, agility, balance, and reaction time obtained data were analyzed with the Pearson product moment correlation.

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Table I

Shows Mean Standard Deviation and Range of Motor Fitness variables and Playing Ability of Basketball players

S. No	Variables	Sample size	Mean	S D	Minimum	Maximum
1	Muscular strength	100	21.26	5.03	12	30
2	Muscular endurance		30	6.11	20	43
3	Cardiovascular endurance		42.50	5.65	30	52
4	Flexibility		24.87	3.97	18	31
5	Body Mass Index		21.72	2.01	17.96	25.39
6	Power		2.61	0.28	2.05	3.11
7	Speed		6.10	0.21	5.70	6.50
8	Agility		4.66	0.30	4.10	5.13
9	Balance		4.59	0.38	3.28	5.22
10	Reaction time		0.12	0.03	0.06	0.18
11	Playing ability		86.93	3.38	78.00	92.00

Table II

Shows Coefficient Correlation values of motor fitness variables and playing ability of basket players

Variables	Muscular strength	Muscular endurance	Cardiovascular endurance	Flexibility	body mass index	Power	Speed	Agility	Balance	Reaction time	Playing ability
Muscular strength		0.76*	0.52*	0.49*	0.35*	0.31*	0.24*	0.16	0.28*	0.09	0.22*
Muscular endurance	0.76*		0.82*	0.59*	0.42*	0.31*	0.39*	0.12	0.39*	0.18	0.06
Cardiovascular endurance	0.52*	0.82*		0.52*	0.22*	0.37*	0.52*	0.11	0.39*	0.30*	0.18
Flexibility	0.49*	0.59*	0.52*		0.47*	0.33*	0.33*	0.37*	0.30*	0.34*	0.38*
Body Mass Index	0.35*	0.42*	0.22*	0.47*		0.22*	0.10	0.26*	0.07	0.18	0.23*
Power	0.31*	0.31*	0.37*	0.33*	0.22*		0.14	0.29*	0.24*	0.32*	0.40*
Speed	0.24*	0.39*	0.52*	0.33*	0.10	0.14		0.32*	0.34*	0.20*	0.09
Agility	0.16	0.12	0.11	0.37*	0.26*	0.29*	0.32*		0.07	0.30*	0.51*
Balance	0.28*	0.39*	0.39*	0.30*	0.07	0.24*	0.34*	0.07		0.33*	0.23*
Reaction time	0.09	0.18	0.30*	0.34*	0.18	0.32*	0.20*	0.30*	0.33*		0.44*
Playing ability	0.22*	0.06	0.18	0.38*	0.23*	0.40*	0.09	0.51*	0.23*	0.44*	

*significant the required table value r (99) = 0.19 at 0.05 level of significance

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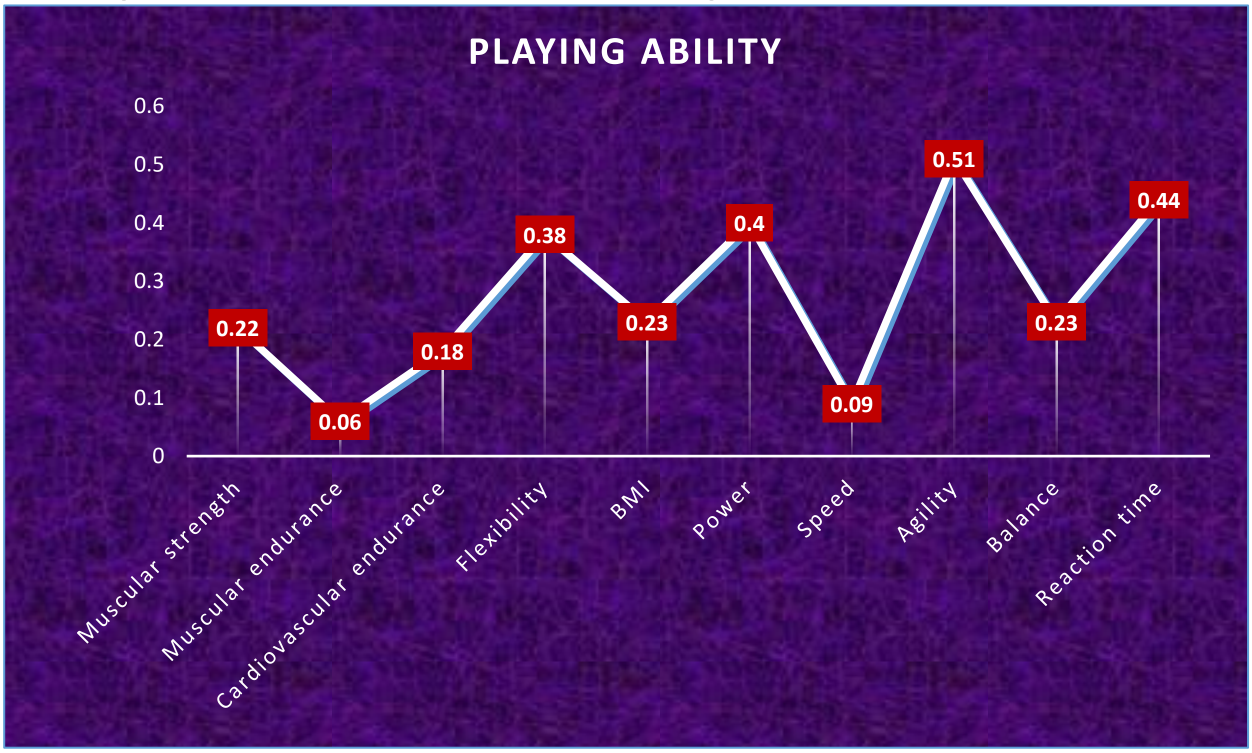
In table II shows pair wise correlation(r) values of playing ability with muscular strength=0.22, muscular endurance=0.06, cardio-vascular endurance=0.18, flexibility=0.38, body mass index=0.23, power=0.40, speed=0.09, agility=0.51, balance=0.23 and reaction time=0.44.

The result of this study there was a significant relationship between playing ability and motor fitness variables of muscular strength=0.22, flexibility=0.38, body mass index=0.23, power=0.40, agility=0.51, balance=0.23 and reaction time=0.44 at 0.05 level of significance. The result of this study there was a significant relationship within motor fitness variables of muscular strength with muscular endurance=0.76, cardio - vascular endurance = 0.52, flexibility = 0.49, body mass index = 0.35, power = 0.31, speed = 0.24 and balance = 0.28. muscular endurance with muscular strength = 0.76, cardio -vascular endurance = 0.82, flexibility = 0.59, body mass index = 0.42, power = 0.31, speed = 0.39 and balance = 0.39. cardio -vascular endurance with muscular strength = 0.52, muscular endurance = 0.82, flexibility = 0.52, body mass index=0.22, power=0.37, speed = 0.52, balance = 0.39 and reaction time = 0.30. flexibility with muscular strength =0.49, muscular endurance = 0.59, cardio -vascular endurance = 0.52, body mass index = 0.47, power = 0.33, speed=0.33, agility=0.37, balance=0.30 and reaction time=0.34. body mass index with muscular strength=0.35, muscular endurance=0.42, cardio -vascular endurance = 0.22, flexibility=0.47, power=0.22 and agility=0.26. power with muscular strength=0.31, muscular endurance=0.31, cardio -vascular endurance = 0.37, flexibility=0.33, body mass index=0.22, agility=0.29, balance=0.24 and reaction time=0.32. speed and muscular strength=0.24, muscular endurance=0.39, cardio -vascular endurance =0.52, flexibility=0.33, agility=0.32, balance=0.34 and reaction time = 0.20. agility with flexibility = 0.37, body mass index = 0.26, power=0.29, speed=0.32 and reaction time=0.30. balance with muscular strength=0.28, muscular endurance=0.39, cardio -vascular endurance =0.39, flexibility=0.30, power=0.24, speed=0.34 and reaction time=0.33. reaction time with cardio -vascular endurance=0.30, flexibility=0.34, power=0.32, speed=0.20, agility=0.30 and balance=0.33 at 0.05 level of significance.

Figure 1: Shows Relationship between Playing Ability and Motor Fitness Variables



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3. RESULTS

- ✓ The conclusion of the study that there was a significant relationship between playing ability and motor fitness variables of muscular strength, flexibility, body mass index, power, agility, balance, and reaction time.
- ✓ The conclusion of the study that there was a significant relationship within motor fitness variables of muscular strength with muscular endurance, cardio-vascular endurance, flexibility, body mass index, power, speed, and balance.
- ✓ The conclusion of the study that there was a significant relationship within motor fitness variables of muscular endurance with muscular strength, cardio -vascular endurance, flexibility, body mass index, power, speed, and balance.
- ✓ The conclusion of the study that there was a significant relationship within motor fitness variables of cardio-vascular endurance with muscular strength, muscular endurance, flexibility, body mass index, power, speed, balance, and reaction time.
- ✓ The conclusion of the study that there was a significant relationship within motor fitness variables of flexibility with muscular strength, muscular endurance, cardio -vascular endurance, body mass index, power, speed, agility, balance, and reaction time.
- ✓ The conclusion of the study that there was a significant relationship within motor fitness variables of body mass index with muscular strength, muscular endurance, cardio -vascular endurance, flexibility, power and agility.
- ✓ The conclusion of the study that there was a significant relationship within motor fitness variables of power with muscular strength, muscular endurance, cardio -vascular endurance, flexibility, body mass index, agility, balance and reaction time.
- ✓ The conclusion of the study that there was a significant relationship within motor fitness variables of speed and muscular strength, muscular endurance, cardio -vascular endurance, flexibility, agility, balance and reaction time.
- ✓ The conclusion of the study that there was a significant relationship within motor fitness variables of agility with flexibility, body mass index, power, speed, and reaction time. balance with muscular strength, muscular endurance, cardiovascular endurance, flexibility, power, speed, and reaction time.
- ✓ The conclusion of the study that there was a significant relationship within motor fitness variables of reaction time with cardio -vascular endurance, flexibility, power, speed, agility and balance.

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IMPACT OF PLYOMETRIC AND TABATA TRAINING ON SPEED ENDURANCE AND VITAL CAPACITY AMONG MEN VOLLEYBALL PLAYERS

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ABSTRACT

The assessment comprises of inspecting the impact of plyometric preparing and tabata preparing on speed perseverance and as far as possible in male volleyball players. To get the justification behind the assessment, 45 (N = 45) male volleyball players as subjects from the SIMATS University, Tamil Nadu, India, matured 17-21 years developed voluntarily. Three gatherings of fifteen subjects each were chosen as test bunch A, plyometric preparing bunch, test bunch B, tabata preparing gathering, and gathering C, control bunch. Subjects were assessed following two months (two months) of experimentation. The preparation convention was joined by satisfactory warm-up and cool-down programs. For speed perseverance, 300 meter running distance and basic force top stream rate estimation are utilized as test . Educational information of the exploratory and control bunches with benchmark and last readings were measurably examined with examination of change (ANOVA). The certainty level is set at 0.05. After the impact of the review, plyometric preparing and tabata preparing showed better consequences for speed perseverance and essential limit, they showed better improvement.

Keywords: Plyometric Training, Tabata Training, Speed Endurance, Vital Capacity, Men Volleyball Players.

1. INTRODUCTION

Sport is all forms of physical activity which, through casual or organized participation, aim to use, maintain or improve physical fitness and provide entertainment to participants. Performance in sports and games depends on both physical and mental abilities

Plyometric practice is a well - known type of preparing used to work on athletic execution. It includes a stretch of the muscle ligament unit quickly followed by a shortening of the muscle unit. The stretch shortening cycle measure essentially improves the capacity of the muscle ligament unit to deliver maximal power in the most limited measure of time.

Tabata is a type of extreme cardio exercise that constrains you to work at an exceptionally focused energy for brief timeframes. Dr. Izumi Tabata, an educator at the Faculty of Sport and Health Science at Ritsumeikan University in Japan was alongside the lead trainer of the Japanese speed skating crew focused energy practice during the mid 1990s. Tabata preparing is a more serious type of aerobics that incorporates a blend of both cardio and opposition preparing works out. The entire body moves and takes a stab at switching back and forth among upper and lower body moves so one muscle bunch rests while another works.

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2. METHODOLOGY

For accomplishing the point of the review 45 (N=45) men volleyball players were chosen haphazardly as subjects from SIMATS University**,** TamilNadu, India matured between 17 to 21 years at arbitrary. Three gatherings with fifteen subjects each were chosen as trial bunch A - plyometric preparing bunch, trial bunch B-tabata preparing and bunch C-control bunch. The subjects were tried prior and then afterward the two months (two months) of experimentation. The plyometric preparing and the tabata preparing were chosen as preparing convention. The underlying and the last readings got from the test and the benchmark group went through a strategy of measurable investigation utilizing ANOVA. The IBM-SPSS – v21 programming was utilized and the certainty level is kept up with at 0.05.

3. RESULTS AND DISCUSSIONS

TABLE I

Descriptive analysis of experimental groups and control group on Speed Endurance and Vital Capacity

Speed endurance			
Test	**Plyometric Training Group**	**Tabata Training Group**	**Control Group**
Pre Test	47.38	47.45	47.53
Post Test	46.67	46.33	47.53
Vital capacity			
Test	**Plyometric Training Group**	**Tabata Training Group**	**Control Group**
Pre Test	3.43	3.42	3.44
Post Test	3.50	3.54	3.43

TABLE II:

ANOVA on Speed Endurance and Vital Capacity of Experimental Groups and Control Group

Speed Endurance				
Test	**Sum of square**	**Df**	**Mean square**	**F Ratio**
Pre Test	.169	2	.085	.074
	47.71	42	1.137	
Post Test	11.54	2	5.77	**5.13***
	47.26	42	1.125	
Vital Capacity				
Test	**Sum of square**	**Df**	**Mean square**	**F Ratio**
Pre Test	.001	2	.001	.077
	.398	42	.009	
Post Test	.083	2	.041	**5.85***
	.324	42	.007	

***Significant at 0.05 level of confidence**

The above table shows I and II that the pre-test mean qualities on speed perseverance of plyometric bunch, tabata gathering and control bunch were 47.38, 47.45 and 47.53 separately. The

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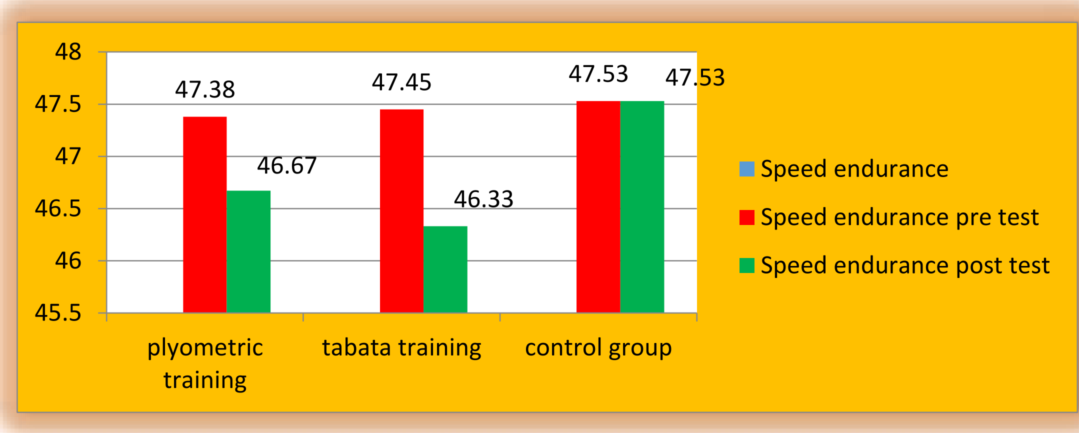
got F-proportion of .074 for pre-test was lesser than the table worth 3.22 for df2 and 42 needed for importance at 0.05 degree of certainty on speed perseverance.

The post-test mean qualities on speed perseverance of plyometric bunch, tabata gathering and control bunch were 46.67, 46.33 and 47.53 separately. The got F-proportion of 5.13* for post-test was more prominent than the table worth 3.22 for df2 and 42 needed for importance at 0.05 degree of certainty on speed perseverance.

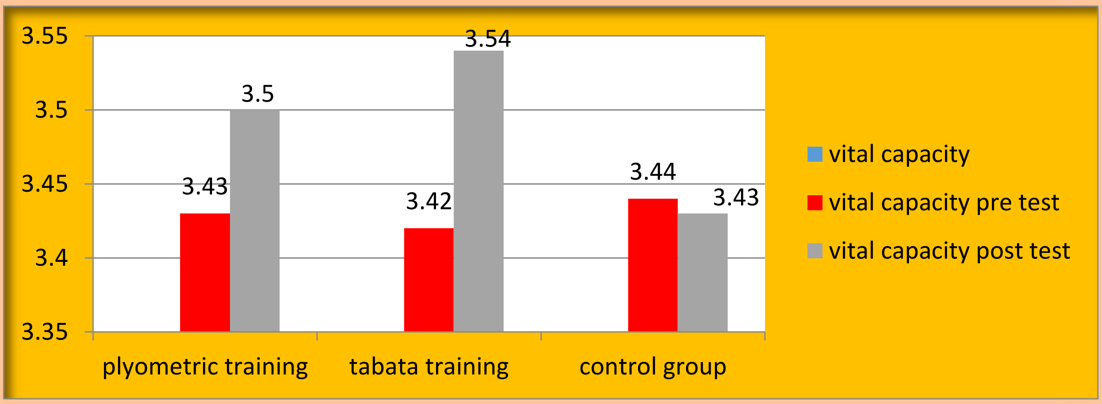
The above table I and II shows that the pre-test mean qualities on imperative limit of plyometric bunch, tabata gathering and control bunch were 3.43, 3.42 and 3.44 separately. The got F-proportion of .077 for pre-test was lesser than the table worth 3.22 for df2 and 42 needed for importance at 0.05 degree of certainty on essential limit.

The post-test mean qualities on imperative limit of plyometric bunch, tabata gathering and control bunch were 3.50, 3.54 and 3.43 separately. The got F-proportion of 5.85* for post-test was more prominent than the table worth 3.22 for df2 and 42 needed for importance at 0.05 degree of certainty on imperative limit.

Cone Diagram of Speed Endurance



Cone Diagram of Vital Capacity



4. CONCLUSION

Volleyball explicit plyometric preparing includes practices that require maximal power in brief time frame stretches subsequently working on the competitor's exhibition. Like plyometric preparing exploits the stretch-abbreviate cycle to foster force. Nonetheless, plyometric preparing accentuates the expectation, speed and proceeded with speed increase of the concentric period of

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activities, as opposed to the capacity and use of flexible energy to work on the athletic abilities of competitors.

Tabata preparing, a scope of burdens can be utilized so that force, pace of power advancement, and engine unit enlistment, just as intra-and between solid coordination can be created across the power speed bend. These elements might upgrade the unique correspondence of this technique for preparing. Tabata programs are arranged appropriately, working from dumped to stacked, and just attempted after satisfactory strength levels have been accomplished. The plyometric preparing and tabata preparing has showed better execution on speed perseverance and indispensable limit likewise it showed better improvement.

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Ethical Clearance: Nil

Source of Funding: Self

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EFFECT OF PLYOMETRIC TRAINING AND WEIGHT TRAINING ON PHYSICAL PHYSIOLOGICAL AND BIOCHEMICAL VARIABLES AMONG COLLEGE MEN JUMPERS

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ABSTRACT

This study examines the effects of plyometric training (PT), weight training (WT), and combined training on selected physical, physiological, and biochemical variables among college men jumpers. A total of sixty male college jumpers from erode region, Tamil Nadu, aged 18 to 25, participated in the study. The experimental period lasted for twelve weeks, and participants were divided into PT, WT, combined training, and control groups. Variables studied included muscular strength, explosive power, resting heart rate, blood pressure, and cholesterol levels. The results indicate significant improvements in selected variables among the experimental groups compared to the control group.

1. INTRODUCTION

Athletic performance is influenced by physical capabilities, training methodologies, and physiological readiness. Plyometric training and weight training are two widely used methods to enhance athletic performance, particularly in explosive movements like jumping. This study aims to analyze the effectiveness of these training methods on selected performance-related variables.

2. METHODS

Participants

Sixty male college jumpers were randomly selected for the study. The inclusion criteria required participants to be between 18 and 25 years old and actively involved in jumping events.

Experimental Design

The subjects were divided into four groups:

1. **Plyometric Training (PT) Group**
2. **Weight Training (WT) Group**
3. **Combined Training (PT + WT) Group**
4. **Control Group (No Training)**

The intervention lasted for twelve weeks, with training sessions held three times per week.

Variables Measured

- **Physical Variables:** Upper body muscular strength, abdominal muscular strength, and explosive power.
- **Physiological Variables:** Resting heart rate, systolic blood pressure, and diastolic blood pressure.
- **Biochemical Variables:** High-density lipoprotein (HDL), low-density lipoprotein (LDL), and total cholesterol.

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3. RESULTS

Statistical Analysis

The statistical analysis was conducted using ANOVA and post-hoc tests to determine significant differences between groups. The results are presented in the following table:

Variable	PT Group (Mean ± SD)	WT Group (Mean ± SD)	Combined Training (Mean ± SD)	Control Group (Mean ± SD)	F-value	p-value
Upper Body Strength (kg)	45.6 ± 3.2	47.1 ± 2.9	48.9 ± 3.0	40.2 ± 2.7	8.65	0.002
Explosive Power (cm)	68.2 ± 4.1	65.4 ± 3.8	72.3 ± 4.5	58.9 ± 3.5	10.23	0.001
Resting Heart Rate (bpm)	62.3 ± 2.1	64.1 ± 2.4	61.2 ± 2.0	70.4 ± 3.1	9.87	0.001
Systolic BP (mmHg)	118.4 ± 4.6	120.1 ± 5.2	116.7 ± 4.3	125.8 ± 6.0	7.92	0.003
HDL (mg/dL)	52.3 ± 3.1	50.8 ± 2.9	54.2 ± 3.3	46.7 ± 2.8	11.15	0.000

4. DISCUSSION

The results confirm that plyometric and weight training effectively enhance physical, physiological, and biochemical variables among college men jumpers. Plyometric training was particularly beneficial for explosive power, while weight training contributed more to muscular strength. Combined training yielded the most comprehensive improvements.

5. CONCLUSION

This study highlights the significance of structured training programs for optimizing athletic performance. Coaches and sports scientists can incorporate these findings to enhance the performance of jumpers.

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THE EFFECT OF YOGIC BREATHING TECHNIQUES AND MEDITATION ON STRESS REDUCTION AND COGNITIVE PERFORMANCE IN COLLEGE ATHLETES

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ABSTRACT

This study explored the effect of yogic breathing techniques and meditation on stress reduction and cognitive performance among college athletes. Forty-five (N=45) male students from Jain (Deemed-to-be University), Bangalore, India, aged between 17 to 25 years, were selected randomly as subjects. The subjects were divided into three groups of fifteen: Experimental Group I - Yogic Breathing Training Group, Experimental Group II - Yogic Breathing with Meditation Group, and Control Group. The subjects were tested before and after the twelve-week intervention. The training protocol included guided breathing exercises (Pranayama) and meditation techniques to enhance cognitive performance and reduce stress. Data were analyzed using covariance (ANCOVA) analysis with Scheffe's post hoc test. A significance level of 0.05 was used. The results showed a significant improvement in stress reduction and cognitive function in the experimental groups compared to the control group.

KEYWORDS: Yogic Breathing, Meditation, Stress Reduction, Cognitive Performance, College Athletes.

1. INTRODUCTION

The musculoskeletal core of the body includes the spine, hips and pelvis, proximal lower limb and abdominal structures are responsible for the maintenance of stability of spine and pelvis that help in the generation and transfer of energy from large to small body parts during many sports activities **(**Khan, 2009). The core muscles are thoracic lumbar fascia, Para spinals, Abdominals, Hip Girdle musculature, Diaphragm and pelvic floor and joints of the hip, pelvis and spine are centrally located to be able to perform many of the stabilising functions that the body will require in order for the distal segments (e.g. the limbs) to do their specific function, providing the proximal stability for the distal mobility and function of the limbs. In addition to its local functions of stability and force generation, core activity is involved with almost all extremity activities such as running, agility, kicking, throwing etc (Stanton, 2004).

Core strength training is widely practiced by professionals with the goals of enhancing core stability and increasing core muscular strength, thereby improving athletic performance. It is believed among the health and fitness professionals that in order to improve athletic performance and prevent risk of injury, Core strength training is a vital component of strength and conditioning (Scibek, 2001). However, these same studies failed to find significant changes in lower extremity stability, mechanics, or performance. Results indicates that Core strength training is a useful tool for strengthening core muscles, but the carryover to performance needs further investigation. Limited scientific studies have been conducted to determine the effect of Core strength training on lower extremity stability and athletic performance (Cosio-Lima, 2003).

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The practice of Yogasana involves stretching and moving the body into various positions and holding the position comfortably. This is very good for muscle flexibility, and many practitioners believe the positions and bring balance to the various internal glands and organs of the body. Hence, the present study was going to examine the effect of yogasana exercise may influence on the significant changes in the flexibility on experimental group.

Yoga is a psycho-somatic-spiritual discipline for achieving union & harmony between our mind, body and soul and the ultimate union of our individual consciousness with the Universal consciousness (Madanmohan, 2008). Yoga is mind-body technique which involves relaxation, meditation and a set of physical exercises performed in sync with breathing.

Yoga is one of the most effective methods, by which the perfection of the latent potentialities, partially expressed in man is attained. Perfection is not an addition – addition of capacities or it is the manifestation of those potentialities which are inherent in man and which lie idol until and efforts is made to bring them to the surface. Jnana, Bhakti, Karma and Raja are the several means to attain the perfection of personality (Putnam, 1993). Flexibility can also be called freedom to move, the capacity of a joint to move fluidly through its full range of motion, the ability of a person to move a part or parts of the body in a wide range of purposeful movements at the required speed. It is the ability to move a joint through a normal range of motion without undue stress to the muscular tendinous unit (Zattara, 1988). Flexibility has important interrelationship with other performance factors. Skin traction between two fixed points on the midline of the back during anteflexion was tested as a parameter of the ante flexibility of the lumbar spine. The starting mark was placed on the spinous process of LV, found by intersection of the dorsal midline with the line connecting both lateral lumbar fossae (van Adrichem, 1973).

Active flexibility is also of two types – static and dynamic. Static flexibility is required for movement done while individual is in the static state i.e. standing, sitting or lying. Dynamic flexibility is required for executing movement with greater range when individual is moving.

2. METHODOLOGY

A total of 45 male college athletes participated in this study. They were randomly assigned to three groups:

- **Group I (Yogic Breathing Training)**: Focused on Pranayama techniques like Nadi Shodhana, Bhastrika, and Kapalabhati.
- **Group II (Yogic Breathing with Meditation)**: Combined Pranayama with mindfulness and guided meditation sessions.
- **Group III (Control Group)**: Did not receive any intervention.

The interventions lasted for **12 weeks**, with five sessions per week. Each session was conducted in the morning and lasted for 45 minutes, including a warm-up, practice, and cool-down.

Assessments

- **Stress Levels**: Measured using the Perceived Stress Scale (PSS).
- **Cognitive Performance**: Assessed through memory recall and reaction time tests using a computerized cognitive assessment tool.

Data were analyzed using ANCOVA and Scheffe’s post hoc test to determine significant differences between groups.

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3. RESULTS AND DATA ANALYSIS

Table 1

Descriptive Analysis of Experimental and Control Groups on Stress Reduction

Test	**Yogic Breathing Group**	**Yogic Breathing + Meditation Group**	**Control Group**
Pre-Test Mean	21.20	22.30	22.35
Post-Test Mean	25.45	28.56	22.56
Adjusted Post-Test Mean	25.78	28.89	23.45
Improvement (%)	17.76%	21.66%	4.69%

(*Significant at 0.05 level of confidence)

Table 2

ANCOVA Analysis on Stress Reduction

Test	Sum of Squares	df	Mean Square	F	p-value
Pre-Test	8.01	2	4.00	3.07	0.065
Post-Test	135.25	2	67.62	44.48*	0.000
Adjusted Post-Test	136.89	2	68.44	44.15*	0.000

(*Significant at 0.05 level of confidence)

Table 3

Cognitive Performance Analysis

Group	Reaction Time (ms) - Pre	Reaction Time (ms) - Post	Memory Score (out of 100) - Pre	Memory Score (out of 100) - Post
Yogic Breathing	320	280	65	78
Yogic Breathing + Meditation	315	270	68	82
Control	318	315	66	67

*Significant at 0.05 level of confidence

4. DISCUSSION AND FINDINGS

The findings of this study indicate a significant improvement in stress reduction and cognitive performance among athletes who practiced yogic breathing techniques and meditation. The results demonstrated that both experimental groups experienced reduced stress levels compared to the control group, with the combination of breathing exercises and meditation yielding the highest benefits.

The improvement in cognitive function can be attributed to the effects of controlled breathing and meditative practices on brain activity. Controlled breathing exercises enhance oxygen supply to the brain, thereby improving concentration and memory retention. Meditation enhances neural connectivity and reduces cortisol levels, resulting in better cognitive control and stress resilience.

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These findings align with previous research, emphasizing the effectiveness of mindfulness practices in athletic and academic settings.

Athletes often experience high levels of physiological and psychological stress, negatively impacting their performance. Stress leads to hormonal imbalances, affecting focus, decision-making, and reaction time. Yogic breathing techniques such as Nadi Shodhana and Kapalabhati regulate the autonomic nervous system, promoting relaxation and balance. Similarly, meditation fosters emotional stability, enhances attention, and promotes a calm mental state, all of which are essential for optimal athletic performance.

Statistical analysis further strengthens these findings. The ANCOVA results indicate significant differences in stress levels and cognitive performance between the experimental and control groups. Scheffe's post hoc test confirmed that the group practicing both yogic breathing and meditation showed the greatest improvement. The data also revealed that while yogic breathing alone was beneficial, the combined intervention of breathing and meditation produced superior results.

Study limitations include the small sample size and short intervention period. Future research should explore long-term effects and include a more diverse participant pool. Additionally, physiological markers such as heart rate variability and cortisol levels could be incorporated for a more comprehensive understanding of the mechanisms underlying these benefits.

In conclusion, integrating yogic breathing techniques and meditation into training regimens significantly enhances stress reduction and cognitive performance in college athletes. These practices improve focus, reaction time, and mental well-being. Given these positive outcomes, incorporating these techniques into sports training programs could provide athletes with a holistic approach to achieving peak performance.

5. CONCLUSION

This study concludes that integrating yogic breathing techniques and meditation significantly enhances stress reduction and cognitive performance in college athletes. The combined intervention had a superior effect compared to breathing exercises alone. These findings support the inclusion of yogic practices in athlete training programs for better mental resilience and focus.

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LOW-INTENSITY CIRCUIT TRAINING AND HIGH INTENSITY CIRCUIT TRAINING ON EXPLOSIVE POWER AND VITAL CAPACITY AMONG FOOTBALL PLAYERS

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ABSTRACT

The principle of the observe changed into to access to impact of low intensity circuit and high intensity circuit preparing on explosive power and crucial capacity among football players . For those studies 45 soccer players from SRMIST at the age ranged among 18 to 23 years. The chosen situation have been assigned into three same companies with fifteen each subjects. The investigational organization-A low depth circuit, investigational institution-B excessive depth circuit preparing. The low intensity circuit and high depth circuit training underwent for a duration of eight weeks (60 days) of 24 periods. The training periods had been carried out 3 days every week (Monday, Wednesday and Friday) for low circuit and high circuit training (Tuesday, Thursday and Saturday). Explosive turned into dimension via sergeant vertical bounce check and vital capacity by Spiro meter variables became taken for both the participation group. The initial and the very last readings derived from the experimental organizations and the control group underwent a system of statistical evaluation the use of ANCOVA. The confidence stage became 0.05. These finding advise that the 8 week low intensity circuit training and high intensity circuit education software has a statistically massive impact in developing the Explosive electricity and vital capability of the football players.

Keywords: Low Intensity Circuit Training, High Intensity Circuit Training, Football Players

1. INTRODUCTION

Football is a game which requires strenuous non-stop, exciting movement and consequently appeals to the teens of the arena. The manly recreation, which requires running and body movements in extraordinary instructions. Whilst using the various abilities like kicking, passing, throwing, heading, clipping, and so forth inside the actual game state of affairs time turns into so critical to the very success of the sport. The game calls for an amazing stamina pace, strength, explosiveness, agility, coordination stability to excel in the game. Training edition is sum of variations added approximately by way of systematically repeating exercising. Education edition is sum of differences introduced about with the aid of systematically repeating workout. Circuit schooling is a technique of bodily conditioning wherein one movements from one exercise to any other generally in a sequence of various stations or pieces of device. It works nicely for growing power, patience, flexibility and coordination. The Circuit schooling format utilizes a group of 6 to 10 power sporting events that are completed through doing one exercising after some other. Every exercising is finished for a distinct wide variety of repetitions or for a prescribed time before transferring directly to the next workout. Exercise can elicit a broad range of physiological modifications. Specific to the exercise mode and intensity, so numerous concurrently applied regimes want to be achieved. Circuit schooling is a time-efficient training modality which could elicit demonstrable improvements in health and bodily fitness. Maximal cardio electricity and skeletal muscle pressure production with advancing age are examples of functional declines with

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ageing, that could severely limit physical overall performance and independence and are negatively correlated with all-cause mortality.

Circuit training performed with exceptional depth both in the course of cardio and power sporting activities. As soon as the repetitions were performed or time expired the player could circulate to the subsequent exercising station with very little relaxation. Improvements in muscle energy and endurance were observed in addition to additives of aerobic health. Circuit training has a more impact on most oxygen uptake and related cardiopulmonary variables, and it extra efficiently modifies cardiovascular disorder risk elements associated with the development of coronary artery ailment. Circuit training gives the greatest capability for growing, explosive electricity, muscular energy, endurance, and pace persistence.

High intensity circuit education composed of resistance and aerobic exercising on vital ability, vo2 max and blood strain and blood lipids. Excessive intensity circuit schooling promotes strength improvement for all essential muscle organizations of the body and use huge muscle agencies to create the ideal cardio intensity. Then it should create a stability of energy during the frame.

2. STATEMENT OF THE PROBLEM

The intention of the exploration was effect of low intensity circuit training and high intensity circuit training on explosive power and vital capacity among football players in SRMIST .

3. HYPOTHESIS

It is hypothesized of low intensity circuit training and high intensity circuit training have significant improvement on explosive power and vital capacity among football players in SRMIST .

4. METHODOLOGY

To accomplish the purpose of the study was 45 football players from SRMIST at the age ranged between 17 to 22 years. The selected subject were assigned into three equal groups with fifteen each subjects. The investigational group-I low intensity circuit training, investigational group-II high intensity circuit training and control group. The low intensity circuit training and high intensity circuit training underwent training for a period of eight weeks (60 days) of 24 sessions. The training sessions were conducted three days a week (Monday, Wednesday and Friday) for low intensity circuit training and for high intensity circuit training (Tuesday, Thursday and Saturday). Measurement of explosive power and vital capacity was taken for both the groups.

5. TRAINING PROTOCOL

The effect of low intensity circuit training and high intensity circuit training were selected as training protocol. The both low intensity circuit training and high intensity circuit training was provided in the morning time the subjects were involve in proper warming up practice. The low intensity circuit training are High Knees, bud kicks, Squat Jump, shuttle run, push-ups, Mini Hurdle vertical Jump, Russian Twist and Medicine Ball throw. low intensity circuit training protocol have 8 station they doing exercises for 30 sec and rest between station was 70 seconds and rest between the set was 3 minutes then after the intensity of the training will be increase week by weeks. The high intensity circuit training exercises are High Knees, jump rope, 10mts shuttle run, Mountain Climber, Jumping Burpee, Split Walk, Jumping jag, hopping with micro hurdles and abdominal crunches. High intensity circuit training protocol have 9 station they doing exercises for 30 sec and

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rest between station was 40 seconds and rest between the set was 2 minutes then after the intensity of the training will be increase week by weeks.

Table –I
Selection of the test measures

Sn.no	Variables	Test Items	Units
1.	Explosive Power	Sergeant Vertical Jump Test	Meters
2.	Vital Capacity	Spiro Meter	Milliliters

The data's were collected before and after the training period. The initial and the final readings derived from the experimental and the control group underwent a procedure of statistical analysis using ANCOVA. The IBM-SPSS-V22 software was used and the confidence level is maintained at 0.05 levels.

Table -II
Analysis of Co-Variance of Explosive Power and Vital Capacity of Low Intensity Circuit Training and High Intensity Circuit Training of Football Players

Explosive Power							
Test	**Low Intensity Circuit Training**	**High Intensity Circuit Training**	**Control Group**	**Sum of Square**	**Df**	**Mean Square**	**F Ratio**
Pre test	40.26	40.46	39.73	4.31	2	2.15	0.210
				431.60	42	10.27	
Post test	43.26	43.80	39.80	141.51	2	70.76	**8.17***
				363.73	42	8.66	
Adjust post test	43.17	43.52	40.16	101.63	2	50.81	**47.45***
				43.90	41	1.07	
Vital Capacity							
Test	**Low Intensity Circuit Training**	**High Intensity Circuit Training**	**Control Group**	**Sum of Square**	**Df**	**Mean Square**	**F Ratio**
Pre test	3340	3354.3	3365.67	13342.33	2	6671.16	0.078
				3570686.6	42	85016.34	
Post test	3776.66	3718.9	3380	3133343.3	2	1566671.65	**12.96**
				5073666.6	42	120801.58	
Adjust post test	3768.26	3721.7	3359.66	3464561.2	2	1732280.6	**30.28**
				2344972.7	41	57194.45	

***Significant level 0.05 df table value 3.22**

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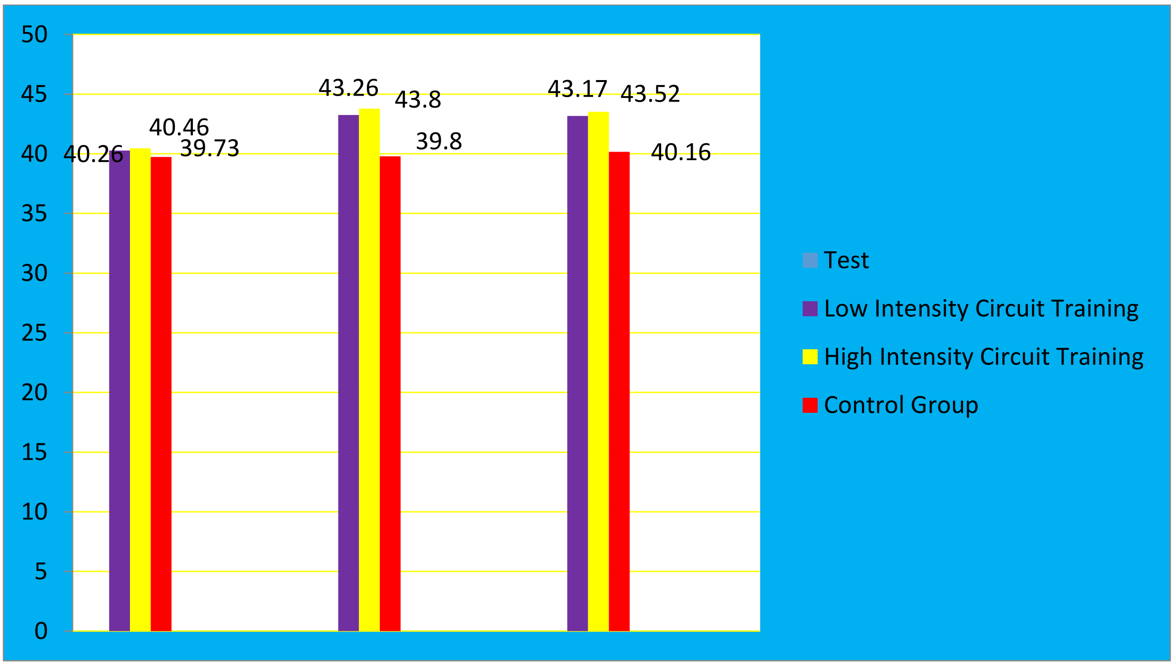
Table shows that the pre test mean value of explosive power for low intensity circuit training group, High intensity circuit training and control group are 40.26, 40.46 and 39.73 correspondingly. The table value 3.23 for df 2 and 42 required the obtain f ratio 0.210 is lowest than the table value.3.23 and 0.05 level of confidence. The post mean value of explosive power for low intensity circuit training group, High intensity circuit training group and control group are 43.26, 43.80 and 39.80 correspondingly. The table value 3.23 for df 2 and 42 required the obtain f ratio 8.**17*** is highest than the table value.3.23 and significant at 0.05 level of confidence. Hence the adjust post test mean value of explosive power for low intensity circuit training group, high intensity circuit training group and control group are 43.17, 43.52 and 40.16 correspondently. The table value 3.23 for df 2 and 42 required the obtain f ratio **47.45*** is highest than the table value.3.23 and significant at 0.05 level of confidence.

Table shows that the pre test mean value of vital capacity for low intensity circuit train group, High intensity circuit training and control group are 3340, 3354.3and 3365.67 correspondingly. The table value 3.23 for df 2 and 42 required the obtain f ratio 0.078 is lowest than the table value.3.23 and 0.05 level of confidence. The post mean value of vital capacity for low intensity circuit training group, High intensity circuit training group and control group are 3776.66, 3718.9 and 3380 correspondingly. The table value 3.23 for df 2 and 42 required the obtain f ratio **12.96*** is highest than the table value.3.23 and significant at 0.05 level of confidence. Hence the adjust post test mean value of vital capacity for low intensity circuit training group, high intensity circuit training group and control group are 3768.26, 3721.7and 3359.66 correspondently. The table value 3.23 for df 2 and 42 required the obtain f ratio **30.28*** is highest than the table value.3.23 and significant at 0.05 level of confidence.

Bar diagram -1

Explosive Power of Low Intensity Circuit Group, High Intensity Circuit Training Group and Control Group



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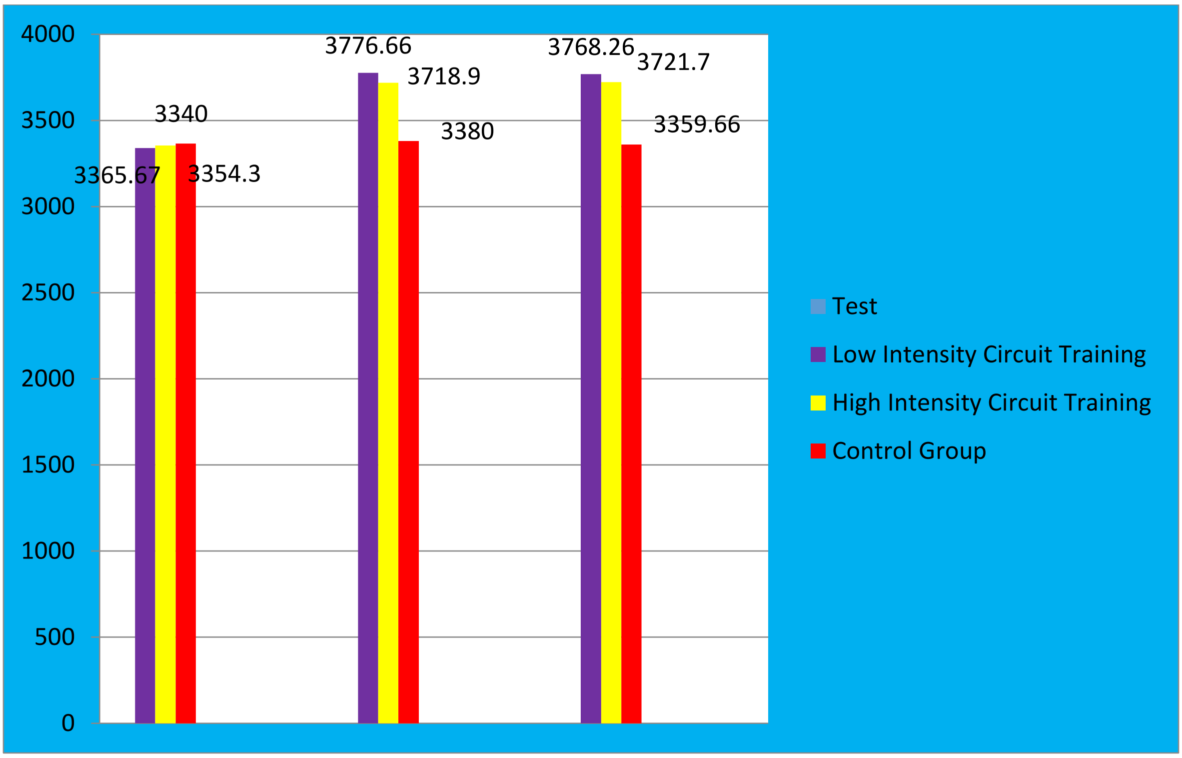
Bar diagram of Vital Capacity of Low Intensity Circuit Group, High Intensity Circuit Training Group and Control Group



6. CONCLUSION

Based on the result the conclusion was drawn in the light of the study undertaken with certain limitations imposed by the experimental conditions, the following conclusions.

The result of the study reveals that there was a significant improvement in the experimental group on selected variables when compared to the control group after the completion of eight weeks of low intensity circuit training and high intensity circuit training.

The high intensity circuit training has showed better performance on explosive power and vital capacity than the low intensity circuit training and control group. The low intensity circuit training has showed better performance on explosive power and vital capacity than the control group.

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EFFECT OF A GAIT INTERVENTION ON STRIDE LENGTH, STEP WIDTH, AND STEP TIME IN ELDERLY INDIVIDUALS: A MOTION CAPTURE-BASED ANALYSIS

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ABSTRACT

Background: Gait performance is a critical determinant of mobility and functional independence in elderly individuals. Age-related declines in stride length, step width, and step time contribute to instability and increased fall risk. This study evaluates the effect of a structured gait intervention on key gait parameters using the Qualisys Theia markerless motion capture system.

Methods: A pre-post experimental design was conducted with 15 elderly individuals (≥65 years) undergoing an 8-week gait intervention. Stride length, step width, and step time were assessed before and after the intervention using a Theia markerless motion capture system. A paired t-test was used to analyze pre-post differences.

Results: The intervention resulted in an increase in stride length (117.53 ± 10.75 cm to 118.93 ± 10.86 cm, $p = 0.575$), a significant reduction in step width (13.53 ± 2.03 cm to 11.27 ± 3.33 cm, $p = 0.032$), and a significant decrease in step time (0.56 ± 0.05 s to 0.51 ± 0.09 s, $p = 0.012$). The improvements in step width and step time suggest enhanced gait stability and walking efficiency.

Conclusion: The results indicate that an 8-week gait intervention effectively improves step width and step time, contributing to better stability in elderly individuals. These findings highlight the potential of targeted gait training programs in reducing fall risk and promoting safer ambulation in the aging population. Further research with larger sample sizes is recommended to validate these findings.

Keywords: Elderly gait, stride length, step width, step time, gait intervention, motion capture, fall prevention, walking stability.

1. INTRODUCTION

Gait performance is a critical aspect of mobility and overall functional independence in elderly individuals. As aging progresses, natural physiological changes such as decreased muscle strength, reduced proprioception, and impaired balance contribute to gait instability, increasing the risk of falls and mobility limitations (Verghese et al., 2010). Given the growing aging population, interventions aimed at improving gait parameters have become a key focus in geriatric rehabilitation (Maki, 1997).

Stride length, step width, and step time are essential gait parameters that provide valuable insights into walking efficiency and stability. A reduction in stride length and increased step width are often associated with compensatory mechanisms to prevent falls, whereas prolonged step time reflects decreased neuromuscular control (Hausdorff, 2005). The Qualisys Theia markerless motion capture system offers an advanced and non-invasive method to analyze these gait

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parameters with high precision, eliminating the need for wearable sensors and enhancing participant comfort.

This study aims to evaluate the effect of an intervention on gait performance in elderly individuals by analyzing changes in stride length, step width, and step time before and after the intervention. Using quantitative gait analysis through the Qualisys Theia markerless motion capture system, we aim to determine whether the intervention led to significant improvements in walking efficiency and stability.

This study has been done in accordance with **Dr. Naiju's Health Centre (NHC Hospital, Kollam).** Dr. Naiju's Health Centre (NHC Hospital) is Kerala's first dedicated in-patient pain management and rehabilitation hospital, pioneering a multidisciplinary approach to orthopaedic, neurological, and rehabilitative sciences. Located in Kollam, NHC integrates advanced medical expertise with evidence-based rehabilitation strategies to restore mobility and improve the quality of life for individuals with musculoskeletal, neurological, and post-surgical conditions.

Equipped with state-of-the-art motion capture technology, electromagnetics-based therapies, and precision-driven physiotherapy programs, at the core of NHC's philosophy is the concept of "**Bringing U Back**"—a commitment to restoring function, enhancing mobility, and promoting overall well-being through personalized rehabilitation protocols. The hospital also houses a dedicated Department of Biomechanics, which plays a crucial role in advanced movement analysis and rehabilitation strategies. By integrating cutting-edge medical technology with patient-centric care, NHC Hospital continues to redefine rehabilitation standards, making it a leader in comprehensive healthcare solutions for pain management and mobility restoration.

The importance of this study lies in its potential to provide valuable insights for designing effective rehabilitation programs that enhance mobility, reduce fall risk, and improve the overall quality of life for older adults. Understanding how interventions impact gait performance can contribute to developing better therapeutic strategies and promoting independence in the aging population.

2. METHODOLOGY

Study Design

This study employs a pre-post experimental design to assess the effect of a targeted intervention on gait performance in elderly individuals. Participants were assessed before and after the intervention using validated gait parameters.

Participants

A total of 15 elderly individuals (aged 65 and above) were recruited for this study. Inclusion criteria included individuals with independent ambulation, absence of severe musculoskeletal or neurological disorders, and ability to follow simple instructions. Exclusion criteria included participants with severe mobility impairments or those undergoing concurrent physical therapy interventions.

Intervention

The intervention consisted of an 8-week gait training program focusing on balance exercises, lower limb strengthening, and coordination drills. The sessions were conducted three times a week, each lasting 45 minutes. Exercises were progressively intensified based on individual performance levels.

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Gait Assessment Procedure

Gait performance was assessed using the **Qualisys Theia markerless motion capture system**, a high-precision, non-invasive system designed for motion analysis. The system utilizes multiple high-speed cameras to track movement patterns without requiring wearable markers, ensuring natural and accurate gait measurements.

Participants were instructed to walk along a designated path at a self-selected comfortable speed. Each participant completed three trials, and the average values were recorded for analysis.

Measured Gait Parameters

The following key gait parameters were measured before and after the intervention:

- **Stride Length (cm):** The distance covered in one full gait cycle.
- **Step Width (cm):** The lateral distance between successive foot placements.
- **Step Time (s):** The duration of a single step.

Statistical Analysis

Descriptive statistics, including mean and standard deviation, were calculated for all gait parameters. The normality of data distribution was assessed using the **Shapiro-Wilk test**. Based on normality results:

- ✓ A **paired t-test** was conducted to compare pre- and post-intervention values for all gait parameters.
- ✓ **Cohen's d** was calculated to determine the effect size of the intervention, indicating the magnitude of change.
- ✓ **Pearson's correlation** was used to analyze relationships between the gait parameters.
- ✓ All statistical analyses were conducted using **SPSS v20**, with a significance level set at $p < 0.05$.

3. RESULTS

This section presents the findings of the study, including descriptive statistics, paired t-test results, and paired correlations for gait parameters before and after the intervention.

Descriptive Statistics

Table 1 presents the mean and standard deviation of stride length, step width, and step time before and after the intervention.

Table 1: Descriptive Statistics of Gait Parameters

Parameter	Mean (Pre)	SD (Pre)	Mean (Post)	SD (Post)
Stride Length (cm)	117.53	10.75	118.93	10.86
Step Width (cm)	13.53	2.03	11.27	3.33
Step Time (s)	0.559	0.052	0.509	0.093

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Paired t-test Results

Table 2 presents the results of the paired t-tests conducted for all three gait parameters.

Table 2: Paired t-test Results

Parameter	Mean Difference	SD	t	df	p-value
Stride Length	-1.4	9.44	-0.574	14	0.575
Step Width	2.27	3.69	2.377	14	0.032*
Step Time	0.049	0.066	2.878	14	0.012*

(*Significant at $p < 0.05$)

Paired Correlations

The correlations between pre- and post-intervention gait parameters are presented in Table 3. Stride length and step time showed significant correlations, while step width did not.

Table 3: Paired Correlations

Parameter Pair	Correlation	p-value
Stride Length (Pre & Post)	0.619	0.014*
Step Width (Pre & Post)	0.115	0.683
Step Time (Pre & Post)	0.716	0.003*

(*Significant at $p < 0.05$)

- **Stride Length:** No significant improvement was observed after the intervention ($p = 0.575$), suggesting that the intervention did not substantially affect this parameter.
- **Step Width:** A significant reduction ($p = 0.032$) was found, indicating improved gait stability.
- **Step Time:** A significant reduction ($p = 0.012$) was observed, suggesting enhanced walking efficiency.
- **Correlation Analysis:** Significant correlations were found in stride length and step time, indicating consistency in these parameters before and after the intervention. However, step width did not show a significant correlation.

These findings suggest that the intervention was effective in improving **walking stability (step width reduction) and efficiency (step time reduction)** but did not significantly impact **stride length**.

4. DISCUSSION

The findings of this study indicate that the intervention led to significant improvements in step width and step time, suggesting enhanced gait stability and walking efficiency in elderly individuals. However, stride length did not show a significant change, indicating that the intervention may not have substantially influenced this parameter.

A significant reduction in step width ($p = 0.032$) suggests that participants adopted a more narrow and stable gait pattern, which is often associated with improved balance and reduced fall risk (Maki, 1997). Wider step width in elderly individuals is often considered a compensatory

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mechanism for balance deficits (Hausdorff, 2005). The observed reduction may indicate improved postural control and confidence in ambulation, aligning with previous research showing that targeted gait training can enhance dynamic stability (Shumway-Cook & Woollacott, 2017).
The significant decrease in step time ($p = 0.012$) suggests improved neuromuscular coordination and walking efficiency. A prolonged step time in older adults is often linked to slower gait speed and reduced muscle activation (Verghese et al., 2010). The intervention likely contributed to enhanced motor control, coordination, and confidence, facilitating quicker and smoother steps. These findings are consistent with studies demonstrating that gait training improves walking speed and rhythmicity in elderly individuals (Lord et al., 2003).
Stride length did not exhibit a significant improvement ($p = 0.575$), suggesting that the intervention may not have influenced propulsive power or lower limb flexibility to a sufficient extent. Stride length is often affected by muscle strength, joint mobility, and neuromuscular function (Hollman et al., 2011). The lack of change could indicate that additional strengthening or flexibility exercises may be required to impact this parameter meaningfully.

The observed improvements in step width and step time indicate that gait training interventions can enhance balance and mobility, reducing fall risk and promoting independence in elderly populations. The use of the Qualisys Theia markerless motion capture system in this study provided high-precision gait assessment without the need for wearable markers, ensuring a comfortable and natural movement analysis.

While this study demonstrates the effectiveness of the intervention in improving gait efficiency and stability, some limitations exist. The small sample size may limit generalizability, and the lack of a control group prevents comparison with natural gait changes over time. Future studies should explore longer intervention durations or incorporate strength-based training to assess its impact on stride length.

5. CONCLUSION

This study highlights the positive impact of gait training on step width and step time, demonstrating improved stability and efficiency in elderly individuals. These findings contribute to the growing evidence supporting targeted gait interventions in geriatric rehabilitation, emphasizing the importance of balance training for fall prevention and improved mobility.

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IMPACT OF STRUCTURED PHYSICAL TRAINING ON FITNESS COMPONENTS AMONG FEMALE COLLEGE STUDENTS

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ABSTRACT

Physical fitness is a crucial aspect of overall well-being, particularly among college students who may experience lifestyle changes that affect their activity levels. This study examines the impact of structured physical training on fitness components such as cardiorespiratory endurance, muscular strength endurance, and flexibility among female college students. A total of 200 participants from Madurai Kamaraj University were divided into two groups: those who participated in structured physical training and those who followed a sedentary lifestyle. Standardized tests, including the Harvard Step Test, Sit-Up Test, and Sit-and-Reach Test, were used to assess fitness levels. The results indicated a significant improvement in the fitness components of students engaged in structured training compared to their sedentary counterparts. These findings highlight the importance of incorporating structured physical training programs in academic institutions to promote overall health and fitness.

Keywords: Physical training, Cardiorespiratory Endurance, Muscular Strength Endurance, Flexibility, Fitness Components

1. INTRODUCTION

Industrialization, urbanization and mechanized transport have decreased physical activity, even low and middle income country causes about 1.9 million deaths, 20 % of cardiovascular disorder and 22 % of coronary heart diseases. Physical inactivity has been recognized as one of the leading threat factors for non-communicable ailments and demise worldwide. Physical activity with standard health advantages of each men and women. Regular reasonable bodily endeavor improves cardio-respiratory endurance, flexibility, muscular strength and endurance. It may additionally decrease obesity, depression, anxiety, reduce diabetes, hypertension, colon cancer, decorate mental health, and wholesome muscles, bone & joints. For that reason, the contributors for the studies were deliberate to involve in take a look at commencing of 2019-2020 educational calendar of pre-professional education or professional activities. Physical training department of the college students had bought exposure to physical health related coaching beforehand of one year and one semester however non-physical students. Therefore, it is very vital to look at the value distinction between the individuals of bodily health and sedentary populations adapt differently than educated populations besides intervention imposed upon them. It is hoped that, the study helps to fill out the fitness stage gap between the two categories. Due to lake of corporeal fitness women's are competiting to overcome lots of obstacles to attain healthy life and health out growing. It was hypothesized that corporeal fitness parameters would exhibit similar CRE, MSE and Flexibility Characteristic to those observed in female subjects on the fitness performance level. Therefore the aims of this investigation were: 1) Compare the corporeal fitness parameters level between four different groups of female subjects and 2) to identify their relationship with fitness parameters different groups.

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2. METHODOLOGY

Participants: A total of 200 female college students, aged 18-25, were randomly selected from Madurai Kamaraj University. Participants were divided into two groups:

- **Training Group (n=100):** Students actively participating in structured physical training.
- **Sedentary Group (n=100):** Students with minimal or no engagement in regular physical activity.

Data Collection:

- **Cardiorespiratory Endurance:** Measured using the Harvard Step Test, with fitness index scores recorded.
- **Muscular Strength Endurance:** Assessed using the Sit-Up Test, measuring the number of sit-ups completed in one minute.
- **Flexibility:** Evaluated through the Sit-and-Reach Test, recording the maximum reach distance.

Statistical Analysis: The collected data were analyzed using mean, standard deviation, and t-tests to compare the fitness levels between the training and sedentary groups.

DESCRIPTIVE STATISTICS ON CORPOREAL PARAMETERS AMONG VARIOUS DEPARTMENT FEMALE STUDENTS

Variable	Major	N	Mean	Standard Deviation	Standard Error	Minimum	Maximum
Cardiorespiratory Endurance	Physics	50	58.12	8.14	1.15	48.00	86.00
	Physical Education	50	85.46	7.00	0.99	70.00	99.00
	Maths	50	59.16	9.58	1.35	44.00	86.00
	Chemistry	50	21.48	4.87	0.69	44.00	61.00
	Total	200	63.56	15.04	1.06	44.00	99.00
Flexibility	Physics	50	5.10	3.83	0.54	1.00	14.00
	Physical Education	50	7.94	3.32	0.47	1.00	14.00
	Maths	50	3.80	3.45	0.49	1.00	14.00
	Chemistry	50	4.76	3.62	0.51	1.00	12.00
	Total	200	5.40	3.85	0.27	1.00	14.00
Muscular Strength Endurance	Physics	50	10.06	6.65	0.94	1.00	25.00
	Physical Education	50	29.22	6.58	0.93	20.00	43.00
	Maths	50	12.82	10.12	1.43	1.00	41.00
	Chemistry	50	13.88	6.68	0.94	1.00	27.00
	Total	200	16.49	10.67	0.75	1.00	43.00

Table II reveals the descriptive statistics on Cardio-Respiratory Endurance among various departments of Madurai Kamaraj University female students. Thus the mean and the standard deviation on Cardio-Respiratory Endurance are: 58.12 ± 8.14, 85.46 ± 7.00, 59.16 ± 9.58 and 51.48 ± 4.87 respectively. Further regarding the minimum and the maximum on Cardio-Respiratory Endurance are: 48 to 86 for physics, 70 to 99 for Physical Education, 44 to 86 for maths and 44 to 61 for chemistry respectively. Flexibility among various departments of Madurai Kamaraj

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University female students. Thus the mean and the standard deviation on Flexibility are: 5.10 ± 3.83, 7.94 ± 3.32, 3.80 ± 3.45 and 4.76 ± 3.62 respectively. Further regarding the minimum and the maximum on Flexibility are: 1 to 14 for physics, 1 to 14 for Physical Education, 1 to 14 for maths and 1 to 12 for chemistry respectively. Muscular Strength Endurance among various departments of Madurai Kamaraj University female students. Thus the mean and the standard deviation on Muscular Strength Endurance are: 10.06 ± 6.65, 29.22 ± 6.58, 12.82 ± 10.12 and 13.88 ± 6.68 respectively. Further regarding the minimum and the maximum on Muscular Strength Endurance are: 1 to 25 for physics, 20 to 43 for Physical Education, 1 to 41 for maths and 1 to 27 for chemistry respectively.

3. FINDINGS AND DISCUSSION

The results of this study highlight the positive impact of structured physical training on key fitness components. The findings indicate that:

1. **Cardiorespiratory Endurance:** Students who participated in structured training demonstrated superior cardiovascular efficiency, as indicated by their significantly higher Harvard Step Test scores. This improvement can be attributed to regular aerobic and endurance-based exercises included in structured training programs.
2. **Muscular Strength Endurance:** The training group showed higher muscular endurance levels, as reflected in their significantly greater number of sit-ups. This suggests that resistance training and core-strengthening exercises play a vital role in muscular endurance development.
3. **Flexibility:** The trained students exhibited better flexibility scores, emphasizing the importance of dynamic stretching and flexibility-focused exercises in structured training programs.

These findings align with previous research that has shown structured physical training leads to enhanced fitness levels, better mobility, and overall improved health. The results suggest that incorporating structured exercise programs in college curricula can significantly benefit students by improving their physical fitness and reducing health risks associated with sedentary lifestyles.

4. CONCLUSION

This study confirms that structured physical training significantly improves fitness components among female college students. Students engaged in regular physical activity exhibited higher levels of cardiorespiratory endurance, muscular strength endurance, and flexibility compared to their sedentary counterparts. These findings emphasize the importance of structured exercise programs in educational institutions to foster a healthier student population.

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CORRELATE MOTOR FITNESS VARIABLES AND PLAYING ABILITY AMONG HANDBALL PLAYERS

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ABSTRACT

The purpose of the study was to find out the relationship between selected motor fitness variables and playing ability among handball players. To achieve the purpose of this study the investigator selected hundred college men handball players from the affiliated colleges of Tamil Nadu Physical Education and Sports University at randomly and their age ranged between 18 to 24 years. The following Motor Fitness variables will be selected to this study: muscular strength, muscular endurance, cardio-vascular endurance, flexibility, body mass index, power, speed, agility, balance and reaction time. Obtained data were analyzed with the Pearson product moment correlation. Power with muscular strength, muscular endurance, cardio vascular endurance, flexibility, body mass index, agility, balance and reaction time. Speed and muscular strength, muscular endurance, cardio -vascular endurance, flexibility, agility, balance, and reaction time. agility with flexibility, body mass index, power, speed and reaction time. balance with muscular strength, muscular endurance, cardio -vascular endurance, flexibility, power, speed, and reaction time. reaction time with cardio -vascular endurance, flexibility, power, speed, agility, and balance.

Keywords: Motor Fitness, Playing Ability and Handball

1. INTRODUCTION

A person doing any physical activity or exercise with undue fatigue is called fitness. Motor fitness means ability to make a movements or motion in one place to another place through of the human body segments with undue fatigue. And also Suitability or preparedness for performing big muscle activity without undue fatigue; it is composed of muscular strength and endurance, cardiovascular endurance, power, flexibility, coordination, balance, speed and agility. It helps to prepare capsules of training based on Handball player's level of fitness. For instance muscular power helps to determine player's explosiveness and spiking ability. Agility helps for better blocking and spiking abilities. Shoulder strength helps to execute on service, spiking, blocking and passing in an efficient manner. The player's reaction time helps to the specific reaction ability during spiking, blocking and ball collecting moments. Abdominal strength helps directly on the core power on air check and body co-ordination on during game situation.

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Handball is an excellent all-round team-sport, and it has been widely accepted as highly competitive and recreational game throughout the world. It is interesting to note that the speed of a powerfully spiked ball in the game of Handball is about 45 metres per second which is much faster than the movement of the ball in most other games. The game offers a wider opportunity for the development of strength, speed, endurance, agility, neuro-muscular skills and coordination of all parts of the body by the actions involved in the game. The game situations demands coordinated team-work, thereby instilling in every player a sense of personal and group responsibility by his individual performance and his ability to combine with the rest of the team (Hubert Dhanaraj, 1991). The ability of an individual to adapt their skill or techniques into a particular sport or events during a competition or a tournament is called as playing ability.

2. METHODOLOGY

The purpose of the study was to find out the relationship between selected motor fitness variables and playing ability among Handball players. To achieve the purpose of this study the investigator selected hundred college men Handball players from the affiliated colleges of Tamil Nadu Physical Education and Sports University at randomly and their age ranged between 18 and 24 years. The following motor fitness variables will be selected to this study: muscular strength, muscular endurance, cardio-vascular endurance, flexibility, body mass index, power, speed, agility, balance, and reaction time. obtained data were analyzed with the Pearson product moment correlation.

Table I

Shows Mean Standard Deviation and Range of Motor Fitness variables and Playing Ability of Handball players

S. No	Variables	Sample size	Mean	S D	Minimum	Maximum
1	Muscular strength	100	21.26	5.03	12	30
2	Muscular endurance		30	6.11	20	43
3	Cardiovascular endurance		42.50	5.65	30	52
4	Flexibility		24.87	3.97	18	31
5	Body Mass Index		21.72	2.01	17.96	25.39
6	Power		2.61	0.28	2.05	3.11
7	Speed		6.10	0.21	5.70	6.50
8	Agility		4.66	0.30	4.10	5.13
9	Balance		4.59	0.38	3.28	5.22
10	Reaction time		0.12	0.03	0.06	0.18
11	Playing ability		86.93	3.38	78.00	92.00

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Table 2 – shows coefficient correlation values of motor fitness variables and playing ability of handball players

Variables	Muscular strength	Muscular endurance	Cardiovascular endurance	Flexibility	body mass index	Power	Speed	Agility	Balance	Reaction time	Playing ability
Muscular strength		0.76*	0.52*	0.49*	0.35*	0.31*	0.24*	0.16	0.28*	0.09	0.22*
Muscular endurance	0.76*		0.82*	0.59*	0.42*	0.31*	0.39*	0.12	0.39*	0.18	0.06
Cardiovascular endurance	0.52*	0.82*		0.52*	0.22*	0.37*	0.52*	0.11	0.39*	0.30*	0.18
Flexibility	0.49*	0.59*	0.52*		0.47*	0.33*	0.33*	0.37*	0.30*	0.34*	0.38*
Body Mass Index	0.35*	0.42*	0.22*	0.47*		0.22*	0.10	0.26*	0.07	0.18	0.23*
Power	0.31*	0.31*	0.37*	0.33*	0.22*		0.14	0.29*	0.24*	0.32*	0.40*
Speed	0.24*	0.39*	0.52*	0.33*	0.10	0.14		0.32*	0.34*	0.20*	0.09
Agility	0.16	0.12	0.11	0.37*	0.26*	0.29*	0.32*		0.07	0.30*	0.51*
Balance	0.28*	0.39*	0.39*	0.30*	0.07	0.24*	0.34*	0.07		0.33*	0.23*
Reaction time	0.09	0.18	0.30*	0.34*	0.18	0.32*	0.20*	0.30*	0.33*		0.44*
Playing ability	0.22*	0.06	0.18	0.38*	0.23*	0.40*	0.09	0.51*	0.23*	0.44*	

*significant the required table value r (99) = 0.19 at 0.05 level of significance

In table II shows pair wise correlation(r) values of playing ability with muscular strength=0.22, muscular endurance=0.06, cardio-vascular endurance=0.18, flexibility=0.38, body mass index=0.23, power=0.40, speed=0.09, agility=0.51, balance=0.23 and reaction time=0.44.

The result of this study there was a significant relationship between playing ability and motor fitness variables of muscular strength=0.22, flexibility=0.38, body mass index=0.23, power=0.40, agility=0.51, balance=0.23 and reaction time=0.44 at 0.05 level of significance.

The result of this study there was a significant relationship within motor fitness variables of muscular strength with muscular endurance=0.76, cardio - vascular endurance = 0.52, flexibility = 0.49, body mass index = 0.35, power = 0.31, speed = 0.24 and balance = 0.28. muscular endurance with muscular strength = 0.76, cardio -vascular endurance = 0.82, flexibility = 0.59, body mass index = 0.42, power = 0.31, speed = 0.39 and balance = 0.39. cardio -vascular endurance with muscular strength = 0.52, muscular endurance = 0.82, flexibility = 0.52, body mass index=0.22, power=0.37, speed = 0.52, balance = 0.39 and reaction time = 0.30. flexibility with muscular strength =0.49, muscular endurance = 0.59, cardio -vascular endurance = 0.52, body mass index = 0.47, power = 0.33, speed=0.33, agility=0.37, balance=0.30 and reaction time=0.34. body mass index with muscular strength=0.35, muscular endurance=0.42, cardio -vascular endurance = 0.22, flexibility=0.47, power=0.22 and agility=0.26. power with muscular strength=0.31, muscular endurance=0.31, cardio -vascular endurance = 0.37, flexibility=0.33, body mass index=0.22, agility=0.29, balance=0.24 and reaction time=0.32. speed and muscular strength=0.24, muscular endurance=0.39, cardio -vascular endurance =0.52, flexibility=0.33, agility=0.32, balance=0.34 and reaction time = 0.20. agility with flexibility = 0.37, body mass index = 0.26, power=0.29, speed=0.32 and reaction time=0.30. balance with muscular strength=0.28, muscular endurance=0.39, cardio -vascular endurance =0.39, flexibility=0.30, power=0.24, speed=0.34 and

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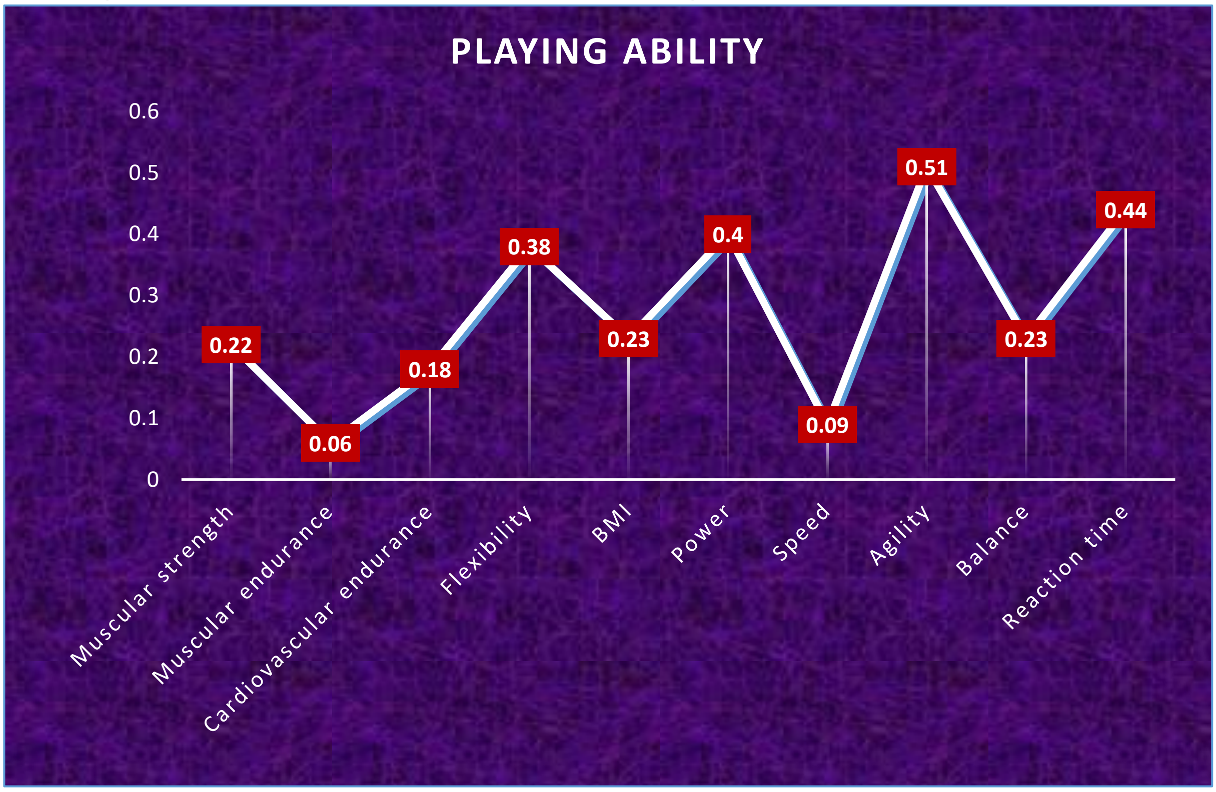
reaction time=0.33. reaction time with cardio -vascular endurance=0.30, flexibility=0.34, power=0.32, speed=0.20, agility=0.30 and balance=0.33 at 0.05 level of significance.

Figure 1. Shows Relationship between Playing Ability and Motor Fitness Variables



3. RESULTS

1. The conclusion of the study that there was a significant relationship between playing ability and motor fitness variables of muscular strength, flexibility, body mass index, power, agility, balance, and reaction time.
2. The conclusion of the study that there was a significant relationship within motor fitness variables of muscular strength with muscular endurance, cardio-vascular endurance, flexibility, body mass index, power, speed, and balance.
3. The conclusion of the study that there was a significant relationship within motor fitness variables of muscular endurance with muscular strength, cardio -vascular endurance, flexibility, body mass index, power, speed, and balance.
4. The conclusion of the study that there was a significant relationship within motor fitness variables of cardio-vascular endurance with muscular strength, muscular endurance, flexibility, body mass index, power, speed, balance, and reaction time.
5. The conclusion of the study that there was a significant relationship within motor fitness variables of flexibility with muscular strength, muscular endurance, cardio -vascular endurance, body mass index, power, speed, agility, balance, and reaction time.
6. The conclusion of the study that there was a significant relationship within motor fitness variables of body mass index with muscular strength, muscular endurance, cardio -vascular endurance, flexibility, power and agility.

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7. The conclusion of the study that there was a significant relationship within motor fitness variables of power with muscular strength, muscular endurance, cardio -vascular endurance, flexibility, body mass index, agility, balance and reaction time.
8. The conclusion of the study that there was a significant relationship within motor fitness variables of speed and muscular strength, muscular endurance, cardio -vascular endurance, flexibility, agility, balance and reaction time.
9. The conclusion of the study that there was a significant relationship within motor fitness variables of agility with flexibility, body mass index, power, speed, and reaction time. balance with muscular strength, muscular endurance, cardiovascular endurance, flexibility, power, speed, and reaction time.
10. The conclusion of the study that there was a significant relationship within motor fitness variables of reaction time with cardio -vascular endurance, flexibility, power, speed, agility and balance.

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THE IMPACT OF EXERCISE ON SLEEP DURATION QUALITY AND MELATONIN SECRETION: A COMPREHENSIVE REVIEW

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ABSTRACT

Sleep is essential for maintaining physical health and cognitive function, yet modern lifestyle factors often disrupt sleep patterns. This review synthesizes research on the impact of physical activity on sleep duration, quality, and circadian rhythms, with a particular focus on melatonin secretion. We examine studies that explore the relationship between exercise and sleep, highlighting how different forms of physical activity influence sleep onset, duration, and quality. Key findings indicate that regular exercise positively regulates melatonin secretion, a hormone critical for sleep-wake cycles, and helps synchronize circadian rhythms. Furthermore, physical activity has been shown to mitigate the negative effects of stress and sleep deprivation on sleep quality. Through mechanisms such as hormonal regulation and circadian rhythm synchronization, exercise emerges as a beneficial intervention for improving sleep. This review underscores the importance of integrating physical activity into daily routines to enhance sleep health and overall well-being.

Keywords: Sleep, Exercise and Melatonin.

1. INTRODUCTION

Sleep is a vital physiological function, influencing various aspects of health, includingcognitive performance, metabolism, and emotional regulation. Over recent years, considerable research has focused on understanding the relationship between physical activity, sleep quality, and melatonin production. This review aims to synthesize findings from key studies examining the interplay between exercise and sleep, particularly the mechanisms of melatonin secretion and circadian rhythm regulation. By understanding how physical activity can improve sleep, this review will highlight practical implications for optimizing sleep health.

2. IMPACT OF SLEEP DURATION AND QUALITY

Hirshkowitz et al. (2015) provided foundational insights into sleep duration recommendations, emphasizing the importance of sufficient sleep for overall health. The National Sleep Foundation's guidelines categorize recommended sleep durations based on age, and their findings suggest a direct link between sleep quality and long-term health outcomes.

However, numerous factors can influence sleep duration and quality, including physical activity. For example, Chtourou and Souissi (2012) reviewed the effects of exercise on sleep, highlighting how different types of physical activity such as aerobic exercise and strength training can lead to improved sleep quality, demonstrating a direct benefit for sleep duration and the ability to fall asleep faster.

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3. ROLE OF EXERCISE IN SLEEP REGULATION

Exercise has been shown to impact sleep in several ways, including the regulation of hormones that influence sleep. Leproult and Van Cauter (2010) explored how sleep and sleep deprivation interact with hormonal release, particularly melatonin. The study found that disruptions in sleep patterns often exacerbated by inadequate sleep can lead to hormonal imbalances, negatively affecting metabolism and energy regulation. Physical activity was noted as an effective strategy to mitigate these disruptions, highlighting its potential in improving hormonal rhythms related to sleep.

Further expanding on the topic of exercise and sleep, Zhang et al. (2016) demonstrated that physical activity plays a crucial role in improving sleep quality by regulating the circadian rhythm, largely through the secretion of melatonin. Melatonin, a hormone responsible for regulating sleep-wake cycles, has been identified as a key factor that exercise helps to balance. Regular exercise was shown to enhance melatonin production, leading to more synchronized and consistent sleep patterns.

4. EXERCISE AND MELATONIN PRODUCTION

Melatonin plays a pivotal role in maintaining healthy sleep cycles, and its secretion can be influenced by various factors, including physical activity. Simpson and Dinges (2007) examined the effects of sleep deprivation and stress on melatonin secretion. They found that sleep deprivation, often accompanied by high stress levels, leads to a suppression of melatonin production, ultimately affecting sleep quality. This underscores the importance of managing both sleep and stress to preserve melatonin secretion.

Studies have suggested that regular exercise can counteract the negative effects of sleep deprivation on melatonin levels. Wright and Chtourou (2013) explored the relationship between exercise and circadian rhythms, focusing on how physical activity influences melatonin production. Their research suggests that moderate-to-vigorous exercise can synchronize the body's internal clock, resulting in better sleep quality by enhancing the natural secretion of melatonin.

Moreover, Matsumoto and Yamada (2015) added to the understanding of how exercise impacts circadian rhythms. They concluded that exercise not only affects the secretion of melatonin but also helps in aligning the body's biological rhythms, particularly those regulating sleep patterns.

5. CIRCADIAN RHYTHMS AND SLEEP

Circadian rhythms are central to understanding sleep regulation. Exercise plays an important rolein aligning and stabilizing these rhythms, thus improving overall sleep quality. Kelley and Kelley (2011) conducted a meta-analysis on the effects of physical activity on sleep outcomes, focusing on adults. Their review showed a consistent improvement in sleep duration and quality following regular physical activity. Exercise, by positively influencing circadian rhythms, was found to enhance both subjective sleep quality and objective measures of sleep, such as sleep latency and wakefulness during the night.

6. CONCLUSION

Exercise has been shown to have a profound impact on sleep duration, quality, and melatonin production, contributing to the regulation of circadian rhythms and overall sleep health. Regular

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physical activity enhances melatonin secretion, mitigates the negative effects of sleep deprivation and stress, and improves circadian synchronization. These findings highlight the importance of integrating exercise into daily routines to optimize sleep quality and promote better overall health.

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EFFECT OF SAQ TRAINING ON SPEED AND AGILITY AMONG MEN VOLLEYBALL PLAYERS

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ABSTRACT

Background: The goal of this research was to see how effect of saq training on speed and agility among men volleyball players. Thirty volleyball players from Tamil Nadu, India, were chosen at random as study subjects to meet the study's goal. The age limit is eighteen to twenty-three years

Methods: The participants were placed into three groups: EG-A, and CG-B. SAQ was carried out in EG-A and control group EG-B, participating in no research programmes other than their everyday activities.

Results: Through data was collected from three pre- and post-experimental parties. The paired sample T-Test was used to statistically assess on speed and agility. In both situations, the significance threshold was chosen at 0.05.

Conclusion: saq preparing has shown better execution on speed and agility than the control group and it shows better execution.

Keywords: Speed Agility Quickness Training, Speed, Agility, T-Test.

1. INTRODUCTION

Volleyball is viewed as a very explosive and high paced sport. Volleyball is an exceptional anaerobic game that joins explosive developments with short times of recuperation. Speed and agility are joined with greatest strength, power is the result. Muscular force enables a given muscle to deliver a similar measure of work in not so great, or a more prominent of work in a same time, which is significant for running, bouncing and quick change of direction.

SAQ preparing and molding empowers a competitor to contend at a higher level and sets him up for different occasions by getting fit and strong and by improving on his skills. Exercise including speed, agility, and quickness is a preparation method pointed toward creating motor abilities and body movement control through the advancement of the neuromuscular system. It plans to work on the competitor's capacity to perform multi directional explosive power developments by reinventing the neuromuscular system, so it can work all the more productively.

Exercise of saq the total range of training intensity, from low intensity to high intensity. Speed is the capacity of the complex, on the grounds that by and large, speed is a capacity that permits a volleyball player to move as fast as conceivable at the degree of specific movement. Agility is a significant quality in a great deal of sports that are played on the field. Speed increase and speed can be effect by changing the development mechanism of the arms or legs.

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2. METHODOLOGY

For the purpose of the research 30 volleyball players from TamilNadu at the age of 18 to 23 years. The subject was divided into two equal groups. The researcher selected the following variables for the current research**.**

Table-I

Sn.no	Variables	Test item	Units
1.	Speed	50 mts dash	Seconds
2.	Agility	t-test	Seconds

True randomized experimental group design has been employed with two groups namely SAQ training group A and control group with 15 subject of each group. Group A participated their respective treatment for a period of eight weeks and general exercise was given to control group. The training should be given at morning time with proper warming up exercise for 3 times a week (Monday, Wednesday and Friday) for eight weeks. The three groups were statistically analyzed by using t-ratio to find out significance of the difference made by the experimental and control groups during the experimental period of eight weeks. All analysis were executed IBM-SPSS 22.0 software was used the confidence level maintained 0.05

Table – II

Summary of mean and paired sample't' test for the pre and post test on SAQ Groups and control group

Variables	Tests	SAQ Training Group	Control Group
	Pre Test & Sd Mean	7.27- 0.19	7.28 – 0.24
	Post Test & Sd Mean	7.19 – 0.16	7.30 – 0.28
Speed	T-Test	6.37*	1.87
Variables	Tests	SAQ Training Group	Control Group
	Pre Test & Sd Mean	11.04 - 0.45	11.37 - 0.80
	Post Test & Sd Mean	10.68 - 0.51	11.44 - 0.78
Agility	T-Test	5.93*	1.69

***Significant level at 0.05 level. The table value required for 0.05 level of significance with df 1 and 14**

The pre test mean value of saq group 7.27 control group 7.28 the post test mean value 7.19 and control group 7.30. The't' value of saq training and control groups for speed were 6.37 and 1.87. The't' values of saq training groups were significantly higher than the required table value of 2.04 with df 14 at 0.05 level of confidence. The result of the study shows that saq training has significantly improved the speed.

The pre test mean value of saq group 11.04 control group 11.37 the post test mean value 10.68 and control group 11.44. The 't' value of saq training and control groups for agility were 5.93 and 1.69. The 't' values of saq training groups were significantly higher than the required table value of 2.04 with df 14 at 0.05 level of confidence. The result of the study shows that saq training has significantly improved the agility.

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Source of Funding: Self

Conflict of Interest: **Nil**

3. CONCLUSION

In the light of this examination endeavored with limit constrained by the preliminary condition, the going with end was drawn. The after effect of the assessment reveals that there was a basic improvement in the exploratory group on chose contrasted group with the control after the completion of saq preparing has shows better execution on speed and agility than the control group and it shows better execution. That effect saq training will helps the volleyball players to further develop her show level in an extraordinary manner**.**

AUTHOR CONTRIBUTION

Statements 1author and 2author conceived of the present research. 1author designed the theory and performed and 2author verified the analytical methods. 2author encouraged 1author to investigate (a research aspect] and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

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LONG-TERM EFFECTS OF AEROBIC EXERCISES ON CARDIO-RESPIRATORY PARAMETERS AND PERFORMANCE IN MALE COLLEGIATE MIDDLE-DISTANCE RUNNERS

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ABSTRACT

The purpose of this study was to investigate the effects of aerobic exercises on cardio-respiratory endurance parameters among college men middle-distance runners. Thirty (N=30) male college students aged 17 to 25 years were selected from ADM College for Women, Nagapattinam, Tamil Nadu, India, during the academic year 2016-17. The participants were divided into two equal groups: an experimental group (n=15) and a control group (n=15). The experimental group underwent a six-week aerobic exercise program, while the control group did not participate in any structured exercise during the study period. Cardio-respiratory endurance, the dependent variable, was measured using the Cooper 12-minute run/walk test, with results recorded in meters. Pre-tests were conducted before the intervention, and post-tests were administered immediately after the six-week program. Data were analyzed using paired sample t-tests and analysis of covariance (ANCOVA) to determine significant differences between the groups. The level of significance was set at $p < 0.05$. The results indicated that the aerobic exercise group showed significant improvements in cardio-respiratory endurance compared to the control group. These findings suggest that a structured aerobic exercise program can effectively enhance cardio-respiratory endurance levels in college men middle-distance runners.

Keywords: Aerobic exercises, Cardio respiratory endurance and Cooper12 min run/walk test.

1. INTRODUCTION

Aerobic exercise (also known as cardio) is physical exercise of low to high intensity that depends primarily on the aerobic energy-generating process. Aerobic literally means "relating to, involving, or requiring free oxygen", and refers to the use of oxygen to adequately meet energy demands during exercise via aerobic metabolism. Generally, light-to-moderate intensity activities that are sufficiently supported by aerobic metabolism can be performed for extended periods of time. When practiced in this way, examples of cardiovascular/aerobic exercise are medium to long distance running/jogging, swimming, cycling, and walking, according to the first extensive research on aerobic exercise, conducted in the 1960s on over 5,000 U.S. Air Force personnel by Dr. Kenneth H. Cooper (2009). Bowman A.J (1992) said Aerobic exercise refers to exercise that involves or improve oxygen consumption by the body. Aerobic means with oxygen and refers to the use of oxygen in the body's metabolic or energy generating process. The steps that can be choreographed in to an aerobic dance routine can be varied by impact (i.e, high impact versus low impact.)

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Aerobic dance exercise (ADE) can usually be completed easily by participants of all ages and fitness level. This is one of the unique characteristics of ADE, in that the same step can be modified by the participants to meet the needs of her individual workout. A typical ADE workout fulfils the cardio respiratory training principles (i, e frequency, intensity, duration, and type of activity continuous) and is similar to any cardio respiratory workout classes begins with a warm up of light activity and stretching exercise for 10 minutes, progress to the 20-30 minutes workout phase and then have a gradual cool down period for 10 minutes. Three parts of a typical 60 minutes program. A number of steps have been defined; walk, run, skip, two-steps, march, jog. Jumping jack, step touch, sidekicks and touch backs. According to the President"s Council on Physical Fitness and Sports, cardio respiratory endurance is defined as the body"s ability to deliver oxygen and other nutrients to tissue and to remove waste products over a sustained period of time. Improving cardio respiratory endurance through aerobic exercise can help reduce the risk of heart disease, some types of cancer and can aid in weight control and weight maintenance. Walking, swimming, cycling and running are examples of exercises that can improve cardio respiratory endurance.

2. METHODS & MATERIALS

The present study was to investigate the effect of aerobic exercises on cardio respiratory endurance parameter among among college men middle distance runners. This study was selected thirty (N=30) college men students were selected from ADM COLLEGE FOR WOMEN, Nagapattinam, Tamil Nadu state, India, during the year 2016-17. The subject"s age ranges from 17 to 25 years. They were divided into two group namely aerobic exercise group I (Experimental group) and control group (group II) each consists of 15 subjects. The experimental groups I were subjected to six weeks of aerobic exercise training respectively, and the group II acted as control. The experimental groups II used exercises v step, turn step, over the top, L step, basic straddle step, side to side, double step side, knee kick, kick forward, kick sideward., but start with smaller number of reps) and the load given were progressively increased from 50%,60%,70% intensity level water aerobic exercise and aerobic exercises drills respectively for one hour per day for three days a week for a period of six weeks. The subjects of all the two groups were tested on cardio respiratory endurance prior to and after the training period. To ascertain cardio respiratory endurance parameter measured by cooper 12 min run/walk test accordingly the mean value count by meters.

3. STATISTICAL TECHNIQUE

The following statistical procedures were used. The "t" ratio was calculated to find out the significance of the difference between the mean of the initial and final test of the experimental group. The significance of the difference among the means of experimental group was found out by pre-test. The data were analyzed and dependen t" test was used with 0.05 levels as confidence.

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Table 1

Analysis of dependent t-test for the Pre and Post Test Means Values for Aerobic exercise group and Control group on cardio respiratory endurance (Cooper 12 min run/walk test mean value measure by meters)

Groups	Mean		Mean Difference	S.D	Standard Error	't' ratio
	Pre	Post				
Experimental	1888	2065.03	177.03	139.38785	35.98875	4.92*
Control Group	1891.3	1877.3	14	72.38784	18.6904	0.75

*****Significance at .05 level of confidence. (The table value required for 0.05 level of significant with df of 28 is 2.04)

The Table-I shows that the mean values of pre test and post-test of control group on cardio respiratory endurance were 1891.3 and 1877.3 respectively. The obtained t" ratio was 0.75, since the obtained t" ratio was less than the required table value of 2.04 for the significant at 0.05 level with 28 degrees of freedom it was found to be statistically insignificant. The mean values of pre-test and post-test of experimental group on cardio respiratory endurance were 1888 and 2065.03 respectively. The obtained „t" ratio was 4.92* since the obtained „t" ratio was greater than the required table value of 2.04 for significance at 0.05 level with 28 degrees of freedom it was found to be statistically significant. The result of the study showed that there was a significant difference between control group and experimental group in cardio respiratory endurance. It may be concluded from the result of the study that experimental group improved in cardio respiratory endurance due to six weeks of Aerobic exercises among college men middle distance runners.

4. DISCUSSIONS ON FINDINGS

The result of the study indicates that the experimental group namely aerobic exercise group had significantly improved the selected dependent variables namely cardio respiratory endurance, when compared to the control group. It is also found that the improvement caused by aerobic exercise when compared to the control group. Gormley SE et al (2008) To determine whether various intensities of aerobic training differentially affect aerobic capacity as well as cardio respiratory endurance. The result significantly increased in all exercising groups by 1888,to 2065 meters in the near-maximal-, the vigorous-, and the moderate-intensity groups, respectively. Percent increases in the near-maximal- (20.6%), the vigorous- (14.3%), and the moderate intensity (10.0%) groups were all significantly different from each other ($P < 0.05$). When volume of exercise is controlled, higher intensities of exercise are more effective for improving cardio respiratory endurance than lower intensities of exercise in healthy, young adults.

5. CONCLUSIONS

1. There was a significant difference between experimental and control group on cardio respiratory endurance variables after the exercise period.
2. There was a significant improvement in cardio respiratory endurance. However the improvement was in favour for experimental group compare better than the control group due to six weeks of Aerobic exercises.

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CONSEQUENCE OF BATTLE ROPE TRAINING ON PHYSICAL VARIABLES AMONG COLLEGE WOMEN KABADDI PLAYERS

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ABSTRACT

The intention of the take a look at become to investigate the result of battle rope schooling on bodily variables amongst college girls kabaddi players. To acquire the look at 30 college women kabaddi players were decided on as difficulty in Thiruvennainallur area, TamilNadu, India at random and their ages ranged from 18 to 23 years. The difficulty turned into divided into two identical companies every of 15 . The study turned into formulated as a real random organization design, which include a pre-test and post-test. The groups had been assigned as rope training and manipulate institution in an equal way. The 2 groups had been participated the education for a duration of 8 weeks to locate the final results of the training applications. The two groups had been statistically analyzed with the aid of the use of analysis of variance (ANOVA). The extent of turned into constant 0.05 degree. Result of the study experimental group had significant improvement on muscular strength and explosive power when compare to control group.

Keywords: Battle rope training, explosive power, muscular strength, women kabaddi players.

1. INTRODUCTION

A game is a coordinated, competitive, engaging and skilful physical work requiring responsibility, technique and reasonable play in which a champ can be characterized by target implies. Sports training are developed in with creating states of being to improve performance and skills at specific games. Kabaddi is an Indian game which requires both power and skill for its play. The sport of Kabaddi is played across the length and broadness of India. This notoriety can be attributed to the effortlessness of the game and the way that it requires no refined gear. The sport of Kabaddi is a common Indian game that includes a lot of agility, endurance, courage and team spirit. In the start of the twentieth century rules of the games were outlined by the Deccan gymkhana. Have a particular training need to improve your strength, speed, endurance or perseverance for a specific game or event do you continue getting harmed or discovering you are hitting levels with your present training program.

Battle rope span preparing is a low-effect, totalbody, and exceptional metabolic methodology. As of late, its notoriety has expanded in different populaces, from general health and fitness trainees to proficient athletes. Battle Ropes or substantial rope training gives the whole body endless advantages. Battle ropes come in all shapes and sizes, regularly going from 26-50ft long, and are anyplace between 1 to 2 inches thick. Their weight can differ enormously, contingent upon the length and thickness of the rope. Battle ropes are usually utilized as an extreme cardio exercise apparatus to build up a athletes strength, power, explosive, just as their anaerobic and aerobic endurance. This activity includes total body muscle action the muscle movement for anterior deltoid, external oblique, and lumbar erector spinae range from most extreme willful isometric withdrawals, though gluteus medias muscle action. The extraordinary thing about training with the Battling Ropes is that developments and procedures can be altered for exercisers of pretty much any wellness level from utilizing two hands to hold and work just one end of the rope, to adding further developed developments that include lower body developments alongside the upper body work.

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2. STATEMENT OF THE PROBLEM

The purpose of this research was to find out the consequence of battle rope training on selected physical variables among college women kabaddi players

3. HYPOTHESIS

It is hypothesized battle rope training have significant improvement on physical variables among college women kabaddi players

4. METHODOLOGY

For this research 30 women kabaddi players were selected from Thiruvennainallur area, TamilNadu, India. Subjects were all minimum participated in the national level college tournaments at age range between 18 to 23 years are participated in this study. The subject was dividing into two equal groups.

The investigator selected the following variables for the present investigation.

Table I

S.no	Variables	Test items	Units
1.	Muscular strength	Push ups	Counts
2.	Explosive power	Standing broad jump	Meters

True randomized experimental group design has been employed with two groups, namely battle rope training group and control group with 15 subjects each. Group I participated their respective treatments for a period of eight weeks and no training were given to the control group. The training should be given at morning time with proper warming up exercises for 3 times a week (Monday, Wednesday and Friday) of eight weeks. The battle rope training exercises are Double waves, Alternate waves, Low alternating waves, Power slams, Alternating wave lunge jump rotational slam, alternative waves, rope claps, squat alternative slam and Russian twist all the exercise will be using of battle rope training. The data should be collected before and after the training protocol. The two groups were statistically analyzed by using analysis of variance (ANOVA).

Table II

Analysis of variance on physical variables of battle rope training and control group of college women kabaddi players

Explosive power						
Test	Battle rope training group	Control group	Sum of square	df	Mean square	F ratio
Pre test	1.23	1.09	0.008	1	0.008	1.67
			0.140	28	0.005	
Post test	1.16	1.09	0.38	1	0.38	10.28*
			0.104	28	0.004	

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Muscular strength						
Test	**Battle rope training group**	**Control group**	**Sum of square**	**df**	**Mean square**	**F ratio**
Pre test	12.73	11.93	4.80	1	4.80	3.22
			41.86	28	1.49	
Post test	15.13	12.46	53.33	1	53.33	29.14*
			51.46	28	1.83	

***Significant 0.05 table value 3.23 df (1, 28)**

The explosive power pre-test for rope training and common group F ratio value 1.67 became found to be decrease than the needful value 3.32 was considerably lesser than the desk value 3.32 df 1 and 28 significance at the level of confidence 0.05. The obtained explosive strength posttest for rope training and common group F ratio fee 10.28* changed into discovered to be higher than the value 3.32 became appreciably greater than the desk fee 3.32 df 1 and 28 importance level of confidence 0.05.

The muscular strength pre-test for rope training and common group F ratio 3.22 became determined to be lower than the considered necessary value 3.32 was drastically lesser than the desk value 3.32 df 1 and 28 significance at the level of confidence 0.05. The obtained explosive power posttest for rope training and common group F ratio fee 29.14* became observed to be better than the considered necessary fee 3.32 became significantly greater than the desk value 3.32 df 1 and 28 significance at the level of confidence 0.05.

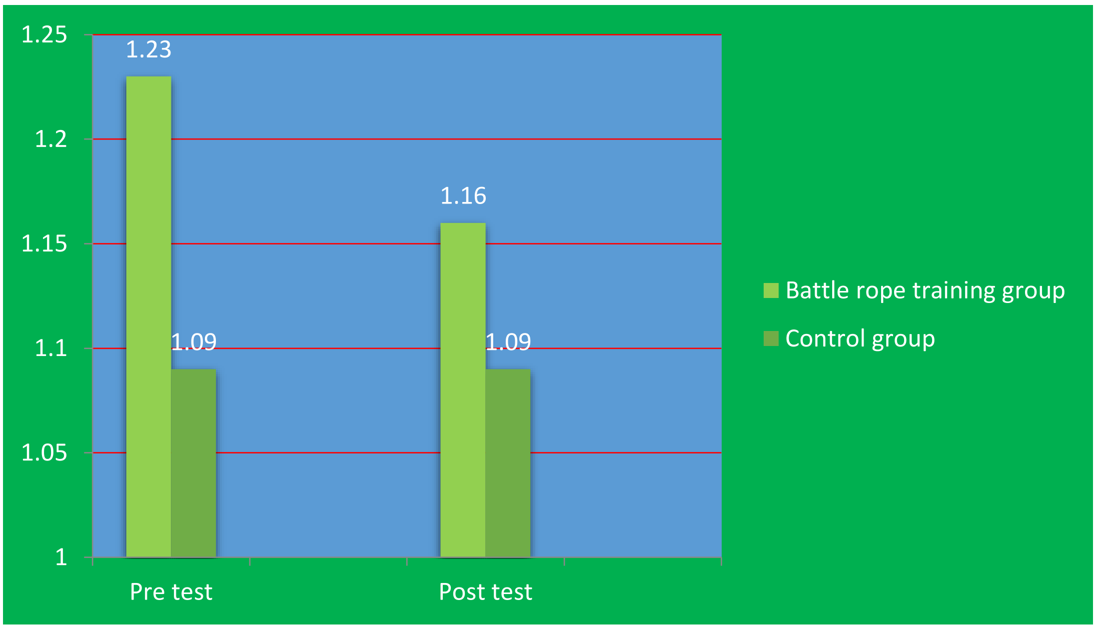

Figure –I Cylindrical Diagram of Muscular Power of Battle Rope Training Group And Control Group

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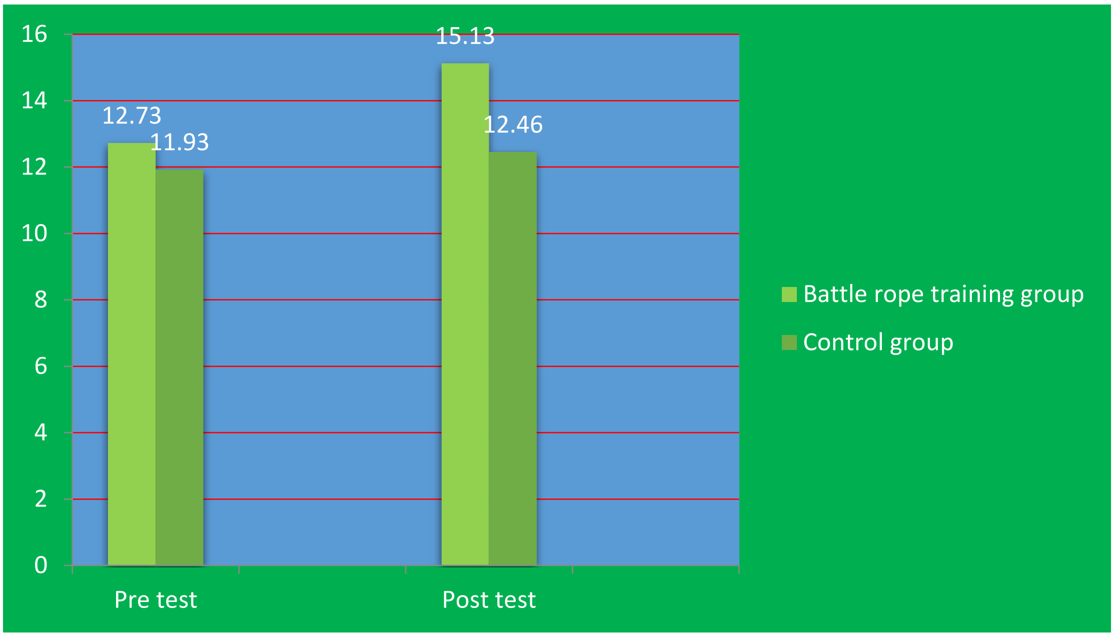

Figure –II Cylindrical Diagram of Muscular Power of Battle Rope Training Group And Control Group

5. CONCLUSION

Battle rope training is a low impact total body exercise modality and has generally been used in various populations from general health and fitness trainees to professional athletes. The nature of physical variables was improved with the responses battle rope training. The improvement was similar in battle rope training groups. The control group did not show any noticeable improvement.

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EFFECT OF PLYOMETRIC TRAINING WEIGHT TRAINING AND COMBINED TRAINING ON PHYSICAL PHYSIOLOGICAL AND BIOCHEMICAL VARIABLES AMONG COLLEGE MEN JUMPERS

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ABSTRACT

This study investigates the effects of plyometric training, weight training, and combined training on selected physical, physiological, and biochemical variables among college men jumpers. Sixty participants aged 18-25 were randomly assigned to three experimental groups: plyometric training, weight training, and combined training, with a control group. The training lasted for twelve weeks. Pre- and post-training assessments measured upper body muscular strength, abdominal muscular strength, explosive power, resting heart rate, blood pressure, total cholesterol, low-density lipoprotein (LDL), and high-density lipoprotein (HDL). The findings indicate significant improvements in all experimental groups compared to the control, with combined training showing superior effects across multiple variables. These results highlight the effectiveness of structured training interventions for athletic performance enhancement.

Keywords: Plyometric Training, Weight Training, Combined Training, Physical Fitness, Biochemical Variables, Athletic Performance

1. INTRODUCTION

Training plays a crucial role in improving athletic performance. The ability to jump, sprint, and perform explosive movements is essential for athletes across various sports. Physical conditioning through structured training programs significantly impacts strength, endurance, and overall performance. Plyometric training, weight training, and combined training are widely used methods aimed at enhancing different aspects of athletic ability. Understanding the effects of these training approaches is vital for optimizing performance and reducing the risk of injury.

Plyometric training involves high-intensity, explosive movements designed to improve power output and neuromuscular efficiency. This form of training capitalizes on the stretch-shortening cycle of muscles, enabling athletes to generate greater force in shorter durations. Common plyometric exercises include jump squats, box jumps, and depth jumps, all of which emphasize rapid force production and agility. Studies have shown that plyometric training improves muscle activation, reaction time, and overall explosiveness, making it an integral component of athletic preparation.

Weight training, on the other hand, focuses on building muscular strength and endurance through resistance-based exercises. This form of training enhances muscular hypertrophy, increases bone density, and strengthens connective tissues, which contribute to injury prevention. Weightlifting exercises such as squats, deadlifts, and bench presses target specific muscle groups, helping athletes develop the foundational strength required for high-performance movements. Research indicates that weight training not only improves maximal strength but also contributes to endurance and muscular efficiency over time.

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Combined training integrates both plyometric and weight training elements, offering a holistic approach to athletic conditioning. By combining explosive power exercises with strength-building routines, athletes can achieve well-rounded development that enhances both speed and endurance. Studies have demonstrated that athletes who engage in combined training experience greater improvements in force production, agility, and cardiovascular efficiency compared to those who follow a single-mode training regimen. This method maximizes the benefits of both training styles, creating a more balanced and adaptable athlete

Methodology Participants:

Sixty college men jumpers (aged 18-25) were randomly divided into four groups:

- **Group I**: Plyometric Training (n=15)
- **Group II**: Weight Training (n=15)
- **Group III**: Combined Training (n=15)
- **Group IV**: Control (n=15)

Training Protocol:

- Plyometric Training: Jump-based exercises focusing on explosive movements.
- Weight Training: Resistance exercises targeting muscle strength.
- Combined Training: Integration of plyometric and weight training.
- Control Group: No structured training.

Assessments:

- **Physical Variables**: Upper body muscular strength, abdominal muscular strength, and explosive power.
- **Physiological Variables**: Resting heart rate, blood pressure (systolic & diastolic).
- **Biochemical Variables**: Total cholesterol, LDL, HDL.
- **Statistical Analysis**: Data were analyzed using ANOVA with a significance level of $p<0.05$.

Results

Variable	Control (Mean±SD)	Plyometric (Mean±SD)	Weight (Mean±SD)	Combined (Mean±SD)	p-value
Upper Body Strength	30±3	38±2	42±3	46±2	<0.05
Abdominal Strength	25±4	35±3	37±4	40±3	<0.05
Explosive Power	220±10	250±12	260±11	280±10	<0.05
Resting Heart Rate	72±3	68±2	66±2	64±1	<0.05
Blood Pressure (sys)	120±5	116±4	114±3	112±3	<0.05

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Blood Pressure (dia)	80±3	78±2	76±2	74±1	<0.05
Total Cholesterol	180±8	170±7	165±6	160±5	<0.05
LDL	110±5	102±4	98±4	92±3	<0.05
HDL	45±3	50±3	52±3	55±2	<0.05

2. DISCUSSION

The findings indicate that all three training methods significantly improved athletic performance and health indicators compared to the control group. Plyometric training effectively enhanced explosive power, while weight training led to substantial gains in muscular strength. Combined training demonstrated the most comprehensive improvements across all variables, suggesting an optimal approach for athletes seeking well-rounded physical development.

3. CONCLUSION

This study confirms the effectiveness of structured training programs in enhancing physical, physiological, and biochemical variables among college men jumpers. Combined training emerges as the most effective approach, integrating the benefits of both plyometric and weight training. Future research should explore the long-term effects of such interventions on elite athletes.

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PSYCHOLOGICAL ASPECTS OF SPORTS PERFORMANCE: A REVIEW OF VISUALIZATION AND MINDFULNESS

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ABSTRACT

This study explores the psychological dimensions of sports performance, focusing on the roles of visualization and mindfulness in optimizing athletic potential. Mental training techniques have become increasingly integral to sports science, enhancing concentration, confidence, and resilience. Visualization aids in skill acquisition and execution, while mindfulness fosters present-moment awareness and stress regulation. This paper examines the theoretical foundations, empirical evidence, and practical applications of these psychological strategies in sports performance.

Keywords: Sports Psychology, Visualization, Mindfulness, Performance Enhancement, Mental Training

1.INTRODUCTION

Success in sports is not solely determined by physical ability; psychological resilience and cognitive strategies significantly impact performance. Visualization and mindfulness have emerged as key mental tools that enable athletes to regulate stress, improve focus, and enhance skill execution. This paper reviews the mechanisms through which these techniques influence athletic performance and their applications in competitive sports.

2. VISUALIZATION IN SPORTS PERFORMANCE

2.1 Concept and Mechanisms

Visualization, or mental imagery, involves creating vivid mental representations of desired performance outcomes. This process activates neural pathways similar to those engaged during actual physical execution, reinforcing motor skills and confidence.

2.2 Empirical Evidence

Studies indicate that athletes who incorporate visualization into their training exhibit improved motor learning, increased accuracy, and enhanced self-efficacy. Functional MRI research suggests that mentally rehearsing movements stimulates the motor cortex, facilitating neural adaptation and muscle memory development.

2.3 Practical Applications

Athletes use visualization to:

- Rehearse game scenarios and strategic decision-making
- Enhance muscle memory through repeated mental practice
- Build confidence by envisioning successful performances

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- Regulate emotions and reduce pre-competition anxiety

3. MINDFULNESS AND ATHLETIC PERFORMANCE

3.1 Concept and Mechanisms

Mindfulness is the practice of maintaining present-moment awareness with a non-judgmental attitude. In sports, mindfulness training helps athletes cultivate attention, regulate emotions, and manage pressure during high-stakes situations.

3.2 Empirical Evidence

Research demonstrates that mindfulness interventions, such as Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Acceptance-Commitment (MAC) approaches, lead to improved focus, reduced stress, and enhanced overall well-being in athletes. Studies highlight that mindfulness training correlates with greater mental resilience and reduced susceptibility to performance anxiety.

3.3 Practical Applications

Athletes integrate mindfulness through:

- Meditation and breathing exercises to improve focus
- Body awareness practices to enhance kinesthetic perception
- Acceptance strategies to cope with mistakes and setbacks
- Mindful pre-performance routines to reduce stress

4. INTEGRATING VISUALIZATION AND MINDFULNESS FOR OPTIMAL PERFORMANCE

Modern sports psychology suggests that combining visualization and mindfulness yields synergistic benefits. Visualization enhances goal-oriented focus, while mindfulness ensures adaptability and presence. Integrating both approaches fosters:

- Greater cognitive flexibility and emotional regulation
- Enhanced adaptability to dynamic game situations
- Increased resilience in high-pressure scenarios

5. DISCUSSION

Advancements in sports psychology emphasize mental training as an essential component of athletic development. Key insights include:

- Visualization strengthens motor learning and confidence
- Mindfulness enhances present-moment awareness and stress management
- A combined approach optimizes both preparation and real-time performance

Future research should explore personalized mental training programs and the long-term impact of visualization-mindfulness integration across diverse sports disciplines.

6. CONCLUSION

The psychological aspects of sports performance, particularly visualization and mindfulness, significantly influence athletic success. Implementing structured mental training strategies can

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enhance focus, resilience, and overall performance. By integrating these techniques into daily training regimens, athletes can maximize their potential and achieve sustained excellence.

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THE EVOLUTION OF TRAINING METHODS IN ENDURANCE SPORTS: ANALYZING PAST AND PRESENT APPROACHES

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ABSTRACT

This study explores the evolution of endurance training, comparing traditional high-volume, low-intensity approaches with modern scientific methods. While early training emphasized aerobic capacity through prolonged workouts, contemporary strategies integrate structured periodization, HIIT, strength conditioning, and technology-driven monitoring to optimize performance and reduce injuries. This paper reviews endurance training advancements, focusing on physiological adaptations, biomechanics, and recovery strategies. Findings suggest that modern approaches provide a more individualized, data-driven framework for enhancing endurance performance.

Keywords: Endurance Training, Periodization, HIIT, Performance Optimization, Exercise Physiology, Sports Science.

1. INTRODUCTION

Endurance sports require sustained effort, demanding aerobic efficiency and muscular endurance. Training methodologies have evolved from high-volume, low-intensity models to structured approaches incorporating strength training and data analytics. This study examines endurance training progression, comparing past and present methods to enhance performance and injury prevention.

2. TRADITIONAL ENDURANCE TRAINING METHODS

2.1 High-Volume,Low-IntensityTraining (HVLIT)

Historically, endurance athletes relied on HVLIT, prioritizing aerobic conditioning.

- **Advantages**: Improves cardiovascular efficiency and endurance with lower injury risk.
- **Limitations**: Time-consuming, lacks race-specific intensity, may lead to overuse injuries.

2.2 Linear Periodization

Developed in the mid-20th century, linear periodization gradually increases intensity while decreasing volume, aiming for peak competition performance. However, it lacks adaptability for multi-race seasons, leading to modern, more flexible models.

3. MODERN TRAINING APPROACHES

3.1 High-Intensity Interval Training (HIIT)

HIIT improves VO2 max and endurance efficiency with shorter training durations but risks overtraining if overused.

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3.2 Non-Linear and Block Periodization

Modern training favors adaptable models that optimize performance for multiple competitions, allowing individualized adjustments based on recovery and progress.

3.3 Strength and Cross-Training

Strength training enhances biomechanics and injury resilience, while cross-training maintains cardiovascular fitness with reduced impact stress.

4. THE ROLE OF TECHNOLOGY IN ENDURANCE TRAINING

4.1 Wearable Technology and Data Analytics

Wearables provide real-time performance tracking, optimizing training load and recovery.

4.2 Nutrition and Recovery Strategies

Modern training integrates nutrition and recovery protocols, including nutrient periodization, hydration strategies, and sleep optimization.

5. DISCUSSION

Endurance training has evolved from rigid volume-based methods to data-driven, adaptable strategies. Key insights include:

- Combining HIIT with aerobic base training enhances endurance.
- Periodization must be tailored to individual responses.
- Strength and cross-training improve biomechanics and reduce injuries.
- Technology enhances training precision and recovery.

Future research should refine methodologies through physiological and genetic studies.

6. CONCLUSION

The shift from mileage-focused training to scientifically driven methods has optimized endurance performance. Integrating evidence-based strategies, technology, and periodization ensures long-term success for endurance athletes.

ACKNOWLEDGMENTS

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EFFECTS OF DIFFERENT RECOVERY TECHNIQUES ON ATHLETIC PERFORMANCE

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ABSTRACT

Recovery plays a crucial role in athletic performance, injury prevention, and long-term training adaptations. Among various recovery techniques, active recovery, cryotherapy, and massage therapy are widely utilized by athletes across different sports. This paper examines their physiological effects, impact on performance, advantages, and limitations. Active recovery enhances circulation and waste removal, cryotherapy reduces inflammation and muscle damage, and massage therapy promotes relaxation and muscle elasticity. While each method has unique benefits, their effectiveness varies depending on the type of sport, intensity of exertion, and individual needs. Understanding these differences can help athletes and coaches make informed decisions about optimizing recovery strategies.

1. INTRODUCTION

Athletes constantly push their physical limits, leading to muscle fatigue, soreness, and micro-damage. Recovery techniques are essential to facilitate muscle repair, prevent injuries, and maintain peak performance. Effective recovery can: Reduce delayed onset muscle soreness (DOMS) Enhance physiological adaptations Improve readiness for subsequent training sessions or competitions.

The three recovery methods analyzed in this paper—active recovery, cryotherapy, and massage therapy—are commonly used across different sports. Each method offers distinct physiological benefits, but their effectiveness varies depending on factors such as training intensity, exercise type, and individual athlete characteristics.

2. ACTIVE RECOVERY

2.1 Mechanism and Physiological Effects

Active recovery involves performing low-intensity exercises post-training or between competitions. Activities like light jogging, swimming, or cycling at a low intensity promote blood circulation, which helps remove metabolic waste products such as lactate and hydrogen ions that accumulate during intense exercise (Dupuy et al., 2018).

Key physiological effects include:

Increased oxygen delivery to fatigued muscles Faster clearance of metabolic byproducts Maintenance of joint mobility and muscle elasticity

2.2 Impact on Performance

Research indicates that active recovery can accelerate lactate removal and reduce muscle stiffness, allowing athletes to maintain higher performance levels in subsequent sessions (Vaile et

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al., 2008). It is particularly beneficial for endurance athletes, as it helps sustain cardiovascular efficiency and prevents venous pooling.

3.MECHANISM AND PHYSIOLOGICAL EFFECTS

3.1 Practical Applications

Should be performed at 30-50% of maximum effort Ideal for endurance athletes or those with frequent training sessions Best suited for recovery after high-intensity workouts or competitions

3.2 Cryotherapy

Cryotherapy involves exposing the body to cold temperatures to reduce inflammation and muscle soreness. Common forms include:

Ice baths (immersion in cold water, typically 10-15°C for 10-15 minutes) Cold packs applied locally to sore muscles Whole-body cryotherapy (exposure to subzero temperatures in cryo-chambers)

Cold exposure leads to vasoconstriction, which reduces inflammation, limits tissue damage, and decreases pain perception (Bleakley et al., 2012).

3.3 Impact on Performance

Cryotherapy is effective in reducing DOMS and muscle soreness post-exercise. However, some studies suggest that excessive cold exposure may blunt the natural inflammatory response needed for muscle adaptation (Peake et al., 2017). While beneficial in short-term recovery, it may not be ideal for athletes aiming for long-term muscle hypertrophy.

3.4 Practical Applications

Effective for strength athletes and post-competition recovery Best used immediately after intense exercise or injury Not recommended for athletes focusing on muscle hypertrophy

4. MASSAGE THERAPY

4.1 Mechanism and Physiological Effects

Massage therapy involves manual manipulation of soft tissues to reduce muscle tension, enhance circulation, and promote relaxation. It has been shown to:

Increase parasympathetic nervous system activation (stress reduction) Improve blood flow and lymphatic drainage Reduce neuromuscular tension and stiffness (Weerapong et al., 2005)

4.2 Impact on Performance

Massage does not directly improve performance but plays a crucial role in reducing muscle stiffness and promoting relaxation. It has been found to reduce subjective feelings of soreness, helping athletes recover mentally and physically (Poppendieck et al., 2016).

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4.3 Practical Applications

Best suited for recovery between training sessions Combines well with other recovery techniques Effective for reducing muscle tightness and stress-related tension.

5. CONCLUSION

Each recovery technique has unique benefits, and their effectiveness depends on the athlete's sport, training regimen, and recovery goals. Active recovery is ideal for endurance athletes needing quick muscle recovery. Cryotherapy effectively reduces inflammation and soreness but may hinder long-term muscle adaptation. Massage therapy aids in relaxation and flexibility but does not directly enhance performance.

A combination of these techniques may offer the best results for overall athletic recovery. Future research should focus on individualized recovery strategies, considering factors such as training load, genetic predisposition, and sport-specific demands.

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BIOMECHANICAL ANALYSIS IN SPORTS PERFORMANCE – REVIEWING HOW BIOMECHANICS INFLUENCES TECHNIQUE AND INJURY PREVENTION

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ABSTRACT

Biomechanics plays a crucial role in optimizing athletic performance and reducing injury risks. This review examines how biomechanical principles influence sports techniques and injury prevention strategies. Understanding the mechanical aspects of movement enhances efficiency, improves training methodologies, and reduces the likelihood of overuse injuries.

Key biomechanical factors such as force application, joint mechanics, and movement efficiency are explored alongside injury prevention strategies, including load management, movement screening, and corrective exercises.

1. INTRODUCTION

Sports performance is determined by multiple factors, including strength, endurance, coordination, and skill execution. Among these, biomechanics—the study of movement mechanics—plays a fundamental role in enhancing technique and preventing injuries. Biomechanics applies principles from physics and engineering to human movement, offering insights into optimal movement patterns, force application, and joint stability

Analyzing sports movements biomechanically allows coaches and athletes to identify inefficiencies and risk factors for injuries. Through tools such as motion capture technology, force plates, and electromyography (EMG), researchers and practitioners can refine techniques to maximize performance while minimizing injury.

2. BIOMECHANICS AND SPORTS TECHNIQUE

2.1 Optimal Technique Development

Biomechanical analysis helps in refining techniques across sports:

- **Running**: Studies suggest that reducing ground contact time and optimizing stride length enhance speed and efficiency
- **Throwing**: Pitchers in baseball benefit from hip-shoulder separation, reducing stress on the elbow
- **Jumping**: Basketball players improve vertical jump height through optimized force production and landing mechanics

By utilizing video analysis and wearable sensors, athletes can fine-tune their techniques to match biomechanical efficiency.

3. BIOMECHANICS IN INJURY PREVENTION

3.1 Identifying Injury Mechanisms

Understanding biomechanical risk factors helps in preventing acute and overuse injuries. Common injury mechanisms include:

- **Excessive joint loading**: High-impact forces in running can lead to stress fractures.

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- **Poor movement mechanics**: Incorrect landing techniques increase ACL injury risk
- **Muscle imbalances**: Weak glutes may lead to knee valgus, causing patellofemoral pain syndrome.

3.2 Case Study: ACL Injury Prevention

Anterior cruciate ligament (ACL) injuries are common in sports requiring cutting and pivoting movements. Research indicates that neuromuscular training reduces ACL injury rates by 50% in female athletes Biomechanical interventions, such as modifying landing mechanics and increasing hip-knee stability, play a vital role in injury prevention.

4. APPLICATION OF BIOMECHANICS IN TRAINING AND REHABILITATION

4.1 Rehabilitation and Return to Play

Biomechanics aids rehabilitation by tracking kinematic symmetry post-injury. Motion analysis ensures injured athletes regain optimal movement patterns before returning to competition.

- Post-ACL rehab: Evaluating limb symmetry index (LSI) in jump tests.
- Tendon injuries: Modifying loading patterns to avoid excessive strain.
- Rehabilitation programs incorporating biofeedback and real-time movement assessment improve recovery outcomes.

5. CONCLUSION

Biomechanics is essential in both enhancing sports performance and reducing injury risk. By analyzing kinetic and kinematic factors, athletes and coaches can refine techniques to improve efficiency and prevent injuries. The integration of motion analysis, movement screening, and strength training principles into sports programs ensures optimal athletic development.

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COMPARATIVE STUDY OF STRENTH TRAINING VS PLYOMETRIC TRAINING IN SPRINTERS

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ABSTRACT

This study examines the effectiveness of strength training versus plyometric training in improving sprint performance. Strength training focuses on maximal force development, while plyometric training enhances explosive power and neuromuscular efficiency. Thirty competitive sprinters participated, divided into two groups following an 8-week training protocol. Speed improvements were measured using 30-meter sprint times. The results indicate that plyometric training leads to greater speed enhancements, while strength training contributes more to acceleration phases. These findings suggest a combined approach may be optimal for sprint performance enhancement.

Keywords: Sprinting, Strength Training, Plyometrics, Speed Development, Athletic Performance, Neuromuscular Adaptation

1. INTRODUCTION

Sprint performance is influenced by multiple physiological and biomechanical factors, including strength, power, and neuromuscular coordination. Two widely used training methods strength training and plyometric training aim to improve speed, but their relative effectiveness remains a topic of discussion.

Strength training enhances force production, which is crucial for acceleration. Plyometric training focuses on rapid muscle contractions, improving stride rate and explosiveness. This study compares the effectiveness of these methods to determine which improves sprint speed more effectively.

2. Strength TRAINING

Strength training primarily increases maximal force output through resistance exercises like squats, deadlifts, and lunges. Greater force production contributes to improved sprint acceleration, as demonstrated in studies linking lower-body strength to sprinting success. However, excessive muscle hypertrophy may reduce stride frequency.

3. PLYOMETRIC TRAINING

Plyometric training involves explosive exercises such as depth jumps, bounding, and sprint drills, targeting fast-twitch muscle fibers. By enhancing the stretch-shortening cycle (SSC), plyometrics improve reactive strength and reduce ground contact time, key factors in sprint speed.

This study aims to analyze the comparative effectiveness of these training methods on sprint speed improvement.

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4. METHODOLOGY

Participants

Thirty male sprinters (mean age = 21.5 ± 2.3 years) from competitive collegiate track teams participated in this study. Inclusion criteria required a minimum of two years of sprinting experience. Participants were randomly assigned to:

1. Strength Training Group (STG) (n=15): Focused on resistance-based exercises.
2. Plyometric Training Group (PTG) (n=15): Performed explosive bodyweight and jump exercises.

Training Protocol

Each group followed an 8-week, three-session-per-week training plan, structured as follows:

- Strength Training Program (3 days/week)
- Squats (4×5 reps)
- Deadlifts (3×5 reps)
- Bulgarian Split Squats (3×8 reps)
- Weighted Sled Pushes (3×20m)
- Plyometric Training Program (3 days/week)
- Bounding Drills (3×30m)
- Depth Jumps (3×8 reps)
- Hurdle Hops (3×6 reps)
- Sprint-Resisted Band Work (3×20m)

Data Collection

Speed improvements were assessed using 30-meter sprint times recorded before and after the training period.

Statistical Analysis

Data were analyzed using paired t-tests and ANOVA to compare pre- and post-training sprint times between groups, with a significance level of $p < 0.05$.

5. RESULTS

Descriptive Statistics

Pre-Training 30m Sprint Time: STG: 4.26 ± 0.12s | PTG: 4.27 ± 0.11s

Post-Training 30m Sprint Time: STG: 4.15 ± 0.09s | PTG: 4.09 ± 0.08s

Comparative Analysis

The PTG showed a greater improvement in sprint times (-0.18s) compared to STG (-0.11s). ANOVA results indicated a significant difference ($p = 0.032$) favoring plyometric training for overall sprint speed.

6. DISCUSSION

Findings suggest that plyometric training enhances speed more effectively due to its impact on neuromuscular efficiency and stride mechanics. Strength training benefits acceleration phases but does not optimize stride frequency as effectively. A hybrid training model may provide the most comprehensive improvements.

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7. CONCLUSION

Plyometric training produced greater improvements in sprint performance than strength training. Coaches should consider incorporating both methods, emphasizing plyometrics for top-speed gains and strength training for acceleration development.

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THE ROLE OF SPORTS PSYCHOLOGY IN TEAM COHESION AND PERFORMANCE

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ABSTRACT

Sports psychology enhances team cohesion and performance by improving leadership, communication, motivation, and resilience. This study examines key psychological theories and interventions that foster trust and effective teamwork, leading to superior competitive outcomes.

Keywords: Sports Psychology, Team Cohesion, Mental Skills, Leadership, Performance

1. INTRODUCTION

Team sports demand more than physical prowess; psychological and social factors are crucial. Effective communication, motivation, and leadership underpin team cohesion, driving performance.

2. THEORETICAL FRAMEWORK

Tuckman's (1965) stages—forming, storming, norming, and performing—outline team development. Carron's (1982) distinction between task and social cohesion underscores the need for balanced focus on goal achievement and interpersonal relationships. Self-Determination Theory (Deci & Ryan, 1985) highlights the role of intrinsic motivation in fostering commitment and teamwork.

3. INFLUENTIAL PSYCHOLOGICAL FACTORS

Effective leadership builds trust, while open communication minimizes conflicts. Mental resilience and stress management techniques (e.g., visualization, mindfulness) enable athletes to perform under pressure. High collective efficacy—the shared belief in team success—also significantly boosts performance.

4. METHODOLOGY

Thirty university athletes were assessed using instruments like the Group Environment Questionnaire (GEQ) and Competitive State Anxiety Inventory-2 (CSAI-2) during a six-week intervention focused on goal setting, communication, and mental skills training. Statistical analysis showed strong correlations between these psychological factors and team performance.

5. RESULTS AND DISCUSSION

Data revealed a strong positive correlation ($r = 0.78$) between team cohesion and performance, with leadership effectiveness ($r = 0.71$) and reduced competitive anxiety ($r = -0.42$) being key contributors. These findings confirm that targeted psychological strategies enhance both teamwork and overall performance.

6. CONCLUSION

Integrating sports psychology into training regimens is essential for optimizing team cohesion and competitive success. Future research should tailor psychological interventions to specific sports to maximize outcomes.

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NUTRITIONAL STRATEGIES FOR ENHANCING ATHLETIC PERFORMANCE

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ABSTRACT

Nutrition plays a crucial role in optimizing athletic performance, recovery, and overall health. This paper explores key nutritional strategies for athletes, including macronutrient balance, hydration, meal timing, and supplementation. It also discusses individualized nutrition plans based on sport-specific demands and personal goals. By integrating evidence-based dietary practices, athletes can enhance endurance, strength, and recovery while minimizing the risk of injuries and fatigue.

1. INTRODUCTION

Athletic performance is influenced by several factors, including training, genetics, and nutrition. Proper nutrition supports energy production, muscle repair, immune function, and mental focus. This paper provides an in-depth review of nutritional strategies that optimize performance across different sports.

2. MACRONUTRIENT REQUIREMENTS

2.1 Carbohydrates

Primary energy source for high-intensity exercise.

Recommended intake: 5–10 g/kg body weight/day depending on training intensity.

Sources: Whole grains, fruits, vegetables, and sports drinks for rapid energy replenishment.

2.2 Proteins

Essential for muscle repair and growth.

Recommended intake: 1.2–2.0 g/kg body weight/day, varying by sport and training phase.

Sources: Lean meats, fish, eggs, dairy, legumes, and plant-based proteins.

2.3 Fats

Supports long-duration, low-intensity activities and overall health.

Recommended intake: 20–35% of total daily calories, with a focus on healthy fats.

Sources: Nuts, seeds, avocados, olive oil, and fatty fish.

3. HYDRATION strategies

- **Pre-Exercise**: Consume 500–600 ml of water or electrolyte-rich fluids 2–3 hours before activity.
- **During Exercise**: Drink 150–250 ml every 15–20 minutes for sessions longer than 60 minutes.

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- **Post-Exercise**: Rehydrate with 1.5 times the fluid lost (monitored via body weight changes).
- **Electrolytes**: Replace sodium, potassium, and magnesium lost in sweat.

4. MEAL TIMING AND NUTRIENT TIMING

Pre-Workout Nutrition:

Aim for a carbohydrate-rich meal 2–3 hours before exercise.

Moderate protein and low-fat intake to prevent sluggishness.

During Exercise Nutrition (for endurance sports):

Consume 30–60g of carbohydrates per hour (e.g., energy gels, sports drinks).

Post-Workout Nutrition:

Protein (20–40g) + Carbohydrates (1.0–1.2 g/kg body weight) within 30–60 minutes to enhance recovery.

5. SUPPLEMENTATION FOR ATHLETIC PERFORMANCE

5.1 Common Performance-Enhancing Supplements

Creatine Monohydrate: Improves strength, power, and recovery.

Caffeine: Enhances endurance and alertness (recommended dose: 3–6 mg/kg body weight).

Beta-Alanine: Reduces muscle fatigue, beneficial for high-intensity exercise.

Branched-Chain Amino Acids (BCAAs): May support muscle recovery, though whole protein sources are preferable.

5.2 Individualized Supplement Use

Supplements should be tailored based on specific needs, training goals, and potential deficiencies.

Consulting a sports nutritionist is recommended to ensure safety and efficacy.

6. SPORT-SPECIFIC NUTRITIONAL CONSIDERATIONS

Endurance Athletes (e.g., Marathon Runners, Cyclists):

High carbohydrate intake for glycogen storage.

Hydration and electrolyte balance are critical.

Strength Athletes (e.g., Weightlifters, Bodybuilders):

High protein intake for muscle synthesis.

Creatine supplementation can enhance performance.

Team Sport Athletes (e.g., Soccer, Basketball):

Balanced macronutrient intake for sustained energy and recovery.

Hydration strategies to prevent cramping and fatigue.

7. CONCLUSION

Optimized nutrition plays a vital role in enhancing athletic performance, recovery, and overall well-being. A well-balanced diet tailored to the athlete's specific needs focusing on macronutrient balance, hydration, meal timing, and appropriate supplementation can significantly improve endurance, strength, and mental focus. Sports nutrition should be individualized and evidence-based to maximize results while ensuring health and safety.

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HORIZONTAL DECELERATION TRAINING IN ACL INJURY PREVENTION – A COMPREHENSIVE REVIEW

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ABSTRACT

Horizontal deceleration is an important component of athletic performance, especially in sports that involve quick changes in direction and rapid braking. Moreover, having strong horizontal deceleration abilities is vital for reducing the possible injuries. This review outlines the biomechanical and neuromuscular requirements of Horizontal Decelerations (HD) highlighting its importance in lowering the risk of Anterior Cruciate Ligament (ACL) injuries.

The biomechanical concerns of horizontal deceleration include optimising braking force attenuation to reduce stress on soft tissues and joints, reducing whole-body mechanical loads, and managing braking ground reaction forces. The main risk factors for non-contact ACL injuries are improper deceleration mechanics, which include significant knee valgus, inadequate knee flexion angles, and inefficient load distribution. Furthermore, the neuromuscular system's eccentric strength and dynamic balance are essential for an athlete to perform safe deceleration mechanics, especially while cutting and breaking.

This paper summarises the recent research on training methods that improve injury resilience and horizontal deceleration ability. Neuromuscular drills, plyometric exercises, eccentric strength training, and task-specific training that mimics the deceleration demands of a sport are all effective strategies. The analysis also emphasises assessment tools that can be used to target training interventions and identify weaknesses in deceleration performance, such as the Change of Direction (COD) and Acceleration-Deceleration Ability (ADA) assessments.

Athletes can achieve better dynamic stability, enhance their braking effectiveness by prioritising HD training in their programs.

This review provides a fresh perspective and valuable recommendations for coaches, strength and conditioning specialists, and sports scientists aiming to optimise both athlete performance and safety.

KEYWORDS : Horizontal deceleration, Anterior Cruciate Ligament (ACL), Braking Force Attenuation, Ground Reaction Forces (GRF), Change Of Direction (COD), Acceleration-Deceleration Ability (ADA) .

1. INTRODUCTION

In most of the sports physical fitness, mental resilience, and strategic execution play crucial roles in achieving success; an athlete's ability to efficiently decelerate is just as crucial as their capacity to accelerate. Horizontal deceleration refers to the ability to reduce whole-body momentum in a controlled manner, ensuring that braking forces are optimally distributed to minimize stress on the musculoskeletal system (McBurnie et al., 2021). This ability plays a fundamental role in dynamic sports movements such as cutting, stopping, and changing direction efficiently, which are essential skills in sports like soccer, basketball, and football (Hewett et al.,

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2005). Deceleration largely relies on eccentric muscle contractions, especially in the lower body, making it a key factor in injury prevention and rehabilitation by reducing excessive joint stress and lowering the likelihood of non-contact injuries (Mclean et al., 2004)**.**

Injury prevention programs must integrate neuromuscular training, strength conditioning, and landing mechanics to mitigate ACL injury risks (Mandelbaum et al., 2005). However, traditional rehabilitation protocols often fail due to compensatory movement patterns, inadequate strength development (particularly eccentric strength), and poor movement skill acquisition (Dos'Santos et al., 2021). Deceleration actions, particularly horizontal deceleration, are of significant interest in Anterior Cruciate Ligament (ACL) injury prevention; a crucial stabilizer of the knee joint, is often compromised during high-intensity movements that require abrupt stops, rapid changes in direction, and pivoting (Larwa et al., 2021). Horizontal deceleration, when not properly executed, can exacerbate these risks by generating excessive external knee valgus moments, internal rotation moments, and improper knee flexion angles—mechanisms commonly associated with ACL injuries (Cochrane et al., 2007)**.** These dynamic movements, especially during horizontal deceleration, can place significant stress on the knee, leading to ACL damage. Beyond the immediate effects, ACL injuries can result in long-term consequences such as early-onset osteoarthritis, an increased risk of reinjury, and psychological distress (Lohmander et al., 2007)**;** (Filbay & Grindem, 2019). Therefore, focusing on proper horizontal deceleration mechanics is essential to reduce joint stress and improve outcomes, highlighting the need for targeted training strategies that address both strength and control during decelerative movements.

2. KEY FINDINGS

Biomechanical Analysis in Horizontal Deceleration

Biomechanical Demands of horizontal deceleration using the sub-categories:

(a) Braking ground reaction forces (GRF)

(b) whole body external mechanical forces

(c) braking force attenuation Harper et al., 2022)**.**

During a horizontal deceleration maneuver, a complex sequence of muscle activation and deactivation is required to achieve precise intra-limb and inter-limb coordination, optimizing the effectiveness of braking force application(Bishop et al., 2002). Maintaining a lower vertical and more posterior center of mass (COM) position relative to the lead leg braking foot is crucial for dynamic stabilization and facilitating the application of a more horizontally oriented braking force(Cesar & Sigward, 2016).The kinematic characteristics of deceleration are defined by the positioning of the limbs relative to the body's center of mass (COM). The primary objective of deceleration is to reduce momentum (mass × velocity) by applying maximum force within the shortest possible time, facilitating a complete stop or a change in direction (force × time = mass × velocity) (Hewit et al., 2011) .Effective braking postures help minimize anterior (center of mass) COM excursion, aligning with the impulse - momentum relationship and optimizing deceleration efficiency.(Cesar & Sigward, 2015)**.** Leg kinematics play a vital role in deceleration, serving as the body's primary mechanism for absorbing force. While rapid deceleration ideally takes place over a few strides, multiple shortened gait cycles help safely slow the body by managing high eccentric forces while minimizing joint stress. As a result, greater braking forces and longer ground contact times are typically observed during rapid deceleration (Andrews et al., 1977)**.**

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Neuromuscular Demands in Horizontal Deceleration

The Four major Neuro-Muscular Performance (NMP) determinants of deceleration were suggested as:

(1) Eccentric strength,
(2) Reactive strength,
(3) Power
(4) Dynamic balance

The quadriceps and gastrocnemius are the primary muscles involved in deceleration. However, unlike the concentric contractions used during acceleration, these muscles function eccentrically to absorb and distribute impact forces. The combination of a relatively extended leg at impact and the predominantly anterior-posterior forces acting on the body can place the leg in a potentially vulnerable position. However, the pre-activation of these muscle groups before ground contact aids in absorbing the significant eccentric forces experienced during landing, as represented by the equation: negative work = eccentric force × downward displacement of the center of mass (COM).(Andrews et al., 1977). Braking force control and Braking force attenuation are the two key components of horizontal deceleration ability align with the implications for Multi-Directional Speed (MDS) performance enhancement and injury-risk reduction. In brief, braking force control requires the athlete to manipulate their centre of mass (COM) posterior to the centre of pressure (COP) to ensure anterior foot placement and the required orientation of the braking force. Whereas braking force attenuation requires muscles and connective tissue structures to attenuate and distribute forces throughout the lower-limbs to help reduce soft-tissue damage and neuromuscular fatigue that can result from repeated intense horizontal decelerations (D. J. Harper et al., 2021).

3. HORIZONTAL DECELERATION ABILITY

Horizontal deceleration plays a vital role in performance across multi-directional sports but also places considerable physiological and biomechanical demands on athletes, increasing the risk of tissue damage and injury. Compared to horizontal acceleration and maximum-velocity sprinting, deceleration generates some of the highest peak ground reaction forces and loading rates, subjecting the musculoskeletal system to significant stress (D. Harper & Kiely, 2018).,(McBurnie et al., 2021)., (D. Harper et al., 2022). To assess an athlete's deceleration ability, standardized protocols such as the Acceleration-Deceleration Ability (ADA) test(D. Harper et al., 2020)., (D. J. Harper et al., 2021).and the Change of Direction (COD) test are commonly employed. The ADA test evaluates an athlete's capacity to decelerate following a sprint and can be performed in two ways: either by initiating deceleration at a specific point or by coming to a complete stop within a designated distance (Hader et al., 2015). (Hader et al., 2016). (Kaneko et al., 2019) (Eriksrud et al., 2022). Identifying the exact moment an athlete reaches peak velocity is essential, as it marks the start of the deceleration phase. This requires measurement devices capable of capturing instantaneous velocity throughout the test, with commonly used technologies including radar, laser systems, GPS, motorized resistance devices, LiDAR (Light Detection and Ranging) technology, and high-speed cameras.(D. Harper et al., 2020). Once the data is collected, an instantaneous velocity-time profile of the athlete can be generated. The deceleration phase starts immediately after the athlete reaches maximum velocity (Vmax) and ends at the lowest recorded velocity (V low). This phase can be further divided into early (DEC Early) and late (DEC Late) horizontal

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deceleration sub-phases, using the time point corresponding to 50% of maximum velocity (50% Vmax) as the dividing marker. In addition to instantaneous velocity-time and acceleration-deceleration data, practitioners also benefit from capturing kinematic data using high-speed video. This allows for a detailed analysis of joint kinematics and foot-to-foot spatial-temporal characteristics, such as ground contact time, step length, step frequency, touchdown distances, and deceleration per foot strike advancements in technology, including inertial measurement units and foot force/pressure-sensing insoles, now enable the assessment of foot-to-foot ground reaction forces generated during braking in horizontal deceleration. This data can provide valuable insights to inform deceleration training programs and return-to-sport protocols, while offering a deeper understanding of the mechanical demands associated with braking during horizontal deceleration (D. Harper et al., 2020).

4. ROLE OF HORIZONTAL DECELERATION IN ACL INJURIES

Anterior cruciate ligament (ACL) injuries are common in sports and often occur without direct contact with another player or object (Boden et al., 2000a). Non-contact ACL injuries frequently take place during landing or deceleration before a change of direction (Boden et al., 2000b). Anterior forces on the tibia, internal/external rotational torque, and valgus torque contribute to strain in the ACL in controlled in vitro and in vivo studies with low-magnitude quasi-static loads(Markolf et al., 1995). The anterior cruciate ligament (ACL) is a key stabilizing structure in the knee joint, preventing excessive anterior translation of the tibia and rotational instability. ACL injuries are common in high-impact sports such as football, soccer, basketball, and skiing, often occurring due to sudden deceleration, pivoting, or improper landing mechanics (Larwa et al., 2021). A key mechanism of non-contact ACL injury involves external knee valgus moment, internal rotation moment, and knee flexion angles, which are considered movement patterns that contribute to ACL injuries during change of direction (CoD) (Yu & Garrett, 2007). ACL injuries significantly affect an athlete’s performance, career longevity, and psychological well-being. The immediate consequences include severe pain, joint instability, and loss of mobility, which can prevent athletes from continuing their sport

Long-term effects include:

- **Prolonged Absence from Sport** (Grindem et al., 2016)
- **Increased Risk of Reinjury** (Paterno et al., 2010).
- **Psychological Impact** (Filbay et al., 2019).
- **Early-Onset Osteoarthritis** (Lohmander et al., 2007).

Training Interventions

During deceleration, reducing the body's velocity and momentum requires generating an impulse greater than the existing momentum. Enhancing the body's capacity to produce higher braking forces is therefore essential. This can be achieved by improving the eccentric strength of muscles through targeted training methods that emphasize eccentric loading and control, such as drop jumps, resisted towing, and vest decelerations (Andrews et al., 1977). Additionally, extending the duration over which braking forces are applied during landing—facilitated by technical cues—can further increase impulse, effectively reducing the athlete's velocity and momentum. (Andrews et al., 1977).

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When designing task-based progressions, it is crucial to first assess the level of loading a task imposes on the body and clearly understand the overall loading demands of each task. Loading can be categorized into:

- **Peak loading** (e.g., peak ground reaction forces)
- **Volume load** (e.g., load multiplied by repetitions)
- **Rate of loading** (e.g., the time frame over which the load is applied or experienced) Proper planning and preparation for all types of loading are essential, along with developing load tolerance for specific tasks. Load is managed through the neuromuscular system and passively absorbed by tendons, ligaments, and joints. A lack of strength reduces the neuromuscular system's ability to eccentrically absorb forces during high-load tasks, leading to increased reliance on passive structures such as tendons, ligaments, and joint complexes for force absorption (Hewett et al., 2010). It is important to monitor the athlete to ensure that the response to the exercise is appropriate, but also that they are progressing optimally and have the appropriate function. The quality of movement and level of stress is important. The authors propose monitoring:

1. The response to the exercise
2. Movement quality during the task
3. Strength
4. Muscle soreness (Hewett et al., 2010).

Training Protocols in Horizontal Deceleration and ACL Injury Prevention.

ACL injuries can have long-term consequences, including an increased risk of osteoarthritis and reduced athletic performance. Therefore, injury prevention programs focusing on neuromuscular training, strength conditioning, and landing mechanics are crucial in reducing ACL injury incidence (Mandelbaum et al., 2005)

Key training protocols include:

1. **Strength Training**(Harper et al., 2021).
2. **Neuromuscular Drills** (Harper et al., 2021).
3. **Plyometric/Jump Training** (Harper et al., 2021).

Current findings indicate that deceleration performance varies in its demands on knee and ankle strength across different sprint distances. Athletes who frequently decelerate over short distances should focus not only on strengthening their knee strength but also on prioritizing ankle strength (Chen et al., 2025).

5. GAPS AND LIMITATIONS

Despite the growing body of research on horizontal deceleration, several gaps and limitations remain. One primary limitation there is limited research on the long-term effects of deceleration training on injury prevention and athletic performance. Most studies focus on short-term interventions and lack follow-up data to assess whether improvements in deceleration mechanics translate into sustained benefits over time. Longitudinal studies that track athletes over multiple seasons would provide valuable insights into the effectiveness and durability of deceleration-focused training programs; simultaneously the influence of psychological and cognitive factors on deceleration performance. While physical conditioning plays a crucial role, decision-making speed, reaction time, and game awareness also affect an athlete's ability to execute controlled deceleration under dynamic conditions. More research is needed to integrate cognitive training into deceleration

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development programs to enhance real-world applicability. Lastly, external factors such as playing surfaces, environmental conditions, and footwear have not been extensively studied in relation to deceleration performance and injury risk. Understanding how these variables interact with biomechanical and neuromuscular factors can help optimize training and competition settings to minimize injury risks. Addressing these gaps will be crucial for advancing the field of sports science and improving athlete safety and performance.

6. FUTURE DIRECTIONS

Future research on horizontal deceleration should focus on developing individualized training programs by applying advancements in wearable technology and artificial intelligence-based motion analysis can provide real-time feedback, allowing for more precise monitoring and refinement of deceleration techniques. Exploring the role of cognitive and perceptual factors in deceleration performance like Reaction time, decision-making, and situational awareness significantly influence an athlete's ability to decelerate effectively under game-like conditions. Incorporating cognitive-motor training strategies enhance an athlete's responsiveness and control during high-speed movements. Also further research is needed on how different surfaces, footwear, and fatigue levels affect horizontal deceleration mechanics, help in optimize training conditions and reduce the risk of injury in various competitive settings. By addressing these areas, future studies can contribute to refining training methodologies and enhancing injury prevention strategies.

7. CONCLUSION

Horizontal deceleration is a crucial aspect of athletic performance, playing a significant role in movement efficiency, injury prevention, and overall athletic capability. Effective deceleration requires precise coordination of biomechanical and neuromuscular factors, including controlled braking forces, optimal limb positioning, and sufficient eccentric strength to absorb impact forces. This review has highlighted the importance of developing these attributes to enhance performance and minimize injury risks, particularly non-contact anterior cruciate ligament (ACL) injuries.

Athletes with superior horizontal deceleration skills demonstrate better dynamic stability, improved braking efficiency, and a reduced likelihood of sustaining lower limb injuries. Common risk factors, such as inadequate knee flexion angles, excessive knee valgus, and poor load distribution, can be mitigated through targeted training programs. These programs should focus on improving eccentric strength, refining neuromuscular control, and incorporating sport-specific deceleration drills to optimize movement mechanics.

The assessment of deceleration ability is critical for designing effective training strategies. Tests such as the Change of Direction (COD) test and the Acceleration-Deceleration Ability (ADA) test provide valuable insights into an athlete's braking efficiency. Additionally, advancements in sports technology, including high-speed video analysis, GPS tracking, and force-sensing devices, have significantly enhanced the ability to monitor and refine deceleration techniques. These tools help practitioners identify weaknesses and tailor interventions to improve overall athletic performance.

To minimize injury risks, training programs should integrate neuromuscular training, eccentric strength development, and progressive deceleration drills. Emphasizing controlled stopping

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techniques and proper joint alignment can reduce the strain on ligaments and joints, enhancing an athlete's resilience to high-impact forces during rapid movement changes.

Looking ahead, future research should explore advanced training methodologies and their long-term impact on both performance enhancement and injury prevention. Investigating the effects of fatigue, biomechanics across different sports, and individualized training adaptations will provide deeper insights into optimizing deceleration ability. Additionally, incorporating real-time feedback and wearable technology could further refine training approaches and injury prevention strategies.

A structured approach to horizontal deceleration training not only benefits individual athletes but also contributes to the broader landscape of sports performance and safety. By prioritizing effective deceleration mechanics, coaches, sports scientists, and strength and conditioning professionals can help athletes reach peak performance levels while significantly reducing the risk of injuries.

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STRENGTH AND POWER DEVELOPMENT IN COMBAT SPORT - BOXING AND TAEKWONDO

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ABSTRACT

Strength and power are the major determinants of success in combat sports and influence directly the force of striking, control of grappling, and overall physical performance. This review explores different strength and power training methods, their physiological adaptations, and their impact on combat athlete performance. Methods of strength training such as maximal strength training, explosive power training, and endurance-based resistance training are vital for maximizing force production, neuromuscular efficiency, and preventing injury. Periodization models—linear, undulating, and block periodization—maximize strength and power development and manage fatigue and optimal performance at competition. Core training techniques, such as Olympic lifting, plyometric training, and contrast training, are employed to develop explosive power, optimize movement economy, and improve reactive strength. This review addresses the neuromuscular and metabolic changes that occur following strength and power training, such as enhanced motor unit recruitment, muscle hypertrophy, elevated rate of force development, and optimized anaerobic energy systems.Different combat sports require specific power and strength adaptations, with boxers requiring upper-body explosiveness, while wrestlers and mixed martial artists require full-body strength and stamina. This review calls for systematic training regimens, injury prevention strategies, and recovery approaches through nutrition and mobility training. Despite adequate evidence to support these strategies, future research must attend to sport-specific periodization, personalized training programs, and integration of strength and power training with technical and tactical skill acquisition. Advances in these areas will maximize athletic performance and reduce the risk of injury for combat sport athletes.

Keywords: Strength training, Power training, Combat sports, Force production, Periodization, Explosive power, Muscle hypertrophy, Rate of force development, Anaerobic energy systems, Sport-specific adaptations, Boxers, Training regimens.

1. INTRODUCTION

Definition of Strength and Power in Combat Sports

Strength and power are two fundamental physical attributes essential for success in combat sports. Strength is the ability to generate force against resistance, often measured through maximal lifts or isometric tests (Suchomel et al., 2016). Power, on the other hand, is the ability to generate force rapidly, crucial for explosive movements such as striking, takedowns, and defensive manoeuvre's (Newton & Kraemer, 1994). In combat sports, where athletes must generate high force outputs in a short duration, the interplay of strength and power determines performance effectiveness.

Importance of Strength and Power Development

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Strength and power contribute significantly to combat sports performance by enhancing an athlete's ability to deliver forceful strikes, execute explosive takedowns, and resist opponent force (Turner et al., 2019). Increased muscular strength allows athletes to improve movement efficiency, reduce injury risks, and sustain high-intensity actions throughout a match (Chaabene et al., 2018). Furthermore, power development enables quick execution of techniques, such as delivering high-velocity punches or rapid grappling movements. Given the physically demanding nature of combat sports, structured strength and power training is necessary to optimize performance and prevent fatigue-related declines during competition.

2. IMPORTANCE OF STRENGTH AND POWER FOR DIFFERENT COMBAT DISCIPLINES

Different combat sports require varying levels of strength and power, tailored to their specific demands:

- **Boxing**: Generating strength and power in boxing requires a combination of strength training, explosive exercises, and sport-specific drills (Loturco et al., 2018). Strength exercises like squats, deadlifts, and bench presses improve force production (Turner et al., 2019). Explosive power is developed through Olympic lifts, plyometrics, and sprints (Newton & Kraemer, 1994). Contrast training (e.g., squats + box jumps) enhances neuromuscular efficiency (Suchomel et al., 2016). Sport-specific drills like heavy bag work and resistance shadowboxing optimize fight performance (Kris Beattie & Alan D Ruddock). Conditioning with sprints and endurance training maintains power output, while recovery strategies prevent fatigue and injuries (Chaabene et al., 2018).
- **Taekwondo**: Requires high levels of lower-body power for dynamic kicking techniques and agility to evade attacks (He & Wan, 2022). Understanding these discipline-specific requirements ensures that strength and power training programs are appropriately tailored to maximize performance in each sport. (Bioa He, Yuwen Wan)

3. PHYSIOLOGICAL BASIS OF STRENGTH AND POWER

Strength and power are fundamental components of athletic performance, particularly in combat sports. Understanding the physiological mechanisms underlying these attributes is essential for developing effective training programs.

4. NEUROMUSCULAR ADAPTATIONS

The initial improvements in strength from resistance training are primarily due to neural adaptations. These include enhanced motor unit recruitment, increased firing frequency, and improved synchronization of motor units, leading to more efficient force production. Such neural adaptations precede significant muscle hypertrophy and are crucial for early strength gains (Buchtal, F. H.& Schmalbruch 1980).

5. MUSCLE HYPERTROPHY

Muscle hypertrophy or muscle building involves a hypertrophy or increase in size of skeletal muscle through a growth in size of its component cells. Two factors contribute to hypertrophy: sarcoplasmic hypertrophy, which focuses more on increased muscle glycogen storage; and myofibrillar hypertrophy, which focuses more on increased myofibril size (Baechle TR et al.,2008).

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Rate of Force Development (RFD)

This study investigates the optimal load for generating the highest values of force, power, and RFD in the upper limbs of MMA (Mixed Martial Arts) fighters, considering their training experience (Alan Langer et al., 2022)

Muscle Architecture and its Impact on Strength and Power

This study examines how resistance training leads to increases in muscle cross-sectional area, volume, and pennation angle, contributing to enhanced force production (P. Aagaard et al., 2001).

Understanding Strength and Power in Combat Sports

This study examines the correlation between maximal strength and power performance, highlighting the importance of strength training in enhancing explosive techniques in taekwondo. (Kazemi et al., 2014)

6. STRENGTH AND POWER IN BOXING:

1. **Lower-Body Strength**: The force generated in a punch originates from the ground up. Strong legs and hips provide the necessary stability and power transfer through the kinetic chain (Rao et al., 2018). Study found that core resistance exercise effectively promotes balance in martial arts athletes, leading to significant improvements in performance. (Shu, Li. 2023).
2. **Upper-Body Strength**: While arm strength alone does not determine punching power, strong shoulders, triceps, and pectoral muscles contribute to punch acceleration and endurance(Rao et al., 2018).
3. **Reactive Power**: Boxers must react quickly to openings and execute counterattacks efficiently. Plyometric and explosive training improve reaction speed and movement agility. (Deng N et al., 2023)

Strength and Power Training for Boxing:

- **Plyometrics**: Medicine ball throws, clap push-ups, and bounding drills enhance explosive power. (Ebben & Blackard, D.O. 1997).
- **Speed and Agility Drills**: Ladder drills, cone drills, and resistance band sprints improve footwork and movement efficiency(He & Wan, 2022).

Strength and Power in Taekwondo

Taekwondo is a striking martial art that relies heavily on dynamic kicking techniques, speed, and flexibility(Rao et al., 2018). Unlike boxing, where hand strikes are dominant, taekwondo athletes primarily use their legs to score points and control distance(Rao et al., 2018).

Best Practices for Strength and Power Development in Boxing and Taekwondo

1. **Periodization**: Structuring training cycles to balance strength, power, endurance (Tyler D. Williams et al., 2017)
2. **Sport-Specific Drills**: Integrating strength work with combat drills maintains functional applicability. **(**Aristide Guerriero et al. 2018)

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3. **Recovery and Nutrition**: Adequate rest, protein intake, and hydration optimize muscle adaptation and prevent overtraining. (Shona L. Halson et al. 2002)
4. **Individualized Training Programs**: Customizing strength programs based on an athlete's weaknesses maximises performance gains. (Carlos Balsalobre-Fernández & Lorena Torres-Ronda 2021)
5. **Progressive Overload**: Gradually increasing training intensity ensures consistent development without excessive fatigue. (Jim Brewster 2015)

How Training Affects Muscle Architecture

Training can induce several changes in muscle architecture, leading to enhanced strength and power:

- **Increased pennation angle:** Resistance training can increase pennation angles, allowing for greater force production. (Kawakami et al., 1993)
- **Fiber type transitions:** Training can induce transitions between muscle fiber types, shifting the balance towards fiber types with greater force-producing capacity. (Plotkin DL et al., 2021)

Optimizing Muscle Architecture for Strength and Power

To maximize strength and power gains, training programs should consider the principles of muscle architecture:

- **Specificity**: Exercises should target specific muscles and movements relevant to the desired activity or sport. (B. K. Pedersen et al., 2000)
- **Progressive Overload**: Gradually increasing the training load over time is essential for inducing adaptations in muscle architecture. (M. H. Stone et al.,1981)
- **Variety**: Incorporating a variety of exercises and training methods can stimulate different muscle fibers and promote overall muscle development. (W. J. Kraemer et al., 2007)

Strength Training for Combat Athletes

Strength training for combat athletes is a systematic approach to developing muscular strength, power, and endurance through resistance exercises. It is tailored to enhance performance in combat sports such as boxing, wrestling, MMA, and jiu-jitsu by improving force production, injury prevention, and overall athleticism (Bompa & Carrera, 2015). This includes training methods like maximal strength development, explosive power exercises, and muscular endurance work to ensure athletes can sustain high-intensity efforts throughout a fight (Kraemer & Häkkinen, 2002)

Types of Strength and Their Role in Combat Sports

Strength is a fundamental component of combat sports, influencing an athlete's ability to generate force, sustain effort, and resist fatigue. Different types of strength contribute uniquely to performance, each playing a critical role in striking, grappling, and overall endurance.

1. Maximal Strength

The highest amount of force an athlete can exert in a single maximal effort (Bumpa & Carrera,2015).

Role in Combat Sports:

- Enhances force production for stronger punches, kicks, and takedowns.
- Provides a foundation for other strength qualities such as power and endurance.
- Improves joint stability and injury resistance.

Example Exercises: Squats, deadlifts, bench press, weighted pull-ups.

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2. Explosive Strength (Power)

The ability to generate force rapidly, crucial for quick and powerful movements (Kraemer &Häkkinen,2002).

Role in Combat Sports:

- Essential for knockout punches, fast kicks, and explosive takedowns.
- Improves reaction time and agility, crucial for counterattacks.
- Increases speed in grappling transitions and striking combinations.

Example Exercises: Olympic lifts (cleans, snatches), plyometrics (box jumps, medicine ball slams), kettlebell swings.

3. Strength Endurance

The ability to sustain force output over an extended period without fatigue (Zatsiorsky & Kraemer,2006).

Role in Combat Sports:

- Helps maintain striking power and grappling strength throughout long fights.
- Delays muscular fatigue, reducing the risk of technical errors.
- Supports high-intensity training and competition demands.

Example Exercises: Circuit training, high-rep bodyweight exercises, resistance band work.

4. Reactive Strength

The ability to rapidly transition from eccentric (lengthening) to concentric (shortening) muscle actions (Verkhoshansky&Siff,2009).

Role in Combat Sports:

- Improves footwork and evasive maneuvers.
- Enhances speed and efficiency in striking combinations.
- Aids in rapid sprawl and counterattacks.

Example Exercises: Depth jumps, rapid-change-of-direction drills, plyometric push-ups.

5. Isometric Strength

The ability to exert force without changing muscle length (Schoenfeld,2016).

Role in Combat Sports:

- Essential for holding dominant grappling positions and clinches.
- Improves grip strength for submissions and control.
- Increases resilience against opponent resistance.

Example Exercises: Wall sits, planks, isometric holds in push-ups and pull-ups.

Overview of Psychological Demands and Sport-Specific Requirements

Beyond physical attributes, combat sports impose significant psychological demands, requiring mental resilience, tactical awareness, and stress management (Slimani et al., 2017). Athletes must maintain focus under high-pressure situations, quickly adapt strategies mid-fight, and cope with the emotional toll of competition. Moreover, sport-specific requirements vary across disciplines; for instance, boxers rely heavily on upper-body power and footwork, while wrestlers and judokas require full-body strength and grip endurance. Understanding these demands ensures that training programs are tailored to the specific needs of each combat sport.

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Purpose of the Review

The purpose of this article review is to examine the role of strength and power development in combat sports by evaluating current literature on training methodologies, physiological adaptations, and their impact on performance. By analyzing recent research findings, this review aims to provide insights into effective training strategies that optimize athletic performance while minimizing injury risks. Additionally, it will explore the integration of sport-specific strength and power exercises tailored to different combat disciplines.

Results and Discussion

This systematic review consolidates on strength and power development in combat sports, specifically boxing and taekwondo. The findings highlight the critical role of these physical attributes in enhancing performance, preventing injuries, and optimizing training strategies.

7. KEY RESULTS AND DISCUSSION POINTS

- **Importance of Strength and Power:**

The review confirms that strength and power are fundamental determinants of success in combat sports. Strength provides the foundation for force production, while power enables the rapid execution of techniques.

This is supported by studies showing a direct correlation between strength and power metrics (e.g., maximal lifts, RFD) and performance outcomes (e.g., punching force, kicking velocity).

- **Sport-Specific Adaptations:**

The review emphasizes the need for sport-specific training programs. Boxers require upper-body explosiveness, while taekwondo athletes need lower-body power and agility.

This is reflected in the training recommendations, which include exercises tailored to the specific demands of each sport (e.g., heavy bag work for boxers, plyometric kicking drills for taekwondo athletes).

- **Physiological Adaptations:**

Strength and power training elicit various physiological adaptations, including neuromuscular enhancements (e.g., increased motor unit recruitment, RFD), muscle hypertrophy, and optimized anaerobic energy systems.

These adaptations contribute to improved force production, movement efficiency, and fatigue resistance. The literature review shows that the RFD is a crucial factor in the sport of combat.

- **Training Methodologies:**

The review highlights the effectiveness of various training methods, including maximal strength training, explosive power training (e.g., plyometrics, Olympic lifts), and endurance-based resistance training.

Periodization models (linear, undulating, block) are essential for optimizing training adaptations and managing fatigue.

- **Core Training and Explosive Power:**

Olympic lifting, plyometric training, and contrast training are effective methods for developing explosive power, optimizing movement economy, and improving reactive strength.

These training methods are crucial for the rapid and powerful movements required in combat sports.

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- **Recovery and Injury Prevention:**

The review underscores the importance of recovery strategies (e.g., nutrition, sleep, mobility training) and injury prevention measures.

Adequate recovery is essential for optimizing training adaptations and preventing overtraining. Injury prevention strategies, such as proper warm-ups and joint stability exercises, are crucial for long-term athletic performance.

- **Neuromuscular and Metabolic Changes:**

The review clearly outlines the importance of the neuromuscular and metabolic changes that occur due to consistent training.

The elevation of the rate of force development, and optimized anaerobic energy systems are very important.

- **Psychological Demands:**

It is important to remember that combat sports also require great psychological fortitude.

Mental resilience, tactical awareness, and stress management are all part of the athlete's training.

- **Future Directions:**

The review identifies several areas for future research, including optimizing sport-specific periodization, personalizing training programs, and integrating strength and power training with technical and tactical skill acquisition.

Further research is also needed to explore the effectiveness of various recovery strategies and long-term injury prevention techniques.

In summary, this review provides a comprehensive overview of the current state of knowledge regarding strength and power development in combat sports. It emphasizes the importance of sport-specific training programs, physiological adaptations, and recovery strategies. The findings underscore the need for evidence-based training approaches to optimize athletic performance and minimize injury risks. Future research should focus on refining training methodologies and exploring new strategies to enhance combat sport performance.

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BIOMECHANICAL ASPECTS OF SHIN SPLINTS – A SYSTEMATIC ANALYSIS

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ABSTRACT

Medial Tibial Stress Syndrome (MTSS) or Shin Splints, is a prevalent overuse syndrome in sprinters that is characterized by the Exercise-induced pain along the Distal Posteromedial aspects of Tibia. The systematic review is intended to discuss the Biomechanical factors contributing of MTSS development in sprinters. Based on a synthesis of evidence of 60 peer-reviewed articles since the year 2000, It explores the underlying mechanisms and associated risk factors of the MTSS condition.

Important findings identify repetitive tibial loading during sprinting as initiating microtrauma, which is perpetuated by Biomechanical inefficiencies like excessive Tibial bending moments, Ankle Eversion (frontal plane motion), Hip Abductor weakness, and Dynamic foot pronation (tri-plane motion). Muscle imbalances especially between the Soleus, Peroneus, Flexor Hallucis Longus, Flexor Digitorum Longus, Tibialis Anterior & Posterior and compromised shock absorption due to muscle fatigue or stiffness are also implicated in MTSS. Fascial traction on the tibial periosteum mainly the soleus, tibialis posterior, and tibialis anterior muscles along with bone stress reactions, are also acknowledged as interlinked etiological pathways.

Kinematic and Kinetic analysis indicated that MTSS runners have higher vertical Ground Reaction Forces (vGRF), altered Centre of Pressure (CoP), and Anterior-Posterior shear force asymmetry. Moreover, pelvic stability deficits and limited Ankle Dorsiflexion increase Tibial strain. Interestingly, Sex-specific results show increased MTSS rates in female sprinters, which can be explained by anatomical and hormonal factors.

The multifactorial, complex nature of MTSS underscores the need for rigorous Biomechanical assessment to guide proper treatment and training strategies in sprinters who have shin splints.

Keywords: Medial tibial stress syndrome (MTSS), Tibial Stress, Shin Splints, Biomechanics, Ground Reaction Force (GRF), Sprinters, Overuse Injury, Kinetics & Kinematics Analysis, Stress Fracture.

1. INTRODUCTION

The shin, primarily comprising the tibia and surrounding musculature, plays a crucial role in weight-bearing and movement. Athletes frequently experience shin-related issues, such as medial tibial stress syndrome (MTSS) and stress fractures, due to repetitive loading. Understanding the biomechanical factors contributing to these injuries is essential for optimizing performance and injury prevention.

Shin splints or Medial Tibial Stress Syndrome (MTSS) refer to pain and discomfort in the lower leg, often caused by repetitive running on hard surfaces or overuse of the muscles involved in foot movement. In 1968, the American Medical Association (AMA) consulted physicians, trainers, and physical educators to establish a standard definition of athletic injuries. They described

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shin splints as inflammation of the muscles and tendons in the shin area, emphasizing that the term should only be used for this type of irritation and not for more serious conditions like stress fractures or circulation issues. (Bates P. 1895)

Shin splints or medial tibial stress syndrome (MTSS), are a common injury among sprinters and runners, often caused by biomechanical anomalies and training-related factors. Understanding the biomechanics behind shin splints is essential for injury prevention and rehabilitation. Characterized by pain along the tibia especially Posterior-medial aspects of shin, shin splints result from repetitive stress on the lower leg and are often exacerbated by biomechanical inefficiencies, training errors, and hip factors such as footwear and surface conditions (Newman. P et al., 2017). The high-impact nature of sprinting places significant stress on the tibia, leading to microtrauma and inflammation, which can progress to stress fractures if not addressed adequately (Moen M.J et al., 2009). Various stress reactions of the tibia and surrounding musculature occur when the body is unable to heal properly in response to repetitive muscle contractions and tibial strain (Galbraith & Lavallee, 2009)

MTSS has been described as an overuse injury or repetitive-stress injury of the shin area, various stress reactions of the tibia and surrounding musculature occur when the body is unable to heal properly in response to repetitive muscle contractions and tibial strain (Galbraith & Lavallee, 2009). In individuals with MTSS, while standing they have higher (more everted) while walking while there is high pressure under the medial metatarsal areas and the COP is more medial. Rearfoot malalignment in individuals with mild to moderate MTSS can be detected on walking, even if the alignment on standing is normal. (Kazuo Kinoshita et al., 2019).

Although MTSS pathology lacks solid evidence, many risk factors contribute to its development (Winters M, 2020). For example, a body mass index (BMI) above 30 kg/m^2, ankle muscle imbalances, and weak/tight triceps surae muscles (medial & lateral gastrocnemius and soleus) (Bhusari & Deshmukh, 2023), may increase MTSS. Mattock J et al., 2021 suggested that deficiencies in ankle plantar flexor endurance, a greater isokinetic concentric eversion strength, and altered neuromuscular recruitment strategies are also linked to MTSS.

The development of MTSS is closely associated with running kinematics. Hence, excessive foot pronation, the navicular drops, internal rotation of the hip, and knee flexion predispose runners to MTSS during the stance phase (Menéndez et al., 2020; Reinking M.F et al. 2017). Foot pronation is a three-dimensional movement, which makes direct measurement challenging. (Okunuki et al., 2019; Mauricio Barramuño-Medina et al., 2021). Foot pronation is a complex, three-dimensional movement that occurs at the subtalar joint of the foot. It's a normal and necessary motion for shock absorption and adapting to different surfaces during walking and running especially sprinting.

1. **Eversion (Frontal Plane):** This is the most recognized component of pronation. Eversion refers to the outward tilting of the heel (calcaneus). The bottom of the foot rotates away from the midline of the body.
2. **Abduction (Transverse Plane):** Abduction is the movement of the forefoot away from the midline of the body. Imagine the front of your foot swinging outwards.
3. **Dorsiflexion (Sagittal Plane):** Dorsiflexion involves lifting the foot upwards towards the shin.

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Sprint biomechanics differ significantly from those of endurance running, involving rapid acceleration, deceleration, and greater ground reaction forces that elevate the risk of shin splints (Pohl M B et al., 2008). Unlike distance runners, sprinters generate higher impact forces within a shorter time frame, which can increase the tibial loading rate and contribute to injury susceptibility (Zifchock R.A et al., 2006 & 2008).

2. PURPOSE OF REVIEW

The purpose of this systematic analysis is to comprehensively analyse the impact of shin splints, specifically medial tibial stress syndrome (MTSS), in sprinters by evaluating its prevalence, underlying biomechanical and physiological risk factors, and potential prevention and rehabilitation strategies. This review aims to explore:

1. **Epidemiology and Prevalence** – Identifying the frequency of MTSS in sprinters, examining trends across different levels of athletic performance, and understanding how various demographic factors (e.g., age, gender, and training volume) contribute to its occurrence.
2. **Biomechanical and Physiological Contributors** – Investigating how factors such as foot pronation, tibial loading, lower limb alignment, and muscle imbalances influence the development of shin splints. Special attention is given to running kinematics, including stride mechanics, ground reaction forces, and their role in stress distribution across the tibia.
3. **Training-Related Factors** – Assessing how sprinting intensity, volume, recovery periods, footwear, and surface conditions affect the likelihood of developing MTSS. This analysis also aims to highlight the role of overtraining, inadequate rest, and improper conditioning in increasing stress on the tibia.

By compiling existing literature on Shin splints or MTSS in sprinters, this analysis intends to bridge gaps in current research, offer evidence-based recommendations for coaches, trainers, and medical professionals & contribute to developing more effective assessment parameters, techniques and injury mitigation strategies in sprinting athletes.

3. METHODOLOGY

This systematic analysis was conducted using databases such as PubMed (NLM), Embase (Elsevier), CINAHL Complete (EBSCO), Web of Science (Clarivate), Science direct, Springer nature and Wiley online library. Keywords included "shin biomechanics," "tibia loading in athletes," "MTSS biomechanics," and "stress fractures in runners." Inclusion criteria were studies published in peer-reviewed journals from 2000 to 2024 focusing on biomechanics and injury mechanisms in athletes.

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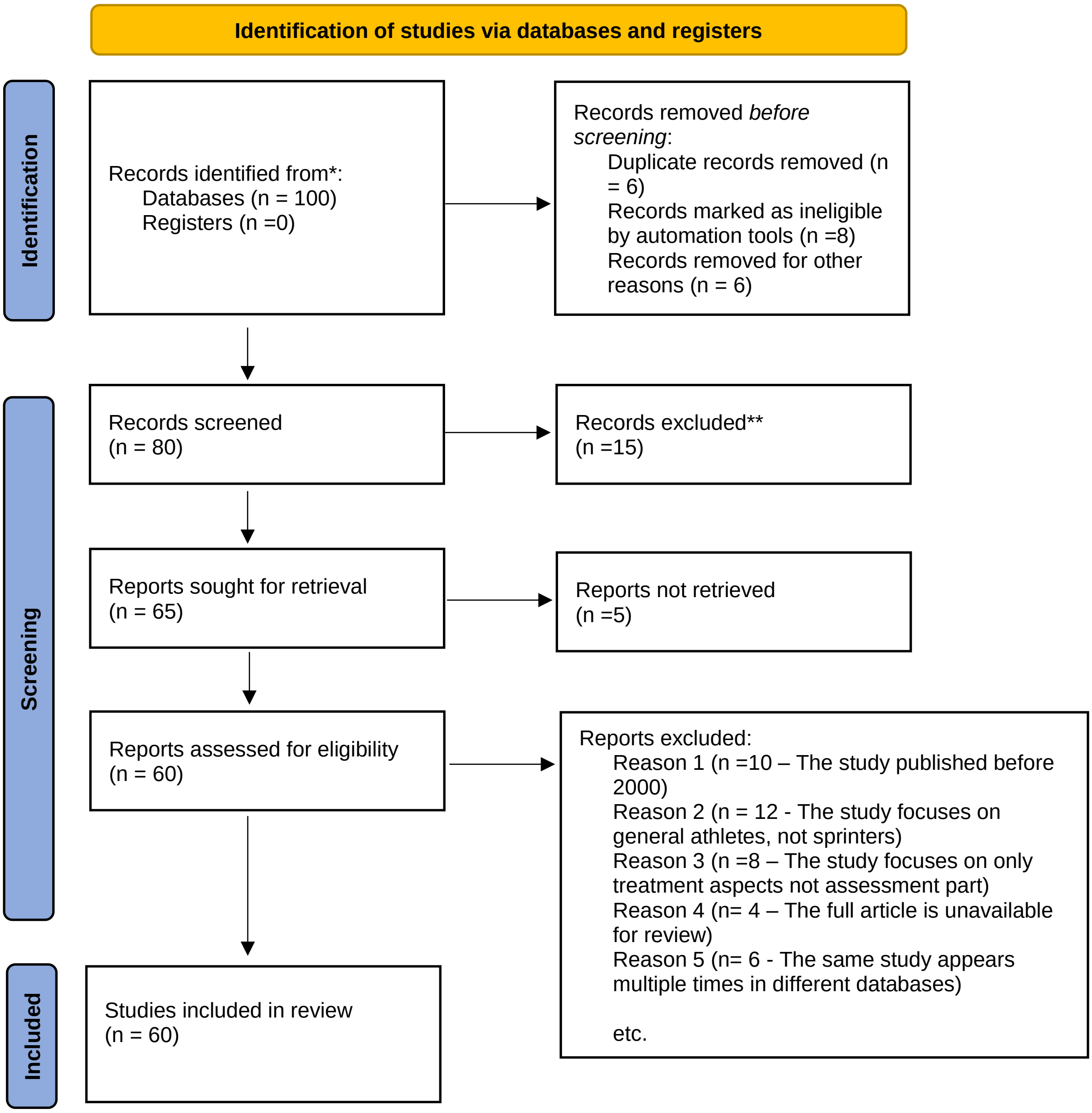
Table – 1

Prisma Flowchart



4. EPIDEMIOLOGY

Shin splints account for approximately 10–20% of all running-related injuries, with a higher prevalence in athletes undergoing intensive training or sudden increases in workload (Yates & White, 2004).

Studies report an incidence of lower extremity running injuries ranged from 19.4% to 79.3%. The predominant site of these injuries was the knee and ankle. There was strong evidence that a long training distance per week in male runners and a history of previous injuries were risk factors for injuries, and that an increase in training distance per week was a protective factor for injuries (van Gent et al., 2007; Willwacher et al., 2022). These results indicate that 70% of exercise-related injuries from overuse, with runners at increased risk of them (Mattock J et al., 2021).

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The knee, ankle, and lower leg accounted for the highest proportion of injury incidence, whereas the knee, lower leg, and foot/toes had the highest proportion of injury prevalence. Achilles tendinopathy (10.3%), medial tibial stress syndrome (9.4%), patellofemoral pain syndrome (6.3%), plantar fasciitis (6.1%), and ankle sprains (5.8%) accounted for the highest proportion of injury incidence prevalence. The ankle (34.5%), knee (28.1%), and lower leg (12.9%) were the 3 most frequently injured sites. In this context, medial tibial stress syndrome (MTSS), or shin splints, is a one of the common lower limb injuries in runners (Kakouris et al., 2021).

It is characterized by pain in the medial side of the distal tibia. MTSS is also described as exercise-induced discomfort along the posteromedial tibial border, identified by palpation over a length of ≥5 cm (Deshmukh & Phansopkar, 2022; Winters M, 2020). This syndrome is usually presented in runners who overtrain or rapidly increase training load magnitude (i.e., volume, intensity, temporality and combination) (Deshmukh & Phansopkar, 2022).

Epidemiological studies have reported varying incidence rates of MTSS among different athletic populations. For instance, MTSS affects approximately 5% to 35% of runners, with higher rates observed in military personnel and novice runners.

(Colli et al. 2024; Yates and White, 2004; Newman P et al., 2012; Moen M.J et al., 2009) concluded that most patients suffering from MTSS report pain on the posteromedial tibial border, usually in the middle or distal thirds of the bone

5. RISK FACTORS

Shin splints, or Medial Tibial Stress Syndrome (MTSS), are influenced by multi-factorial risk factors, including biomechanical abnormalities, anatomical variations, training errors, and inadequate recovery. Overpronation, excessive tibial strain, and muscle imbalances contribute to increased injury susceptibility. Additionally, improper footwear, high-impact training surfaces, and sudden workload changes further elevate the risk of MTSS in athletes.

The causes of overuse injuries can generally be grouped into three main categories: Anatomical structural issues, Training mistakes and the relationship between the way shoes interact with the running surface. Structural issues refer to things like misalignments or imbalances in the body that make certain areas more prone to stress. Training mistakes include things like suddenly increasing intensity, improper technique, or lack of recovery time. Lastly, the combination of footwear and running surface plays a big role—wearing the wrong shoes or running on hard, uneven, or overly soft surfaces can increase the risk of injury over a period (James S L et al., 1978).

Gender Differences

A study evaluating the incidence of MTSS in a group of high school cross country runners showed that females had 5.46 times more MTSS than males (19.1% in females and 3.5% in males, P.003) and found that found that tibial stress syndrome accounted for 10.7% of the injuries in men and 16.8% in women (Bennett JE et al., 2001) (Reinking M.F et al. (2017)

In a study focusing on Physical Education, the incidence of MTSS was found to be 20%, with a higher prevalence in females compared to males. (Reinking M.F et al., 2017; Alessa et al., 2024).

Biomechanical Considerations

Biomechanical abnormalities, including overpronation and increased tibial internal rotation, are strongly associated with MTSS. Overpronation leads to excessive medial stress on the tibia,

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while internal rotation further exacerbates bone strain, making the tibia more susceptible to microtrauma. Additionally, muscle imbalances, particularly weakness in the tibialis anterior and soleus, can contribute to inefficient shock absorption and increased loading on the tibia bone (Willems T.M et al., 2006).

The biomechanics of sprinting differ markedly from those of long-distance running due to the need for explosive power and rapid propulsion. Sprinters generate higher vertical and horizontal forces, increasing the mechanical demands on the lower limb (Mann & Sprague, 1980). The ground reaction forces experienced during sprinting can exceed three to five times body weight, placing substantial strain on the tibia and surrounding musculature (Bezodis I.N et al., 2008).

In sprinting, factors such as poor running mechanics, excessive foot pronation, muscle fatigue, and improper footwear have been identified as contributors to MTSS. Studies indicate that excessive tibial strain due to repeated impact loading is a primary cause of shin splints, particularly when training regimens lack adequate recovery periods (Beck, 1998).

Stride length, cadence, and foot strike patterns also play a crucial role in injury risk. Sprinters predominantly utilize a forefoot or midfoot strike to maximize propulsion and move forward, but this pattern can elevate stress on the tibial cortex, particularly when combined with inadequate strength and improper landing mechanics (Nigg B M et al., 1995).

(Crowell, H. P. & Davis, I. S. 2011) stated that a more balanced foot strike pattern and optimized landing mechanics can help distribute impact forces more effectively and reduce tibial stress.

Moen M.J et al. (2009) highlighted that higher vertical loading rates could predispose runners to MTSS by increasing the mechanical load on the tibia.

Franklyn-Miller et al. (2009) identified excessive tibial strain due to repetitive loading as a primary cause of MTSS in sprinters.

6. IMPROPER RUNNING MECHANISM WITH MOVEMENTS

Sprinting involves high-impact forces, and improper foot strike patterns (e.g., excessive forefoot or heel striking) can concentrate stress on the lower leg rather than distributing it efficiently (Pohl M B et al., 2008).

1. Ankle Eversion Moments: Runners with MTSS history exhibit significantly larger ankle eversion moments during stance phase, increasing traction on medial tibial structures. Even after the disappearance of the symptoms of MTSS (Ohmi T et al., 2023; Becker J et al., 2018).

2. Hip and Pelvic Mechanics: Reduced hip flexion and greater pelvic anterior tilt during running are linked to MTSS recurrence (Bramah C et al., 2018; Loudon, J. K., & Reiman, M. P, 2012) (Reinking M.F et al. 2017).

(Bramah C et al., 2018) Suggested that the injured runners demonstrated greater contralateral pelvic drop (CPD), and forward trunk lean at midstance and a more extended knee and dorsiflexed ankle at initial contact.

Becker J et al. (2018) reported that runners with a history of MTSS exhibited greater hip internal rotation compared to their uninjured counterparts. Similarly, a study by Newman et al. (2013) & Reinking M.F et al. 2017) reported that runners with MTSS exhibited greater hip internal rotation compared to uninjured runners, further supporting the role of hip kinematics in MTSS development.

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3. Foot Over Pronation: Excessive hindfoot eversion and forefoot abduction during gait amplify tibial stress (Naderi A et al., 2022; Viitasalo, J. T., & Kvist, M. 1983).

Several studies have explored the relationship between foot posture and MTSS. Tweed J. L et al. (2008) investigated the association between functional and static foot posture and MTSS in distance runners, finding that overpronation was a significant risk factor. Similarly, Hamstra-Wright et al. (2014) conducted a systematic review and meta-analysis, identifying overpronation as a contributing factor to MTSS in physically active individuals and identified elevated vertical loading rates as a risk factor for MTSS. These studies emphasize that the foot mechanics play a crucial role in the development of MTSS also importance of load management in preventing MTSS.

Okunuki T et al. (2019) suggested that an independent t-test was used to compare kinematic data between groups, subjects with MTSS exhibited significantly greater hindfoot eversion and abduction during walking and running than subjects without MTSS, significantly greater forefoot eversion and abduction during walking, and significantly greater forefoot abduction during running. Hindfoot and forefoot kinematics during walking and running were significantly different between subjects with and without MTSS. For prevention and rehabilitation of MTSS, it may be important to focus on not only hindfoot but also forefoot kinematics during both running and walking.

INADEQUATE FOOT ARCH SUPPORT

Flat feet (overpronation) or high arches (under pronation) can lead to inefficient shock absorption, resulting in excessive tibial strain (Nigg B M, 2001).

TRAINING LOAD AND SHIN SPLINTS

Training volume and intensity are one of the key factors in the development of shin splints. Sudden increases in sprinting workload, particularly without sufficient adaptation periods, can contribute to tibial stress injuries. Plyometric exercises, commonly incorporated into sprint training, also contribute to increased tibial stress. While plyometrics enhance explosive power and neuromuscular efficiency, they involve repeated high-impact landings that can exacerbate microtrauma in the tibia. Therefore, progressive training protocols with appropriate load management are essential in minimizing the risk of shin splints., When muscles are fatigued, their ability to absorb impact diminishes, forcing bones and joints to bear more stress, increasing the likelihood of shin splints (Fredericson, M., & Weir, A. 2006).

Sprinters who engage in high-frequency, high-intensity training with insufficient rest are at greater risk of developing MTSS due to cumulative loading on the tibia (Hreljac, A 2004).

FOOTWEAR AND SURFACE CONDITIONS

The type of footwear worn by sprinters significantly affects impact absorption and tibial stress distribution. Shoes with inadequate arch support or insufficient cushioning can lead to excessive tibial strain, particularly in athletes with predisposing biomechanical factors such as flat feet or high arches (Nigg B M, 2001). Research suggests that footwear designed to optimize shock absorption and enhance proprioception can reduce the likelihood of developing shin splints. Poorly cushioned or worn-out sprinting shoes fail to provide adequate impact dispersion, leading to excessive tibial stress. Training surfaces also play a role in injury risk. Hard surfaces, such as synthetic tracks and concrete, increase ground reaction forces, whereas softer surfaces, like grass

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or cushioned tracks, may reduce impact forces and lower the risk of tibial stress injuries (Bishop et al., 2006). Alternating training surfaces and incorporating cross-training can help mitigate excessive loading and prevent shin splints in sprinters.

FASCIAL TRACTION MODEL

Excessive foot protonation leads to a medial shift in the centre of pressure, prompting increased soleus muscle activity to stabilize the foot, control protonation and regulates tibial advancement over the foot during the stance phase of running (Becker J et al., 2018; Naderi A et al., 2022) Previous studies suggest that increased protonation may lead to hyperactivation of the soleus muscle (Hunt & Smith, 2004; Murley, G. S et al., 2009; Naderi A et al., 2022). The soleus muscle exerts pulling forces on the tibia and surrounding tissues, with prolonged activation potentially causing strains in the distal tibia and contributing to MTSS (Becker J et al., 2018; Naderi A et al., 2022). Reducing soleus activity could minimizes tibial stress, helping to prevent microtrauma, inflammation, and stress-related injuries over time (Naderi A et al., 2022). Excessive traction stress on the soleus fascia and tibial periosteum during running is a key contributor to MTSS. This is exacerbated by ankle eversion moments and altered foot kinematics (Bouché, R. T., & Johnson, C. H; Winters M 2020)

MUSCLE WEAKNESS AND IMBALANCES

Insufficient strength in the tibialis anterior, gastrocnemius, and soleus muscles reduces their ability to absorb impact forces, increasing stress on the tibia (Willems T.M et al., 2006).

Weakness in hip abductors and plantar flexors correlates with increased tibial strain, as seen in kinematic studies (Okunuki T et al., 2019).

D H Richie et al., 1993 concluded that, Excessive eccentric muscle activity has been associated with increased muscle damage, and recent investigations have linked medial tibial shin pain with actual structural damage to the muscle-fascial attachments to the posteromedial aspect of the tibia. Therefore, this study tends to verify the previous assumption that running on hard, noncompliant sport surfaces would predispose running and dancing athletes to shin muscle damage and resultant pain.

Primary Muscles Involved in Overpronation

1. **Tibialis Posterior (Weak/Inhibited) –** Unable to provide adequate support to the medial arch, leading to excessive foot collapse.
2. **Tibialis Anterior (Weak/Inhibited)** – Fails to control foot motion during gait, allowing excessive pronation.
3. **Peroneus Longus (Overactive/Tight)** – Pulls the foot laterally, increasing pronation force.
4. **Flexor Hallucis Longus (Weak/Inhibited)** – Reduced ability to stabilize the medial arch.
5. **Flexor Digitorum Longus (Weak/Inhibited**) – Contributes to poor foot posture and arch instability.

Secondary Muscles Contributing to Overpronation

1. **Gastrocnemius & Soleus (Tight/Overactive)** – Limited ankle dorsiflexion leads to compensatory foot pronation.

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2. **Intrinsic Foot Muscles (Weak)** – Weakness in the abductor hallucis, flexor digitorum brevis, and lumbricals reduces arch support.

3. **Hip Abductors & External Rotators (Weak)** – Weak gluteus Medius and gluteus maximus cause excessive internal rotation, affecting foot alignment.

7. RESULTS

The results indicate that shin splints (MTSS) in sprinters are primarily influenced by biomechanical factors such as overpronation, increased tibial strain, and altered running kinematics, leading to excessive stress on the tibia. Muscle imbalances, particularly weak plantar flexors and hip instability, further contribute to injury risk. Training errors like overtraining, inadequate recovery, hard surfaces, and improper footwear exacerbate the condition. Additionally, female sprinters show a higher incidence of MTSS due to anatomical differences.

EMG analysis revealed imbalanced calf muscle activation during sprinting in MTSS athletes.

3D motion capture showed altered pelvic tilt and knee valgus in sprinters with MTSS.

Runners who developed MTSS demonstrated tighter iliotibial bands, weaker hip abductors, more pressure under the medial aspect of their foot at initial foot contact, greater contralateral pelvic drop.

Factor	Findings
Prevalence	MTSS affects 5%–35% of runners, with sprinters at higher risk due to greater tibial loading.
Foot Pronation & Biomechanics	Causes of overpronation are excessive rearfoot eversion, and navicular drop increase tibial stress, excessive tibial internal rotation, reduce hip flexion, excessive hip internal rotation
Running Kinematics	High vGRF, tibial strain, and altered stride mechanics increase MTSS risk in sprinters.
Muscle Imbalances	Weak plantar flexors, tibialis, hip abductors, flexor hallucis longus, flexor digitorum longus, tight peroneal groups, gastrocnemius, soleus, plantar fascia, excessive hip internal rotation, excessive, excessive pelvic anterior tilt and hip instability contribute to shin splint development.
Training Factors	Overtraining, hard surfaces, improper footwear, and lack of recovery time increase MTSS risk (When muscles are fatigued, their ability to absorb impact diminishes, forcing bones and joints to bear more stress)
Gender Differences	Female runners have a higher incidence of MTSS due to anatomical and neuromuscular factors.

These findings demonstrate that the development of MTSS is multifactorial, with passive range of motion, muscle strength, plantar pressure distributions, and both proximal and distal kinematics all playing a role. We suggest that coaches or sports medicine professionals screening runners for injury risk consider adopting a comprehensive evaluation which includes all these areas.

8. DISCUSSION

The findings from this systematic analysis, based on 60 peer-reviewed articles, provide a comprehensive understanding of shin splints (Medial Tibial Stress Syndrome - MTSS) in sprinters.

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Shin splints remain one of the most common overuse injuries among athletes, significantly impacting performance and training continuity. This discussion evaluates the key contributing factors, preventive strategies, rehabilitation approaches, and areas for future research.

Biomechanical and Physiological Factors

One of the primary contributors to MTSS is abnormal lower limb biomechanics, particularly excessive foot pronation, increased tibial stress, and muscular imbalances. Studies indicate that over-pronation leads to excessive medial tibial stress, contributing to inflammation and microdamage. Weakness in hip abductors, plantar flexors, and tibialis anterior has been consistently linked to increased susceptibility to shin splints. Furthermore, asymmetries in gait mechanics and improper running posture exacerbate the condition by increasing strain on the tibial region.

Training Load Factors

Training errors are among the most significant extrinsic risk factors for shin splints. Abrupt increases in training intensity, volume, or frequency often result in cumulative stress on the tibial bone and surrounding musculature. Sprinters training on hard surfaces or uneven terrains experience greater ground reaction forces, which elevate tibial strain and contribute to injury. Additionally, inadequate recovery periods, insufficient warm-ups, and lack of cross-training further predispose athletes to MTSS.

Gender Differences Risk Factors

Recent research suggests that female sprinters are at a higher risk of developing shin splints due to hormonal influences on bone density, different muscle activation patterns, and structural variations in the lower limb. Women with lower bone mineral density or those exhibiting excessive valgus knee movement may experience increased tibial stress, highlighting the need for targeted injury prevention programs.

Role of Footwear and Surface Interaction

Improper footwear selection is a well-documented external contributor to shin splints. Shoes lacking adequate arch support, shock absorption, and stability increase the mechanical load on the tibia. Athletes using worn-out footwear or transitioning to minimalist shoes without proper adaptation phases may experience greater stress on the tibial cortex, elevating injury risk. Studies emphasize the need for customized footwear solutions to optimize load distribution and reduce tibial stress.

9. CONCLUSION

This discussion underscores the multifactorial nature of shin splints in sprinters (Medial Tibial Stress Syndrome - MTSS) arise due to multiple intrinsic and extrinsic factors. Biomechanical issues such as excessive foot pronation, tibial stress, and poor running mechanics significantly contribute to MTSS development. Muscular imbalances, particularly weak plantar flexors and hip stabilizers, further increase susceptibility to the condition. Training errors, including sudden mileage increases, inadequate recovery, and running on hard surfaces, play a crucial role in injury onset. Improper footwear and insufficient shock absorption further exacerbate the problem. Female sprinters are at

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higher risk due to hormonal and structural differences affecting bone density and muscle activation. Early detection through biomechanical analysis and gait assessment is key in preventing shin splints. Strengthening exercises, particularly targeting the lower limb and core stability, may help mitigate the risk. Proper training modifications, recovery strategies, and load management are essential for both injury prevention and rehabilitation.

10. FUTURE RESEARCH RECOMMENDATION

Running biomechanics has largely focused on long-distance athletes, there is a need to examine shin splint risk factors specifically in sprinters to develop targeted prevention and rehabilitation strategies, so While significant progress has been made in understanding MTSS, future studies should focus on based EMG, 3D MOCAP in sprinters, individualized rehabilitation approaches incorporating advanced imaging techniques such as bone scans and MRI to detect early signs of tibial stress. Research on genetic predisposition to stress-related injuries may provide deeper insights into athlete-specific risk factors. Additionally, exploring innovative recovery modalities such as blood flow restriction therapy, wearable biomechanical feedback devices, and regenerative medicine interventions could offer novel therapeutic advancements.

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ANALYSIS OF PELVIC BIOMECHANICS DURING SPRINTING – A SYSTEMATIC REVIEW

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ABSTRACT

Sprinting is a high-intensity movement that requires precise coordination of multiple body segments, with the pelvis playing a crucial role in force transfer and movement efficiency. This review analyzed over 40 peer reviewed articles on pelvic structure, kinematics and muscle activation during sprinting, sourced from databases like Google scholar, PubMed and Scopus. The studies were selected based on relevance and quality.

This review explores the biomechanics of the pelvis during sprinting, focusing on kinematic aspects, muscle activation patterns, and their implications for performance and injury prevention. The pelvis undergoes coordinated movements, including lateral flexion, tilting, and rotation, which influence sprint velocity, step length, and lower limb recovery.

Structurally, the pelvis consists of the iliac, ischial, and pubic bones, functioning as a weight-bearing unit connected to the spine via the sacroiliac joint (SIJ). Stability is maintained through various muscle groups, including the deep core muscles and four muscle slings—anterior oblique, posterior oblique, deep longitudinal, and lateral slings. These systems work collectively to regulate pelvic positioning and enhance sprint mechanics.

Pelvic movement occurs across three planes: Tilting (Sagittal), Hiking & drop (Frontal), and Rotation (Transverse). Additionally, sacral nutation provides joint stability during sprinting. Recent advancements in biomechanical analysis have improved our understanding of pelvic orientation and its effect on sprint performance. Research highlights the importance of minimal backside mechanics and optimal frontside mechanics for improved sprinting efficiency and reduced injury risk. By improving pelvic function, sprinting performance can be enhanced, leading to better outcomes.

Keywords : Sprinting biomechanics, Pelvic Kinematics, Pelvic tilting, Pelvic Rotation, Frontside mechanics, Backside mechanics, Pelvic stability, Sports Performance, Injury prevention.

1. INTRODUCTION

In the musculoskeletal system the pelvis is one of the most vital components. The pelvis, or pelvic bone, derived from the Latin word 'basin', is an anatomical structure found in most vertebrates.

Sprinting is a complex activity that requires precise coordination of multiple body segments to achieve optimal performance. The pelvis serves as a link between the upper and lower body, facilitating force transfer and movement. Understanding the biomechanics of the pelvis and its role is essential for performance enhancement and prevention of injuries in athletes. The pelvis goes through varied phases of positioning during different phases of a sprint and can differ between sports as well. Pelvic lateral flexion toward the free leg side is crucial for determining step length during sprinting (Preece et al., 2016) he free leg side lumbosacral joint torsional torque

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contributes significantly to the forward rotation on the pelvis of the stance leg side toward the free leg side in the transverse plane, supporting in the recovery of leg motion of the stance leg (Sado et al., 2017). Therefore, it is reasonable to consider that the hip abduction torque, free leg side lumbosacral joint lateral flexion torque, and torsional torque during sprinting may play an important role in achieving high sprinting velocity. The coordinated anteroposterior tilting of the pelvis during the stance and swing phase of running is also extremely important as a mild anterior tilt can aid in optimal extension of the hip during stance leg toe off, while the same anterior tilt can be counterproductive during the terminal swing phase and when the swing leg comes in contact with the ground. Sprinting movement with minimal backside mechanics and optimal frontside mechanics have been proposed to enhance sprinting (Mann and Murphy, 2015). This approach has been found to improve sprint performance (Clark et al., 2020) and prevent hamstring injuries (Mendiguchia et al., 2021). Notably, minimal backside mechanics are important as opposed to optimal frontside mechanics (Haralabidis et al., 2022).

Recent studies have delved into various aspects of pelvic mechanics during sprinting. For instance, research has examined the relationships between pelvic range of motion, step width and performance during the sprint start, highlighting how pelvic kinematics influence initial acceleration phases. (Paul Sandamas et al., 2020). Investigations into three dimensional kinetic behaviour of pelvic rotation during max velocity sprinting have provided insights into the mechanical contributions of pelvic movements to overall sprint performance. (Sado et al., 2016). Advancement in measurement technologies have also enhanced our ability to assess pelvic orientation during sprinting, offering practical applications for both training and performance analysis. Another important factor is the lumbosacral joint as well as the SI joint movements during a sprint, especially maximum velocity sprinting. Studies have revealed that improving sprinting speed during sprinting produces greater free leg side lumbosacral joint torsional torque during the stance phase and assists the recovery of leg motion, resulting in a high step frequency (Ota et al., 2024), which can be a reason for increased sprint speed.

2. METHODOLOGY

This review examines the biomechanics of the pelvis during sprinting by analyzing peer-reviewed literature from reputable databases including Google scholar, Pubmed & Scopus. A total of 40+ studies were selected based on relevance, methodological rigor and contribution to understanding pelvic kinematics, muscle activation and their impications for sprint performance. A structured search strategy was employed using keywords like " Pelvic kinematics", "Pelvic tilting", " Pelvic rotation", "Sprint biomechanics", etc. Studies were included if they were published in peer-reviewed journals and included athletic population or sprint-specific movement analysis. Studies were excluded if they focused solely on walking and jogging or non sports specific analysis.

The selected studies were systematically reviewed for data on pelvic structural mechanics, kinematics and muscle function during sprinting. Recent advancements in motion capture, EMG and force plate analysis were considered to provide a better understanding of pelvic function in sprinting. Each study was assessed for methodological quality and reliability using established

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biomechanical research standards. Studies with a strong experimental design, appropriate sample size and validated measurement techniques were prioritized.

3. LITERATURE REVIEW

1. Structure of the pelvis

The pelvis is a structure in the human body that connects the lower extremities to the upper part of the body. A mature pelvic bone is an integration of the iliac, the ischial bone and the pubic bone. These three structures merge to form the acetabulum, through which the pelvic bone interacts with the femoral head. The role of pelvis is to transfer gravitational and external load under controlled strain across the sacroiliac joint and hip joint. The pelvis is the most important part of the human skeleton, which contributes to the stability of human body and the protection of organs inside. The compressive force of the body weight that passes from sacrum to sacroiliac joint can be resolved into two components, one will go down word and laterally to the acetabulum while the other component goes downward medially to the symphysis pubis. The acetabulum and adjoining pelvic bones are one of the most important weight bearing structures in the human body. The structure of the pelvis is a sandwich material, with the thin layers of cortical bone carrying most of the load. On the superior aspect, the pelvis is connected to the spine through the sacroiliac joint (SI joint). The Sacroiliac Joint (SIJ) is the largest axial joint in the body. It connects the spine to the pelvis and transfers load between the lumbar spine and the lower extremities. Research has shown the sacrum has very little movement. Numerous ligaments across the joint support and limit movement of the SIJ. (Kiapour et al., 2020) The sacrum tightly wedges between the ilia and the ligaments provide resistance to shear loads. Additional resistance is also provided by grooves and ridges to protect the joint against shearing. Although several of the body's largest and powerful muscles surround the SIJ, no muscle directly affects sacral movements.

2. Pelvic Stabilization

There are a large number of muscles that play a role in pelvic stabilization and movement. The muscles present anteriorly with respect to the pelvis serve has flexors and anterior stabilizers, preventing an anterior tilt. (Iliopsoas, rectus femoris, sartorius). The muscles present posterior to the pelvis act as extensors and posterior stabilizers, preventing a posterior tilt. (Gluteus Maximus, hamstrings, erector spinae). The muscles present on the lateral side aide in controlling lateral stability and prevents excessive hip drop. (Gluteus medius, Gluteus minimus, tensor fascia latae). Deep and pelvic floor muscles (transverse abdominis, obliques, rectus abdominis, levator ani, coccygeus, pubococcygeus, iliococcygeus, multifidus, Quadratus lumborum) stabilize the pelvis and control intra-abdominal pressure. Deep hip rotators (piriformis, obturator internus and externus, gemellus superior and inferior, quadratus femoris) control hip rotation (pelvic & femoral) and fine motor movements. Another important factor in providing pelvic stability, particularly SI Joint stability, is the force closure mechanism(Liebenson , 2004). These are provided by a number muscle groups in tandem, known as slings. There are particularly 4 muscle slings that provide stability to the pelvis, They are :-

(i) **Anterior Oblique sling (AOS)** :External and internal obliques connecting with contralateral adductor muscles via the adductor-abdominal fascia. Contraction of these group of muscles provides stability, compressing the pelvic girdle, resulting in force closure of the pubic symphysis

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(ii) **Posterior Oblique Sling (POS)** : Latissimus dorsi, Gluteus maximus, biceps femoris and interconnecting Thoracolumbar fascia· Muscles work as synergists to directly stabilise the pelvic girdle. Force closure increases indirectly due to the anatomical attachments of the gluteus maximus and the thoracolumbar fascia with the sacrotuberous ligament. POS works with AOS to create balance

(iii) **Deep Longitudinal sling** : Erector spinae, multifidus, Thoracolumbar fascia, Sacrotuberous ligament and Biceps femoris. The sling allows for movement in the sagittal plane while also influencing local stability. The iliac attachments of multifidus together with erector spinae pull the posterior parts of the iliac bones toward each other and therefore limiting further nutation. Contraction of erector spinae and long head of biceps may increase force closure due to their anatomical attachments with the sacrotuberous ligament. Contraction of erector spinae and multifidus has broadening effect (inflation of the fascial cylinder), this will increase tension and assist with force closure.

(iv) **Lateral sling** : Gluteus medius, Gluteus minimus, Tensor Fascia Latae (TFL) and Iliotibial band (ITB)· Sling provides stability in the coronal plane and involved in pelvo-femoral stability in dynamic movements (gait, lunges, stair climbing). To understand the relevance of the lateral sling, the actions of the muscles need to be understood - Hip abduction and medial rotation (gluteus medius and minimus). Tensor Fascia Latae works in synergy with these muscles to hold pelvis level in single leg movements. Tensor Fascia Latae also works with gluteus maximus on ITB to stabilise the hip joint by holding the head of the femur in the acetabulum. (Lee et al., 2011)

3. MOVEMENTS IN THE PELVIS

Movements in The pelvis Generally, motions of the pelvis are described as rotations about one of three cardinal axes, each of which creates motion in one of the planes (Cappozzo et al., 2005). Rotation about a mediolateral axis produces motion within the sagittal plane, and is often referred to as anterior or posterior tilt or rotation. With anterior pelvic tilt, the anterior superior iliac spines (ASIS) each move anteriorly and inferiorly while the posterior superior iliac spines (PSIS) each move superiorly (Levangie and Norkin 2011; Murray, Kory, Sepic 1970; Neumann 2010). Conversely, posterior pelvic tilt occurs when the ASIS move posteriorly and superiorly while the PSIS move inferiorly.

Rotation about an anteroposterior axis creates motion within the frontal or coronal plan. This motion occurs when one side of the pelvis moves lower as the other side moves higher, and is often referred to as pelvic drop or hike; or in some fields, pelvic obliquity or list. Typically, this occurs while weight-bearing on a single lower extremity and is described by the motion of the contralateral side of the pelvis (Levangie and Norkin 2011; Neumann, 2010).

Conversely, when the left side of the pelvis is raised, this is considered pelvic hike. Sometimes this is referred to as contralateral pelvic drop or hike in order to convey the sense that the description refers to the side away from the stance lower extremity.

Rotation about a vertical axis produces motion in the transverse or horizontal plane. In some fields, this is referred to as forward and backward rotation (Levangie and Norkin 2011),

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or similarly as anterior and posterior rotation. Again, the naming convention is based on the motion of the side contralateral to the hip controlling the motion. For example, when standing on the right lower extremity, forward rotation is when the contralateral side is moving forward or anteriorly. Backward rotation is when the contralateral side is moving backward or posteriorly. Others refer to these motions as internal and external rotation (Neumann, 2010), and is named similarly to the motions of the lower extremity segments. Just as right femoral internal rotation is counter-clockwise rotation of the femur when viewed from a superior perspective, internal rotation of the pelvis during right stance is counter-clockwise rotation of the pelvis or backward rotation. (Neumann, 2010)

The Sacrum also has some movement that aids in overall pelvic motion. It moves relative to the iliac bones in the saggital plane. The movements are Nutation (when the sacrum is rotated forwards relative to the iliac bones) and Counter nutation (when the sacrum is rotated backwards relative to the iliac bones), which occurs only during non-weight bearing. According to Willard et al nutation can be regarded as anticipation for joint loading, as it is more stable than counternutation.

4. KINEMATICS OF PELVIS IN SPRINTING

The kinematics of the pelvis during sprinting play a crucial role in optimizing performance and prevent injuries. Here are the different planes in which the pelvis moves during sprinting and how they affect performance:-

A) **Saggital Plane motion (Anterior and Posterior tilt)** : The pelvis tilts both anteriorly and posteriorly during a sprint. Primarily an anterior tilt relative to normal pelvic position occurs during extension in the stance phase, and a posterior tilt occurs during the hip flexion during swing phase (Schache et al., 2002). It has been shown that during gait, the pelvis is typically tilted anteriorly throughout the cycle (O'Neill et al. 2015). Following initial contact, the pelvis tilts posteriorly for less than 20% of the gait cycle. It then begins to tilt anteriorly again until the contralateral foot contacts the ground at approximately 50% of the gait cycle. The cycle then repeats itself, tilting posteriorly, and anteriorly again. The total excursion of this movement is relatively small, approximately 2 to 5 degrees (Bruening et al. 2015; Crosbie, Vachalathiti, Smith 1997; Kadaba, Ramakrishnan, Wootten 1990; Murray, Drought, Kory 1964; Smith, Lelas, Kerrigan 2002)

From a performance perspective, studies showed that smaller angles of displacement, both anteriorly as well as posteriorly, improved sprint speed by increasing stride frequency, as limiting an anterior tilt can prevent the thigh of the stance leg from remaining backward during the flight phase, promoting faster forward leg recovery. (Ota et al., 2024). It is also seen that the pelvis moves from an anterior position to a more stable and upright position as the body moves from a forward lean, during the acceleration phase, to an upright position during max velocity running. (Paul Sandamas et al., 2020). Excessive anterior tilt of the pelvis also increases lumbar lordosis and can potentially lead to hamstring overruse injuries. (Preece et al., 2008).

B) **Frontal Plane motion (Mediolateral motion)**: The pelvis also moves mediolaterally during sprinting. A slight contralateral pelvic drop occurs during the stance phase to maintain balance and optimize ground reaction force application. (Novacheck, 1998). The kinematic

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pattern of pelvic rotation indicates that the pelvis rotates backward toward the stance leg side, and that the maximum backward rotation toward the stance leg side occurrs in the middle of the stance phase, along with forward rotation toward the free leg side.The kinetic pattern of pelvic rotation indicates that the lumbosacral joint torsional torque toward the stance leg side is greater until the middle of the stance phase, and that the lumbosacral joint torsion torque toward the free leg side is greater. This suggests that the pelvis on the stance leg side rotates forward by exerting a large lumbosacral joint torsional torque on the free leg side from the middle of the stance phase. The hip joint force on the stance leg increases the forward force to pull the stance leg forward (Sado et al., 2017), whereas the joint force on the pelvis of the stance leg attempts to pull the leg backward during the stance phase (Ota et al., 2022; Sado et al., 2017).Thus, it can be said that when the lumbosacral joint torsional torque is greater during the stance phase and smaller during the flight phase it results in a greater forward rotation on the pelvis of the stance leg side toward the free leg side prior to toe-off and contributing to the faster recovery of leg motion to increase high step frequency.(Kazuki Ota et al., 2024). A weakness in the muscles involved in lateral stability of the pelvis (Gluteus medius, Gluteus minimus, tensor fascia latae) can lead to an excessive hip drop, reducing running efficiency and increasing a risk of injury. (Schache et al., 2002). An inefficient control of the pelvis can also indicate previous hamstring injury history. Sprinters with previous hamstring injury are less stable and more asymmetrical than healthy sprinters during stance. (Cameron Nurse et al., 2023)

C) **Transverse Plane motions (Pelvic rotation)**: The pelvis does have a limited degree of rotation that it does during sprinting. It rotates forward/internally on the swing leg side and backward/externally on the stance leg side. This can enhance stride length (Mann & Sprague, 1980). Rotations of the pelvis or trunk in the transverse plane will not displace the CoM. However, it has been shown that arm motion during running functions to counterbalance the rotational angular momentum of the swinging legs (Arellano and Kram, 2014, Hamner et al., 2010). Thus a coordination pattern between the pelvis and spine must emerge which facilitates the necessary arm movement for angular momentum balance. It been suggested (Pontzer, Holloway, Raichlen, & Lieberman, 2009) that this coordination is achieved via a mass-damped system in which motion of the arms is driven passively by the motion of the torso. (Pontzer et al., 2009) also suggest that thorax motion is driven passively by motion of the pelvis. If all of this is true then a coordination pattern can be observed in which the pelvis precedes and controls the action of the torse. Therefore it is possible that the close coupling between these two segments facilitates the thoracic rotation required to passively drive arm motion. (Preece et al., 2016). Efficient sprinters exhibit controlled pelvic rotation to minimize energy loss and maximise propulsive forces. (Schache et al., 2002)

5. MUSCLE ACTIVATION PATTERNS AIDING IN PELVIC MOTION

Pelvic motion and stabilization is controlled by coordinated muscle activation across the core, hip and lower limb musculature during sprinting.

A) Saggital plane control and movement (Anterior-posterior pelvic tilt)

(i) **Hip flexors (Iliopsoas, Rectus Femoris and sartorius)** : They are responsible for hip flexion in the swing phase and provide eccentric control and stabilization during the

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late swing and stance phase. (Schache et al., 2000). Overactivity of these muscles can cause excessive anterior pelvic tilt and result in hamstring injuries.

(ii) **Gluteus maximus and Hamstrings (Biceps femoris, Semitendinosus and semimembranosus)** : They provide posterior pelvic tilt control during hip extension in the stance phase (Schache et al., 2012). Gluteus maximus also contributes to forward propulsion and stabilization of the pelvis during sprinting.

(iii) **Erector spinae (Iliocostalis, longissimus, spinalis)** : It counteracts excessive posterior pelvic tilt during the late swing phase (Novacheck, 1998). Its action is constant throughout the phases of the sprint.

B) Frontal plane control and movement (Lateral pelvic tilt)

(i) **Gluteus Medius & Minimus** : They control contralateral pelvic drop during the stance phase (Farrokhi et al., 2008). Weakness can lead to a trendelenburg sign.

(ii) **Adductors (Adductor magnus, longus, brevis, Gracilis, Pectineus)** : They help stabilize the pelvis against excessive lateral sway (Schache et al., 2012). They also work with gluteus medius to provide frontal plane stability.

(iii) **Quadratus Lumborum** : It helps elevate the pelvis on the swing leg side, counteracting its excessive drop (Neumann, 2010).

C) Transverse plane control and motion (Pelvic rotation)

(i) **Obliques (external & internal), Rectus abdominis** : They assist in contralateral pelvic rotation during the full sprint cycle. (Schache et al., 2002) Stronger obliques can improve rotational stability and transfer of power.

(ii) **Multifidus & Rotatores** : They provide segmental control of pelvic rotation and minimize energy loss during stance phase.

(iii) **Gluteus maximus (Contralateral side)** : It assists in pelvic rotation by pulling the hip into external rotation during the push off phase. (Bezodis et al., 2008)

6. CONCLUSION

Pelvic biomechanics play a crucial role in optimizing sprint performance and minimizing injury risk. This review highlights the importance of pelvic stability, control and muscle coordination for sprinting efficiency. The pelvis functions as a central hub for force transfer between the upper and lower body, influencing sprint velocity, step length and stride mechanics through coordinated movements across all planes of motion.

Key findings indicate that optimal frontside mechanics and minimal backside mechanics contribute to improved sprint performance. Proper pelvic alignment and control – achieved through activation of deep core muscles and the for pelvic slings- enhance stability and efficiency. Additionally, sacral nutation and controlled pelvic rotation are essential for joint stability and effective force application during sprinting.

Advancements in motion capture, EMG anlysis have provided deeper insights into the role of pelvic biomechanics in sprinting. The findings emphasize the need for targeted strength and mobility training to improve pelvic function, reducing the likelihood of injuries such as hamstring strains and lower back issues.

Overall, enhancing pelvic biomechanics through structured training programs, injury prevention strategies and biomechanical assessments can significantly improve sprint

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performance. Future research should explore individualized interventions and real-time feedback mechanisms to further optimize pelvic control for elite and developmental sprinters.

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SODIUM BICARBONATE SUPPLEMENTATION AND ITS IMPLICATION ON SPORTS PERFORMANCE: A COMPRENHENSIVE REVIEW

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ABSTRACT

Sodium bicarbonate ($NaHCO_3$) has emerged as a well-researched ergogenic aid with substantial evidence supporting its efficacy in enhancing athletic performance. This compound functions primarily as a buffering agent during high-intensity exercise, counteracting exercise-induced acidosis that contributes to fatigue. Research demonstrates particular effectiveness for exercise tasks lasting between 30 seconds and 12 minutes, including muscular endurance activities, combat sports, and high-intensity cycling, running, swimming, and rowing.

Both acute (0.2–0.5 g/kg body weight, 60–180 minutes before exercise) and chronic (divided doses over 3–7 days) supplementation protocols have shown significant improvements in power output, time to exhaustion, and recovery. The optimal dose appears to be 0.3 g/kg, as higher doses increase gastrointestinal side effects risk. Recent research highlights potential cognitive benefits during prolonged exercise, indicating applicability in skill-based sport.

While adverse gastrointestinal effects are common, these can be minimized through enteric-coated capsules, split dosing, and consumption with high-carbohydrate meals. Given the variability in individual responses, personalized supplementation protocols are recommended to maximize benefits while minimizing side effects. Future research should explore cognitive and skill-execution benefits under fatigue conditions, contributing to more holistic applications in competitive sports.

Keywords: Sodium Bicarbonate , Ergogenic Aid , Buffering Agent , Recovery , Muscular Endurance , Acute supplementation , Sports Performance

1. GROWING IMPORTANCE OF ERGOGENIC AIDS IN MODERN SPORTS SCIENCE

Sodium bicarbonate ($NaHCO_3$), commonly known as baking soda, has emerged as a well-researched ergogenic aid with substantial evidence supporting its efficacy in enhancing athletic performance. This compound functions primarily as a buffering agent during high-intensity exercise, counteracting exercise-induced acidosis that contributes to fatigue. According to the International Olympic Committee, sodium bicarbonate ranks among the top five supplements for performance enhancement in specific sporting scenarios, with reportedly 80% of endurance athletes at the 2024 Paris Olympics utilizing it.(Grgic, Pedisic, et al., 2021a; McNaughton et al., 2016)

The physiological mechanism behind sodium bicarbonate's ergogenic effects involves increasing extracellular buffering capacity. During intense exercise, skeletal muscles produce hydrogen ions (H+) that can exceed the body's natural buffering capacity, decreasing pH and impairing muscle function. Sodium bicarbonate supplementation enhances the body's ability to

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buffer these acids, facilitating the removal of hydrogen ions from working muscles and potentially delaying fatigue onset.(Farney et al., 2020; Varovic et al., 2023)

Research demonstrates that sodium bicarbonate provides performance benefits across various exercise modalities. A randomized, double-blind study found that ingestion of 0.3 $g \cdot kg^{-1}$ improved muscular endurance, power, and velocity in the bench press exercise, particularly in later sets, suggesting it attenuates acidosis-induced suppression of muscle contractility. An umbrella review of meta-analyses revealed moderate-quality evidence for ergogenic effects on peak and mean power in the Wingate test and Yo-Yo test performance, with low-quality evidence supporting benefits for endurance events lasting approximately 45 seconds to 8 minutes.(Grgic, Grgic, et al., 2021a; Grgic, Pedisic, et al., 2021a; McNaughton et al., 2016)

The standard dosage protocol involves acute ingestion of 0.3 $g \cdot kg^{-1}$ body mass (approximately 21g for a 70kg athlete) consumed 1-2 hours before exercise(Grgic, Pedisic, et al., 2021a). A meta-analysis concluded this dosage resulted in a mean performance enhancement of 1.7% in a single 1-minute sprint in male athletes. Beyond acute performance, sodium bicarbonate may enhance training adaptations; one study showed significantly greater improvements in time to exhaustion (164% vs. 123%) when supplemented before interval training sessions over an 8-week period.(Farney et al., 2020)

Athletes competing in high-intensity events where large muscle mass is recruited—such as swimming, running, cycling, and rowing—may benefit most from supplementation. Recent research also demonstrates improved performance in CrossFit workouts, with reduced completion times for benchmark tests.(Miller et al., 2016) The exercise duration appears influential, with more consistent benefits observed in activities lasting between 30 seconds and 7 minutes.(Grgic, Grgic, et al., 2021b)

Despite its efficacy, sodium bicarbonate supplementation can cause gastrointestinal distress, potentially negating performance benefits.(Grgic, Pedisic, et al., 2021a) Therefore, individualized protocols considering timing, dosage, and gastro- resistant formulations are recommended to maximize benefits while minimizing side effects. (Refer Table 1)

2. HISTORY OF RESEARCH ON SODIUM BICARBONATE AND EXERCISE

The impact of sodium bicarbonate ($NaHCO_3$) on athletic performance has been studied since the 1930s, with the first documented research by Dennig et al. at Harvard University showing improved exercise performance through induced alkalosis. The modern era of sodium bicarbonate research began with a pivotal 1977 study by Jones et al., which demonstrated significant performance enhancements during high-intensity cycling tasks after ingestion of sodium bicarbonate. Participants cycled for an average of **438 seconds** after consuming sodium bicarbonate, compared to **160 seconds** in the acidosis condition and **270 seconds** in the placebo condition.

The 1980s saw a surge in international interest, with numerous studies confirming the ergogenic benefits of sodium bicarbonate for high-intensity activities such as cycling, running, and swimming. Most of these studies utilized randomized, double-blinded, cross-over designs with small participant groups, consistently supporting sodium bicarbonate's role in improving performance by buffering lactic acid accumulation during strenuous exercise.

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As research on sodium bicarbonate continues to grow, it has become one of the most extensively studied ergogenic aids in sports science. Its ability to enhance performance in short-duration, high-intensity events makes it a valuable supplement for athletes seeking to improve their competitive edge.

3. OVERALL EFFECTIVENESS REGARDING SUPPLEMENTATION.

Sodium bicarbonate (SB) has conducted extensive research through training, which shows that SB tax 0.3 g · kg-1 BM increases 1.7 ± 2.0% training performance . Nevertheless, evidence is pluralized, as several studies have reported that theoretically stalks are theoretically affected by movement poisoning with muscles. Recently, it was suggested that the type of intervention studies analyzed (i.e., using the average differences between groups or trials) does not consider the potentially high differences in individuals, thus threatening the size of the intervention effect . However, re -administration of experimental treatment at the same individual in general allows for quantitatively determine individual reactions and, in addition to standard analysis, determine the consistency of these reactions . The dose ratio and the degree of blood alkalosis have long been weak after SB intake, and the large individual blood -ph and bicarbonate reactions to replenishment variations can cause the possible mechanism that is based on the potential ergogenic effect on the ergogenic effect of SB is not always present in all persons , which is possible training results. Saunders et al.Recently, this has shown that the training reaction changes significantly after SB reception. In addition, high-intensity circulatory capacity improvements were only shown to people who prevented the gastrointestinal (GI) discomfort from the analysis, although the GI-up was unable to explain the lack of improvements to all individuals. It is important that most studies have tested SB effects in isolated studies rather than certain blood and motor reaction populations and individual consistency with equal intensity compared to several studies.(Grgic, Pedisic, et al., 2021d)

The purpose of this study was to study repeated trials using the same individual and exercise protocols to test the consistency of the blood reaction and high -intensity circulation skills. It is assumed that SB supplement to SB will always increase blood bicarbonate and pH, and subsequent exercise responses will be more varied because individuals do not always improve their exercise capacity.(De Araujo Dias et al., 2015)

4. DOSAGE RECOMMENDATIONS

The standard dosage range for sodium bicarbonate is between 0.2 to 0.5g/kg of body weight. For optimal performance enhancement, a dose of 0.3 g/kg is often recommended, taken 1 to 3 hours prior to exercise. In chronic supplementation protocols, a total daily intake of 0.4 to 0.5 g/kg can be divided into smaller doses throughout the day for 3 to 7 days leading up to an event. Adjustments should be made based on individual tolerance to minimize gastrointestinal distress.(Viribay et al., 2020)

5. Timing of Supplementation

Timing plays a crucial role in the efficacy of sodium bicarbonate supplementation. For acute protocols, ingestion should occur 60 to 180 minutes before exercise, while chronic protocols involve multiple days of supplementation leading up to the event This approach not only enhances performance but also helps in adapting the body to the supplement over time.(Viribay et al., 2020)

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Study/Source (Table 1)	Focus	Key findings	Recommended Dosage	Performance Impact
1.	Sodium Bicarbonate as Ergogenic Aid	Sodium bicarbonate improves performance in high-intensity exercise across various sports.	0.3 g/kg body weight, 1-2 hours before exercise.	Significant improvement in middle-distance race performance, sprint performance in elite athletes.
2.	Recent Developments in Sodium Bicarbonate	Benefits observed in high-intensity intermittent activity and skill-based sports, with variability in individual response.	0.3 g/kg body weight; higher doses (0.4 g/kg) may enhance effects.	Performance improvements noted in short-duration high-intensity exercises and prolonged bouts (up to 60 minutes).
3.	Effects on Physical Performance	Enhances strength, coordination, and performance in high-intensity exercises; beneficial for muscular endurance.	Not specified; general recommendation aligns with 0.2-0.5 g/kg range.	Improves time to exhaustion and performance in interval training and muscular endurance activities.
4.	Ergogenic Effects of Sodium Bicarbonate	Provides resistance against fatigue from acid-base imbalance during exercise.	Not specified; related studies suggest 0.2-0.5 g/kg range.	Enhances performance through buffering capacity during high-intensity exercise.
5.	International Society of Sports Nutrition Position Stand	Supplementation improves performance in muscular endurance and various combat sports.	0.2 to 0.5 g/kg body weight recommended for effectiveness.	Positive effects on performance across multiple athletic disciplines, including combat sports.

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Study/Source (Table 1)	Focus	Key findings	Recommended Dosage	Performance Impact
6.	Ergogenic Effects of Sodium Bicarbonate	Alkalizing agents improve performance, particularly in CrossFit-like activities.	Not specified; implied to align with common dosing practices (0.3 g/kg).	Significant ergogenic effects noted across various sports and activities.
7.	Impact on Performance Related to Duration of Exercise	Investigates the role of exercise duration on the effectiveness of sodium bicarbonate supplementation.	Not specified; further research needed for optimal dosing based on exercise duration.	Potentially enhances performance by reducing acidosis during varying durations of exercise.

(Grgic, Pedisic, et al., 2021b, 2021c; Hadzic et al., 2019a) (Table 1)

Forms of Administration

Sodium bicarbonate is available in various forms including **pills, powders, solutions**, and encapsulated forms. Each form has its own advantages depending on personal preference and convenience. Powders can be mixed with liquids for faster absorption, while pills may offer a more convenient option for some users.(Viribay et al., 2020)

Tolerability

Gastrointestinal distress is a common side effect associated with sodium bicarbonate supplementation. To mitigate this, strategies such as **split dosing** (taking smaller amounts throughout the day) and co-ingestion with meals can be effective These methods help reduce the likelihood of discomfort while maximizing the benefits of supplementation.

In conclusion, sodium bicarbonate can be a valuable tool for athletes seeking performance improvements when used correctly. Understanding the appropriate dosages, timing, forms of administration, and tolerability strategies is essential for maximizing its benefits while minimizing adverse effects.(SODIUM BICARBONATE: Overview, Uses, Side Effects, Precautions, Interactions, Dosing and Reviews, n.d.)

(“Scientific Opinion on the Substantiation of Health Claims Related to Sodium Bicarbonate and Reducing Gastric Acid Levels (ID 1653) Pursuant to Article 13(1) of Regulation (EC) No 1924/2006,” 2010)

Sodium bicarbonate ($NaHCO_3$) has emerged as a prominent ergogenic aid in sports science, particularly for its role in enhancing performance across various athletic disciplines. This review explores the effects of sodium bicarbonate on anaerobic and high-intensity performance, endurance sports, team sports, and emerging research areas.

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Anaerobic and High-Intensity Performance

Sodium bicarbonate is particularly beneficial for anaerobic activities such as sprinting, weightlifting, and cycling. Research indicates that supplementation can significantly enhance power output and peak performance during high-intensity efforts. A meta-analysis revealed that sodium bicarbonate supplementation improves performance in events lasting **1 to 7 minutes**, with a pooled effect size indicating substantial benefits for muscular endurance and anaerobic capacity.(Acute versus Chronic Sodium Bicarbonate Ingestion and Anaerobic Work and Power Output - ProQuest, n.d.)

In sprinting, athletes have shown marked improvements in repeated sprint performance after sodium bicarbonate ingestion. For instance, one study noted a **14% increase** in performance during the Yo-Yo intermittent recovery test following supplementation. In weightlifting, while results vary, some studies indicate that experienced lifters can perform more repetitions under high-intensity conditions after taking sodium bicarbonate. (Peart et al., 2012)

A notable finding was that athletes could complete **six more squats** in their first set when supplementing with sodium bicarbonate compared to a placebo group

Cycling studies also support these findings, with one investigation reporting an increase in time to exhaustion by **4.5 minutes** among cyclists who ingested sodium bicarbonate. The mechanism behind these enhancements is primarily attributed to sodium bicarbonate's ability to buffer hydrogen ions (H^+) produced during anaerobic metabolism. By neutralizing acidity in the muscles, it allows athletes to sustain higher intensities for longer periods and recover more effectively between bouts of high-intensity exercise.(Grgic, Grgic, et al., 2021c; Peart et al., 2012)

Endurance Sports

In endurance sports characterized by intermittent high-intensity efforts—such as rowing and middle-distance running—sodium bicarbonate plays a supportive role. Research has demonstrated that athletes can experience improved performance during the latter stages of races when fatigue sets in. For example, rowers showed significant improvements during the final **1,000 meters** of a 2,000-meter race after sodium bicarbonate supplementation.(Kaçoğlu et al., 2024)

However, the benefits of sodium bicarbonate are less pronounced in purely aerobic activities where sustained low-intensity efforts dominate. In these scenarios, the body typically manages acid-base balance without external buffering agents. Studies indicate that while there may be some improvements in performance metrics for aerobic events lasting **45 seconds to 8 minutes**, the overall ergogenic effects are limited compared to those observed in anaerobic or intermittent activities

Team Sports

Sodium bicarbonate has also been shown to enhance performance in team sports such as soccer, basketball, rugby, and hockey—where intermittent high-intensity efforts are common. Evidence suggests that supplementation can improve sprint performance and recovery during matches characterized by repeated bouts of intense activity. For instance, soccer players who supplemented with sodium bicarbonate demonstrated enhanced sprinting capabilities and reduced perceived exertion levels compared to a control group.(Sodium Bicarbonate Supplements and Exercise Performance, n.d.)

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The buffering capacity of sodium bicarbonate allows athletes to maintain higher levels of performance throughout games and recover more efficiently between sprints or intense plays. This is particularly advantageous given the unpredictable nature of team sports where players frequently alternate between high-intensity bursts and lower-intensity recovery periods.(Grgic, Grgic, et al., 2021c)

Emerging Research Areas

Recent studies have begun exploring the effects of sodium bicarbonate on skill-based performances and cognitive-motor tasks under conditions of fatigue. Preliminary findings suggest that enhancing acid-base balance may not only aid physical performance but also improve cognitive function during prolonged exercise sessions. This could have significant implications for athletes requiring quick decision-making skills alongside physical exertion

As research continues to evolve, understanding how sodium bicarbonate affects both physical and cognitive aspects of sports performance will be crucial for developing comprehensive training regimens.

In conclusion, sodium bicarbonate serves as a valuable ergogenic aid across various types of sports performance. Its ability to buffer acidity enhances anaerobic and high-intensity efforts while providing benefits in endurance events with intermittent intensity fluctuations.

Furthermore, its potential impact on team sports highlights its versatility as a supplement for athletes seeking to optimize their performance across diverse athletic disciplines. Continued research will further elucidate its role in skill-based tasks and cognitive function under fatigue conditions.(Acute versus Chronic Sodium Bicarbonate Ingestion and Anaerobic Work and Power Output - ProQuest, n.d.; Sodium Bicarbonate Supplements and Exercise Performance, n.d.; Grgic, Grgic, et al., 2021; Kaçoğlu et al., 2024; Peart et al., 2012)

Factors Influencing Effectiveness.

Individual Variation: Genetic predispositions, training status, and habitual diet significantly impact how individuals respond to sodium bicarbonate. Some individuals may experience greater performance enhancements due to inherent physiological differences, while others may be more susceptible to gastrointestinal distress. A person's training level also plays a crucial role, with some studies suggesting that well-trained athletes may experience more pronounced benefits compared to their less-trained counterparts. Habitual diet can affect baseline acid-base balance, influencing the magnitude of the response to bicarbonate loading.(Hadzic et al., 2019b; Sodium Bicarbonate, Cheap and Effective?, n.d.)

Environmental Considerations: Environmental factors such as heat and altitude can affect bicarbonate metabolism. Heat stress may exacerbate gastrointestinal issues associated with sodium bicarbonate, while altitude-induced changes in blood pH could alter its effectiveness. Hydration status is also critical, as adequate hydration supports optimal physiological function and may mitigate some adverse effects of supplementation.(Grgic, Pedisic, et al., 2021c; Hadzic et al., 2019b

Exercise-Specific Factors: The type of exercise significantly influences the effectiveness of sodium bicarbonate. High-intensity exercise lasting between **30 seconds and 10 minutes** benefits most from sodium bicarbonate supplementation. While it may improve sprint performance and

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recovery in intermittent sports, the benefits are limited in purely aerobic activities.(Duncan et al., 2014)

Supplementation Protocols: The effectiveness of sodium bicarbonate varies between acute and chronic supplementation protocols. Acute loading typically involves a single dose **60-180 minutes** before exercise, while chronic protocols involve multiple doses over several days. Research indicates that both methods can enhance performance, but the optimal approach may depend on individual tolerance and the specific demands of the activity. Some studies suggest that a dosage of 0.3 grams per kg taken **60–180 minutes** before exercise is most effective.(Hadzic et al., 2019b)

Adverse Effects and Limitations of Sodium Bicarbonate

Sodium bicarbonate, commonly used as an antacid and in various medical treatments, comes with several adverse effects and practical limitations.

6. COMMON ADVERSE EFFECTS

1. **Gastrointestinal Discomfort**: Sodium bicarbonate can cause gastrointestinal side effects such as nausea, bloating, and belching when taken orally. These symptoms are generally mild but can be uncomfortable for some individuals.(Do et al., 2022)
2. **Risk of Metabolic Alkalosis**: One of the more serious side effects is the risk of metabolic alkalosis, especially in sensitive individuals. Metabolic alkalosis occurs when the body's pH becomes too alkaline, which can lead to symptoms like delirium, seizures, and arrhythmias. This condition is often asymptomatic until severe, but it can be triggered by excessive intake of sodium bicarbonate.(Faisy et al., 2016; Lookabill et al., 2024)

7. PRACTICAL LIMITATIONS

1. **Taste and Logistical Challenges**: Sodium bicarbonate has a distinct, often unpleasant taste, which can make it difficult to consume, especially in large quantities. Additionally, preparing solutions of sodium bicarbonate requires careful measurement and dissolution to avoid gastrointestinal irritation.
2. **Compliance**: The unpleasant taste and potential gastrointestinal side effects can lead to poor compliance among users. This is particularly challenging in scenarios where consistent dosing is crucial for therapeutic efficacy.(Faisy et al., 2016; Lookabill et al., 2024; Sodium Bicarbonate - StatPearls - NCBI Bookshelf, n.d.)

8. REGULATORY CONCERNS

1. **Anti-Doping Regulations and WADA Guidelines**: Sodium bicarbonate is not explicitly banned by the World Anti-Doping Agency (WADA), but its use can be scrutinized under certain conditions. Athletes may use it to buffer lactic acid during intense exercise, potentially enhancing performance. However, there is no clear evidence that it provides significant benefits in most sports contexts, and its use is generally not prohibited unless it leads to a violation of other doping rules.(Brinkman & Sharma, 2023; Do et al., 2022; Faisy et al., 2016; Lookabill et al., 2024)

In conclusion, while sodium bicarbonate is generally safe when used appropriately, it poses risks such as metabolic alkalosis and gastrointestinal discomfort. Practical challenges include its

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taste and logistical issues in preparation. Regulatory bodies do not typically restrict its use, but athletes should be aware of potential scrutiny under anti-doping guidelines. Further research is needed to fully understand its effects and limitations in various contexts.

9. SODIUM BICARBONATE COMPARED TO OTHER ERGOGENIC AIDS

Sodium bicarbonate functions as an extracellular buffer, neutralizing hydrogen ions that accumulate during high-intensity exercise. Its effectiveness in enhancing performance in events lasting 1-10 minutes is well-established, though gastrointestinal distress remains a significant limitation.

Beta-Alanine and Carnosine

Beta-alanine supplementation increases muscle carnosine content, enhancing intracellular buffering capacity. Unlike sodium bicarbonate's acute effects, beta-alanine requires chronic supplementation (4-6g daily for 4-12 weeks) to significantly elevate muscle carnosine levels. The complementary nature of these supplements sodium bicarbonate acting extracellularly while carnosine buffers intracellularly suggests potential additive benefits. Research examining co-supplementation shows mixed results, with some studies demonstrating enhanced performance beyond individual supplementation. (Moesgaard et al., 2024; Trexler et al., 2015)The combined approach appears most effective during high-intensity exercise lasting 30 seconds to 10 minutes, where both buffering systems are significantly stressed.(Ferragut et al., 2024; Grgic, Pedisic, et al., 2021a)

Sodium Citrate

Sodium citrate represents an alternative extracellular buffer that metabolizes to produce bicarbonate. Administration of 500 mg/kg body mass effectively induces alkalosis, potentially with reduced gastrointestinal symptoms compared to sodium bicarbonate. However, optimal timing differs significantly, with peak blood bicarbonate concentrations occurring approximately 200 minutes after capsule ingestion. This extended timeline necessitates earlier pre-competition supplementation than sodium bicarbonate.(Grgic, Pedisic, et al., 2021f; Moesgaard et al., 2024; Trexler et al., 2015)

Creatine and Caffeine Combinations

Research investigating potential synergistic effects between sodium bicarbonate and other popular ergogenic aids including creatine and caffeine indicates limited additive benefits. While creatine enhances phosphocreatine availability for very short-duration activities and caffeine improves endurance performance through adenosine antagonism, combining these supplements with sodium bicarbonate does not consistently produce performance enhancements beyond their individual effects. This suggests athletes might benefit most from selecting the specific ergogenic aid most appropriate for their competitive event rather than combining multiple supplements.(Moesgaard et al., 2024; No Additive Effect of Creatine, Caffeine, and Sodium Bicarbonate on Intense Exercise Performance in Endurance-Trained Individuals - PubMed, n.d.)

The practical implementation of buffering agents requires careful consideration of individual response variability, event-specific demands, and strategies to minimize gastrointestinal discomfort

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while maximizing ergogenic benefits.(Higgins et al., 2016; Kaçoğlu et al., 2024b; Montalvo-Alonso et al., 2024)

Future Research Directions in Sodium Bicarbonate Supplementation

The efficacy of sodium bicarbonate as an ergogenic aid has been well-established in high-intensity exercise contexts, yet several critical areas warrant further investigation to optimize its application and broaden our understanding of its effects.

Long-Term Safety and Efficacy Considerations

The current body of evidence demonstrates that sodium bicarbonate supplementation significantly improves performance across various exercise modalities, particularly in high-intensity activities lasting between 30 seconds and 12 minutes.(Grgic, Pedisic, et al., 2021g) While research indicates that long-term use of sodium bicarbonate before training sessions may enhance adaptations such as increased time to fatigue and power output, comprehensive longitudinal studies examining chronic supplementation remain scarce. The potential physiological adaptations to repeated sodium bicarbonate administration deserve thorough examination, considering both performance benefits and possible adverse effects. Current evidence highlights concerns about prolonged use, including electrolyte disturbances and acid-base imbalances(Saunders et al., 2022) Future research should establish clear safety profiles for chronic supplementation protocols and determine whether performance benefits persist or diminish over extended periods. Additionally, investigating potential health implications beyond performance, such as kidney function during long-term supplementation, represents a critical research direction given sodium bicarbonate's applications in nephrology contexts(Grgic, Pedisic, et al., 2021g)

Need for Research in Diverse Populations

A striking gap in the literature concerns population diversity, with only 20% of sodium bicarbonate studies including female participants and merely 7.4% providing women-specific analyses.(Saunders et al., n.d.) This gender disparity necessitates targeted research on female physiological responses to sodium bicarbonate supplementation. The preliminary evidence suggests women experience substantial increases in blood bicarbonate following supplementation with likely ergogenic effects, though data remain limited.(Eraky et al., 2024) Similar gaps exist regarding youth athletes and older populations, whose unique physiological characteristics may significantly alter supplementation responses. Age-related changes in acid-base balance, buffering capacity, and side effect profiles represent unexplored territory that could inform more personalized supplementation strategies across the lifespan.

Unexplored Areas of Investigation

The interaction between sodium bicarbonate and other ergogenic aids offers a promising research avenue. While some evidence suggests potential additive effects when combining sodium bicarbonate with creatine or beta-alanine, interactions with caffeine or nitrates remain ambiguous.(Saunders et al., 2022) Exploring these supplement combinations systematically would provide athletes with evidence-based multi-ingredient supplementation strategies. Furthermore, sodium bicarbonate's effects extend beyond purely physiological domains. Recent research with combat athletes indicates potential cognitive benefits via lactate metabolism pathways(Grgic,

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Pedisic, et al., 2021h) suggesting an unexplored role in cognitive-dominant and skill-based sports performance. Investigating sodium bicarbonate's influence on decision-making, reaction time, and technical execution during fatigue could revolutionize supplementation strategies for tactical sports.

Environmental and Technological Innovations

Addressing the well-documented gastrointestinal discomfort associated with sodium bicarbonate supplementation remains crucial for practical application. Current strategies include timing adjustments, dose modifications, co-ingestion with carbohydrates, and enteric-coated delivery methods.(Grgic, Pedisic, et al., 2021g; Saunders et al., 2022) Future research should focus on refining these approaches and developing novel delivery systems that maintain ergogenic benefits while minimizing side effects. Environmental considerations also warrant investigation, particularly regarding supplementation efficacy under various conditions such as heat, altitude, or humidity, which may independently alter acid-base balance. Such research would inform context-specific supplementation protocols for athletes competing in diverse environmental conditions.

10. CONCLUSION

The future of sodium bicarbonate research lies in expanding beyond established performance benefits toward nuanced understanding of long-term effects, diverse population responses, supplementation interactions, cognitive impacts, and improved delivery methods. Addressing these research directions will enable more personalized, effective, and safe supplementation strategies across athletic populations and competitive contexts.

Sodium Bicarbonate Supplementation and Its Implication on Sports Performance: A Concise Conclusion

This comprehensive review establishes sodium bicarbonate ($NaHCO_3$) as a well-researched and effective ergogenic aid for athletic performance enhancement. The evidence convincingly demonstrates that sodium bicarbonate functions primarily as a buffering agent, counteracting exercise-induced acidosis by facilitating the removal of hydrogen ions from working muscles, thereby delaying fatigue onset. With the International Olympic Committee ranking it among the top five performance-enhancing supplements, its widespread adoption—reportedly by 80% of endurance athletes at the 2024 Paris Olympics—underscores its recognized efficacy.

The literature consistently supports a standard acute dosage of 0.3 $g \cdot kg^{-1}$ body mass consumed 1-2 hours before exercise, though chronic supplementation protocols also show promise performance benefits are most pronounced in high-intensity activities lasting between 30 seconds and 7 minutes, with documented improvements in sports ranging from swimming and cycling to team sports and CrossFit.

Despite its effectiveness, individual variation in response remains significant, influenced by factors including genetics, training status, and habitual diet. Gastrointestinal distress represents the primary limitation to supplementation, necessitating individualized protocols regarding timing, dosage, and formulation.

In conclusion, sodium bicarbonate supplementation offers a legitimate performance advantage for athletes engaged in appropriate exercise modalities when properly implemented. Future

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research focusing on optimizing individual protocols and exploring potential cognitive benefits during fatigue will further enhance its application in sports science.

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THE IMPACT OF COGNITIVE LOAD ON ATHLETES IN TEAM SPORTS

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ABSTRACT

Cognitive load directly influences an athlete’s performance in team sports, impacting skills like decision making, effectiveness under pressure and efficiency in skill execution. This review synthesizes the current understanding of cognitive load and its impact on athletic performance in team sports. Utilizing Cognitive Load Theory as a framework, the analysis explores how various mental demands influence athletes' decision-making, attentional control, and overall efficacy. The review differentiates between intrinsic, extraneous, and germane cognitive loads, examining their respective contributions to both positive and negative performance outcomes. Optimum levels of cognitive load promote effective decision making and fosters adaptability by enabling athletes to devise strategies in crucial game scenarios. A critical evaluation of existing research identifies effective strategies for cognitive load management, including simulation training, psychological techniques, and environmental modifications, while also highlighting limitations in the current body of knowledge. Specifically, the need for more sport-specific research, ecologically valid long-term studies, and the integration of advanced technologies for cognitive assessment are emphasized. Furthermore, the necessity for personalized training approaches that account for individual differences is underscored. This review concludes that optimizing athletic performance requires a nuanced understanding of cognitive load and the implementation of evidence-based interventions to manage it effectively in dynamic, high-pressure sporting contexts. Future research directions are proposed, aimed at addressing existing knowledge gaps and enhancing training methodologies for athletes.

Keywords: Cognitive Load Theory, Team Sports, Psychological Techniques, Athletic Performance, Cognitive Processes, Mental Fatigue, Training Interventions, Environmental Modification, Working Memory, Decision-Making.

1.INTRODUCTION

Imagine a basketball player, mid-game, surrounded by roaring fans, while also tracking teammates, opponents, and the ball's trajectory, all within a fraction of a second. This scenario illustrates the complex cognitive demands placed on athletes in team sports. These sports are inherently dynamic and complex (Lord et al., 2020), requiring athletes to engage in intermittent, high-intensity activities such as sprints, jumps, and rapid changes of direction (Abdelkrim et al., 2007; Paulauskas et al., 2019). Traditionally, sports training focused primarily on physical conditioning. However, the crucial role of cognitive skills is now widely acknowledged, leading to an increased emphasis on cognitive load management in athletic preparation (Ericsson, 2006; Mann et al., 2007a). This shift highlights the necessity of addressing not only the physical but also the cognitive demands athletes face to optimize performance. The increasing tactical and strategic sophistication in modern team sports, coupled with the accelerating pace of games, demands faster and more efficient cognitive processing (Gabbett, 2016). Furthermore, the mental aspect of sports is increasingly recognized as a critical competitive advantage with the prevalence of mental

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exhaustion and burnout among athletes underscoring the importance of effectively managing cognitive load (Gustafsson et al., 2018). This review will explore how cognitive load theory informs our understanding of performance in team sports, while examining strategies to mitigate its negative effects and identifying future research needs.

Cognitive load refers to the total mental effort imposed on working memory (Sweller et al., 1998). This mental effort fluctuates based on task difficulty, environmental conditions, and individual athlete characteristics. Prolonged exposure to cognitively demanding tasks can result in mental fatigue, characterized by decreased cognitive performance, exhaustion, and reduced motivation (Marcora et al., 2009). In team sports, cognitive load is affected by intrinsic factors, like the complexity of the game, and extraneous factors, such as crowd noise and coaching instructions. Sports such as ice hockey are considered to have high intrinsic loads due to the fast pace and rapid, multi-directional movements, requiring athletes to process numerous cues simultaneously. When an athlete experiences excessive cognitive load, it can lead to errors, slow decision-making, reduced situational awareness, and mental fatigue, impairing performance and increasing the risk of injury (Schücker et al., 2013; Smith et al., 2016). Conversely, an optimal cognitive load can enhance focus, decision-making, and skill execution (Faubert, 201 3), particularly in high-pressure situations. Understanding the impact of cognitive load is crucial for coaches, sports scientists, and psychologists seeking to optimize athletic performance. This understanding influences not only individual athlete performance but also team dynamics, as communication and coordination depend on shared cognitive resources (Memmert & Furley, 2007). The study of cognitive load in sports is increasingly interdisciplinary, incorporating insights from sports science, psychology, and neuroscience to provide a holistic understanding of its impact and management (Furley & Wood, 2016; Mann et al., 2007b).

2. COGNITIVE LOAD THEORY (CLT)

Cognitive Load Theory (CLT), developed by Sweller, van Merriënboer, and Paas in 1998, provides a foundational framework for understanding the impact of cognitive load on performance. Its application in team sports is especially pertinent because of the dynamic and unpredictable environment that places substantial cognitive demands on athletes. For instance, a central midfielder in soccer must simultaneously track the positions of teammates and opponents, the trajectory of the ball, while also anticipating the next play, and deciding whether to pass, dribble, or attempt a long-range shot. This dynamic environment places a high intrinsic and extraneous load on working memory (Baddeley, 2003). As working memory has limited capacity and duration, effective management of competing demands is crucial (Cowan, 2010). When working memory capacity is exceeded, processing speed decreases, decision-making quality is compromised, and performance suffers.

CLT categorizes cognitive load into three types:

- **Intrinsic Load:** This refers to the inherent difficulty of a task, determined by its complexity and the learner's prior knowledge (Sweller, 2010). In team sports, intrinsic load is affected by factors such as game rules, opponent strategies, and the need for rapid decision-making. Complex tactical strategies, like those employed in rugby or basketball that involve multiple players and a high degree of coordinated movement, increase the intrinsic load (Young & Salmela, 2010). Sports with fast-paced, multi-directional movement patterns, such as ice hockey, also have a high intrinsic load as they require athletes to process multiple complex cues simultaneously (McGarry & Franks,

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2000). This type of load is generally unavoidable, as it's directly tied to the nature of the sport (Sweller, 2010).

- **Extraneous Load:** This represents unnecessary cognitive effort imposed by how information is presented or the environment (Sweller, 2010). In sports, extraneous load can be generated by distractions such as crowd noise, poorly designed drills with confusing instructions, unclear coaching instructions, or poor communication among teammates (Broadbent et al., 2015). For instance, over-communication on the sidelines, the use of confusing terminology by coaches, or the implementation of drills that do not reflect the game conditions can divert athletes' attention away from critical cues. Environmental factors such as temperature, lighting, and weather conditions can also add to this type of load.
- **Germane Load:** This relates to the mental effort devoted to learning and schema (mental structures that organize knowledge and actions, allowing skilled athletes to perform tasks automatically) formation (Sweller et al., 1998). Germane load is associated with skill acquisition and the development of automaticity, reducing the cognitive demands of complex tasks. Effective coaching strategies focus on optimizing germane load. Coaches can facilitate germane load through strategic questioning, reflection, and providing feedback that promotes understanding of game situations (Van Merrienboer & Sweller, 2005). This type of load should be intentionally promoted to enhance skill development.

CLT has been extensively applied in educational settings, and its relevance to sports is increasingly recognized (Broadbent et al., 2015). For example, a novice basketball player might struggle to dribble while being mindful of teammates and opponents, whereas an expert player is capable of this without much cognitive load. Furthermore, instructional methods that are highly effective for novices may become counterproductive for experts, a phenomenon known as the expertise reversal effect (Kalyuga, 2007).

3. COGNITIVE PROCESSES IN TEAM SPORTS

Team sports place considerable demands on athletes' cognitive processes, encompassing attention, anticipation, memory, perception, spatial awareness, and decision-making. These processes are interdependent and are influenced by the level of cognitive load experienced during performance (Wickens, 2008). Efficient perception of the situation feeds into effective decision-making and attentional control, which is in turn affected by working memory.

- **Attention:** Athletes must selectively focus on relevant cues (e.g., the position of teammates and opponents, the trajectory of the ball) while ignoring distractions (e.g., crowd noise, sideline activity). High cognitive load can narrow attentional focus, leading to inattentional blindness, where critical cues are missed (Memmert & Furley, 2007). Effective performance requires both selective attention (focusing on one thing while ignoring others) and the ability to shift focus between relevant cues (attention switching), as well as divided attention (tracking multiple sources of information simultaneously) (Wickens, 2008). For example, in a fast-paced soccer game, a midfielder might need to use selective attention to track the ball, attention switching to anticipate the movements of teammates and opponents, and divided attention to keep awareness of the overall game situation. The ability to filter irrelevant information and prioritize relevant stimuli is crucial for effective performance.

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- **Anticipation:** Anticipation is a vital cognitive function, enabling athletes to preempt potential events based on observed cues, which reduces cognitive load and allows for quicker, proactive responses (Mann et al., 2007b). This involves perceptual anticipation (predicting the path of an object) and cognitive anticipation (predicting the actions of others) (Abernethy & Wood, 2001). A skilled quarterback might use perceptual anticipation to gauge the trajectory of a football, while using cognitive anticipation to predict the receiver's route based on the defender's position and movement patterns, which allows them to release a throw without needing to fully watch the play unfold (Roca et al., 2013). Skilled players can often anticipate an opponent's actions based on posture or movement and respond faster than less experienced players, who must process the action as it unfolds (Mann et al., 2007b).
- **Memory:** Working memory is essential for temporarily storing and processing information, such as play strategies, opponent tendencies, or the positions of teammates (Baddeley, 2000). Excessive cognitive load can overwhelm working memory, impairing recall and decision-making (Memmert & Furley, 2007). The capacity of working memory is limited, and when exceeded, the athlete may experience cognitive overload (Cowan, 2010). For example, a rugby player who is unable to remember a new play due to cognitive overload might hesitate, missing their cue, which would compromise team cohesion.
- **Perception:** Athletes rely on perceptual skills to interpret visual and auditory cues in real-time (Mann et al., 2007b). Cognitive load can impact on perceptual accuracy, particularly in fast-paced sports such as soccer and basketball (Faubert, 2013). This includes the speed and accuracy of processing relevant information to make well-informed decisions (Vickers, 2007). For example, if a soccer player is experiencing cognitive overload, they may inaccurately gauge the speed and distance of an incoming pass.
- **Spatial Awareness:** Understanding the position and movement of oneself and others in a three-dimensional space is crucial for athletes to react effectively within dynamic game environments (Mann et al., 2007b). This involves tracking moving objects and predicting trajectories (Helsen & Starkes, 1999). For instance, understanding the positioning of oneself and others in a three-dimensional space allows a soccer player to make informed passes and movements to not be offside or to pass into a free space. Another example can be in basketball, where players require an in-depth understanding of each other's positions to make good passes and create offensive strategies.
- **Decision-Making:** Effective decision-making in team sports requires integrating multiple information sources under time pressure (Mann et al., 2007b). High cognitive load can slow decision-making and increase the likelihood of errors (Broadbent et al., 2015). Athletes must quickly evaluate the information available to them and select an appropriate course of action (Raab, 2012). For example, a hockey player under cognitive overload might pass to a defender instead of a forward on the opposing team, leading to a turnover.

Understanding these cognitive processes and their interaction with cognitive load is critical for developing training programs that enhance performance and reduce the risk of errors (Ericsson et al., 1993). Research is also starting to explore the neural basis of these cognitive processes, providing insight into underlying mechanisms (Krakauer et al., 2017).

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4. IMPACT OF COGNITIVE LOAD ON PERFORMANCE

Cognitive load significantly influences athlete performance in team sports, affecting decision-making, skill execution, and overall effectiveness during competition (Smith et al., 2016). While optimal cognitive load can enhance focus and performance, excessive cognitive load often leads to errors, fatigue, and decreased efficiency (Schücker et al., 2013). The relationship between cognitive load and performance can be represented by an inverted-U relationship, where both very low and very high cognitive loads are detrimental, with optimal performance occurring at a moderate load (Yerkes & Dodson, 1908). At very low cognitive loads, athletes may experience boredom and disengagement, resulting in decreased effort and focus. Conversely, high levels of cognitive load cause overload, impacting information processing and decision-making (Sweller et al., 1998). The optimal level of cognitive load can vary depending on individual factors and the specific task, highlighting the need for nuanced management approaches (Ericsson et al., 1993).

A closer look at cognitive load reveals both positive and negative effects on athletes in team sports.

4.1 Positive Effects of Cognitive Load: When managed effectively, cognitive load can enhance an athlete's performance by promoting focus, adaptability, and decision-making under pressure (Faubert, 2013). A moderate cognitive load can increase arousal levels, leading to improved attention and faster reaction times (Memmert & Furley, 2007). For example, a well-designed drill that introduces a challenge without being overwhelming, helps an athlete develop their skills while increasing arousal. Under conditions of controlled cognitive load, athletes can push themselves to their 'challenge point,' where they are challenged sufficiently to develop new skills without being overwhelmed. Elite athletes demonstrate the ability to use their developed schemas and automaticity to process complex information efficiently (Furley & Wood, 2016). Additionally, cognitive load can facilitate learning and skill acquisition during training as athletes adapt to new scenarios (Broadbent et al., 2015).

4.2 Negative Effects of Cognitive Load:

Excessive cognitive load can cause athletes to prioritize speed over accuracy, or vice versa, leading to errors or missed opportunities in fast-paced team sports. Research indicates that both speed and accuracy are compromised under high cognitive load (Chow et al., 2006) . Furthermore, high levels of cognitive load can overwhelm an athlete's working memory, reducing their ability to process information (Van Merrienboer & Sweller, 2005). For example, under cognitive overload, a basketball player might make a hasty pass to a well-defended player instead of making a better decision, resulting in a turnover. High intrinsic load, such as processing multiple cues simultaneously, leads to slower decision-making and increased errors (Smith et al., 2016). Extraneous load, such as environmental distractions or unclear instructions, can worsen these effects by diverting attention away from the task (Memmert & Furley, 2007). Over time, sustained high cognitive load can result in mental fatigue, which negatively impacts both physical and cognitive performance (Schücker et al., 2013). Mentally fatigued athletes exhibit reduced accuracy in passing, shooting, and tactical decision-making, particularly in the latter stages of a game (Smith et al., 2016). High cognitive loads can also increase susceptibility to injury due to reduced awareness and focus (Schücker et al., 2013; Smith et al., 2016).

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4.3 Individual Differences in Managing Cognitive Load: The impact of cognitive load varies among athletes based on factors such as experience, skill level, biological sex, age, cognitive abilities, cultural background, learning style, expertise, motivational profile, and personality (Furley & Wood, 2016). Experienced athletes manage cognitive load better due to developed schemas and automaticity, allowing them to perform complex tasks with minimal mental effort (Faubert, 2013). Conversely, novice athletes often struggle with high cognitive load due to a lack of expertise to filter out irrelevant information (Memmert & Furley, 2007). Furthermore, differences in working memory capacity and attentional control affect how athletes respond to cognitive load (Furley & Wood, 2016). Psychological factors such as resilience, self-efficacy, pre-competitive anxiety, and motivation also play a role (Crust, 2008). For example, athletes with high trait anxiety may find it more difficult to manage cognitive load compared to those with low anxiety levels, particularly during high-stakes situations.

5. STRATEGIES TO MANAGE COGNITIVE LOAD

Effectively managing cognitive load is essential for optimizing performance and reducing errors in team sports (Broadbent et al., 2015). Coaches, sports scientists, and psychologists have developed several strategies to help athletes manage cognitive load, including training interventions, psychological techniques, and environmental modifications (Furley & Wood, 2016). These strategies can be used in an integrated way to optimize performance.

5.1 Training Interventions: Training interventions are effective in reducing intrinsic and extraneous cognitive load while optimizing germane load (Sweller et al., 1998). Simulation training allows athletes to practice in game-like scenarios, promoting automaticity and reducing cognitive effort during competition (Broadbent et al., 2015). This can include drills that mimic game scenarios, such as small-sided games, and the use of immersive technologies like virtual reality (VR). For example, a basketball team might use a scrimmage-like training drill to simulate match conditions, improving their decision-making without the additional stress of competition. VR can replicate the complexity of a real game, thereby helping athletes manage cognitive load efficiently (Gray, 2017). For instance, VR technology can simulate different game scenarios to enable athletes to make quick, informed decisions under pressure. Video analysis is another valuable tool that enables athletes to review performance and identify areas for improvement without real-time pressure (Memmert & Furley, 2007). Decision-making drills can enhance an athlete’s ability to process information accurately, reducing cognitive load during play (Smith et al., 2016). For example, soccer players often use small-sided games to simulate match conditions and improve decision-making. Error management training exposes athletes to challenging situations that might lead to errors, teaching them to recognize and overcome errors, thereby reducing stress and fatigue during real games (Keith & Frese, 2005). In volleyball, coaches use 'block and react drills' to develop reactive agility, also providing an opportunity for error management and skill development. These strategies should, however, be implemented in a way that does not add to the extraneous load experienced by athletes. A table summarizing these strategies is included below.

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Strategy	Cognitive Load Type Target	Explanation	Examples
Simulation Training	Reduces Intrinsic, optimizes germane load	Provides practice in game-like scenarios, promoting automaticity and reducing cognitive effort during competition	Small-sided games, VR simulation
Video Analysis	Reduces Extraneous Load	Allows athletes to review performance and identify areas for improvement without real-time pressure	Analysis of game footage
Decision-Making Drills	Reduces Intrinsic Load	Enhances ability to process information accurately, reducing cognitive load during play.	Drills that impose constraints on time, space, or touches to improve decision-making speed and quality.
Error Management Training	Reduces Extraneous Load	Exposes athletes to challenging situations to learn from mistakes and reduce stress and fatigue during games.	Reactive drills, focused reflection

5.2 Psychological Techniques: Psychological techniques improve focus, reduce stress, and enhance mental resilience, thereby managing cognitive load (Schücker et al., 2013). Mindfulness training improves attentional control and reduces the impact of extraneous load (such as environmental distractions). For example, athletes can use mindfulness techniques to intentionally redirect their focus away from distractions to relevant cues. Visualization techniques, where athletes mentally rehearse their performance, can reduce cognitive load by enhancing confidence and familiarity with game scenarios (Broadbent et al., 2015). For example, a football player might use visualization to 'see' the pass before they make it, reducing on-the-spot cognitive burden. Stress management strategies, such as controlled breathing and positive self-talk, help athletes maintain optimal arousal and prevent overload in high-pressure situations (Smith et al., 2016). Elite athletes like LeBron James use visualization techniques to enhance performance under pressure, reducing stress and improving focus. These strategies should be tailored to suit the individual's needs and preferences, because there is no one size that fits all solution.

5.3 Environmental Modifications: Modifying the training and competition environment can significantly reduce extraneous cognitive load (Memmert & Furley, 2007). Minimizing distractions

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during practice, such as reducing crowd noise, and limiting unnecessary coaching instructions help athletes focus on task-relevant information (Broadbent et al., 2015). Simplifying communication among teammates using clear signals can also reduce cognitive load and improve coordination (Furley & Wood, 2016). For example, using hand gestures instead of verbal communication can streamline decision-making. Structured training environments can help athletes develop schemas and automaticity, reducing the cognitive effort required for complex tasks (Sweller et al., 1998). Teams like the New Zealand All Blacks use structured huddles and clear communication protocols to minimize cognitive load (Mann et al., 2007b). During time-outs, simplified instructions and tactical cues are used. In competition, team managers might design pre-game routines to minimize distractions and implement communication protocols that use cues and symbols to reduce cognitive load. Furthermore, team talks during timeouts may also be simplified to ensure the transmission of important information without overloading the athlete (Oh, 2023).

6. GAPS AND LIMITATIONS

While sports such as soccer and basketball have been extensively studied, others such as rugby, hockey, and volleyball remain under-researched in the context of cognitive load (Furley & Wood, 2016; Smith et al., 2016). Most studies are also short-term or laboratory-based, limiting their ecological validity in assessing the long-term impacts of cognitive load on performance and injury risk (Abernethy & Wood, 2001; Broadbent et al., 2015; Schücker et al., 2013). Furthermore, studies often focus on skill acquisition in athletes but less on the transfer of these cognitive skills in real-time game play (Chow et al., 2006). Methodological challenges such as a lack of easily measurable and ecologically valid assessments of cognitive load have also hindered research (Paas et al., 2003). Studies often rely on lab-based tests that do not fully replicate the dynamic nature of on-field conditions, where there is more variability in player movement, environmental changes, and opponent behavior (Pinder et al., 2011). This lack of ecological validity is a significant limitation. Furthermore, there is limited exploration of how individual differences like age, gender, biological sex, cognitive abilities, learning styles, cultural background, expertise and motivational profiles influence cognitive load management in team sports (Furley & Wood, 2016). Research has predominantly focused on individual athletes, leaving a gap in understanding how cognitive load affects team-level dynamics, including communication, coordination, and decision-making (Memmert & Furley, 2007) .There is also a lack of research on the long-term effects of chronic cognitive overload and burnout among athletes in team sports. In addition to quantitative approaches, more qualitative research may also provide rich contextual insights into athletes' cognitive experiences (Cushion & Jones, 2006). There is also a lack of longitudinal studies that examine cognitive load over time (e.g. a season or a career). Research in this area is limited by both methodological and theoretical constraints.

7. FUTURE RESEARCH DIRECTIONS

Future research should involve collaboration between sports scientists, psychologists, neuroscientists and technologists to develop innovative solutions for managing cognitive load. A focus should be on personalized approaches, investigating individual differences in cognitive load management and designing interventions based on factors like working memory capacity, attentional control, personality traits, learning styles, expertise, biological sex, and motivation (Memmert & Furley, 2007). Integrating advanced technologies such as eye-tracking, EEG, and VR

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can provide real-time data on cognitive processes, enabling more accurate measurement and targeted interventions (Faubert, 2013; Smith et al., 2016). For example, future research should use EEG to identify neural markers of cognitive overload during gameplay and to develop personalized, real-time training strategies based on this data. Techniques like electroencephalography (EEG) can help measure neural activities related to cognitive load and attentional focus. Future research can also evaluate the use of wearable technology to measure not only physiological but also neural data to correlate it with cognitive load. Furthermore, future studies should expand beyond individual athletes to examine the impact of cognitive load on team dynamics, including communication, coordination, and collective decision-making, while developing strategies to optimize team-level cognitive load management (Furley & Wood, 2016; Memmert & Furley, 2007). This includes considering how collective cognitive load affects overall team functioning. Artificial intelligence (AI) tools could also be used to analyze patterns in athlete behaviors and performance. Future research should focus on how AI can be used to monitor cognitive patterns for the development of personalized training programs (Pillay & Rensburg, 2018). These technologies must be implemented responsibly, with attention being paid to the ethical implications of using data from athletes to monitor and modify their training.

Longitudinal studies are essential to understand how cognitive load management impacts skill development, performance trajectories, and the potential for long-term skill acquisition and retention. These studies could involve tracking athletes over a season or across multiple years to assess the impact of training on cognitive load management. Future research should also explore team-level cognitive load and its influence on communication, coordination, and collective decision-making (Broadbent et al., 2015; Memmert & Furley, 2007). Additionally, more qualitative research should also be undertaken to get more insight into athletes' experiences.

8. CONCLUSION

Cognitive load plays a vital role in the performance of athletes in team sports, shaping their decision-making, skill execution, and overall effectiveness under pressure (Broadbent et al., 2015; Smith et al., 2016). This review has highlighted the dual nature of cognitive load: managed effectively it enhances focus and adaptability, but excessive cognitive load can lead to errors and mental fatigue (Furley & Wood, 2016; Schücker et al., 2013). By examining intrinsic, extraneous, and germane sources of cognitive load, this review offers a framework for understanding its impact on individual athletes and team dynamics(Memmert & Furley, 2007; Sweller et al., 1998).

The evidence-based strategies discussed, including simulation training, mindfulness techniques, and environmental modifications, offer practical tools for optimizing cognitive load management (Broadbent et al., 2015; Smith et al., 2016). Critical gaps remain, including sport-specific research, longitudinal studies, and the integration of technologies like eye-tracking and VR to measure cognitive load in real-time (Faubert, 2013; Furley & Wood, 2016). Addressing these research gaps by leveraging innovative, evidence-based approaches will empower athletes to navigate the cognitive demands of their sport with greater resilience and efficiency. As we continue to delve deeper into the complexities of cognitive load, the potential for transforming how we train and prepare athletes remains considerable. Future research should focus on applying these findings

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to improve the efficacy of training methods, enhancing the performance of athletes, and optimizing their mental well-being, ensuring they are able to flourish in competitive sport.

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THE IMPORTANCE OF FASCIA AND FASCIAL TRAINING TO IMPROVE SPORTS PERFORMANCE

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ABSTRACT

Fascia, a complex network of soft connective tissue that envelopes muscles, organs, and structures throughout the body, forming an uninterrupted web throughout, playing a pivotal role in optimizing movement efficiency, force transmission, and musculoskeletal health. Historically underappreciated in rehabilitation and athletic training, recent studies have highlighted its significance in biomechanics, proprioception, and injury prevention.

This review delves into the anatomical and physiological characteristics of fascia, including classification based on structure and function, emphasizing its function in distributing loads, storing energy, and coordinating movement. The interconnected nature of fascia facilitates efficient force transfer between muscle groups, contributing to enhanced performance and reduced injury risk. Various fascial mechanisms and training principles, such as myofascial release, manual fascial therapy, dynamic stretching etc. are explored for their impact on tissue remodeling, mobility and neuromuscular function.

Furthermore, the discussion addresses the consequences of fascial dysfunction like stiffness, adhesions, and decreased elasticity, which can lead to musculoskeletal pain and impaired movement mechanics. The review discusses the integration of fascial training into rehabilitation programs, with a focus on evidence-based methods to improve movement efficiency, injury resilience, and functional recovery.

By synthesizing current research on fascia and its training methods, this review highlights the need for a comprehensive approach to musculoskeletal health, which moves beyond conventional muscle-centric training models. Optimizing fascial properties can enhance athletic performance depending on the sport (with change significance being different for different sports), sex, and age, but also reduces injury risk, and improves overall movement quality in both clinical and sports settings.

Keywords: Fascia, Fascial Anatomy, Biomechanics of Fascia, Catapult Mechanism, Fascial Proprioception, Fascial Training Principles, Manual Therapies, Myofascial Release, Fascial Manipulation.

1. INTRODUCTION

What is Fascia?

Fascia is a connective tissue with a 3-dimensional structure present throughout our body from our head to our toe. Fascia, recognized by the Fascia Research Congress in 2007, is the soft tissue component within the body's connective tissue network. It creates a 3-dimensional framework that supports the entire body. This viscoelastic matrix envelopes muscles, bones and organs, forming an uninterrupted web throughout. (Findley et al., 2012). Since the fascia is made up of collagenous matrix, the potential of this matrix of fascia to influence muscle tissue is great (Bond et al., n.d.).

This continuous network of tissue consists of ligaments, tendons, joint capsules, retinaculae, aponeuroses, muscle envelopes and intramuscular connective tissues. Fascia plays a key role in our body including – transmitting mechanical forces between muscles, changing mechanical forces into electrical energy due to its piezoelectric property (Findley et al., 2012). Fascia plays a vital, active role in numerous bodily functions, highlighting its importance in health and diseases. It contributes to lymphedema, influences the origin of pain, helps maintain posture, and is intimately linked to proprioception due to its network of free nerve endings, muscle spindles, and mechanoreceptors, which connect to the afferent nervous system. Fascia is also crucial for force transmission and coordination, aids in improving range of motion (ROM), and impacts the functions of organs and glandular systems in both normal and pathological states. This wide-ranging involvement underscores its significance as a key player in overall bodily function and well-being(Varghese & Geetha Hari Priya, 2017). Fascia possesses a unique ability to adapt its consistency under stress (plasticity) and recover its elasticity through manipulation (malleability) (Findley et al., 2012).

2. ANATOMY OF THE FASCIA:

The fascia is fundamentally made of three layers – 1. Superficial Fascia, 2. Deep Fascia and 3. Muscle related layers – Epimysium, Perimysium and Endomysium (Findley et al., 2012). The Fascial Integration Conceptual Anatomical Tool (FICAT) categorizes fascia based on location in two ways: (i) in relation to the body region: fascia of the head and neck, fascia of trunk and limb fascia. (ii) In relation to the surrounding structure: Subcutaneous fascia, visceral fascia, parietal fascia and fascia extraserosalis (any fascia located between the parietal and visceral fascia) (Kumka & Bonar, 2012).

a. The Superficial Fascia:

Superficial fascia is comprised of the subcutaneous loose connective tissue which contains a web of collagen, including fibers of mostly elastin, containing fat within its meshes. (Findley et al., 2012) stated that superficial fascia is absent in the soles of feet, the palms of the hands and in the face. However, (Varghese & Geetha Hari Priya, 2017) contracticted this, stating that fascia is present throughout the body, and has arrangements and thickness that varies according to the region, body surface, and genders. Superficial fascia also plays a role in the integrity of the skin and support for subcutaneous structures, especially the veins, by ensuring their patency.

b. The Deep Fascia:

Deep fascia is a dense connective tissue layer, surrounding individual muscles and groups of muscles, separating them into fascial compartments. It sheaths muscles, nerves and vessels, and envelops organs and glands, but unlike the superficial layer, this layer is devoid of fat. Both the superficial layer and the deep layers are richly supplied with free nerve endings. The deep fascia contains many sensory receptors, including nociceptors (pain), proprioceptors (movement), mechanoreceptors (pressure and vibration), chemoreceptors (chemical changes), and thermoreceptors (temperature). Mechanical forces that stretch the fascia are sensed the Paccinian corpuscles and Ruffini nerve endings. Avascular in nature, the inner layer of the deep fascia contains hyaluronic acid (HA) secreting cells are the apparent source of the lubricant hyaluronic acid. In the limbs, the deep fascia forms well-defined connective tissue layers such as the fascia lata (that is 1mm thick), crural fascia, and brachial fascia (Findley et al., 2012; Varghese & Geetha Hari Priya, 2017).

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c. **The Epimysial Layer**

The epimysium consists of fascia that covers each single muscle and is continuous with the perimysium and endomysium and has a direct involvement in the play of muscle spindles and Golgi tendon organs and its close relation with the muscle spindles reveals its role in peripheral coordination and proprioception. The epimysium lies beneath the deep fascia and glides freely in some regions while it binds with the deep fascia in other regions. The epimysium subdivides the muscle into bundles; within the bundle, the endomysium has few elastic fibers and no adipose tissue, while outside the bundle, it contains many adipose tissues and elastic fibers. Overstretching the epimysial fascia can lead to chronic stretching and overactivation of connected muscle spindles, potentially causing constant stimulation and contraction of associated muscular fibers leading to trigger points, muscular imbalances, recurrent cramps, and restricted joint movement. Normal muscular function, hence, relies on normally well-hydrated functioning fascia, and the epimysial fascia could be considered a key element in peripheral motor coordination (Findley et al., 2012; Varghese & Geetha Hari Priya, 2017).

3. FUNCTIONAL CLASSIFICATION OF THE FASCIA

A functional classification of the fascia was developed by Kumka & Bonar, 2012 to organize the fascia nomenclature according to the FICAT (Federative International Committee on Anatomical Terminology), comprising four categories: Linking, Fascicular, Compression, and Separating Fascia.

a. Linking Fascia:

The linking fascia category, characterized by its dense regular parallel ordered unidirectional connective tissue proper and high collagen type I content, includes structures such as muscle fascia, regional fascia (head & neck, trunk, limbs), aponeuroses, tendinous arches, and neurovascular sheaths. Functionally, it is subdivided into dynamic and passive components. The dynamic division is heavily involved in movement and joint stabilization, with a greater presence of contractile and proprioceptive fibers. The passive division contributes to overall body continuity and the formation of tunnels and sheaths, primarily influenced by extra-muscular forces.

b. Fascicular Fascia:

Forming adaptable tunnels for vessels and fascicles in muscle, tendon, bone, and nerve, fascicular fascia is vital for organization, transport, strength, and locomotion. This category consists of a blend of loose and dense regular multidirectional connective tissues, primarily composed of collagen types I and III, with minor contributions from Types V, VI, XII, and XIV. The intramuscular connective tissue (IMCT) component is key to myofascial force transmission, boosting muscle force and allowing transfer of forces within muscles to synergistic muscles, and via linking fascia, to antagonistic muscles.

c. **Compression Fascia:**

Forming a stocking-like layer around the limbs, compression fascia is composed of dense regular woven and multidirectional parallel ordered connective tissue. This fascial category contributes significantly to locomotion and venous return by modulating compartmental pressure, muscle contraction, and force distribution. Examples of compression fascia include the fascia lata, crural fascia, brachial fascia, and antebrachial fascia.

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d. **Separating Fascia**:

Composed of loose and dense irregular fusocellular connective tissue, separating fascia's ECM mainly contains reticular Type III collagen and elastic fibers, with minor amounts of collagen Types V and VII. This type of fascia, according to FICAT, includes parietal, visceral, extraserosal, and investing /subcutaneous fascia (previously fascia superficialis), as well as synovial sheaths and fasciae of the limbs. Its primary function is to facilitate the sliding of tissues, accommodating forces and friction.

4. PURPOSE OF REVIEW

Sports require innovative training methods, making it essential to move beyond traditional training regimes. Newer methods will help us improve athletic performance, reduce injury risks and make fitness more accessible (Luiselli et al., 2011). The purpose of this review is to understand the Fascial system of the human body, its important functions and roles, and how it helps to improve sports performance. This review also explores methods for training the fascial system to enhance performance.

5. CONTRIBUTION OF FASCIA TO SPORTS PERFORMANCE

Biomechanics of Fascia:

The fascia is composed of multiple layers of collagen fibers with different spatial orientations: with each layer exhibiting anisotropic characteristics, i.e. the mechanical load response of a single layer differs if the layer is loaded along the direction of the collagen fibers or along another direction (Findley et al., 2012). The arrangement of collagen fibers in the layers gives the fascia the ability to adapt and withstand specific tensile loads (Bonaldi et al., 2023).

The stress-strain curve of fascia is non-linear due to the uncrimping of collagen fibers and the elasticity of elastin fibers. The initial portion of the stress-strain curve demonstrates high deformation with low force. As strain increases, the fascia responds with a corresponding increase in stress (Bonaldi et al., 2023; Fede et al., 2021; Stecco et al., 2020).

Fascia's force transmission capabilities challenge the traditional myotendinous pathway model of force transfer to bones and joints. This force transmission can be studied by examining how intramuscular connective tissue (endomysium, perimysium, epimysium) affects structures within and beyond the muscle compartment (Bond et al., n.d.). Traditionally, skeletal muscles have been thought to transmit force to bone insertions via the myotendinous junction. However, research now indicates that intermuscular and extra-muscular fascial tissues also serve as force transmission pathways. The magnitude of force transmission via these pathways is influenced by the mechanical properties of myofascial tissue. Myofascial tissue stiffness or compliance can affect intermuscular force transmission and muscle mechanics (Zügel et al., 2018).

The Catapult Mechanism: Elastic Recoil of the Fascial Tissues:

Human fasciae possess a kinetic storage capacity like that of kangaroos and gazelles. During movement, muscle fibers may contract almost isometrically, while fascial elements function elastically, behaving like a yo-yo. The lengthening and shortening of these fascial elements largely drive the actual movement. However, with age, the elasticity of gait diminishes, and the fascial architecture adopts a more haphazard and multidirectional fiber arrangement compared to the typical two-directional lattice arrangement of fascia for young people. Regular exercise can lead to a more youthful collagen architecture, characterized by a wavy fiber arrangement and increased

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elastic storage capacity (Bond et al., n.d.; Schleip & Müller, 2013).

Stretching and Myofascial Health:

While pre-competition stretching may hinder performance, consistent dynamic stretching can improve the elasticity of connective tissue when performed correctly. Regular static and dynamic stretching can lead to long-term gains in force, jump height, and speed (Schleip & Müller, 2013). Different stretching methods appear to target different components of the fascial tissue (Schleip & Müller, 2013; Warneke et al., 2024). Traditional weight training strengthens fascial tissues arranged in series with active muscle fibers by loading the muscle within its typical range of motion. Dynamic muscular loading, which involves brief muscle activation in a lengthened position, may offer the most comprehensive stimulation of fascial tissues (Schleip & Müller, 2013).

A study showed that both static and dynamic stretching decreased stiffness in muscles, with static stretching having larger effects on stiffness and ankle range of motion. Static stretching reduced both muscle and fascia stiffness, while dynamic stretching did not reduce stiffness when compared to a control condition (Warneke et al., 2024).

Hydration and Renewal

It is crucial to understand that fascial tissues consist of approximately two-thirds water. When mechanical forces are applied, such as stretching or local compression, a substantial amount of water is displaced from the more stressed areas, much like squeezing water from a sponge. With the release of stress, this region is again filled with new fluid which comes from surrounding tissues and local vascular network (Schleip & Müller, 2013).

Fascia as a Sensory Organ:

Fascia is richly supplied with sensory nerves, including proprioceptive receptors, multimodal receptors, and nociceptive nerve endings. Tissues with a denser innervation can detect subtle changes in the direction of mechanical forces, while less densely innervated tissues, such as the lacertus fibrosus, are specialized for transmitting unidirectional forces passively. Fascia is crucial for proprioception, acting as our most important organ for this function. Recent discoveries show that the superficial fascial layers are more densely populated with sensory nerve endings compared to deeper connective tissues (Schleip & Müller, 2013; Suarez-rodriguez et al., 2022).

6. TRAINING PRINCIPLES

a. Preparatory Counter Movement

This movement principle leverages the catapult effect of fascial tissues. In an exercise known as 'the flying sword', the body's axis is briefly tilted backward while simultaneously lengthening upward. This action increases the elastic tension in the fascial network, enabling the upper body and arms to propel forward and downward with a catapult-like motion as the weight shifts. Conversely, when straightening up, the catapult effect is activated by pre-tensioning the fascia in the back, allowing for a dynamic release of stored energy(Schleip & Müller, 2013).

b. The Ninja Principle

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Stairs can be transformed into effective training equipment by using them with gentle stepping techniques. The goal of producing minimal noise provides valuable feedback, as quieter movements indicate a greater utilization of the fascial spring effect. Practicing barefoot or with barefoot-like footwear enhances this "stair dancing" by promoting better plantar contact with the ground. To achieve a smooth and elegant quality of movement, changes in direction should be preceded by gradual deceleration and followed by gradual acceleration, avoiding any abrupt or jerky actions. This approach ensures that each movement flows seamlessly into the next (Schleip & Müller, 2013)

c. Slow and Dynamic Stretching

Instead of holding a static stretch, a more dynamic approach is recommended. This involves fluid movements that can be both fast and slow, incorporating multidirectional actions with slight angle changes. These movements might include sideways, diagonal, or spiraling rotations, engaging extensive areas of the fascial network simultaneously. An example of this method is the Big Cat Stretch, which involves a slow, flowing movement that stretches the long posterior chain from the fingertips to the sit bones, and from the coccyx to the top of the head and heels (Schleip & Müller, 2013; Stecco et al., 2020).

d. Proprioceptive Refinement

It is crucial to emphasize the significance of fascial proprioception throughout the training process. In line with this, the proposed fascia training encourages a refined perception of shear, gliding, and tensioning motions within superficial fascial membranes. By leveraging elastic recoil properties, the training incorporates 'fascial refinement' elements, which involve experimenting with diverse movement qualities. These include extreme slow-motion movements, very quick micro-movements that may be imperceptible, and large macro-movements that engage the entire body (Findley et al., 2012; Schleip & Müller, 2013; Unalmis & Muniroglu, 2023).

e. Squeezing and Rehydrating the Sponge

Special foam rollers or similar materials can be beneficial for inducing temporary localized tissue dehydration, akin to squeezing a sponge, which leads to renewed hydration. An example of this is the "Octopus Tentacle" exercise, where slow-motion extensional movements throughout the leg are performed, evoking tensional fascial proprioception through creative muscle activation patterns. This approach also involves deep myofascial stimulation, targeting both the fascial envelopes and the septa between muscles. Additionally, specific foam rollers can provide localized tissue stimulation similar to manual myofascial release, offering comparable benefits.

7. MANUAL THERAPIES

Myofascial Release:

Myofascial release techniques (MRTs) are widely used to enhance athletes' range of motion (ROM) by releasing tension in the fascia. However, their effectiveness can vary based on the specific method employed. MRTs help prevent pain and discomfort caused by tight muscles and improve circulation by breaking down fascial adhesions, which is a key short-term physiological effect. Techniques like foam rolling, stretching, and proprioceptive neuromuscular facilitation (PNF) are commonly used for myofascial release. Systematic reviews have confirmed that MRTs reduce pain, improve muscle function, enhance performance, and aid recovery. They also improve

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blood circulation, facilitating the delivery of oxygen and nutrients to tissues and promoting metabolic changes between the fascia and extracellular matrix. While MRTs are beneficial across various sports, it is unclear which sports benefit the most, and factors like gender may influence their effectiveness (Antohe et al., 2024; Khan et al., 2022; Martínez-Aranda et al., 2024; Šćepanović et al., 2024).

Fascial Manipulation

Manual fascial therapy can contribute to reducing metabolic expenditure, improving exercise tolerance, and enhancing motor coordination. One technique, Fascial Manipulation (FM), developed by Luigi Stecco, is used to treat musculoskeletal disorders. To promote collagen synthesis and regeneration, it is recommended to stimulate fascial tissues once or twice a week. Studies have shown that fascial mobilization and manipulation techniques can positively impact performance by improving flexibility, sprinting, jumping, and anaerobic power. FM has also been found to enhance muscle reaction time, motor time, peak activity time, and peak force time. The manipulation involves applying deep friction to densified points to restore fascial gliding properties, leading to pain reduction, increased range of motion, and improved function (Findley et al., 2012; Khan et al., 2022; Unalmis & Muniroglu, 2023; Varghese & Geetha Hari Priya, 2017). Manual therapies, including massage, osteopathy, and Rolfing—a technique focused on symmetrical body alignment—have been employed to enhance fascial tissue regeneration and improve athletic performance. However, the effectiveness of these methods remains to be fully validated (Zügel et al., 2018)

Challenges and Limitations

A significant limitation of one study was the intervention's duration, which may not have been sufficient to fully capture the effects on the fascial system. Given that fascia adapts slowly, a longer study period, such as six months or more, could offer more comprehensive insights. Additionally, examining other aspects of human performance, like muscular power or endurance, might be more effective in assessing the impact on fascial tissue (Bond et al., n.d.). One of the significant limitations of another study is the lack of a universally accepted protocol in the literature for the application of performance-oriented fascial therapy, particularly in terms of mode and duration, across different sports disciplines (Unalmis & Muniroglu, 2023). The lack of methodological consistency across studies hinders the development of a universally accepted self-myofascial release (SMR) protocol for athletes (Martínez-Aranda et al., 2024). The effectiveness of myofascial release techniques in different sports remains unclear, as it is not well understood which sports benefit most from these methods. Additionally, gender factors may influence the efficacy of myofascial release, as there is limited research, with only one study examining its impact on range of motion (ROM) in female athletes (Antohe et al., 2024). Future studies should prioritize advanced strain elastography protocols to enhance the reliability of fascial stiffness assessments. This is particularly critical given that the sole significant correlation observed in our study was between fascia stiffness and range-of-motion (ROM) improvements, underscoring the need for further validation of these findings. Also, ultrasound assessments can be subject to methodological limitations, primarily due to the subjective nature of probe pressure, measurement angle, and

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location. To mitigate these issues, extensive pilot measurements were conducted to ensure consistent results (Warneke et al., 2024).

Directions for Future

Fascia is believed to play a crucial role in proprioception due to its rich innervation with mechanoreceptors, which primarily respond to tension. The transmission of tensile forces to these receptors presents a promising area for further investigation. The discovery of a connective signaling network within fascia could significantly enhance our understanding of health and disease (Langevin, 2021). Additionally, determining the in vivo viscoelastic mechanical properties of fascia at various body locations could profoundly impact the design of manual therapy interventions (Findley et al., 2012). Fascia is also considered a piezoelectric material capable of converting mechanical forces into electrical energy, suggesting that changes in its mechanical properties before and after manual therapies—due to piezoelectric effects—could be a valuable area of research (Suarez-rodriguez et al., 2022). Previous research often overlooked the impact of connective tissue properties when examining flexibility improvements resulting from stretching. The study done by (Warneke et al., 2024) was the first to investigate the acute effects of various stretching techniques on muscle and fascia stiffness, correlating these with changes in range of motion (ROM). By demonstrating that fascial tissue responds acutely to mechanical overload, it was suggested that future studies should adopt a more comprehensive approach, considering both muscle and fascia, rather than focusing solely on muscle parameters. Quantifying hyaluronic acid (HA) in the deep and muscular fasciae across different anatomical regions and in various pathological conditions can significantly enhance our understanding of the pathophysiology of these tissues (Fede et al., 2018). A deeper cellular and molecular insight may reveal changes that are not visible during clinical examination and are not anticipated by current clinical practices. Furthermore, identifying the specific cellular and molecular structures involved in fascial dysfunctions could enable more targeted therapeutic approaches (Pratt, 2021).

8. CONCLUSION

Fascia is not merely a simple band of connective tissue; it is a complex and vital structure that supports, envelops, connects, and interacts with various bodily tissues. The fascial system pervades the entire body, facilitating the integrated functioning of all its systems. Each cell within the fascia and every component of the extracellular matrix has distinct roles, can respond to diverse stimuli, and can be modulated. Factors such as aging, exercise, and hormonal changes can influence the fascial system (Fede et al., 2021). Fascia demonstrates nonlinear elastic and plastic deformation capabilities influenced by load magnitude, duration, and rate. Its viscoelastic behavior arises from the combined influence of architectural organization, molecular composition, and hydration levels within its connective tissue components. Additionally, fascia houses a rich network of interstitial myofascial receptors that act as specialized mechanoreceptors, responsive to both tension and compressive forces (Bond et al., n.d.). Fascia Lata and Plantar Fascia are extremely stiff tissues. They require forces significantly beyond the normal physiological range to achieve just 1% compression or shear. In vitro studies have shown that both Fascia Lata and Plantar Fascia exhibit similar behavior when stretched. Higher loads are necessary to produce the same amount of strain when the rate of stretching is increased (Findley et al., 2012). To standardize the terminology of fascia, we developed a functional classification system that divides fascia into four categories: i) linking, ii) fascicular, iii) compression, and iv) separating fasciae. This classification is based on

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the functional properties of fasciae, supported by observations from the literature on their gross anatomical, histological, and biomechanical characteristics (Kumka & Bonar, 2012). Understanding fascial biomechanics provides crucial insights into how these tissues adapt and respond to different stretching techniques. By analyzing their mechanical properties, researchers can systematically explain fascial reactions – including both temporary elastic changes and lasting structural adaptations – when subjected to varying stretching forces, durations, and velocities. This knowledge forms the scientific basis for developing targeted therapeutic interventions (Stecco et al., 2020). In a study involving taekwondo athletes, fascial training focused on the lower extremity muscle groups led to relaxation of fascial tissues. This training resulted in significant enhancements in explosive force, flexibility, and limb speed. Fascia plays a crucial role in movement, enabling actions to be performed more efficiently, quickly, and with reduced energy expenditure (Unalmis & Muniroglu, 2023). Through research, it was shown that myofascial release techniques (MRTs) can potentially enhance athletes' range of motion more effectively than active or passive control methods. Also, younger athletes may experience increased range of motion benefits from MRTs, with both male and female athletes likely to achieve similar improvements in flexibility (Antohe et al., 2024). A six-month fascial training program for volleyball players did not yield significant overall results, although it did improve jumping efficiency during in-season games. Further, more extensive research with a longer duration is needed to fully assess and validate the potential benefits of this type of training (Vychodilová et al., n.d.). It can be concluded that self-myofascial release (SMR) is positively linked to improving tissue flexibility, range of motion (ROM), and perceptual recovery factors. However, given the current scientific evidence and the limited number of studies showing positive effects on certain physical performance aspects in athletes, SMR exercises should be used cautiously. They should be applied with specific objectives in mind and consideration of the variables where their benefits are most evident (Martínez-Aranda et al., 2024).

Through this article, it can be concluded that, fascia plays an important role in human function and movement and training this connective tissue has a possible effect on enhancing sports performance, including improved range of motion (ROM), action efficiency, better proprioception of muscles. Hence, coaches and athletes should not neglect it as it takes very minimal time to do fascial training and only needs to be done 2-3 times a week.

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BIOCHEMICAL MARKERS OF TRAINING LOAD IN ATHLETES: APPLICATIONS IN PERFORMANCE MONITORING AND RECOVERY

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ABSTRACT

Managing training load is required in order to achieve optimal athletic performance and minimizing the risks of overtraining, injuring them, or making them ill. Traditional approaches rely on estimation methods such as the Rating of Perceived Exertion (RPE), or RPE, which is inherently flawed in precision. Biochemical monitoring offers a more objective and quantifiable means of assessing metabolism and physiological changes to training. As primary objective, this review aims at biochemical benchmarks by presenting their importance in performance improvement and recovery management.

Metabolic markers, including blood lactate and glucose levels, are used to assess anaerobic threshold, exercise intensity, and energy availability. IGF-1 insulin like growth factor, and C:T Cortisol-Testosterone ratio serve as hormonal markers and denote stress from training alongside anabolic recovery. Microtrauma from exercise is assessed and monitored under muscle damage markers with creatine kinase (CK) and myoglobin being vital. Systemic inflammation that relates to training load is monitored with inflammatory markers C-reactive protein (CRP) and interleukin-6 (IL-6). Oxidative stress markers, malondialdehyde (MDA), superoxide dismutase (SOD), glutathione (GSH) are used to measure cellular injury recovery mechanisms. Plasma electrolytes, urine specific gravity (USG) classed as hydration markers aid in identifying fluid loss and helps in effective fluid loss management.

Breakthroughs in sampling methods like saliva and urine, as well as non-invasive biosensor devices, have facilitated real-time biochemical monitoring. Nevertheless, issues with biomarker fluctuations, high costs, and insufficient defined benchmark ranges hinder broader adoption.

Monitoring biochemical indicators is profoundly valuable for training periodization, injury prevention, and recovery facilitation. More work is required to establish definitive protocols and standards, ease access, and apply AI for automated data decision analytics focused on sports performance for optimized outcomes. Enhanced monitoring capabilities will be crucial in the advancement of athlete health, performance, and longevity.

Keywords: Training Load Monitoring, Biochemical Markers, Athlete Performance, Overtraining Syndrome, Sports Physiology

1. INTRODUCTION

An athlete's training load is defined as the accumulated physiological stress brought about by exercise. It includes both external load (e.g. training volume, intensity, and duration) and internal load (e.g. heart rate, oxygen consumption, and biochemical responses) (Halson, 2014). Monitoring training load is critical for optimizing performance and avoiding detrimental physiological effects like overtraining syndrome (OTS). OTS develops when there is an imbalance between training stress and recovery, resulting in reduced performance, higher chances of injury, and increased

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vulnerability to infections (Meeusen et al., 2013). Effective management of training load is achieved by incorporating objective physiological metrics alongside subjective self-reports to facilitate proper adaptation and recovery.

The use of biochemical monitoring is an important new development in assessing an athlete's physiological condition. Unlike subjective methods such as Rating of Perceived Exertion (RPE), biochemical markers offer quantifiable data that reflect a range of metabolic processes including hormonal, muscular, inflammatory, oxidative stress, and hydration levels (Saw et al., 2016). These biomarkers are crucial in assisting coaches and sports scientists in identifying early signs of training stress, thereby enabling timely interventions aimed at mitigating risks associated with Overtraining Syndrome (OTS) while optimizing performance levels. For instance, creatine kinase (CK) and lactate dehydrogenase (LDH) are markers indicative of muscle damage, and the ratio of cortisol and testosterone reflects an athlete's endocrine response to the training load (Hecksteden et al., 2017).

This review seeks to explore exhaustively the relevance of biochemical markers in the monitoring of the training load in athletes. The discussion will address selected biomarkers in each of the physiological domains, namely: indicators of metabolic stress (blood lactate, blood glucose), hormonal response cortisol, testosterone), muscle damage CK, LDH), inflammatory cytokines (IL-6, TNF-α), oxidative stress (malondialdehyde, glutathione), and hydration (urine specific gravity, plasma osmolality). The use of biochemical monitoring alongside conventional assessments of training load would aid practitioners in coming up with strategies that would enhance performance while reducing the risks posed by excessive training.

2. METABOLIC MARKERS

The metabolic markers are essential in evaluating an athlete's physiological reaction towards training. Blood lactate is among the most common used metabolite of anaerobic metabolism indicating an athlete's ability to endure and clear lactate during high intensity exercise. An increase in lactate concentration signifies a greater reliance on anaerobic metabolism which makes blood lactate testing significant for estimating anaerobic threshold (AT)—the level over which, lactate removal cannot keep pace with accumulation. This threshold is very important in the setting training intensities because it enables athletes to enhance endurance and sprint performance by training at or close to their AT (Faude et al., 2009). Lactate clearance rates after intense exercise also provide a good indication of recovery and enhanced clearance is associated with better aerobic conditioning and metabolic efficiency (Jones et al., 2017).

Glucose concentration is yet another important metabolic indicator, offering perspectives on energy availability as well as glycogen reserves. Endurance and performance during prolonged exercises are best maintained with stable blood glucose levels, however, drop in glucose levels (hypoglycemia) indicates depletion of glycogen stores and results in fatigue and drop in performance (Jeukendrup, 2017). Finer adjustments of carbohydrate consumption strategies prior, during and post training are made through regular monitoring of glucose levels aiding performance and recovery.

One of the emerging trend in sports science is the use of continuous glucose monitoring (CGM) technology. Continuous glucose monitoring provides real-time feedback on glucose fluctuations, enabling immediate dietary and training changes by athletes and coaches. This technology has proven important in endurance sports and intermittent high-intensity sports such as soccer and basketball, where energy demands fluctuate rapidly (Abbiss et al., 2021). With increasing advances

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in CGM technology, its use in individualized training load management is expected to improve, enhancing metabolic efficiency and performance outcomes in athletes.

3. HORMONE MARKERS

These markers provide valuable information on an athlete's physiological stress, recovery state, and anabolic-catabolic level balance. One of the most common markers is the cortisol to testosterone ratio (C:T) which is useful in evaluating training stress and recovery. Cortisol is a catabolic hormone released during physical and psychological stress, leading to proteolysis and inhibiting muscle metabolism. On the other hand, testosterone is an anabolic hormone that facilitates muscular repair, growth, and functional adaptation (Crewther et al., 2018). A raised C:T ratio indicates excessive training load, insufficient recovery, and risk of overtraining syndrome (OTS) which contributes to fatigue, decline in performance, and increased injury risks (Urhausen et al., 2021).

Another important marker is Insulin-like Growth Factor 1 (IGF-1) whose relevance is in muscle repair, recovery, and training adaptation. Post exercise, IGF-1 stimulates protein synthesis related to muscle hypertrophy and assists in tissue repair (Nindl et al., 2019). Low levels of IGF-1 are linked to overtraining, chronic fatigue, and poor recovery and thus serves as a crucial biomarker for evaluating training adaptation and recovery plans.

The advent of non-invasive monitoring technologies, such as salivary hormone evaluations, has made hormonal assessments much easier and more accessible for athletes. As noted by Papacosta and Nassis (2011), the measurement of salivary cortisol and testosterone provides a non-intrusive option when compared to blood sampling, allowing for more frequent assessment of hormonal changes due to training. This makes it possible for athletes to receive immediate feedback on training adjustments, ensuring that an optimal level of stress and strain is maintained.

4. MUSCLE DAMAGE MARKERS

The physiological demands of high-intensity exercise and training volumes inevitably result in muscle damage, making bio-chemical markers important for assessing recovery or injury risk. Biochemically, one of the most popular markers of exercise-induced muscle damage is creatine kinase (CK). Brancaccio et al. (2010) explain that production of this enzyme occurs in muscle cells and its release into the circulation is induced by mechanical stress to the muscle due to eccentric and high-resistance exercise activities. The presence of CK in the bloodstream after exercise suggests some degree of muscle microtrauma, which is, to some degree, proportional to the intensity and volume of exercise performed (Magal et al. 2010). The problem with CK is that responses differ greatly among tested individuals due to factors such as genetics, muscle fibre type, and previous training history, which each influence the interpretation of threshold values (Baird et al. 2012).

Another important indicator is myoglobin which is a heme protein that gets released quickly and enters the bloodstream after severe muscle injury. Myoglobin's sensitivity is high regarding muscle injury, its concentration increases within a few hours of exercise and falls quicker than CK (Tidball, 2011). This allows myoglobin to be used as an early marker for muscle strain, especially in sports that involve several quick, powerful movements like sprinting, weightlifting, and combat sports (Lippi et al., 2018).

Recent studies have pointed out the need for individualized monitoring of biochemical parameters, their emphasis being that CK and myoglobin levels with regards to the athlete's training

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history, recovery potential of muscles, and their genetics are to be used. This allows optimal periodization of training, reducing overtraining while maximizing performance improvements.

5. INFLAMMATORY MARKERS

Despite the fact that inflammation helps with muscle recovery and remodeling, too much inflammation elevating from high exercise training loads can trigger overtraining syndrome (OTS), chronic fatigue, and increases the risk of injury. In athletes, inflammatory responses are tracked with biochemical markers such as C-reactive protein (CRP) and interleukin-6 (IL-6). C-Reactive Protein (CRP) is well-known as a marker of systemic inflammation. It is manufactured within various tissues upon the rise of several cytokines, particularly IL-6 and Tumor necrosis factor-alpha (TNF-α) (Smith, 2000). Intense exercises, especially those associated with endurance and contact sports that cause a great amount of muscle destruction and inflammatory reaction, result in marked elevation of CRP (Neubauer et al., 2008). CRP levels increase significantly after exercise but drop rapidly in a short time. However, consistently high CRP levels across several instances may suggest insufficient recovery, excessive training, or an underlying injury. This makes CRP a useful biomarker for tracking training stress and the effectiveness of recovery (Margonis et al., 2007).

Interleukin-6 (IL-6) is part of a group of pro-inflammatory cytokines that is generated due to muscle contractions and tissue damage (Fischer, 2006). IL-6 serves a purpose: its acute surge after a bout of exercise facilitates adaptation by assisting muscle repair and glycogen resynthesis. Yet, chronic over-elevation indicates heightened inflammation, excessive stress, and increased catabolism risk (Nieman, 2003). Patterns of and managing IL-6 concentration helps in distinguishing normal training recovery from overtraining.

6. APPLICATION IN TRAINING

With CRP and IL-6 assessment at regular intervals, coaches and sports scientists can manage training adequacy, direct recovery strategies, and mitigate injury risks. Increased inflammatory markers indicate a need to alter the training session intensity, enhance recuperation, or employ active recovery strategies like diet, rest, and sleep optimization to avert performance drops.

7. OXIDATIVE STRESS MARKERS

Every cell of the human body continuously produces energy. This energy is produced through a series of reactions known as metabolism. During metabolism, energy-rich molecules known as ATP (Adenosine Triphosphate) are formed. The normal biological functions of a living organism needs energy, tissue maintenance, growth, and repair, thereby releasing free oxygen radicals. Free radicals are incomplete molecules that have an unpaired valence bond electrons, potency to react with surrounding molecules, and can strongly oxidize other substances. If the production of these free radicals surpasses the cell's capacity to neutralize them, the cell undergoes oxidative stress. The oxidative stress markers are categorized based on the targets in cellular structure that are getting damaged. Malondialdehyde (MDA), superoxide dismutase (SOD), and glutathione (GSH) are important markers of disrupted cell function and cell death caused by oxidative stress.

Malondialdehyde (MDA) is a common indicator of oxidative injury lipids, often used to indicate the extent of oxidative damage to cellular membranes. Research indicates that MDA levels increase after high-intensity endurance and resistance exercises, marking muscle fatigue as well as

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recovery status (Bloomer et al. 2005). However, in the context of chronic elevation, this may suggest inadequate recovery and greater risk of muscle damage and inflammation (Nikolaidis et al. 2008).

The role of Antioxidant Defense Mechanisms (ADM) is vital for the neutralization of ROS (Reactive Oxygen species). Superoxide dismutase (SOD) is a particular class of enzymatic antioxidant, which protects muscle tissues from the oxidative damage by superoxide radicals, through their transformation into less injurious substances (Powers & Jackson, 2008). Another critical antioxidant GSH contributes to the redox equilibrium. Its post-exercise level dip is indicative of oxidative stress and suggests a need for recovery strategies in the form of rest, sleep, and proper nutrition (Michailidis et al., 2007).

Emerging Methods

Modern innovations include the development of portable devices that enable real-time monitoring of oxidative stress in athletes. These non-invasive measures of oxidative biomarkers in the field allow for more personalized and targeted recovery plans, thus enhancing overall athletic performance (Finaud et al., 2006).

Hydration and Electrolyte Markers

Proper hydration is necessary for optimal athletic performance, thermoregulation, and recovery. Dehydration, in addition to having electrolyte imbalance, may cause fatigue, reduced cognition, and elevated injury risk. Various biochemical markers can measure the hydration and electrolyte levels in athletes.

Blood Electrolytes

Sodium (Na^+) and potassium (K^+) are two essential electrolytes which maintain fluid balance, control impulses along the nerves, and permit muscle movement. An example of low sodium level is Hyponatremia – which can occur due to excessive sweating and intake of fluids. This can result in dizziness, confusion, and in extreme cases, seizures (Hew-Butler et al., 2015). High amount of sodium – Hypernatremia – is indicative of dehydration. Likewise, low levels of potassium – hypokalemia – have effect on muscular endurance and performance, whereas high potassium levels – hyperkalemia - affect the normal heart rhythm (Sawka et al., 2007).

Urine Specific Gravity

For athletes, USG is an effective and inexpensive strategy to assess their hydration status. Dehydration is represented by values above 1.020 while optimal hydration would show values lower than 1.010 (Armstrong et al., 1994). USG is part of monitoring for athletes as it helps ensure that athletes take in enough fluids prior to competitions and training.

Advances: Wearable sweat sensors

Wearable sweat sensors have recently been developed that monitor electrolyte levels and hydration in real-time. These devices provide personalized hydration plans by assessing sodium loss and sweat rate on an individual basis for athletes (Gatorade Sports Science Institute, 2020). This innovation aids in maximizing fluid consumption during training and competition windows, allowing athletes to maintain optimal performance.

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Factors affecting Biochemical Parameters

Biochemical monitoring offers profound information on an athlete's physiological response to training; however, many factors affect biomarker levels. These variables are important to understand for proper interpretation and training modification.

Individual Variability

Changes in genetic features, also known as polymorphism, impact a person's biochemical markers both at rest and during exercise. For instance, SNPs in CKM muscle-type genes affect the recovery phase of exercise by altering the levels of creatine kinase (CK) (Ahmetov & Fedotovskaya, 2015). Moreover, younger athletes tend to recover faster than older individuals due to their anabolic hormone levels, which shifts with age (Kraemer & Ratamess, 2005). On the other hand, testosterone and estrogen modify muscle damage, inflammation, and oxidative stress, creating differences in recovery patterns between the sexes (Hackney, 2020).

Environmental Conditions

Hydration as well as oxidative stress markers are negatively affected by external factors like heat, altitude, and humidity. For instance, high temperatures cause the body to sweat more, that results in changes in the concentration of sodium, potassium, and osmolality present in plasma (Sawka et al., 2007). Training at higher altitudes causes an increase in EPO (Erythropoietin), that stimulates red blood cell production. However, heightened oxidative stress indicators like malondialdehyde (MDA) due to hypoxic conditions simultaneously increase (Pialoux et al., 2009). Dehydration is worsened in humid conditions, that increases the need for proper evaluation of USG as well as plasma electrolytes in order to enhance performance and recovery (Casa et al., 2000).

Training Type & Nutrition

As discussed, the biochemical responses of an individual vary depending on the type of training performed (resistance vs. endurance). Resistance training activates pathways related to testosterone secretion, IGF-1, and muscle damage (as shown with CK and myoglobin), while saga-altering features of endurance training yield higher cortisol levels and greater oxidative stress (Kraemer & Ratamess, 2005). The availability of carbohydrates influences metabolic markers as well – low levels of glycogen increase blood lactate as well as cortisol levels and hinder recovery and performance (Meeusen et al., 2013). Effective nutritional approaches, such as incorporating protein for muscle repair as well as antioxidant intake for recovery, help in controlling biochemical responses to training (Powers et al., 2011).

Biochemical Parameter Measurement Methods

Monitoring the biochemical markers must be done accurately in order to evaluate the training load. Different sampling methods and use of modern technology have improved the ability for biochemical monitoring, but lack of standardization and high cost still remains a challenge.

Sampling Techniques

Every sample type can provide an array of biological fluids which can be used to determine certain biochemical markers, each having their own pros and cons:

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1. **Blood Sampling (Invasive):**

a. It is regarded as the gold standard of analyzing hormonal, metabolic, muscle damage, and oxidative stress markers (Banfi et al., 2012).

b. It provides highly accurate data, however, highly trained staff and controlled environments are a requirement due to its invasive nature (Halson, 2014).

2. **Urine Sampling (Non-Invasive):**
   - For tracking hydration (urine specific gravity) and electrolyte balance (sodium, potassium), as well as monitoring metabolic byproducts (Sawka et al, 2007).
   - Less invasive and easier to obtain; however, varying concentration due to fluid intake and circadian rhythms can challenge interpretation (Maughan & Shirreffs, 2010).
3. **Saliva Sampling (Practical for Field Testing):**
   - Increasingly applied to hormonal markers such as cortisol, testosterone, and IGF-1 due to ease of collection, which is non-invasive and rapid (Papacosta & Nassis, 2011).
   - Salivary assays show strong correlations with blood concentrations making them applicable for chronic monitoring of stress and recovery (Cardoso et al., 2016).

Technological Advances

1. **Portable devices:**
   - Handheld lactate analyzers provide immediate feedback on metabolic stress, enabling quick response (Jeukendrup & Gutha, 2011).
   - Wearable sensors that monitor sweat have been able to continuously track electrolyte levels and hydration in real-time (Gao et al., 2016).
2. **Lab-on-chip technology:**
   - Microfluidic devices allow for the real-time, multiplex analysis of different biomarkers using minimal sample volumes (Lee et al., 2016).
   - They are used to detect oxidative stress markers (MDA, SOD) and muscle damage markers (CK, myoglobin), as well as hydration status.

Challenges

1. **Standardization Issues:**
   - Different sampling protocols and collection timing, along with inter-individual variability, creates difficulty in interpreting biomarker data (Meyer et al, 2017).
2. **Cost-Effectiveness:**
   - Limit accessibility to small-scale training facilities and individual athletes due to high cost of advanced real time monitoring devices (Peake et al., 2013).
   - New methods will seek to improve field testing techniques to be less expensive and easier to use.

Applications in Athlete Monitoring

Monitoring the biochemical markers in an athlete's body is essential for optimizing the training periodization, injury prevention, and recovery definition for the individual athlete. With constant monitoring of biochemical markers, it is easier for sports scientists and coaches to make decisions on how to manage workload, recovery processes, and their health.

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Training Periodization

Training periodization is an organized balance in workload cycling to improve athletic performance while minimizing the possibility of overtraining. Biochemical markers offer valuable feedback within the framework of physiological stress and recovery:

- Blood lactate along with glucose concentration are metabolic markers that strictly define anaerobic thresholds as well as energy availability, which will necessitate an alteration of the training intensity (Mujika & Padilla, 2000).
- Cortisol-to-testosterone (C:T) ratio is a hormonal marker indicating training stress, increased ratios denoting heightened workload and insufficient recovery (Lehmann et al., 1993).
- C-reactive protein (CRP) and interleukin-6 (IL-6) are inflammatory markers that give information about the immune system's activity level, so that training loads do not lead to immune suppression and illness (Smith, 2000).

Implementation of these biochemical changes into training programs will enhance the periodization technique and increase adaptation while minimizing fatigue.

Injury Prevention

The use of biochemical markers can prevent injuries and overtraining syndrome (OTS) by aiding in the early detection of physiological stress:

- The assessment of muscle damage with creatine kinase (CK) and myoglobin levels can indicate injury. Insufficient recovery and increased risk of injury will lead to elevated CK and Myoglobin levels (Banfi et al., 2012).
- Muscloskeletal injuries caused by inadequate recovery can be detected by monitoring oxidative stress markers, malondialdehyde (MDA), and superoxide dismutase (SOD), which are linked to overexerted oxidative damage (Viguie et al., 1993).
- Endurance sports have been linked to dehydration-related injuries such as cramps and heat exhaustion. Hydration markers, including urine specific gravity (USG) and plasma sodium concentration, are essential for preventing these injuries (Sawka et al. 2007).

Sports scientists can monitor these markers to identify at-risk athletes, allowing for timely adjustment of training intensity, recovery nutrition, and hydration strategies to avoid overtraining.

Case Studies: Biomarker-Driven Adjustments in Elite Sports

Biochemical monitoring has been successfully integrated into training for several elite sports teams and institutions:

- **Cycling and Endurance Sports:**

Professional athletes have been able to manage hypoglycemia better using real time fueling strategies enabled by continuous glucose monitoring (CGM), enhancing overall performance (McLean et al., 2019).

- **Soccer and Team Sports:**

In a study on elite soccer players, it was established that monitoring the C:T ratio enhanced training load management at the macro level, subsequently leading to lower injuries and improved performance during competitive seasons (Heisterberg et al., 2013).

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- **Olympic Track & Field Athletes:**

Research on Olympic middle distance runners showed that IL-6 and CK monitoring enabled individualized recovery strategies, enhancing readiness for competition and decreasing the number of training sessions that had to be missed due to illness or injury (Meeusen et al., 2013).

The cases presented demonstrates the introduction of biochemical monitoring into athlete management as having the potential to improve performance, decrease the likelihood of sustaining injuries, and provide better training adjustments.

There are still challenges and limitations when it comes to using Biochemical monitoring.

Even though the use of biochemical markers in monitoring athletes is increasingly widespread, there are challenges and limitations to it. These difficulties stem largely from variability, accessibility, and lack of uniformity.

8. CHALLENGES AND LIMITATIONS IN BIOCHEMICAL MONITORING

An important component to improving biochemical monitoring is variability in athlete responses to biomarkers. Inter-athlete variability refers to the differences that exist within the groups or populations of athletes (Knechtle et al., 2020). Things like genetics, sex, age, training history, and individual physiological adaptations can all play a role. Take for example the levels of creatine kinase (CK) after performing a certain exercise. Most likely the levels will differ from one end of the population to the other due to genetics and muscle fiber type composition (Brancaccio et al, 2008).

Additionally, some hormonal markers, like the cortisol-to-testosterone (C:T) ratio, display diurnal variation and are impacted by psychological stress, making interpretation difficult (Hecksteden et al., 2017).

Furthermore, intra-athlete variability poses a challenge for systematic assessment. Components like nutrition, hydration level, and recent bouts of activity can alter biomarker values. Minor infections or unrelated stressors can impact training markers like C-reactive protein (CRP) and interleukin-6 (IL-6) (Pedersen & Hoffman-Goetz, 2000). Variability like this makes it more useful to longitudinally monitor change over time rather than take single-point measurements.

Accessibility and Cost Limitations

Biochemical testing services, especially when lab-based, face issues with their wide availability. Specialized equipment and trained personnel are needed for mass spectrometry and ELISA, which increases expense for many sports organizations (Timon et al., 2016). Blood sample collection is also frequently impractical for athletes as the procedure is invasive, leading to poor compliance.

Emerging technologies, such as wearable biosensors and portable field devices, allow for non-invasive monitoring of biomarkers in real-time, improving accessibility (Peake et al., 2018). These methods are still undergoing validation, losing reliability and staying accurate.

Future Perspectives in Biochemical Monitoring for Athletes

We discussed about advances to neural interfaces. As they become more prominent, athlete monitoring will seamlessly integrate with other fields. The construction of wearable biosensors,

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AI, and the algorithms of machine learning offer great prospects. Nevertheless, the greatest hurdle stands standardization of monitoring biochemical processes in sport and physical activities.

Wearable Technology and Real-Time Monitoring

Current transformative breakthroughs in wearable devices, under the scope of biosensors, enable instant monitoring of vital biomarkers like glucose concentration, electrolyte content of sweat, and hydration level (Gao et al, 2016). Microfluidic devices represent a new frontier in medicine and offer continuous and non-invasive determination of sodium, potassium, and lactate, making blood sampling technically less necessary (Kim et al, 2019). Such devices provide real-time feedback to athletes which may enhance performance through timely adjustments in nutrition, hydration, or other changeable factors. Much work is still needed to overcome the sensor's precision, calibration and data as well as interpretation hurdles.

AI and Machine Learning in Biochemical Monitoring

Introduction of AI to sports science changed the muscle's dynamics of biomarker examination. Algorithms developed for AI are capable of monitoring and identifying peculiarities in the trends of changing the levels of hormones practiced, inflammation markers, muscle destruction signs, and many more (Pino-Ortega et al, 2021).

Machine learning algorithms can help to create personalized training and recovery plans for athletes by forecasting injury risks and overtraining through the analysis of multi-marker profiles. Algorithm validation, transparency, and data privacy are still unresolved issues though.

Standardization and Global Reference Ranges

Creating standardized reference values for diverse sports and populations is one of the challenges in biomarker application. Reference ranges for biochemical markers would make data collected from athletes across the world more reliable and comparable (Hecksteden et al., 2017). Cohort studies that are large scale, multi-ethnic, and multi-sport are required to define normative values and develop consistent methodologies for biomarker assessment and analysis.

Performing sports will benefit from the integration of wearable biosensors, real-time AI-driven analytics, and standardized global reference values on training, injury prevention, and performance optimization biomarker monitoring.

9. CONCLUSION

Biochemical monitoring considering training load is an invaluable addition to sports science as it provides an objective framework to gauge an athlete's physiological responses to training. Assessing metabolic, hormonal, muscle damage, inflammation, oxidative stress, and stress markers enable sports scientists and coaches to fine-tune training regimens, mitigate the risk for overtraining syndrome (OTS), and thereby, enhance performance and recovery.

The blood lactate and glucose level metabolic markers provide information about energy expenditure and exercise intensity. Training stress and anabolic recovery are assessed with hormonal markers such as the cortisol-to-testosterone ratio (C:T) and IGF-1. Muscle damage markers creatine kinase (CK) and myoglobin, C-reactive protein (CRP) and interleukin-6 (IL-6), denote microtraumatic damage and inflammatory response, respectively. Furthermore, oxidative stress markers malondialdehyde (MDA) and antioxidant enzymes illustrate the extent of cellular harm and recovery potential due to training. Sodium and potassium concentration within plasma as well as urine-specific gravity (USG) gauge hydration and help prevent fluid and electrolyte imbalance.

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The advantages of continuous biochemical monitoring is accompanied by several challenges and shortcomings. Differences in biomarker response, cost, and lack of established reference values for some markers impede biomarker adoption. However, recent advances in wearable biosensors integrated with AI-powered data analysis and machine learning algorithms are shifting the paradigm of athlete monitoring from manual monitoring to automated, real-time adaptive training personalization.

In order to reap the full benefits of biochemical tracking, more future work is required in the area of establishing standard biomarker reference values, improving the precision and availability of portable diagnostic devices, and employing AI-enabled athlete management systems. Moving forward, the combination of biochemical monitoring with training periodization, injury risk assessment, and performance optimization will become increasingly important in directing the future of elite athletic performance.

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ANTHROPOMETRIC VARIABLES AND VOLLEYBALL PLAYING ABILITY: A COMPREHENSIVE ANALYSIS

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ABSTRACT

This study investigates the relationship between anthropometric variables and volleyball playing ability among Annamalai University volleyball players. The primary objective was to identify which anthropometric measurements significantly predict volleyball performance. Data were collected from 20 male and female volleyball players, focusing on height, leg length, arm length, calf girth, and thigh girth. Multiple regression analysis revealed that height, leg length, and arm length were the most significant predictors of playing ability, explaining a substantial portion of the variance. Height demonstrated the strongest correlation (r = 0.775), followed by arm length (r = 0.743) and leg length (r = 0.657). Calf and thigh girths showed moderate correlations but were not included in the final predictive model due to their lower explanatory power. The derived prediction equation highlights the critical role of these anthropometric factors in determining volleyball proficiency. These findings underscore the importance of considering physical dimensions when evaluating and developing volleyball talent. Coaches and trainers can utilize these insights to optimize player selection and tailor training programs to enhance specific attributes that maximize athletic potential. Future research should explore longitudinal impacts and interactions among these variables to refine predictive models further and inform strategic player development.

Keywords: Volleyball, Anthropometry, Playing Ability, Sports Science.

1. INTRODUCTION

Volleyball is a sport characterized by its dynamic nature, requiring players to exhibit exceptional technical skills, physical fitness, psychological resilience, and anthropometric advantages. Among these factors, anthropometric variables—such as height, limb lengths, and body circumferences—play a pivotal role in determining an athlete's suitability and success in volleyball. This sport demands players to cover large areas quickly, reach high for spikes and blocks, and maintain agility and balance throughout intense matches. Consequently, understanding how anthropometric characteristics influence volleyball playing ability is crucial for optimizing player performance and team strategies.

Anthropometry involves the systematic measurement of the human body's physical properties, including size, shape, and composition. In sports science, these measurements help assess athletes' physical capabilities and potential. For volleyball, where height and reach are advantageous, anthropometric variables provide valuable insights into a player's natural predisposition for success. Previous studies have highlighted the significance of height, leg length, and arm length in predicting volleyball performance. Height, in particular, has been consistently identified as a

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critical factor, enabling players to dominate at the net and cover more court space effectively. Longer limbs facilitate greater reach and leverage, enhancing spiking and blocking abilities. Despite the recognized importance of anthropometric variables, comprehensive analyses integrating multiple measurements to predict volleyball playing ability remain limited. Most existing studies focus on individual attributes or small subsets of variables, often neglecting the holistic impact of combined anthropometric factors. This gap underscores the need for a detailed investigation into how various anthropometric measurements collectively contribute to volleyball proficiency.

The current study aims to address this gap by examining the relationship between selected anthropometric variables and volleyball playing ability among Annamalai University volleyball players. By employing rigorous statistical methods, we seek to identify the most influential predictors and develop a robust prediction model. This research will provide coaches and trainers with actionable insights to enhance player evaluation and development processes, ultimately contributing to improved team performance and competitive success.

2. METHODOLOGY

The study involved 20 male and female Annamalai University volleyball players whose anthropometric measurements were meticulously recorded. Predictor variables included height, leg length, arm length, calf girth, and thigh girth. Volleyball playing ability, serving as the criterion variable, was subjectively rated by three expert evaluators. The stepwise selection method in multiple regression analysis was utilized to determine the most influential predictors among the anthropometric variables.

Data Collection

Anthropometric data were collected using standardized protocols. Height was measured using a stadiometer, while leg and arm lengths were assessed using a measuring tape. Calf and thigh girths were measured at their respective maximum circumferences. All measurements were taken twice to ensure accuracy, and the average values were used for analysis.

Statistical Analysis

Descriptive statistics were calculated for each anthropometric variable, providing means, standard deviations, minimum and maximum values, and ranges. Pearson product-moment correlation coefficients were computed to examine the relationships between each anthropometric variable and volleyball playing ability. Multiple regression analysis employed the stepwise method to identify significant predictors, with a significance level set at 0.05.

RESULTS

Descriptive Statistics

Table 1 presents the descriptive statistics for the selected anthropometric variables

Variable	N	Range	Min	Max	Mean	SD
Height	20	11	175	186	179.05	2.93
Leg Length	20	18	94	112	102.04	4.76
Arm Length	20	11	74	85	79.73	2.82

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Calf Girth	20	27	27	34	30.33	1.8
Thigh Girth	20	11	43	54	49.63	2.28

Correlation Analysis

Pearson product-moment correlations revealed significant relationships between volleyball playing ability and several anthropometric variables

Variable	**Correlation Coefficient (r)**
Height	0.775
Arm Length	0.743
Leg Length	0.657
Calf Girth	0.659
Thigh Girth	0.67

Regression Analysis

Stepwise multiple regression identified three key predictors explaining approximately 84.3% of the variance in playing ability.

Height- Arm Length- Leg Length

The derived prediction equation is:

[{Volleyball Playing Ability} = 53.064 + 0.361({Height}) + 0.133({Arm Length}) + 0.181({Leg Length}]

3. DISCUSSION

The findings of this study underscore the significant influence of anthropometric variables on volleyball playing ability. Height emerged as the most critical predictor, aligning with previous research emphasizing its importance in reaching higher for spikes and blocks. Players with greater height possess a natural advantage in dominating the net, which is crucial for offensive and defensive plays. Arm length also proved vital, facilitating extended reach and enhancing spiking and blocking capabilities. Longer arms allow players to cover more area, making them formidable opponents at the net.

Leg length contributed substantially to the predictive model, reflecting its role in agility and explosive movements. Players with longer legs can generate more power and speed, essential for quick lateral movements and jumps. While calf and thigh girths showed moderate correlations, they did not add significant explanatory power beyond the contributions of height, arm length, and leg length. This suggests that muscle mass distribution may be less influential compared to overall body dimensions in predicting volleyball proficiency.

These results corroborate earlier studies highlighting the importance of height and limb lengths in volleyball performance. For instance, Sudhakara (2018) found significant relationships between height, leg length, arm length, and playing ability. Similarly, Govindaraj and Murugesan (2020) identified leg length, standing height, and arm length as common characteristics predicting volleyball playing ability among college-level men players.

4. CONCLUSION

In conclusion, this study confirms that height, arm length, and leg length are the most significant anthropometric predictors of volleyball playing ability. These findings offer practical implications for coaches and trainers, emphasizing the importance of considering physical

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dimensions during player selection and development. Tailoring training programs to enhance these attributes could maximize athletic potential and improve team performance. Future research should explore longitudinal impacts and interactions among these variables to refine predictive models further. Investigating gender-specific differences and incorporating additional anthropometric measurements could provide deeper insights. Additionally, integrating advanced technologies like motion capture systems might offer real-time assessments of how these variables affect in-game performance.

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DIFERENTIATION OF AERODYNAMIC AND OPTIMAL ANGLE BETWEEN SHOT-PUT AND DISCUS

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ABSTRACTS:

The purpose of the study was to find out the differentiation of aerodynamic and optimal angle between shot-put and discus. Method: this review is the narrative type of systemic review. Where we can find the average optimal angle of shot put is 37° where releasing speed is 13.5 m/s and the average optimal angle for discuss is 30-35° with the release speed is 25-27m/s. Both discus and shot-put height of release is approximately 2m. Conclusion: affect of air resistance effecting in optimal angle for throws, releasing speed and release of height

Keywords: Optimal angle, aerodynamics, releasing height, shot-put, discus.

1. INTRODUCTION:

The optimal projection principle refers to the range of angle that an object is projected achieve a particular goal. Normally there are relationships among projection speed, height and angle. Kudson explained that, different events have different projectile motion. So, depending on events and depending on athlete's unique characteristics of a particular angle of projection also change.

The major components for optimal angle for projectile motion compromise between height of release and the horizontal, vertical component of release velocity. Though the horizontal motion and vertical motion study separately, but for projectile motion both work combinedly in trajectory will be unchanged.

So the magnitude of horizontal and vertical component are always quantified so that if they were added together through the process of vector composition, the resultant velocity vector would be equal in magnitude and direction to the original initial velocity vector (Susian J Hall) .

For throwing, jumping, kicking in football athletes major target will be covering maximum horizontal displacement with maximum speed. Hay explains in his paper explained about projectile that 'the quality of performance depends very largely on the performers ability to control and/or predict the outcome of the projectile motion involved'.

The first generalization of the Optimal Projection Principle explain that" In most throwing or striking events ,when a mix of maximum horizontal speed and displacement are of interest, the optimal angle of projection tend to be below 45° and next generalization relates with upward displacement. It stated that the optimal angle of projection for tasks emphasizing vertical displacement or mixed vertical displacement and time of flight tend to be above 45°. The athletes are not like machine so the optimal angle of trajectory used to be manipulated by wind or fatigue from numerous throws.

So, the purpose of the study is aerodynamic differently affecting the optimal angle of shot-put and discus.

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2. FACTORS AFFECTING OPTIMAL ANGLE OF PROJECTILE MOTION IN SHOT-PUT:

Shot-put throwing is physically and technically demanding event in track and field that requires athletes to perform a sequence of highspeed movements in a limited space. Basically, there four types of technique are the glide, rotation, leg reverse and shuffle (Scholfield et al ;2019). Among all the four glide and rotation technique is more popular. These techniques are differed in initial stage but the power position and the delivery phase is similarly in both. Shot putting requires great explosive strength, together with the ability to perform precisely in confined space (Linthorne et al, 2001).

The main biomechanical parameters for shot-put is release height or height of release, angle of release and speed of release. Air resistance implies minimal due to the shape and weight of the shot (Tutevich et al 1969; Linthorne et al;2001).

The horizontal distance traveled by a projectile released at a certain angle to horizontal depends on its initial velocity (V_o) release angle(α_o) and release height(h_o) (Zatsiorsky et al; 1981). In the paper Zatsiorsky stated that as the horizontal distance (L) covered during flight is proportional to the release velocity squared.

$$L = \frac{V_0^2}{g} \cos\alpha_0 \left(\sin\alpha_0 + \sqrt{\sin^2\alpha_0 + \frac{2gh_0}{V_0^2}}\right)$$

Where g is the acceleration due to gravity. Normally the phases of both technique can be divided by basic four categories preparatory phase, momentum building, flight phase and delivery phase. But for rotation technique we can sub divided more – first double supports, first single support, flight start, second single support and flight release. These techniques are mainly use for acceleration of the body. Nicholas P. Linthorne in the year 2001 stated his research paper stated that average speed of release is 13.5m/s for the displacement of 19-23m for world class shot-putters. Hay and Susian J Hall both explained that for maximum displacement should less than 45^o. When the relative projectile angle is the angle of projection that produces maximum displacement in 45^o and relative projectile height increases the optimum angle of projection decreases.

Lichten berg and Wills (1978) calculated the optimum release angle should be about 42^o for world class athlete of 22m from a typically released height of 2.14m. Michael Yound and Lili explain for projectile motion has observed release speed in their present study is 12.4m/s. with range of 11.9 m/s to 13.2 m/s. Mc Coy et al (1984) and Greoyor et al (1990) suggested that greater release speeds are produced at low release speeds are produced at low release speeds are produced at low release angles shot putters can produce more force when projecting the shot at low releasing angle. McWatt (1982) noted that when the releasing angle around 37^o placing the arm in strongest position. Linthorne et al, 2001, stated that optimal release angle of 37^o was obtained by an appropriate selection of co efficient for the relation between release speed and release angle.

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Most of the athlete can imply more force near to the horizontal displacement rather than vertical direction.

3. FACTORS AFFECTING OPTIMAL ANGLE OF PROJECTILE MOTION:

In discus the athlete tries to project the disc as far as possible while remaining within the confine of throwing circle. A discus is normally spherical and symmetrical, having a arm around the perimeter. Its measurements must meet the International Association Athletics Federation (IAAF) standards, which dictate a diameter of 220mm the weight less than 2kg for men and for women it 181mm of diameter with weight of 1kg. The shape of the disc and comparatively light weight make the air to imply lift and drag force.

A discus in a flight is subjected by the force exerted upon it by the air through the pass. The magnitude of the pressures exerted by the air on the discus and hence the effects are similar to shot put the speed of release, the angle of the release, the attitude angle or angle of tilt, the velocity of the wind and angular velocity of the discus release.

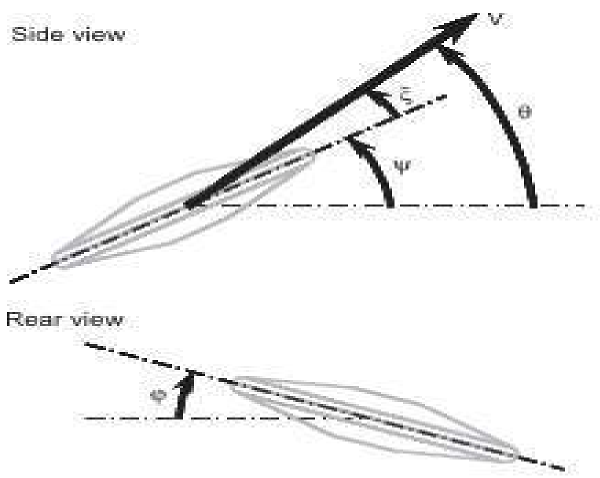

Fig 1: Discus release parameters: release velocity (V), release angle (h), tilt angle (w), attack angle (n), and roll angle (/).(Leigh et al,2009)

Gangstan conducted an interesting series of studies into aerodynamic factors influencing the flight of the discus making a parabolic path way. Hay stated in his paper 1995 that there is no such thing the wind velocity for maximum distance. The vacuum flight distance and aerodynamic distance are the official distance in the discus throw (Hay and Yu,1995; Leigh and Yu et al; 2007). The release angle effects of the discuss in vacuum.

The aero dynamic mainly affected by the angle of attack Leigh and Liu et al 2009 stated aerodynamic distance increased as the released angle increased and the speed of the implement change as the release angle changes. They stated that the optimal angle is 35^{o} with the attacking angle of 10^{o}. Hay stated that release speed is 27-29 m/s . The discuss throw can be divided into two stages that launch and flight (Hubbard et al,1989). Bartlett stated through the research stated that in his paper that average 25m/s of release speed can cover maximum approximately 65 m with the throwing angle of 35 and tilt angle is 15.5^{o}. The release height should be as high as is consistent with other optimal release conditions. According to Bartlett the discus should be thrown to maximize its spin but with zero rolling and pitching angular velocities in release.

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4. CONCLUSION:

Through the all-literature review here is the conclusion we under stand that height of the subject how much increased reduction of optimum angles occur more. The optimal angle of shot put is 37-39 degree whereas discus throws optimal angle is 35degree. Average release height for both event are same near to 2m but speed of release is totally different; for discus it 25m/s and shot put it is 13.5m /s.

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THE IMPACT OF TRAINING ON MUSCLE ARCHITECTURE: A SYSTEMATIC REVIEW

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ABSTRACT
Resistance training is one of the major training methods to improve muscle strength, hypertrophy, and sports performance. However, many studies have been conducted regarding its in effect on muscle architecture, such as physiological cross-sectional area (PCSA), pennation angle, muscle thickness, and fascicle length. it has direct influence on force production, contraction velocity, and overall functional capacity, it is crucial to understand these structural changes. In this context, a systematic review will be provided on different training modes, such as eccentric, concentric, and isometric training and the synthesis of the latest evidence regarding the impact of resistance training on muscle structure. The review will also explore the relationship between the volume of the Nordic Hamstring Exercise and its effectiveness in improving eccentric strength and as a preventative measure of injury. The study will summarize the findings of several research studies to provide indepth information on optimized training protocols for improved muscle structure, optimal performance, and minimized risk of injury. Furthermore, to understand the impact of different training programs on muscle shape, the review will identify the gaps in the literature that currently exist and make recommendations for future research.

Keyword: Muscle Architecture, Resistance Training, Eccentric Training, Concentric Training, Isometric Training, Muscle Hypertrophy, Fascicle Length, Pennation Angle, Physiological CrossSectional Area (PCSA) Nordic Hamstring Exercise (NHE)

1. INTRODUCTION

Skeletal muscle is a flexible tissue that can significantly change its shape and structure when subjected to resistance training. These adaptations are essential for important performance traits like strength, power, and endurance. The structure of the muscle is influenced by factors such as fascicle length, pennation angle, and physiological cross- sectional area (PCSA), all of which play a key role in how muscles work and their biomechanics.

Each type of resistance training, whether eccentric, concentric or isometric contractions, is responsible for inducing these architectural changes. The characteristics of each training modality cause a unique mechanical and neuromuscular load on muscle Fibers, and muscle Fibers are adapted to them in different ways. For example, eccentric training leads to greater fascicle length increase, but concentric training is characterized by the greatest increase in PCSA. Knowledge of these features is necessary for the targeted design of training programs for specific performance goals and for the treatment of injuries.

Furthermore, recent research has highlighted the importance of specific training interventions, such as the Nordic Hamstring Exercise (NHE), in promoting eccentric strength and preventing injuries, particularly in athletes. Despite growing evidence supporting its benefits, optimal training volumes and intensities remain debated.

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This systematic review will give an overview of the influence of resistance training on muscle architecture by combining evidence from existing research. It will discuss the effects of different training techniques on muscle structure, compare their efficacy, and provide conclusions on practical implications for strength training, rehabilitation, and prevention of injury. This review will also identify gaps in existing literature and propose avenues for future research.

2. MUSCLE HYPERTROPHY & VOLUME CHANGES

In resistance training one of the most prominent factors is muscle hypertrophy. It occurs due to increased protein synthesis and changes within the muscle cells, leading to greater muscle size. Research shows that the type of training can influence these hypertrophy adaptations. Aagaard et al. (2001) discovered that eccentric training leads to larger increases in muscle size compared to concentric and isometric training. Yagiz et al. (2022) found that high-load training (at least 80% of one's one-repetition maximum) results in significant increases in muscle cross-sectional area. Seynnes et al. (2007) observed that long-term training (12 weeks or more) produces stronger hypertrophic responses than shorter training periods Wakahara et al. (2013) demonstrated that regional hypertrophy occurs depending on exercise selection, emphasizing the importance of targeting specific muscle regions in training programs.

3. FASCICLE LENGTH ADAPTATIONS

Fascicle length, an important factor for power generation and effective contraction, significantly changes in response to strength training. Alonso-Fernandez et al. (2017) showed that eccentric training leads to a considerable increase in fascicle length. This increase enhances force transmission and reduces the risk of injury. Kawakami et al. (1995) illustrated that sprinting and plyometric training also cause elongation of the fascicles, facilitating fast force production. Valamatos et al. (2018) postulated that concentric training, although helpful in muscle hypertrophy, exerts a weaker influence on fascicle length. Cuthbert et al. (2019) observed that NHE interventions of six weeks and longer led to increased fascicle length, with larger adaptation magnitude found in low-volume interventions. Cuthbert et al. (2019) found that NHE interventions of at least six weeks resulted in significant increases in fascicle length, with a greater magnitude of adaptation seen in low-volume interventions. Timmins et al. (2016) observed that increased fascicle length in hamstrings is associated with a lower risk of muscle strain injuries, making eccentric training crucial for injury prevention in high-speed sports. Behan et al. (2019) found that fascicle length adaptations depend on exercise selection, with lengthening contractions playing a crucial role in elongating muscle Fiber.

4. PENNATION ANGLE ADJUSTMENTS

Pennation angle is the angle of the Fibers of muscle to the tendon and determines how much force a muscle can generate. According to Eguchi (2018), it was discovered that the higher the pennation angle, the greater the muscle growth and force production. Mirzayev (2017) noted that pennation angles change with eccentric training, which improves the transmission of force. Cuthbert et al. (2019) suggested that the reduction in the pennation angle is associated with an increase in eccentric strength after half squats with a negative movement. Ema et al. (2016) have pointed out that alterations in pennation angle differ in different muscle groups, underlining the importance of training specificity of Fiber arrangement

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5. DISCUSSION AND CONSLUSION

This review demonstrates that resistance training influences muscle architecture and results in significant hypertrophy and structural adaptations when utilizing eccentric and high-load training. In addition, NHE interventions are effective for increasing fascicle length and injury resistance. Muscle architecture and modulation by training modality have implications for Athletes who aim to increase power output. They can benefit from eccentric training in order to increase fascicle length and transfer of force. As a result, the use of NHE and eccentric loading can prevent muscle strain by allowing for longer fascicle lengths. Injured patients can perform resistance training to facilitate their recovery by ensuring the maximum architectural adaptation. Coaches and practitioners can adapt the resistance training regimen to the structural adaptation needed for a player. Future research may investigate the influence of resistance training on muscle architecture in different populations in the long term. Evaluating the effect of genetic predispositions on resistance traininginduced muscle architecture adaptation. Determining an optimal training intensity and volume for the maximum fascicle length increase with minimum injury risks. Evaluation of sexbased differences in muscle architecture adaptation to resistance training.

The exercise largely changes the muscle architecture with increasing of the muscle thickness, the length of the fascicle, the angle of the pennation and the PCSA. Eccentric and high load training have a particularly high impact on hypertrophy, power output and injury prevention. Resistance training is a key tool for altering muscle architecture. It can be utilized to improve performance, injury prevention, and increase muscle strength. By understanding the impact of different training method on muscle architecture, trainer or coaches can develop evidence-based programs that are tailored to meet the specific needs and performance goals of the individuals. The results of this review demonstrate the importance of exercise specificity in eliciting the desired changes in muscle architecture. The use of eccentric training has been shown to be particularly effective in promoting increases in fascicle length, which, in turn, optimizes force transmission. Similarly, interventions like the Nordic Hamstring Exercise have been shown to improve eccentric strength and reduce the risk of muscle strains. These findings suggest that training modalities, such as eccentric training and the Nordic Hamstring Exercise, can be used to enhance the physical capabilities of athletes and, potentially, reduce their risk of sustaining injury.

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PLANTAR PRESSURE DISTRIBUTION AND ITS IMPACT ON WALKING BIOMECHANICS: A SHORT LITERATURE REVIEW

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ABSTRACT:

Plantar pressure distribution (PPD) is a crucial aspect of walking biomechanics, influencing gait efficiency, balance, and injury risk. This literature review explores the key factors affecting PPD, including foot structure, body weight, walking speed, aging, fatigue, and footwear. Findings indicate that obese individual exhibit increased mid foot and forefoot pressures, while older adults experience reduced plantar pressures, impacting stability and fall risk. PPD analysis has significant clinical applications, particularly in managing diabetic foot ulcers and rehabilitation for post-stroke patients. In sports biomechanics, understanding plantar pressure helps optimize performance and prevent injuries in athletes. Advancements in wearable technology and real-time pressure mapping offer promising developments for personalized gait assessments. This review underscores the importance of PPD in clinical and athletic contexts, highlighting the need for further research on innovative assessment methods and interventions.

Keywords: Plantar pressure distribution, Gait biomechanics, Walking stability, Foot structure, Obesity, Fatigue, Diabetic foot ulcers.

1. INTRODUCTION

Walking is a fundamental human activity that relies on complex biomechanical processes, including the interaction between the foot and the ground. One of the key factors influencing gait mechanics is plantar pressure distribution (PPD), which refers to the way force is applied across different regions of the foot during walking. Analyzing PPD provides valuable insights into foot function, balance, and overall gait efficiency, making it a critical area of study in biomechanics, clinical rehabilitation, and sports science (Hessert et al., 2005).

The measurement of plantar pressure distribution is essential for understanding normal and pathological gait patterns. Research has demonstrated that plantar pressure varies across different anatomical regions of the foot, including the heel, mid foot, and forefoot, and is influenced by factors such as age, body weight, foot structure, and fatigue (Hills et al., 2001). For instance, older adults exhibit lower pressure in the medial calcaneus and hallux regions, which may contribute to balance impairments and increased risk of falls (Hessert et al., 2005). Similarly, obesity has been linked to elevated plantar pressures, particularly in the forefoot and mid foot, which can increase the likelihood of foot pain and musculoskeletal disorders (Hills et al., 2001).

In addition to individual physiological differences, external factors such as prolonged walking and footwear also play a significant role in plantar pressure distribution. Studies on long-distance walking have revealed that fatigue leads to increased heel loading and reduced toe-off forces, which alters the overall walking pattern and may contribute to injury risk (Stolwijk et al., 2010). The ability to accurately measure and analyze PPD using tools such as force plates and in-shoe pressure sensors has provided deeper insights into how various populations adapt to changes in walking conditions (Stolwijk et al., 2010).

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Given the clinical and biomechanical significance of plantar pressure distribution, this review aims to explore the key factors influencing PPD during walking and its implications for health, rehabilitation, and footwear design. By synthesizing some existing research, this study will highlight the importance of plantar pressure analysis in optimizing gait mechanics and preventing lower limb injuries.

2. AIM OF THE STUDY

The aim of this literature review was to analyze and synthesize some of the existing research on plantar pressure distribution during walking, focusing on the key factors that influence pressure patterns, such as age, obesity, fatigue, and footwear. this study seeks to highlight the biomechanical significance of plantar pressure distribution, its implications for gait efficiency, injury prevention, and clinical applications in rehabilitation and footwear design.

3. METHODOLOGY

This literature review was conducted by selecting peer-reviewed journal articles related to plantar pressure distribution during walking from the Google scholar. Selection criteria focused on studies examining plantar pressure patterns, gait biomechanics, and foot loading, particularly those utilizing validated measurement techniques like force plates and in-shoe pressure sensors. Articles involving diverse populations, including young adults, elderly individuals, and obese participants, were included to explore variations in plantar pressure. Key findings were extracted and analyzed to synthesize current knowledge on plantar pressure distribution and its implications for health, rehabilitation, and footwear design.

4. BIOMECHANICS OF WALKING AND PLANTAR PRESSURE DISTRIBUTION

Walking is a dynamic process that involves coordinated lower limb movements and ground reaction forces, with plantar pressure distribution (PPD) playing a crucial role in stability and propulsion (Burnfield et al., 2004). During the stance phase, pressure shifts from the heel (heel strike) to the mid foot (mid stance) and finally to the forefoot and hallux (toe-off), enabling forward motion (Jonely et al., 2011)

Factors such as walking speed, foot structure, and footwear influence PPD. Faster walking speeds increase forefoot pressure, while cushioned footwear helps distribute pressure evenly, reducing injury risk (Segal et al., 2004). Additionally, prolonged walking can lead to fatigue-related shifts in pressure, increasing heel loading and reducing toe-off efficiency (Burnfield et al., 2004). Understanding these biomechanics is vital for optimizing gait, preventing injuries, and designing effective footwear.

5. FACTORS AFFECTING PLANTAR PRESSURE DISTRIBUTION

Plantar pressure distribution (PPD) is influenced by several intrinsic and extrinsic factors, including foot structure, body weight, walking speed, age, fatigue, and footwear. These factors alter pressure patterns across different foot regions, affecting gait biomechanics, injury risk, and clinical interventions.

5.1. Foot structure and arch type

The morphology of the foot, particularly the medial longitudinal arch (MLA), significantly affects plantar pressure distribution. Individuals with flat feet (low arches) tend to experience

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higher mid foot pressures, whereas those with high arches exhibit increased pressure under the heel and forefoot (Jonely et al., 2011). Studies indicate that arch height and flexibility influence pressure redistribution, with lower arches leading to increased medial foot loading during walking (Hessert et al., 2005).

5.2. Body weight and obesity

Obesity plays a critical role in plantar pressure patterns, with higher body mass leading to increased peak pressures across the foot (Hills et al., 2001). Research shows that obese individuals exhibit greater mid foot and forefoot pressures, which can contribute to foot discomfort and musculoskeletal issues. Additionally, their foot structure adapts by increasing the contact area, yet pressure remains elevated due to excessive loading (Hills et al., 2001).

5.3. Walking speed and stride parameters

Walking speed directly influences PPD, with faster speeds increasing forefoot pressures due to enhanced push-off forces (Segal et al., 2004). Heel pressure is also affected by stride length and foot velocity before contact, highlighting the biomechanical interplay between walking dynamics and plantar loading (Burnfield et al., 2004).

5.4. Age and gait adaptations

Aging is associated with reduced peak plantar pressures at the heel and hallux, which may contribute to balance impairments and fall risks in older adults (Hessert et al., 2005). Older individuals tend to adopt a more cautious walking pattern, characterized by shorter steps and lower impact forces, which alters plantar pressure distribution.

5.5. Fatigue and prolonged walking

Prolonged walking and muscle fatigue significantly alter plantar pressure patterns. Studies indicate that fatigue leads to increased heel loading and reduced toe-off efficiency, which may heighten the risk of overuse injuries (Stolwijk et al., 2010). This is particularly evident in endurance walking or long-distance walking events, where gait adaptations occur to reduce discomfort and maintain efficiency.

5.6. Footwear and surface conditions

Footwear significantly impacts plantar pressure by modifying foot-ground interaction. Cushioned shoes help distribute pressure evenly, reducing peak loads, whereas minimal footwear or barefoot walking results in localized pressure increases, especially at the forefoot (Burnfield et al., 2004). Walking on hard surfaces also generates greater plantar loads, increasing discomfort and injury susceptibility (Segal et al., 2004).

Understanding these factors is essential for designing effective footwear, developing injury prevention strategies, and optimizing clinical interventions for individuals with altered plantar pressure distributions

6. CLINICAL APPLICATION

PPD analysis is widely used in diabetic foot care, as high plantar pressures contribute to foot ulcers and tissue damage. Studies indicate that reducing plantar pressures in diabetic patients

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through customized insoles and therapeutic footwear can prevent ulcer recurrence and improve mobility (Owings et al., 2009). Additionally, abnormal pressure patterns have been linked to conditions such as rheumatoid arthritis and osteoporosis, where pressure redistribution strategies help alleviate discomfort and prevent joint degeneration (Minns & Craxford, 1984)

In rehabilitation, plantar pressure analysis assists in designing interventions for post-stroke patients and individuals recovering from orthopedic injuries. Research highlights that post-stroke patients exhibit altered plantar pressures, affecting balance and gait stability, making pressure measurements valuable in rehabilitation planning (Hillier & Lai, 2009). Similarly, patients with pes planus (flat feet) or hallux valgus benefit from orthotic modifications that redistribute pressures and improve gait efficiency (Kernozek et al., 2003).

7. SPORTS APPLICATION

In athletics, PPD assessment is essential for injury prevention and performance enhancement. Studies show that runners with improper plantar loading are at higher risk of stress fractures and metatarsal injuries, especially due to excessive forefoot pressure (Michelson et al., 2002). Moreover, foot posture abnormalities, such as excessive pronation or supination, influence plantar loading patterns and contribute to conditions like Achilles tendinitis and plantar fasciitis (Queen et al., 2009).

Footwear design is another area where PPD plays a critical role. Research indicates that athletic shoes with proper arch support and cushioning reduce impact forces and optimize plantar pressure distribution, helping to prevent overuse injuries (Sneyers et al., 1995). Additionally, real-time plantar pressure monitoring through smart insoles provides valuable feedback to athletes, allowing them to adjust foot mechanics and improve running efficiency (Teyhen et al., 2009).

8. CONCLUSION

Plantar pressure distribution (PPD) plays a fundamental role in understanding gait mechanics, diagnosing foot-related conditions, and optimizing rehabilitation and athletic performance. This review highlights how factors such as foot structure, body weight, walking speed, aging, fatigue, and footwear significantly influence plantar pressure patterns, affecting both stability and injury risk (Hessert et al., 2005; Hills et al., 2001). Research indicates that obese individuals experience higher mid foot and forefoot pressures, increasing their likelihood of developing musculoskeletal complications, whereas older adults exhibit reduced heel and forefoot pressures, which may contribute to balance issues and a higher fall risk (Hessert et al., 2005; Stolwijk et al., 2010).

Clinically, PPD analysis is essential for managing diabetic foot ulcers, improving orthotic interventions, and addressing conditions such as pes planus and hallux valgus (Owings et al., 2009; Minns & Craxford, 1984). In sports biomechanics, understanding plantar pressure helps prevent injuries and optimize performance, especially in athletes prone to foot posture abnormalities and high-impact forces (Queen et al., 2009; Michelson et al., 2002). Advances in wearable technology and real-time pressure monitoring offer promising future applications for more personalized gait assessments and treatment strategies (Teyhen et al., 2009). Continued research and innovation in plantar pressure analysis will further enhance clinical and athletic interventions, ensuring improved foot health and mobility outcomes.

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THE ROLE OF BIOMECHANICS IN BASKETBALL SHOT

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ABSTRACT:
This literature review examines the critical biomechanical factors influencing basketball jump shot performance. Key kinematic variables, such as joint angles and velocities, and kinetic elements, including force generation and impulse, are identified as essential for optimizing shot success. The review highlights the importance of lower limb power, release height, and upper body coordination in achieving effective jump shots. Additionally, it discusses the significance of ground reaction forces and landing techniques in minimizing injury risks. The findings emphasize the importance of sport-specific training and neuromuscular coordination in enhancing jump shot efficiency. Practical implications for coaching strategies and training interventions are also discussed, focusing on the use of countermovement jumps as a diagnostic tool for assessing lower limb power. Overall, the review underscores the complex interplay of biomechanical factors in achieving proficient basketball shooting techniques.

Keywords: Jump shot, Joint angles, angular velocities, Release angle, Force generation, Counter movement jump.

1. INTRODUCTION

The jump shot is a critical scoring technique in basketball, where success depends on a complex interplay of biomechanical factors. Research has shown that both kinematic aspects (such as joint angles and timing) and kinetic elements (such as force generation and impulse) are essential for optimizing shot performance (Doe, 2020; Smith & Johnson, 2019). For example, variations in lower limb mechanics during take-off can significantly affect the force production necessary for achieving the proper arc and velocity (Doe, 2020). Similarly, upper body mechanics, including shoulder and wrist coordination, have been associated with improved ball release accuracy and consistency (Brown, 2018). These studies collectively indicate that effective jump shot performance is not solely reliant on physical strength, but also on precise movement patterns and neuromuscular control (Smith & Johnson, 2019).

This literature review aims to integrate these findings by examining the key biomechanical factors influencing jump shot performance. It explores how joint movements, force dynamics, and body coordination work together to affect shot outcomes, ultimately providing insights that can inform coaching strategies and training interventions for basketball players (Doe, 2020).

2. BIOMECHANICAL FACTORS IN JUMP SHOT PERFORMANCE

The jump shot is a critical skill in basketball, frequently used by players to score points (Struzik, Pietraszewski, & Zawadzki, 2014). Its prevalence, accounting for over 70% of shots taken during a game, underscores the necessity for athletes to achieve a high level of proficiency in its execution (Oudejans et al., 2012; Struzik, Pietraszewski, & Zawadzki, 2014). The jump shot requires automation and repeatability so that players achieve maximum repeatability, regardless of external factors (Kornecki et al., 2002; Struzik, Pietraszewski, & Zawadzki, 2014).

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Key kinematic variables

Previous biomechanical research has identified several kinematic variables crucial to jump shot performance. These include maximum angular values and velocities in individual joints (McClay et al., 1994a), temporal profiles of angular changes and velocities (Kornecki & Lenart, 1997), release angle and velocity of the ball, the movement and velocity of the center of mass, and upper body rotation (Miller & Bartlett, 1996; Struzik, Pietraszewski, & Zawadzki, 2014). Furthermore, initial ball rotation (Tran & Silverberg, 2008) and foot position during shooting also play a significant role (Spina et al., 1996; Struzik, Pietraszewski, & Zawadzki, 2014).

Ground reaction forces and landing technique

Analysis of ground reaction forces (GRF) provides insights into the take-off and landing phases of the jump shot (McClay et al., 1994b; Struzik, Pietraszewski, & Zawadzki, 2014). GRF analysis allows researchers to focus on not only the jumping performance, but also on the health-oriented aspects of this movement (Struzik, Pietraszewski, & Zawadzki, 2014). A soft landing technique is essential to minimize excessive load on the lower limbs (Brizuela et al., 1997; Struzik, Pietraszewski, & Zawadzki, 2014), reducing the risk of overload and potential injuries. Players should absorb shock by flexing their lower limbs during landing (Struzik, Pietraszewski, & Zawadzki, 2014). Midfoot landing is generally preferred over heel contact to decrease impact force (Bober et al., 2002; DeVita & Skelly, 1992; Struzik, Pietraszewski, & Zawadzki, 2014). The average maximum ground reaction forces in the landing phase were 5.57 ± 1.22 multiplied by the average body weight for the jump shot and 5.39 ± 1.3 for the CMJ without an arm swing (Struzik, Pietraszewski, & Zawadzki, 2014).

Release height

The height at which the ball is released, or the release point, is a critical determinant of jump shot success, particularly when facing aggressive defenders (Oudejans et al., 2012; Rojas et al., 2000; Struzik, Pietraszewski, & Zawadzki, 2014). Factors influencing release height include the shooter's body height, jump height, and the arrangement of body parts (Miller & Bartlett, 1996; Struzik, Pietraszewski, & Zawadzki, 2014). Training should focus on maximizing release height to enable shots from more advantageous positions (Struzik, Pietraszewski, & Zawadzki, 2014).

Lower limb power and motor abilities

Given that basketball involves explosive movements, the power generated by the lower limbs is a vital motor ability (Struzik, Pietraszewski, & Zawadzki, 2014). The countermovement jump (CMJ) is often used to assess lower limb power (Hara et al., 2006; Struzik, Pietraszewski, & Zawadzki, 2014).

3. KEY FINDINGS FROM THE RESEARCH

This study compared the biomechanical characteristics of lower limbs during a jump shot without the ball and a countermovement jump (CMJ) without an arm swing in second-league basketball players (Struzik, Pietraszewski, & Zawadzki, 2014). Surprisingly, the research revealed that the participants exhibited more advantageous biomechanical variables during the jump shot compared to the CMJ (Struzik, Pietraszewski, & Zawadzki, 2014).

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Specifically, the study found the basketball players had significantly improved take-off times, peak power, overall mean power during the take-off phase, and relative mean power when performing the jump shot (Struzik, Pietraszewski, & Zawadzki, 2014). There were no significant differences in jump height between the two movements, although there was a small difference found in seven of the subjects (Struzik, Pietraszewski, & Zawadzki, 2014).

The average maximum ground reaction forces in the landing phase were 5.57 ± 1.22 multiplied by the average body weight for the jump shot and 5.39 ± 1.3 for the CMJ without an arm swing (Struzik, Pietraszewski, & Zawadzki, 2014). This indicates a tendency for the players to land softly in both types of jumps, potentially to mitigate the impact forces (Struzik, Pietraszewski, & Zawadzki, 2014).

The authors suggest that the observed advantages in the jump shot are likely due to the high level of training and skill of the basketball players, enabling them to maximize their speed-strength abilities during this specific movement (Struzik, Pietraszewski, & Zawadzki, 2014). They recommend the use of the CMJ without an arm swing as a valuable tool for assessing and predicting the progression of a player's jumping ability (Struzik, Pietraszewski, & Zawadzki, 2014).

4. DISCUSSION AND CONCLUSION

A study revealed that second-league basketball players exhibited more advantageous biomechanical variables during the jump shot compared to the countermovement jump (CMJ) without an arm swing (Struzik et al., 2014). Specifically: Shorter take-off times, Higher peak power and Greater relative mean power.

Surprisingly, jump height showed no significant difference between the two movements (0.365 m for jump shot vs. 0.368 m for CMJ) (Struzik et al., 2014). This suggests that the players maximized their motor abilities during the jump shot, likely due to sport-specific training (Struzik et al., 2014).

Biomechanical efficiency in jump shots

The improved performance during jump shots may stem from:

Technical mastery: Players optimized their speed-strength abilities through repetitive jump shot practice (Struzik et al., 2014).

Neuromuscular coordination: The jump shot’s technical demands (e.g., upper body positioning) likely enhanced power transfer efficiency (Kornecki et al., 2002).

Training specificity: Basketball drills prioritize explosive, game-relevant movements over generic vertical jumps (Miller & Bartlett, 1996).

Landing Mechanics and Injury Risks

Both jumps exhibited high ground reaction forces during landing leading to impact ratios of 2.04 and 2.26, respectively (Struzik et al., 2014). These values suggest players prioritized soft landings (midfoot contact, limb flexion) to reduce injury risk (DeVita & Skelly, 1992; Bober et al., 2002). Excessive forces during hard landings could lead to chronic lower-limb injuries (Brizuela et al., 1997).

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Practical implications for training

Focus on sport-specific drills: Jump shot practice enhances both technical and speed-strength performance.

Use CMJ without arm swing as a diagnostic tool to assess lower-limb power progression (Struzik et al., 2014).

Prioritize power development (mean: 1,757 W for jump shot) over raw jump height.

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KINETIC CHAIN OF TENNIS SERVE PHASE ANALYSIS

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ABSTRACT:

The tennis serve is a biomechanically complicated manoeuvre that uses an efficient kinetic chain to create power, precision, and control. This study investigates the sequential activation of body segments, focussing on the function of ground reaction forces, kinetic energy transfer, and muscle activation patterns. The serve is separated into three main phases: preparation, acceleration, and follow-through, with each contributing to power creation and injury prevention. Motion capture, electromyography (EMG), and force platform analysis offer information on joint torques, angular velocities, and energy transfer during the serve.

Keyword: ground reaction force, kinetic chain, joint torque, impulse, momentum, elastic energy, stretch shortening cycle.

1. INTRODUCTION:

The tennis serve is a fundamental stroke in the game, requiring a complex combination of biomechanics, kinetics, and coordination to generate power and accuracy. A well-executed serve involves the sequential activation of different body segments, following the principles of the kinetic chain to maximize efficiency and performance. Ground Reaction Force (GRF), The legs generate force against the ground, transferring energy upward through the body to maximize power (7). Kinetic Chain & Sequential Motion, Energy transfers from larger muscle groups (legs, core) to smaller ones (shoulders, wrist), ensuring maximum racket speed at impact. Joint Torque and Angular Velocity, Hip and shoulder rotation generate racket acceleration, while wrist snap further increases ball speed. Impulse and Momentum, A longer force application results in greater ball velocity, while follow-through helps control momentum and prevent injuries (9). Elastic Energy & Stretch-Shortening Cycle (SSC), Pre-stretching muscles (e.g., shoulder external rotation) stores elastic energy, leading to a more powerful and efficient serve.

Methods of Data Collection:

This review system is narrative types of review. For the subject 11 papers are covered.

Quantities Measured:

Key biomechanical quantities analyzed in the tennis serve include:

- **Kinetic Energy Transfer:** Efficient force application from legs to racket.
- **Angular Velocities:** Shoulder and wrist movements for racket speed.
- **Ground Reaction Forces:** Lower body force application.
- **Muscle Activation Patterns:** EMG studies of trunk and shoulder muscles.

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- **Joint Angles and Ranges of Motion:** Optimal positions to prevent injury.

2. THE KINETIC CHAIN IN A TENNIS SERVE AND SEQUENTIAL ACTIVATION OF BODY

The Kinetic Chain of a tennis serve refers to the sequential activation of body segments, muscles, and joints to generate power, speed, and control for the serve. It's a coordinated movement pattern that involves the entire body, from the legs to the arm, to produce a powerful and effective serve.

Key Components of the Kinetic Chain in a Tennis Serve:

1. **Legs and Hips:** Generate power and momentum through weight transfer, hip rotation, and knee extension.
2. **Core and Torso:** Transfer power from the legs to the upper body through core rotation and torso stabilization.
3. **Shoulder and Scapula:** Position the arm for optimal serving technique, using scapular rotation and shoulder flexion.
4. **Arm and Forearm:** Generate racket head speed and control through arm extension, forearm rotation, and wrist flexion.
5. **Racket and Ball:** Make contact with the ball, using the generated power and control to produce a precise and powerful serve.

3. THE KINETIC CHAIN OF THE TENNIS SERVICE MOTION

This passage explains how the kinetic chain influences the tennis serve by transferring energy from the lower body to the racquet. It emphasizes the role of the legs and trunk in generating force and stability, which significantly contributes to the final speed and power of the serve. The mathematical modeling highlights how a loss of energy in the trunk would require substantial compensation in either velocity or mass to maintain the same force at the hand, reinforcing the importance of lower-body strength and proper energy transfer. The **kinetic chain** refers to how different body segments work together to efficiently transfer energy. In the tennis serve, energy is generated from the **ground up**, starting with the legs and moving through the trunk, shoulder, arm, and finally, the racquet. Here's a deeper look at each phase and how the kinetic chain works.

1. Preparation Phase (Stages 1-4) – Storing Potential Energy:

This phase involves the **loading of energy** that will later be converted into kinetic energy.

- **Legs & Hips:** Players bend their knees and rotate their hips to store energy.
- **Trunk Rotation:** The upper body coils like a spring, increasing stored potential energy.
- **Back Leg Load:** A strong push-off from the back leg starts the forward momentum.

2. Energy Transfer:

This is where stored potential energy is converted into kinetic energy for a powerful serve.

- **Leg Drive & Hip Rotation:** The legs extend, transferring force into the hips and trunk.

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- **Trunk Rotation & Shoulder Action:** The trunk uncoils, transferring force into the shoulder.
- **Elbow Extension & Wrist Snap:** The energy moves through the arm and finally into the racquet.

❖ **Key Concept:**

The **legs and trunk contribute 50%–60% of the kinetic energy** needed for an effective serve. If the trunk loses 20% of its energy, the arm must compensate with a **35% increase in velocity or a 70% increase in mass**, which is inefficient and increases injury risk (1)(6).

3. Deceleration & Stability:

- The body absorbs the leftover energy to prevent injury.
- A smooth, controlled finish ensures the next movement is efficient (4)(1).

4. THE 3 MAJOR TYPES OF SERVES IN TENNIS

These are the three primary types of tennis serves—**flat, slice, and topspin (kick)**—and their impact on muscle activation and kinetic chain mechanics.

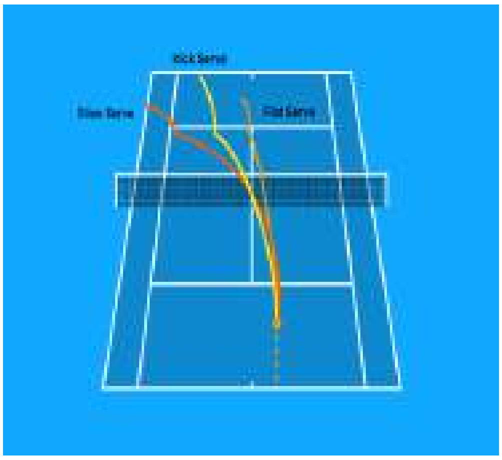

Fig1: Tennis Serve

Serve Types & Their Characteristics:

- **Flat Serve:** Minimal spin, maximum speed.
- **Slice Serve:** Sidespin causes the ball to curve.
- **Topspin (Kick) Serve:** Heavy topspin makes the ball bounce (8)(1).

Speed vs. Spin Relationship:

- More **speed** = Less **spin** (flat serve).
- More **spin** = Less **speed** (kick serve).

Lower Body Activation:

- **The legs and lower trunk** play a consistent role across all serve types.
- Kick serves require more lower trunk activation (Not supported by research).
- No significant differences in **eight lower trunk muscles** during different serves.

Upper Body & Kinetic Chain Differences:

➢ Differences **occur higher** in the kinetic chain.

➢ **Key variations**:

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- **Forearm pronation** (how the palm turns downward).
- **Internal shoulder rotation** (helps control racket face angle).

THE 8-STAGE AND THE 3-PHASES OF THE TENNIS SERVE

Three Phases:

1. **Preparation Phase** – Energy storage
2. **Acceleration Phase** – Energy release
3. **Follow-Through Phase** – Deceleration

1. Preparation Phase (Energy Storage)

Phase 1: Start

- Individualized style; minimal muscular activation.
- Goal: Proper body alignment to maximize ground force generation.

Phase 2: ReleaseBall is tossed; toss position affects shoulder mechanics.

- Toss should be slightly lateral (~100° arm abduction).
- Improper toss (too close to head) can lead to subacromial impingement and shoulder pain.

Phase 3: Loading

- **Goal:** Generate potential energy for power transfer.
- Two loading techniques:
  - **Foot-up:** Higher reach, stronger vertical force, greater rear knee extension.
  - **Foot-back:** More stable, allows deeper squat, greater front knee extension.
- Leg drive correlates with increased service velocity.
- Proper core stability and lateral trunk flexion optimize energy transfer.
- Loading phase is crucial for reducing shoulder and elbow stress.

Fig 2: Phases of Preparation

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Phase 4: Cocking

- Racket moves down and back, maximizing potential energy.
- Requires optimal **range of motion**, **stabilization**, and **shoulder flexibility**.
- **High internal rotator eccentric loads** occur before acceleration.
- Overuse can lead to **shoulder external rotation imbalance** and **injuries** (e.g., posterior impingement).
- Core muscle activation is highest at the end of this phase.

2. Acceleration Phase (Energy Release)

Phase 5: Acceleration

- Fastest stage; elite players accelerate faster than beginners.
- Key muscles: **Pectoralis major, subscapularis, latissimus dorsi, serratus anterior**.
- Peak **leg drive**, **knee extension velocity**, and **trunk rotation** occur.
- Vertical force generated = **1.68 to 2.12 times body weight**.

Phase 6: Contact

- Optimal shoulder abduction **~100°**; racket velocity **85–105 mph**.
- **Trunk tilt ~48°** at impact; wrist flexion and elbow flexion minimal.
- Ball velocity depends on **shoulder internal rotation** and **wrist flexion**.
- More lateral flexion correlates with **higher impact point and better serve height(1).**

3. Follow-Through Phase (Deceleration)

Phase 7: Deceleration

- **Most violent phase**, requiring eccentric control.
- **Posterior rotator cuff, serratus anterior, deltoid, and latissimus dorsi** stabilize shoulder.
- **Distraction forces = 0.5 to 0.75 times body weight**.
- **Right erector spinae** highly active to balance trunk posture.

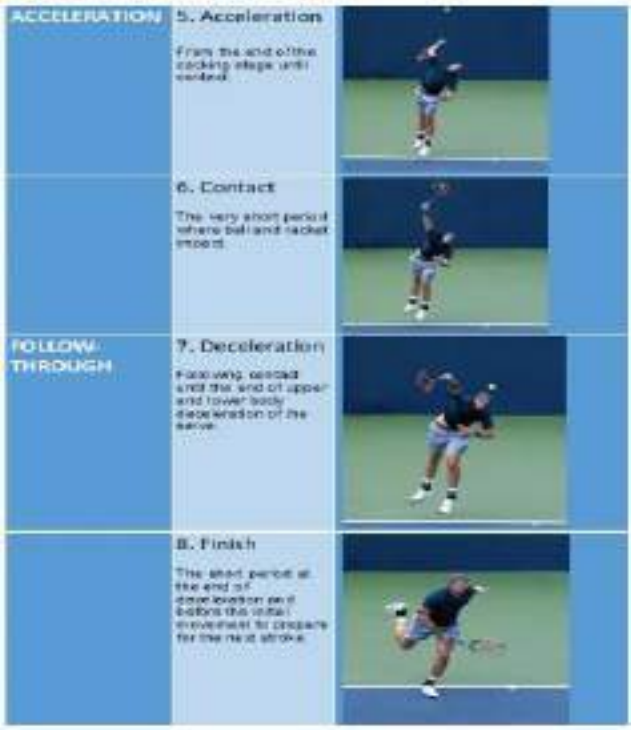

Fig 3: Acceleration and Follow Through

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Phase 8: Finish

- **Lower body landing** absorbs eccentric forces.
- **Foot-up technique** generates higher **horizontal braking forces**, which may affect serve-and-volley players.
- **No major kinematic differences** between male and female players, so mechanics remain the same for both(4)(1)(11).

5. CONCLUSION:

The tennis serve is a biomechanically complex movement that relies on the kinetic chain to generate power and accuracy. The sequential activation of body segments, from the legs to the racket, ensures efficient energy transfer. Proper technique minimizes energy loss and reduces injury risks. Understanding the biomechanical principles, serve variations, and phase-specific mechanics allows players and coaches to optimize performance and prevent injuries.

ACKNOWLEDGEMENT:

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MEDIAL TIBIAL STRESS SYNDROME IN ATHLETES: A LITERATURE REVIEW

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ABSTRACT

Background:

Medial Tibial Stress Syndrome (MTSS) is a common overuse injury of the lower extremity. Medial Tibial Stress Syndrome is one of the most common athletic injuries. the pain will be present during the beginning of exercise and less noticeable as exercise progresses.

Overtime, the condition can worsen and pain may be felt throughout any exercise regime and continue after exercise.

Patient education and a graded loading exposure program seem the most logical treatments. Conservative therapy should initially aim to correct functional gait, and biomechanical overload factors. Recently ‘running retraining’ has been advocated as a promising treatment strategy and graded running programme has been suggested as a gradual tissue-loading intervention.

Overstress avoidance is the main preventive measure of MTSS or shin-splints. The main goals of shin-splints treatment are pain relieve and return to pain-free activities.

Objectives:

The Objectives of this study was to perform a literature review of the last 10 Year regarding evidence for the risk factor and treatment of the MTSS

Data source

A Search for the studies documenting the MTSS risk factor and treatment was carried out in GOOGLE SCHOLAR, PUBMED, MEDLINE and the COCHRANE LIBRARY. After considering inclusion criteria 10 article of literature review comparitive study.

1. INTRODUCTION

MEDIAL TIBIAL STRESS SYNDROME

Medial Tibial Stress Syndrome (MTSS) is a common overuse injury of the lower extremity. Medial Tibial Stress Syndrome is one of the most common athletic injuries.

It typically occurs in runners and other athletes that are exposed to intensive weight bearing activities such as jumpers, or when someone participates in a sport with frequent starts and stops. Training errors, shoe wear, and changes in training intensity. It presents as exercise induced pain over the anterior tibia and is an early stress injury in the continuum of tibial stress fractures. It has the layman’s moniker of “shin splints”.

Medial tibial stress syndrome develops when there is irritation where the calf muscles attach to the shin bone. It affects both the muscle on the inside of the shin and the bone to which it attaches, causing the connection between them to become irritated or even develop minor tears due to overwork.

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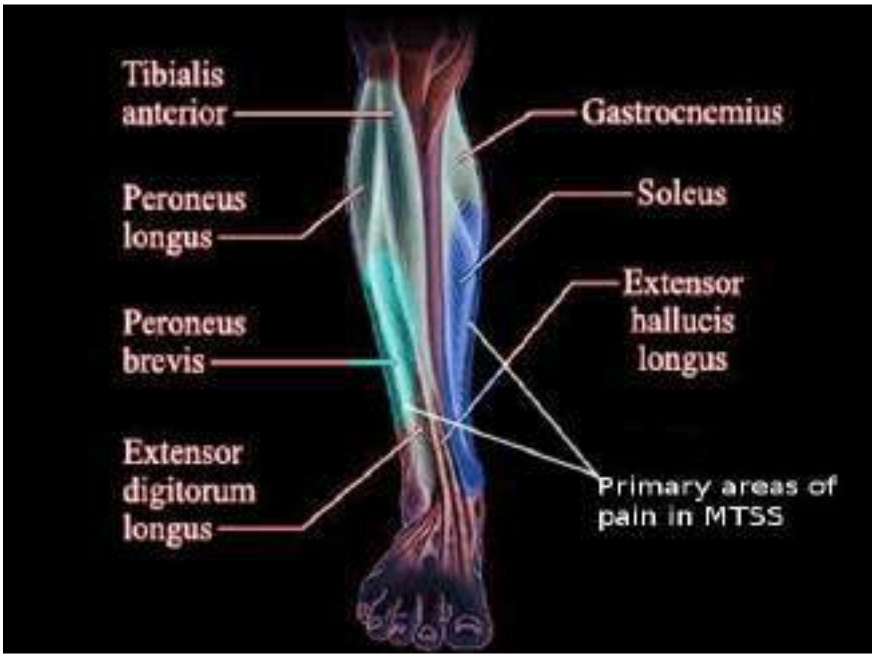

The muscles that attach to tibia can cause an overload of stress on the bone, and strain themselves at their intersection onto the bone as well. These muscles include, the soleus muscle the posterior tibialis muscle, and the flexor digitorum longus muscle.

The pain may feel in the middle or bottom third of the inside of the shin. The pain may be sharp when you touch the tender area, or occur as an ache during or after exercise. Generally, however the pain will be present during the beginning of exercise and less noticeable as exercise progresses. Overtime, the condition can worsen and pain may be felt throughout any exercise regime and continue after exercise.

2. EPIDEMIOLOGY

- The incidence of MTSS ranges between 13.6% to 20%
- Common, can account for between 5% and 35% of novice-running injuries; frequently occurs bilaterally
- Shin splints tend to occur most often in athletes, military personnel and dancers.
- Female gender, previous history of shin splints, fewer years of running experience, orthotic use, increased body mass index, increased navicular drop, and increased external rotation hip range of motion in males are all significantly associated with an increased risk of developing shin splints.
- People who are unfit who suddenly start exercising are at risk of developing a stress fracture of the tibia.
- Contributing factors may include varus hind foot, excessive forefoot pronation, genu valgum, excessive femoral anteversion and external tibial torsion

3. PATHOPHYSIOLOGY

The underlying pathophysiologic process resulting in MTSS is related to unrepaired microdamage accumulation in the cortical bone of the distal tibia. There is typically an overlying periostitis at the site of bony injury, which also correlates with the tendinous attachments of the

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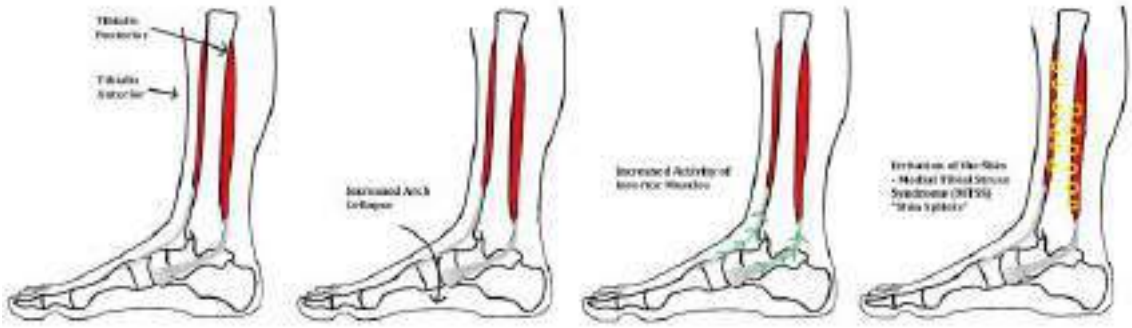
soleus, flexor digitorum longus, and posterior tibialis. Given the mechanical connection of Sharpey's fibers, which are perforating fibers of connective tissue linking periosteum to the bone, the belief is that repetitive muscle traction may be the underlying cause of the periostitis and cortical microtrauma. However, it remains unclear if periostitis occurs before cortical microtrauma or vice versa. The pain is secondary to inflammation of the periosteum as a result of excessive traction of the tibialis posterior or soleus, supported by bone scintigraphy findings of a broad linear band of increased uptake along the medial tibial periosteum. But a case-controlled ultrasound is based study which compared periosteal and tendinous edema of athletes with and without medial tibial stress syndrome found no difference between the groups.

4. ETIOLOGY

The exact etiology of shin splints is unknown it is thought that the pain is a result of irritation of the tibia. It has been suggested that the irritation is caused by over activity (pulling) of the tibialis anterior and tibialis posterior on the tibia.



- Multifactorial anatomic and biomechanical factors
- Overuse injuries causing or limited by
- Microtrauma from repetitive motion leading to periosteal inflammation
- Overpronation of the subtalar joint and tight gastrocnemius/soleus complex with increased eccentric loading of musculature inserting along the medial shin
- Interosseous membrane pain
- Periostitis
- Tears of collagen fibers
- Enthesopathy
- Anatomic structures affected include
- Flexor hallucis longus
- Tibialis anterior
- Tibialis posterior
- Soleus
- Crural fascia

5. RISK FACTORS

INTENSITY TRAINING:

A rapid change in training, such as increasing intensity, can bring on pain in medial tibial. Shin splint are common early in a sports season when people start or intensity training.

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HYPERPRONATION:

Excessive pronation refers to when most or all of the body weight rest on the inside sole of the foot, hyperpronation can cause increased eccentric loading of the soleus and tibialis posterior muscles in the calf which can lead to shin splint pain.

HAVE FLAT FOOT (PES PLANUS):

Like people who hyperpronate, people who have flatfoot, called pes planus ten to put more stress on the inside sole of foot.

HAVE SLIGHTLY DIFFERENT LEG LENGTH:

A person can have slightly different leg lengths and not be aware of it. A relatively small leg length difference can cause problems in running biomechanics, leading to shin splints or other repetitive use injuries.

WEAR IMPROPER FOOTWEAR:

Running shoes that do not provide enough cushion and support proper foot mechanics may encourage the development of shin splints.

RUN ON HARD SURFACE

Running on hard surfaces, such as concrete sidewalks, increases the impact on the musculoskeletal system and can lead to shin splints.

RUN ON UNEVEN SURFACE:

Running on uneven trails or pavement can force the body to make constant adjustments, causing strains that can lead to shin splints.

HAVE BAD RUNNING FORM:

A runner who has poor form puts additional stress and strain on the musculoskeletal system, which can lead to shin splints.

A person with shin splints may have only one of these risk factors or all of them.

SYMPTOMS:

Below are common symptoms associated with shin splints. Although mild swelling sometimes occurs, swelling of the lower leg, numbness, and weakness are not associated with shin splints and should prompt evaluation for other disorders.

Dull pain:

Athletes report a dull pain that affects most of the inside shin (medial tibia), particularly in the middle or lower part of the shin.

Pain occurs during activity:

Shin pain typically develops while running or doing other athletic activities, such as dancing, or shortly after these activities. As the condition progresses, pain may be noticeable even when walking.

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Tenderness:

The inside of the shin may be tender and painful if pressed or squeezed.

Tight calf muscles:

Athletes may notice their calf muscles are tight.

Decreased ankle flexibility:

Just as the calf muscles may become tight, the ankle may become less flexible.

6. DIAGNOSIS

Most people with shin splint pain never need to go to the doctor for a formal diagnosis. However, athletes may want to consult with their doctors if shin splint pain is not relieved after a couple of weeks of resting, icing, and taking over-the-counter NSAIDs, such as ibuprofen.

Patient interview:

The doctor will ask the patient many questions, including questions about his or her training regime, what brings on pain and what relieves pain.

Physical examination:

Pain along the medial tibia is most often present with running and sports, but may progress to be triggered by walking as well. Tenderness to palpation is present along the medial tibial border. Tight calf muscles and decreased ankle motion are common. Neurovascular exam is normal.

Medical imaging:

X-rays, bone scan, and MRI are often negative with shin splints, but they may help to differentiate shin splints from stress fractures. X-rays may demonstrate some generalized periosteal thickening. A bone scan may demonstrate some generalized uptake of the tracer substance used in these scans along a length of the medial tibia, which indicates locations where the bone's metabolism is increased.

7. TREATMENT

The majority of patients are able to treat their shin splints with rest and other home-care methods, but some need help from medical professionals. Several of the treatments listed below can be done at home, while others require a doctor or physical therapist.

Cut back on training:

Athletes should decrease training to a point where discomfort is no more than mild. This may require taking some time off running and sports. During this time, athletes can do non-impact cross-training, such as water running, cycling or using an elliptical machine.

Improve running form:

Adjustments in running form can lessen the impact on the body, thereby decreasing the likelihood the shin splints will become chronic or more painful. For example, a running technique that lessens the risk of shin splints is to avoid footfall on the heel and move to the mid- or forefoot.

Change shoes:

Switching out athletic shoes for newer or different pair can decrease the impact when feet hit the ground.

Use shoe inserts:

Like changing shoes, using inserts (orthotics) can help, especially for athletes with flat feet.

Ice:

Applying a cold pack for 20 minutes two or three times a day can decrease inflammation.

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NSAIDs:

Over the counter NSAIDs can help relieve pain and control inflammation.

Stretching and strengthening exercises:

Helpful exercises will stretch the calves and strengthen the lower leg muscles.

Electrical stimulation:

This type of therapy is used to treat muscle pain and spasms, and may be helpful when damage to calf muscles is the underlying cause of shin splints.

Ultrasound:

Concentrated, low ultrasonic frequencies stimulate blood flow, potentially promoting cell healing and speeding up recovery. Ultrasound therapy is different from ultrasound used for medical imaging.

Iontophoresis:

This treatment uses a mild electrical current to push a topical steroid medicine into the affected shin(s).

Dry needling or acupuncture:

Inserting ultra-thin needles into specific locations on the skin might relieve musculoskeletal pain and dysfunction, including shin splints.

Massage:

Manual therapy and soft tissue massage can improve limitations in joint motion and flexibility.

8. PHYSICAL THERAPY MANAGEMENT

Patient education and a graded loading exposure program seem the most logical treatments. Conservative therapy should initially aim to correct functional gait, and biomechanical overload factors. Recently 'running retraining' has been advocated as a promising treatment strategy and graded running programme has been suggested as a gradual tissue-loading intervention. Overstress avoidance is the main preventive measure of MTSS or shin-splints. The main goals of shin-splints treatment are pain relieve and return to pain-free activities.

Acute phase:

2-6 weeks of rest combined with medication is recommended to improve the symptoms and for a quick and safe return after a period of rest. NSAIDs and Acetaminophen are often used for analgesia. Also, cryotherapy with Ice-packs and eventually analgesic gels can be used after exercise for a period of 20 minutes.

- There are a number of physical therapy modalities to use in the acute phase but there is no proof that these therapies such as ultrasound, soft tissue mobilization, electrical stimulation would be effective. A corticoid injection is contraindicated because this can give a worse sense of health. Because the healthy tissue is also treated. A corticoid injection is given to reduce the pain, but only in connection with rest.
- Prolonged rest is not ideal for an athlete

Subacute phase:

The treatment should aim to modify training conditions and to address eventual biomechanical abnormalities. Change of training conditions could be decreased running distance, intensity and frequency and intensity by 50%. It is advised to avoid hills and uneven surfaces.

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- During the rehabilitation period the patient can do low impact and cross-training exercises (like running on a hydro-gym machine).). After a few weeks athletes may slowly increase training intensity and duration and add sport-specific activities, and hill running to their rehabilitation program as long as they remain pain-free.
- A stretching and strengthening (eccentric) calf exercise program can be introduced to prevent muscle fatigue. (Level of Evidence: 3a) (Level of Evidence: 3a) (Level of Evidence: 5). Patients may also benefit from strengthening core hip muscles. Developing core stability with strong abdominal, gluteal, and hip muscles can improve running mechanics and prevent lower-extremity overuse injuries.
- Proprioceptive balance training is crucial in neuromuscular education. This can be done with a one-legged stand or balance board. Improved proprioception will increase the efficiency of joint and postural-stabilizing muscles and help the body react to running surface incongruities, also key in preventing re-injury.
- Choosing good shoes with good shock absorption can help to prevent a new or re-injury. Therefore, it is important to change the athlete's shoes every 250-500 miles, a distance at which most shoes lose up to 40% of their shock-absorbing capabilities. In case of biomechanical problems of the foot may individuals benefit from orthotics. An over-the-counter orthosis (flexible or semi-rigid) can help with excessive foot pronation and pes planus. A cast or a pneumatic brace can be necessary in severe cases.
- Manual therapy can be used to control several biomechanical abnormalities of the spine, sacro-illiac joint and various muscle imbalances. They are often used to prevent relapsing to the old injury.
- There is also acupuncture, ultrasound therapy injections and extracorporeal shock-wave therapy but their efficiency is not yet proved.

9. LITERATURE REVIEW

Phil Newman, et al [2013]:

Medial tibial stress syndrome (MTSS) affects 5%–35% of runners. At the present time, understanding of the risk factors and potential causative factors for MTSS is inconclusive. A systematic review of the literature identified ten papers suitable for inclusion in a meta-analysis. Measures with sufficient data for meta-analysis included dichotomous and continuous variables of body mass index (BMI), ankle dorsiflexion range of motion, navicular drop, orthotic use, foot type, previous history of MTSS, female gender, hip range of motion, and years of running experience.

S. Yagi, et al [2013]:

A total of 230 runners participating in high school running teams were evaluated. All runners aged 15 years as first grade of high school were involved in the study. They were followed up for 3 years. The measured items included height, weight, body mass index (BMI), range of hip and ankle motion, straight leg raising (SLR), intercondylar and intermalleolar interval, Q-angle, navicular drop test, hip abductor strength and physical conditioning. Each runner was followed for 3 years to report occurrence of MTSS and Stress fracture. A total number of 102 MTSS (0.29 athlete exposures) and 21 SF (0.06 athlete exposures) were identified. In females, BMI significantly increased the risk of MTSS after adjustment for the other variables in this study (adjusted odds ratio, 0.51; 95 % confidence interval, 0.31–0.86). Increased internal rotation of the hip significantly increased the risk of MTSS (adjusted odds ratio, 0.91; 95 % confidence interval, 0.85–0.99). In males, limited SLR also significantly increased the risk of SF with adjustment for the other variables in this study (adjusted odds ratio, 1.38; 95 % confidence interval,1.04–1.83).

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Becker J, Nakajima M, et al [2018]:

Medial tibial stress syndrome (MTSS) is one of the most common overuse injuries sustained by runners. Despite the prevalence of this injury, risk factors for developing MTSS remain unclear. Twenty-four National Collegiate Athletic Association Division 1 cross-country runners participated in this study. Participants underwent a clinical examination documenting passive range of motion and muscle strength at the hips and ankles. Plantar pressure analysis was used to quantify mediolateral pressure balances while walking and 3D motion capture was used to quantify running kinematics. Participants were followed up for a 2-yr period during which time any runners who developed MTSS were identified by the team's certified athletic trainer. Runners who developed MTSS demonstrated tighter iliotibial bands (P = 0.046; effect size [ES] = 1.07), weaker hip abductors (P = 0.008, ES = 1.51), more pressure under the medial aspect of their foot at initial foot contact (P = 0.001, ES = 1.97), foot flat (P < 0.001, ES = 3.25), and heel off (P = 0.034, ES = 1.30), greater contralateral pelvic drop (P = 0.021, ES = 1.06), and greater peak amounts (P = 0.017, ES = 1.42) and durations (P < 0.001, ES = 2.52) of rearfoot eversion during stance phase. A logistic regression (χ = 21.31, P < 0.001) indicated that every 1% increase in eversion duration increased odds of developing MTSS by 1.38 (P = 0.015).

A Naderi, et al [2022]:

Our aim was to assess the effects of adding arch-support foot-orthoses (ASFO) to a multimodal therapeutic intervention on the perception of pain and improvement of recovery from medial tibial stress syndrome (MTSS) in recreational runners. Pain during bone pressure using a numerical Likert scale (0-10), MTSS severity using an MTSS scale, perceived treatment effect using the global rating of change scale, and quality of life using the short Form-36 questionnaire were determined at week 6, 12, and 18.

MC Griebert, et al [2016]:

Medial tibial stress syndrome (MTSS) is an overuse injury occurring among the physically active. Linked to increased strain on the medial tendons of the ankle, studies emphasize controlling medial foot loading in the management of this condition. Kinesio taping (KT) has gained popularity for treating musculoskeletal pathologies; however, its effect on MTSS remains uninvestigated. This study aimed to determine if healthy participants and patients with current or previous history of MTSS differ in the rate of loading, and if KT affects plantar pressures in these participants.

Twenty healthy participants and 20 participants with current or previous history of MTSS were recruited and walked across a plantar pressure mat prior to KT application, immediately after application, and after 24-h of continued use. Time-to-peak force was measured in 6 foot areas and compared across groups and conditions.

M Winters, et al [2017]:

Medial tibial stress syndrome (MTSS), also known as shin splints, is one of the most common sports injuries. Although 20% of the jumping and running athletes have MTSS at some point while engaging in sporting activities, A number of interventions have been studied in randomised controlled trials over the past 40 years. These include shockwave therapy, lower leg braces, dry needling, lower leg stockings, strengthening exercises, a graded running rehabilitation program and ice massage. which intervention is most effective, however, has remained unclear. Measuring outcomes that matter to the patient are highly important. These so-called patient-reported outcome

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measures (PROMs) are considered the cornerstone for outcome assessment and measuring treatment success in medicine. There was no PROM for athletes with MTSS prior to this thesis' commencement, which prevented the standardised measurement of outcomes in athletes with MTSS. A number of studies, described in this thesis, sought to fill these important gaps in the field. This thesis reports that making the diagnosis MTSS based on history and physical examination has almost perfect reliability among clinicians: k = 0.89 (95%CI 0.74 to 1.00), p<0.000001. This support making the diagnosis of MTSS clinically, without using additional and expensive imaging.

Rodrigo E Martinez , et al [2020]:

A standard treatment protocol for medial tibial stress syndrome (MTSS) has not been identified. Clinical practice focuses on local evaluation and treatment neglecting a global approach. The Myokinesthetic (MYK) System includes a full-body postural assessment to identify compensatory patterns that may lead to MTSS. The purpose of this study was to assess the effects of the MYK System in treating patients diagnosed with MTSS. Paired T-tests were utilized to assess change. The change in patient reported pain was statistically significant ($t_{(17)} = 10.48$, $p < .001$, Cohen's d = 2.48) and represented an average decrease of 96% in patient reported pain. The change in disablement was statistically significant ($t_{(17)} = 7.39$, $p < .001$, Cohen's d = 1.74) and represented an average decrease of 88.2% in patient reported disablement.

Marinus Winters, et al [2013]:

Medial tibial stress syndrome (MTSS) is a common exercise-induced leg injury among athletes and military personnel. Several treatment options have been described in the literature, but it remains unclear which treatment is most effective. Eleven trials were included in this systematic review. All RCTs revealed a high risk of bias (Level 3 of evidence). Both non-randomized clinical trials were found to be of poor quality (Level 4 of evidence). RCTs, studying the effect of a lower leg brace versus no lower leg brace, and iontophoresis versus phonophoresis, were pooled using a fixed-effects model. No significant differences were found for lower leg braces (standardized mean difference [SMD] -0.06; 95 % CI -0.44 to 0.32, p = 0.76), or iontophoresis (SMD 0.09; 95 % CI -0.50 to 0.68, p = 0.76). Iontophoresis, phonophoresis, ice massage, ultrasound therapy, periosteal pecking and extracorporeal shockwave therapy (ESWT) could be effective in treating MTSS when compared with control (Level 3 to 4 of evidence). Low-energy laser treatment, stretching and strengthening exercises, sports compression stockings, lower leg braces and pulsed electromagnetic fields have not been proven to be effective in treating MTSS.

J Saeki , et al [2018]:

Previous history of medial tibial stress syndrome (MTSS) is a risk factor for MTSS relapse, which suggests that there might be some physical factors that are related to MTSS development in runners with a history of MTSS. The relationship between MTSS and muscle stiffness can be assessed in a cross-sectional study that measures muscle stiffness in subjects with a history of MTSS, who do not have pain at the time of measurement, and in those without a history of MTSS. The purpose of this study was to compare the shear elastic modulus, which is an index of muscle stiffness, of all posterior lower leg muscles of subjects with a history of MTSS and those with no history and investigate which muscles could be related to MTSS. Twenty-four male collegiate runners (age, 20.0±1.7 years; height, 172.7±4.8 cm; weight, 57.3±3.7 kg) participated in this study; 14 had a history of MTSS, and 10 did not. The shear elastic moduli of the lateral gastrocnemius,

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medial gastrocnemius, soleus, peroneus longus, peroneus brevis, flexor hallucis longus, flexor digitorum longus, and tibialis posterior were measured using shear wave elastography. The shear elastic moduli of the flexor digitorum longus and tibialis posterior were significantly higher in subjects with a history of MTSS than in those with no history. However, there was no significant difference in the shear elastic moduli of other muscles. The results of this study suggest that flexor digitorum longus and tibialis posterior stiffness could be related to MTSS.

Parisa Sedaghati, et al [2019]:

Somatosensory afferent signals from from the environment are required for the posture control. The disorder of somatosensory systems results in impairment in on-time and efficient signaling and its upcoming postural instability. The present study aimed at investigating the effect of proprioceptive, vestibular and visual changes on posture control among the active girls with and without medial tibial stress syndrome. In this case-control study, 60 girl athletes were purposefully selected with a history of regular physical activity, among them 30 girls had medial tibial stress syndrome and others were healthy athletes. The assessment of posture during the single-leg stance test was carried out on both groups (with and without medial tibial stress syndrome) in six different sensory positions.

10. METHODOLOGY

STUDY DESIGN: Literature review

DATA SOURCE: The following sites and their comprising references were used for the selection of article.

- PUBMED
- GOOGLE SCHOLAR
- MEDLINE

MATERIALS AND METHODS: Studies were identified using the key words MTSS, MTSS Management, MTSS risk factor Physiotherapy for MTSS.

STUDY SELECTION: The present study selection includes systemic review, literature review, randomized control trial, comparative study.

11. ELIGIBILITY CRITERIA

Inclusion Criteria:

- Original research studies published after 2010 were selected.
- Studies published on English were only selected.
- Published full length articles of randomized control trial, systemic review, literature review, comparative study.
- Population in the study should be ATHLETES with MTSS

Exclusion criteria:

- Articles which were not related to MTSS were excluded from the study.
- Articles not related risk factor and management of MTSS were excluded from the study.
- Articles which did not yield adequate information about the topic were excluded.
- Irrelevant studies i.e, article not related to MTSS and management of MTSS were excluded.

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12. DATA EXTRACTION:

Initially screening of information based on titles and abstracts and subsequent screening used the full text of identified articles. The final number of articles obtained based on inclusion and exclusion criteria were 20. Further, articles were narrowed down considering information only related to the risk factor and management and 10 articles were selected for the study. Data extraction was done regarding methodological quality, design, population, sample size, intervention, outcome, and result was subsequently reached.

13. DISCUSSION

Phil Newman, Jeremy Witchalls, Gordon Waddington on Risk factors associated with medial tibial stress syndrome in runners, proved that the following factors were found to have a statistically significant association with MTSS: increased hip external rotation in males (standard mean difference [SMD] 0.67, 95% confidence interval [CI] 0.29–1.04, P<0.001); prior use of orthotics (risk ratio [RR] 2.31, 95% CI 1.56–3.43, P<0.001); fewer years of running experience (SMD −0.74, 95% CI −1.26 to −0.23, P=0.005); female gender (RR 1.71, 95% CI 1.15–2.54, P=0.008); previous history of MTSS (RR 3.74, 95% CI 1.17–11.91, P=0.03); increased body mass index (SMD 0.24, 95% CI 0.08–0.41, P=0.003); navicular drop (SMD 0.26, 95% CI 0.02–0.50, P=0.03); and navicular drop >10 mm (RR 1.99, 95% CI 1.00–3.96, P=0.05).

Study on incidence and risk factors for medial tibial stress syndrome and tibial stress fracture in high school runners by S Yagi concluded that a total number of 102 MTSS (0.29 athlete exposures) and 21 SF (0.06 athlete exposures) were identified. In females, BMI significantly increased the risk of MTSS after adjustment for the other variables in this study (adjusted odds ratio, 0.51; 95 % confidence interval, 0.31-0.86). Increased internal rotation of the hip significantly increased the risk of MTSS (adjusted odds ratio, 0.91; 95 % confidence interval, 0.85-0.99). In males, limited SLR also significantly increased the risk of SF with adjustment for the other variables in this study (adjusted odds ratio, 1.38; 95 % confidence interval, 1.04-1.83). A significant relationship was found between BMI, internal hip rotation angle and MTSS in females, and between limited SLR and SF in males.

According to Becker J Nikajima M the study on Factors Contributing to Medial Tibial Stress Syndrome in Runners. Concluded that the development of MTSS is multifactorial, with passive range of motion, muscle strength, plantar pressure distributions, and both proximal and distal kinematics all playing a role. We suggest that coaches or sports medicine professionals screening runners for injury risk consider adopting a comprehensive evaluation which includes all these areas.

According to A Naderi, S Bagheri the study on Foot Orthoses Enhance the Effectiveness of Exercise, Shockwave, and Ice Therapy in the Management of Medial Tibial Stress Syndrome proved that**,** Pain intensity and MTSS severity were lower, and the perceived treatment effect and physical function were better in the ASFO than in the sham flat noncontoured orthoses group at week 6 and week 12. Cohen's dz effect size for between-group differences showed a medium difference. However, arch-support foot-orthoses did not add to the benefits of multimodal therapeutic intervention on pain, MTSS severity and perceived treatment effect at week.

According to Lower-leg Kinesio tape reduces rate of loading in participants with medial tibial stress syndrome a review done by MC Griebert, AR Needle, J McConnell concluded that ANOVA revealed a significant interaction between group, condition, and foot area (F = 1.990, p = 0.033). MTSS participants presented with lower medial midfoot time-to-peak force before tape application

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(95%CI: 0.014–0.160%, $p = 0.021$) that significantly increased following tape application ($p < 0.05$).

These results suggest that KT decreases the rate of medial loading in MTSS patients. Future research might assess mechanisms by which this effect is achieved.

According to M Winters the study on medial Tibial Stress Syndrome: Diagnosis, Treatment and Outcome Assessment proved that the most logical treatment is load management, increasing loading capacity through gradual load exposure and strengthening the calf muscles. Lastly, this thesis describes the development and validation of a new PROM: the MTSS score. Items for this outcome measure were developed together with researchers, clinicians and patients. The items and scale were tested for their validity, reliability and responsiveness in a large population of 133 athletes with MTSS recruited from 15 sports medicine, military medicine and physiotherapy practices in The Netherlands. This study showed that the MTSS score is a valid, reliable and responsive 4-item scale that can be used to assess outcomes relevant to the athlete with MTSS.

A review on Exploring treatment of medial tibial stress syndrome via posture and the Myokinesthetic system by Rodrigo E Martinez , Evelyn Benitez Lopez , concluded that Implementation of the MYK System to treat MTSS led to significant decreases in patient reported pain and dysfunction. A full-scale clinical investigation of the MYK System is warranted to determine its effects compared to traditional treatment options).

According to Marinus Winters , Michel Eskes the review on the treatment of medial tibial stress syndrome proved that Iontophoresis, phonophoresis, ice massage, ultrasound therapy, periosteal pecking and extracorporeal shockwave therapy (ESWT) could be effective in treating MTSS when compared with control (Level 3 to 4 of evidence). Low-energy laser treatment, stretching and strengthening exercises, sports compression stockings, lower leg braces and pulsed electromagnetic fields have not been proven to be effective in treating MTSS (level 3 of evidence).

A study of Muscle stiffness of posterior lower leg in runners with a history of medial tibial stress syndrome by J Saeki , M Nakamura was concluded as The shear elastic moduli of the lateral gastrocnemius, medial gastrocnemius, soleus, peroneus longus, peroneus brevis, flexor hallucis longus, flexor digitorum longus, and tibialis posterior were measured using shear wave elastography. The shear elastic moduli of the flexor digitorum longus and tibialis posterior were significantly higher in subjects with a history of MTSS than in those with no history. However, there was no significant difference in the shear elastic moduli of other muscles. The results of this study suggest that flexor digitorum longus and tibialis posterior stiffness could be related to MTSS.

Study on the the effect of proprioceptive, vestibular and visual changes on posture control among the athletes with and without medial tibial stress syndrome by Parisa Sedaghati , Hamid Zolghare , Maryam Shahbazi results showed a significant difference in posture control in five different positions (opened-eye, head hyperextension, closed eyes on hard surface, closed eyes followed by head hyperextension, opened-eye and head hyperextension and closed eyes on soft surface) between athletes with medial tibial stress syndrome and healthy athletes ($P=0.001$). It seems that in the presence of the coordinated function of three senses, the posture control of the girls with a medial tibial stress syndrome is similar to healthy girls and in the absence of each of the three senses, the posture control would impair.

13. CONCLUSION

After a thorough review of these articles, I found out that risk factors like Hyperpronation, having flat foot, slight difference in leg, wearing improper shoes, Running on hard surface.

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Treatments includes for MTSS such as NSAIDS Stretching and Strengthening of lower leg muscles, Electric stimulation, Ice, Iontophoresis, dry needling massage has been proposed as an effective treatment for MTSS.

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INFLAMMATORY BIOMARKERS AMONG PATIENTS WITH NECK PAIN -A LITERATURE REVIEW

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ABSTRACT:

Chronic neck pain is one of the debilitating healthcare burdens to society. Most often, neck pain occurs without any specific cause, termed as nonspecific neck pain. Numerous illnesses that affect the area above the shoulder blades may present with neck pain.[1] Blood tests of individuals suffering from musculoskeletal issues, like upper quadrant, low back, or neck region show elevated inflammatory markers. Previous studies have demonstrated that patients with nonspecific neck pain showed elevated systemic inflammatory markers, which may indicate persistent low-grade inflammation when there is persistent tissue stress or strain, like in the case of employees who have neck pain from protracted, repetitive postures and job related strain.[2] Poor lifestyle choices, such as smoking, eating poorly, not exercising, having trouble sleeping, and being obese, are also linked to systemic inflammation.[3]

This investigation aimed to analyse the existence of inflammatory biomarkers in patients with neck discomfort. An extensive literature search was performed from the year 2004 to 2024 to create a comprehensive narrative regarding the presence of inflammatory biomarkers among neck pain patients. To do this, search for key terms such as chronic nonspecific neck pain, neck pain, and inflammatory biomarkers in PubMed, MEDLINE, EMBASE, CINHAL, Ovid, and Google Scholar. Five electronic databases—MEDLINE, PubMed, CINAHL, Google Scholar, and Cochrane—are being searched to find literature. Full-text articles published between 2004 and 2024 were included; 5 of these studies were featured in this review of the literature.

Results: Data extraction was performed using the Oxford Centre for Evidence-Based Medicine for the studies selected for the review. Diversified search in various databases includes articles out of 60 articles, 5 articles were selected for the narrative review which considered presence of inflammatory biomarkers among neck pain patients. Systematic reviews showed no indication of research overlap. The publications chosen for their evidence level were examined by the Centre for Evidence-Based Medicine (CEBM). According to CEBM levels of indication, tool assigned two studies with a rating of 1a and four studies with a rating of 1b.

Keywords: Neck pain, chronic nonspecific neck pain, inflammatory biomarkers.

1. INTRODUCTION

Neck pain is a prevalent problem in the general and working population, leading to absenteeism and lower productivity. The age-standardized prevalence rate of one of the most prevalent musculoskeletal conditions in 2019 was neck pain which was 27.0 per 1000 persons.[1]Chronic neck pain is highly prevalent in participants exposed to many different working positions, repetitive motions, and the precise movements needed for precise work. There isn't a single, effective remedy for neck pain.[4] However, a variety of treatments, both pharmaceutical & non-pharmacological, have been suggested, such as massage, acupuncture, yoga, laser therapy, and aquatic therapy.

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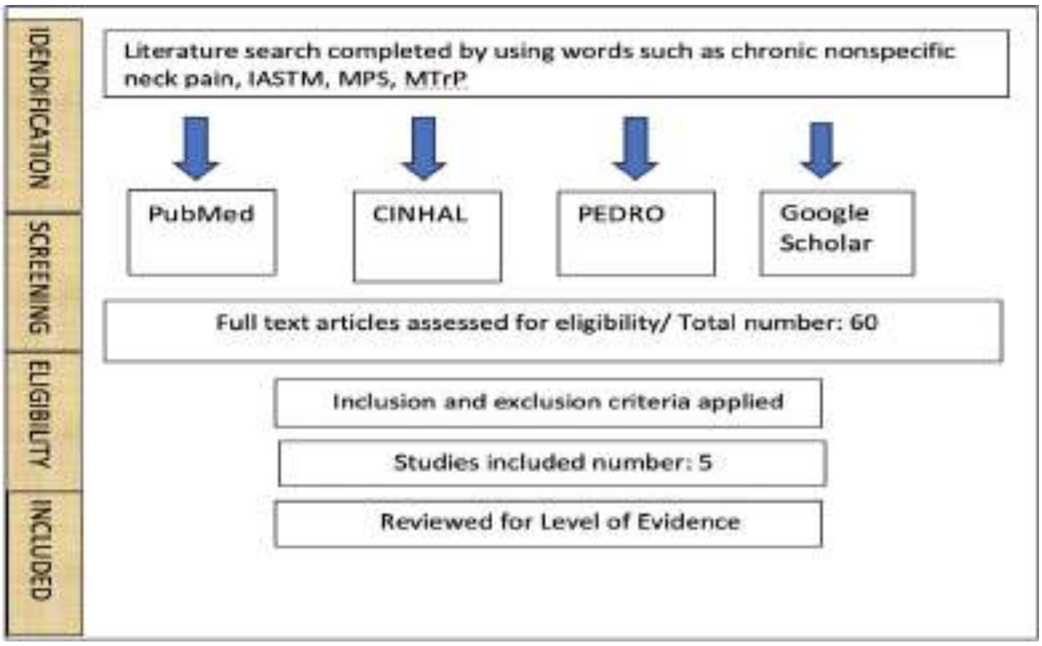
According to experimental and clinical observations, nonspecific neck pain is linked to a local inflammatory response, even though the underlying pathophysiology of neck pain is thought to be complex and has not yet been fully understood. Studies conducted earlier revealed that the biochemical and structural alterations associated with inflammatory processes, specifically concerning compounds to pain like glutamate, serotonin, prostaglandin E 2, bradykinin & IL-6 is important.[5] Inflammatory biomarkers in serum has been associated with level of nocioception around neck and upper extremities was reported.

According to observations in clinical along with autopsy studies, persistent low-grade inflammation in chronic whiplash-associated disorders might be persistent tissue injury that results in a protracted immunological response (Lord et al., 1996; Sterling et al., 2013; Taylor et al., 1993).[6] When persistent tissue stress or strain occurs in employees who have neck pain from prolonged, repetitive tasks and postures, elevated systemic inflammatory markers may indicate persistent low-grade inflammation in individuals with nonspecific neck pain (Matute Wilander et al., 2014).[7] According to earlier research, a major contributing factor to LBP is systemic inflammation, and inflammatory and neuropathic pain have been found to rise with high concentrations of indicators of inflammation, such as TNF-A, IL-1beta, and IL-6. Results linked to nonspecific low back pain may be correlated with the levels of various inflammatory biomarkers in tissue, blood, or other fluids.[8] According to studies, certain biomarkers are linked to particular musculoskeletal pain syndromes, while others are linked to non-specific syndromes (Djade, C. D. et al. 2024). This review study aims to analyze inflammatory biomarkers' presence among neck pain patients.

Materials & Methods: PubMed, MEDLINE, Allied Health Literature, The Cumulative Index to Nursing, and the Physiotherapy Evidence Database [PEDro] were its four online databases and search engines from January 2004 to January 2024 where studies were located. The following keywords were used to gather these studies: Inflammatory biomarkers, neck discomfort, and nonspecific neck pain.

Study Selection:

Table 1: Flow chart of search methodology of studies



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- **Data Extraction:** The acquired data were sorted chronologically and tabulated according to the sample size, treatment, outcome measures, results, and level of evidence. Utilizing the CEBM levels of evidence, the study's quality was evaluated.
- **Inclusion Criteria:** The present review included studies (1) published in English; 2) nonspecific neck pain and the existence of "mesh" phrases such as "Inflammatory biomarkers & Nonspecific neck pain" (3) Referenced only in peer-reviewed publications; (4) Human adult participants were analyzed; (5) This study incorporates both RCTs and systematic reviews.
- **Exclusion Criteria:** 1) Editors' professional judgment; 2) Case studies and case reports; and 3) No case-control studies were included in the study.

2. LITERATURE EVALUATION

Outcome of its present review was varied. Out of 60 original articles, 5 studies were eligible for the review according to the requirements for inclusion. The studies ranged from RCTs to a single systematic review, including meta-analysis. Three investigations were prospective cohort design. The selected studies were ranked using the Center for Evidence-Based Medicine (CEBM)(Table 2). Out of five studies, two were ranked 1a & 1b, respectively, and the remaining were ranked 2b.

3. DATA SYNTHESIS

Michele Sterling's 2013 longitudinal cohort study, which was assigned a 2b CEBM grade, sought to investigate variations in the levels of serum inflammatory biomarkers from the acute to the chronic phases following whiplash injury. Determining the associations between MRI images showed biomarker levels, psychosocial variables, fatty muscle infiltrations of the cervical extensors, and hyperalgesia was another goal of this investigation. According to the findings, there are moderate correlations between mechanical and cold hyperalgesia and initially elevated serum CRP levels after whiplash injury which last in people with chronic moderate to severe pain & disability. On the other hand, people who recover well or fairly have higher serum levels of TNF-α, which is inversely correlated with the degree of fatty accumulation in the extensor muscles of the cervical region. It seems that the manifestation of both acute and chronic WAD is linked to inflammatory biomarkers.[6]

A study by Anna Matute Wilander 2014 has been marked as 1b, a randomized controlled trial assessing the presence of inflammatory serum biomarkers in participants who experienced neck and shoulder pain at work. MIP-1β, IL-12, & CRP levels in the serum were greater than controls in healthy females experiencing persistent shoulder/neck pain, and Levels of MIP-1α, MIP-1β, and CRP were associated with pain intensity.. These outcomes confirm earlier discoveries that inflammatory processes contribute to musculoskeletal problems associated with the workplace.[7]

Another prospective cohort study by Bijar Ghoufuri 2016 has been ranked 2b which was conducted to recognize indicators of systemic inflammation in farmers suffering from musculoskeletal conditions. It was determined that, in comparison to other referents, farmers with pre-existing musculoskeletal problems had different protein levels of biomarkers. It suggests systemic inflammation is more common in farmers suffering from musculoskeletal conditions. A combination of these protein biomarkers could potentially be utilized to determine and stop MSDs connected to the workplace. It is also likely that the differences in proteins found may provide hints about the biochemical changes that occur during the onset and course of MSD in farmers.[9]

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S F Farrel's 2020 systematic review and meta-analysis, which has been designated as 1a, involves a thorough examination of 10 RCTs with 706 participants to measure blood inflammatory markers in patients with neck discomfort. The review showed that chronic neck discomfort was associated with elevated levels of TNF-alpha and IL-1beta. As per a study, neck pain may be caused by a systemic inflammatory reaction.[2]

Bijar Ghafouri 2024 conducted a study marked as 2b as individual cohort research work. This study assessed self-reported data on pain intensity, psychological distress, quality of life, and pain pressure threshold. Forklift truck drivers who experience pain can be distinguished from healthy individuals based on their self-reported health, pain sensitivity, intensity, and plasma biomarker profiles. Combining objective biomarker tests with self-reported data can help better understand the pathophysiological mechanisms underlying shoulder and neck pain connected to the workplace.[10]

Table 2: Study results and level of evidence on CEBM for the review

Sl No.	Authors	Study Design	Participant number	Condition	Control Group	Outcome measure	Results	Level of Evidence
1	Michele Sterling et al.2013	Prospective Longitudinal Cohort Study	44	Whiplash-associated disorders serum inflammatory biomarkers	present	1. VAS 2. NDI 3.SF-36 4. Post-traumatic stress diagnostic scale 5. Coping strategies questionnaire 6. Pain pressure threshold 7. Inflammatory biomarkers/MRI muscle measures &analysis	According to research, inflammatory biomarkers may influence events after whiplash injuries. They are also linked to fatty muscle infiltration in the cervical extensors and hyperalgesia.	2b
2	Anna Matute Wilander et al. 2014	RCT	60	Work-related neck/shoulder complaints	present	Borg scale	Compared to controls, MIP-1β, IL-12, and CRP levels were greater, while there was a correlation among pain severity even MIP-1α, MIP-1β, and CRP levels.	1b
3	Bijar Ghafouri et al.2016	Prospective cohort study	13	Neck pain	NA	Plasma protein analysis		2b
4	S F Farrel et al 2020	Systematic Review with metanalysis	10 RCTs	Chronic neck pain	NA	NA	Elevated blood inflammatory indicators are linked to chronic neck pain. Which could indicate a persistent inflammatory	1a

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							process in this population.	
5	Bijar Ghafouri et al.2024	Individual cohort study	26	Workplace shoulder even neck pain	Present	1. Numeric rating scale (NRS) 2. Hospital Anxiety & Depression Scale (HADS) 3. Quality-of-life scale (QOLS) 4. Inflammatory biomarkers	Inflammatory proteins in the blood, self-reported health, pain sensitivity, and intensity can all be used to distinguish between pain-affected individuals and controls.	2b

4. DISCUSSION

The present study has extensively researched the variations in the presence of inflammatory biomarkers among patients who complain of neck pain and musculoskeletal disorders involving the cervical spine. Out of 60 articles, 5 articles were found relevant for the review. These five studies consisted of one systematic review with metanalysis; the remaining studies belong to prospective longitudinal cohort design. The present review focused on the various alterations in the parameters of serum inflammatory biomarkers among patients suffering from neck pain. Mary F. Barbe et al. 2013 suggested that most serum inflammatory cytokines such as TNF-α, demonstrated force-repetition interactions which support the use of key pro-inflammatory cytokines as biomarkers of acute tissue damage and the fatigue failure hypothesis as a mechanism underlying work related musculoskeletal disorders (WMSDs).[11]Studies have demonstrated presence of ongoing inflammatory process among population who are suffering from chronic neck pain. A 2014 study by Anna Matute Wilander et al. showed that increased IL-12 levels in the blood and CRP among patients complaining of mechanical neck and shoulder pain correlate with increased pain levels compared to controls. Previous studies have also shown evidence of associations of biomarkers about pain and function among patients suffering from both severe along with persistent low back pain. In 2020, a systematic review by S F Farrel showed that systemic inflammation is linked to neck pain. As per the meta-analysis, chronic neck discomfort was associated with higher levels of TNFα and IL-1β but not MCP-1. As stated by the meta-analysis, there was no group difference in TNFα in acute neck pain. Increased levels of TNFα and IL-1β discovered in chronic neck pain: TNFα levels were 83% greater in chronic neck pain on average than in controls, and the concentration of IL-1β was 73% higher. Although systemic inflammation is linked to this meta-analysis, and comprehensive review of neck pain revealed moderate evidence of elevated CRP in chronic neck pain.

5. LIMITATIONS OF THE STUDY FUTURE RECOMMENDATIONS

The current investigation has limited paucity of literature on raised inflammatory biomarkers among people who suffer from persistent neck pain. Many future studies considering a homogenous group population with a bigger sample size could be conducted regarding Systemic inflammation in patients who experience chronic neck pain.

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6. CONCLUSION

In this current literature review found a correlation between raised inflammatory biomarkers among people who suffer from both acute and persistent neck pain. Also, systemic inflammation among chronic neck pain population was substantial evidence regarding establishing correlation of inflammatory biomarkers among patients experiencing chronic neck pain.

Conflict of Interest: None.

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CORRELATION OF QUADRICEPS ANGLE WITH FOOT POSITION IN KNEE OSTEOARTHRITIS

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ABSTRACT:

Purpose: Foot posture assessment is usually neglected in knee osteoarthritis patients. Alteration in the foot posture causes a more rapid progression to knee dysfunction. Therefore, the purpose of the study was to find the correlation of quadriceps angle with foot position in patients with knee osteoarthritis.

Methods: A cross-sectional study was conducted on 100 subjects diagnosed with osteoarthritis in the age group of 50-70 years which included 70 females and 30 males. The quadriceps angle for both the knees was measured with universal Goniometer and the foot posture was evaluated on foot posture index.

Results: Correlation of Q angle of left leg with left foot posture index shows $r = 0.663$ which is statistically significant ($p>0.01$). Correlation of Q angle of right leg with right foot posture index shows $r = 0.65$ which is statistically significant ($p>0.01$).

Conclusion: It was concluded that a positive correlation exists between the Q angle and the foot position in patients with knee osteoarthritis.

Keywords: foot pronation, genu varum, knee osteoarthritis, pes planus.

1. INTRODUCTION

Osteoarthritis is a degenerative joint disease. It is a progressive disorder of the joints caused by gradual loss of cartilage and resulting in the development of bony spurs and cysts at the margins of the joints. It results from deterioration or loss of the cartilage that acts as a protective cushion between bones. As the cartilage is worn away, the bone forms spurs, areas of abnormal hardening, and fluid-filled pockets known as subchondral cysts.[15]

As the disorder progresses, pain results from deformation of the bones and fluid accumulation in the joints. The pain is relieved by rest and made worse by movement. In early OA, the pain is minor and may take the form of mild stiffness in the morning. In the later stages of OA, inflammation develops, the patient may experience pain even when the joint is not being used, and the patient may suffer permanent loss of the normal range of motion in that joint.[15]

The quadriceps angle (Q Angle) is defined as the angle between the quadriceps muscles (primarily the rectus femoris) and the patellar tendon and represents the he angle of quadriceps muscle force. Q angle of 10 to 15 degrees measured with the knee either in full extension or slightly flexed is considered "normal".[7] Normally, the Q-angle is 13 degrees for males and 18 degrees for females when the knee is straight.[6] A Q angle of 20 degrees or more is considered abnormal, it increases the lateral pull on the patella against lateral femoral condyle, thus contributing to patella subluxation and other patellofemoral disorders. An increased Q angle is often associated with increased femoral ante version, genu valgum, lateral displacement of tibial tubercle, or increased lateral tibial torsion and pronated foot. [13,3]

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A high Q angle increases the chances of developing various knee problems. One of the most common problems associated with an increased Q angle is patella femoral tracking syndrome. A high Q angle interferes with the smooth gliding movement between the patella and the femur. Over time, especially with repetitive activities, this type of micro trauma causes non-specific pain to the anterior knee. As this abnormal tracking continues between the patella and the femur, various knee muscles become imbalanced, and the cartilage on the underside of the patella begins to wear and thin. Eventually the knees become degenerative and develop osteoarthritis.[7]

Normally, genu varum at the knee brings the toes to face medially and hence causing adduction of the foot.i.e. supination. Conversely, the genu valgum at the knee brings the toes to face laterally and hence causing abduction of the foot.i.e. pronation.[7]

Over pronation or flat foot is one of the most common causes of an increased Q angle. Excessive pronation is a result of too much rolling inward of the heel and mid-foot beyond the normal limits during standing, walking or running. Supination is one of the most common causes of a decreased Q angle. Supination is a result of rolling outward of the heel and mid-foot beyond the normal limits during standing.

This study considers a new clinical tool, the Foot Posture Index (FPI). It examines its utility in a physiotherapy outpatient setting with a cohort of patients with osteoarthritis of the knee, and investigates the relationship of quadriceps angle with FPI scores. Foot examination often gets neglected by the physiotherapist, during routine examination of the patients with knee osteoarthritis.

Studies have been done to show relationship between flat foot position with Q angle and knee pain in freestyle wrestlers but there is dearth of literature on correlation between quadriceps angle with foot position in patients with knee osteoarthritis.1,11

2. METHODS

A cross-sectional study was conducted on 100 subjects diagnosed as having osteoarthritis since 1yr in the age group of 50-70 years which included 70 females and 30 males. Patients with neurological pathology, peripheral nerve injury, recent surgical, ankle OA, rheumatoid arthritis, post-traumatic knee stiffness or having undergone total knee arthroplasty were excluded from the study. A written consent was obtained from the subjects before assessing them.

Subjects were explained about the method. Approval for the study was obtained from the institutional ethical committee and the educational review board. (ECR/90/Inst/MH/2013)

The Q angle is the angle formed between the line connecting the ASIS to the midpoint of the patella and a line connecting the tibial tuberosity and the midpoint of the patella.[13]

With the help of measuring tape and goniometer, the Q angle was measured as follows:-

- A line was drawn from anterior superior iliac spine (ASIS) to mid-point of patella on the same side and from mid-point of patella to tibial tuberosity.
- The angle formed by crossing of these two lines is the Q angle ,which was measured with the help of plastic goniometer.[15,13]

Obtained data was documented and tabulated.

The foot posture index is a diagnostic clinical tool aimed at quantifying the degree to which a foot can be considered to be in a pronated, supinated or neutral position.[2,4,10]

The patient should stand in their relaxed stance position with double limb support. The patient should be instructed to stand still, with their arms by the side and looking straight ahead. It may be

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helpful to ask the patient to take several steps, marching on the spot, prior to settling into a comfortable stance position.

Features commensurate with an approximately neutral foot posture are graded

As zero, while pronated postures are given a positive value, and supinated features a negative value.

When the scores are combined, the aggregate value gives an estimate of the overall foot posture. High positive aggregate values indicate a pronated posture, significantly negative aggregate values indicate a supinated overall foot posture, while for a neutral foot the final FPI aggregate score should lie somewhere around zero.

Components of foot posture index include:

1. Talar Head Palpation (Palplation for talo-navicular congruence)
2. Supra and Infra Lateral malleolar curvature (Observation and comparison of curves above and below lateral ankle malleoli)
3. Calcaneal frontal plane Position (Inversion / eversion of the calcaneus)
4. Bulging in the region of the talo- navicular joint (TNJ)
5. Height and congruence of the medial longitudinal arch
6. Abduction/ adduction of the forefoot on the rear foot. (Too many toes sign)

3. DATA ANALYSIS

Pearson correlation co-efficient test was used to co-relate between quadriceps angle and foot posture index. All the analysis was done using SPSS version 12.

Table 1: Correlation between Quadriceps angle and foot posture index of left leg**.**

		Q angle left	**FPI left**
Q angle left	Pearson Correlation	1	.398(**)
	Sig. (2-tailed)	.	.000
	N	99	99
FPI left	Pearson Correlation	.398(**)	1
	Sig. (2-tailed)	.000	.
	N	99	99

** Correlation is significant at the 0.01 level (2-tailed).

Table 2: Correlation between Quadriceps angle and foot posture index of right leg**.**

		Q angle right	**FPI right**
Q angle right	Pearson Correlation	1	.583(**)
	Sig. (2-tailed)	.	.000
	N	99	99
FPI right	Pearson Correlation	.583(**)	1
	Sig. (2-tailed)	.000	.
	N	99	99

** Correlation is significant at the 0.01 level (2-tailed).

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4. RESULTS

Correlation of Q angle of left leg with left foot posture index shows r = 0.663 and correlation of Q angle of right leg with right foot posture index shows r = 0.65 which is statistically significant (p>0.01).

5. DISCUSSION

In this study, 100 subjects were included, 70 were females and 30 were males. It has been proved that the knee osteoarthritis is commonly seen in females and due to broader pelvis they have a tendency for increased Q angle.[6]

This study shows that there was a positive correlation between quadriceps angle and foot position. From table and graph 1and 2, it was found that positive correlation exists between Q angle and FPI (p=0.00, r=0.398).

The osteoarthritis of knee joint may involve medial or lateral compartment of tibiofemoral joint and patellofemoral joint. In case of involvement of medial compartment, the genu varum deformity is observed, which exhibits an increase in quadriceps angle due to the medial tibial torsion impeding its normal external rotation during gait progression in the stance phase. This excessive internal tibial rotation transmits abnormal forces upward and produces stress over medial knee joint[16] which in turn results in compensatory excessive pronation at subtalar joint, and forefoot valgus causing decrease in the medial longitudinal arch.[6,1] Similarly, involvement of lateral compartment results into genu valgum with a subsequent decrease in quadriceps angle and lateral tibial torsion which is compensated by motions like subtalar supination and forefoot varus.[6] Studies have shown that pes planus i.e. pronation and increase in varus at the subtalar joint is highly associated with anterior knee pain.[11,14]

The combination of a higher Q angle with excessive pronation causes a more rapid progression to knee dysfunction, to patellofemoral arthralgia, to degenerative joint disease.[9] One of the effective way to decrease a high Q angle and lower the biomechanical stresses on the knee joint is to prevent excessive pronation with custom-made, flexible orthotics.[5] One study found that using soft corrective orthotics was more effective in reducing knee pain than a traditional exercise program.[8] Studies have also shown that medial/lateral wedge insoles would be helpful in reducing the load in lateral and medial compartment knee osteoarthritis.[12]

6. CONCLUSION

The study shows that a positive correlation exists between the Q angle and the foot position i.e as the Q angle increases, the score of the foot posture index increases and vice-versa.

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CREATING A STANDARD PHYSICAL EDUCATION TEST WITH SCORING SYSTEM: A CALL FOR HOLISTIC DEVELOPMENT IN INDIAN EDUCATION

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ABSTRACT

This research article explores the development of a standardized physical education (PE) test with a comprehensive scoring system to incorporate physical and mental health assessments into the school curriculum. By highlighting the necessity of addressing holistic development in education, it exposes the challenges faced by the Indian education system and emphasizes the global demand for healthy, well-rounded individuals. The proposed standardized PE test aims to bridge the gap between academic and physical well-being, fostering a healthier, more balanced educational environment.

1. INTRODUCTION

In an era where academic excellence dominates the educational landscape, the significance of physical and mental well-being often takes a backseat. The Indian education system, known for its rigorous academic demands, has long been criticized for neglecting the holistic development of students. While intellectual growth is paramount, it is equally essential to nurture physical fitness and mental health to create well-rounded individuals capable of thriving in a dynamic world.

This paper addresses the pressing need for a standardized physical education (PE) test with a comprehensive scoring system that seamlessly integrates physical and mental health assessments into the school curriculum. Such a test not only promotes physical well-being but also reinforces the importance of mental health, fostering a balanced approach to education.

2. REVIEW OF LITERATURE

Current State of Physical Education in India

Physical education (PE) in India forms an essential component of the school curriculum, aimed at fostering the physical, mental, and social well-being of students. Despite its significance, the implementation and quality of PE programs across the country exhibit considerable variation. This review explores the current state of PE programs in Indian schools, identifying key challenges, government initiatives, and success stories.

Challenges Faced

Lack of Infrastructure: Many schools, especially in rural areas, lack adequate sports facilities and equipment. This infrastructure gap limits students' opportunities for physical activities (Seth, 2021).

Limited Resources: The shortage of trained PE teachers further hampers the effective delivery of PE programs. Many schools depend on general teachers for PE classes, impacting the quality of instruction (Ravi, 2022).

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Inadequate Emphasis: Despite its mandatory status, PE is often given lesser importance compared to academic subjects, resulting in reduced time allocation and lower priority in the school curriculum (Kumar, 2023).

3. GOVERNMENT INITIATIVES

The Indian government has introduced various programs to promote physical education and sports in schools. Notably, the Khelo India program aims to revive the sports culture at the grassroots level by building a robust framework for all sports and establishing India as a significant sporting nation (Government of India, 2018). Additionally, the Fit India Movement, launched in 2019, encourages schools to integrate physical activities and sports into their daily routines, promoting fitness and health among students (Ministry of Youth Affairs and Sports, 2019).

Success Stories

Several schools have successfully integrated PE into their curriculum, yielding positive outcomes. For instance, schools adhering to the Central Board of Secondary Education (CBSE) guidelines for PE report improved student fitness levels and overall well-being (CBSE, 2020). Furthermore, private schools with better resources offer well-developed PE programs, including access to sports facilities, trained coaches, and a variety of extracurricular sports activities (Mohan, 2022).

4. REVIEW OF CURRENT PE PROGRAMS IN INDIAN SCHOOLS

Despite the efforts and initiatives, there is a pressing need for change to enhance the effectiveness of PE programs in Indian schools. The following areas require attention:

1. **Infrastructure Development:** Investment in sports facilities and equipment is essential to provide students with adequate opportunities for physical activities. Schools, especially in rural areas, need access to playgrounds, indoor sports facilities, and modern equipment (Patel, 2023).
2. **Teacher Training:** Professional development programs for PE teachers are crucial to ensure they have the necessary skills and knowledge to deliver high-quality instruction. Training programs should focus on modern teaching methods, sports science, and student engagement techniques (Suraswal & Shukla, 2022).
3. **Curriculum Enhancement:** The PE curriculum should be regularly updated to include a diverse range of activities that cater to the interests and abilities of all students. Incorporating mental health assessments and promoting holistic development should be key components of the curriculum (Patel, 2023).
4. **Policy Support:** Strong policy support from the government and educational authorities is needed to prioritize physical education and allocate sufficient resources. Policies should focus on promoting physical fitness, mental well-being, and overall development of students (Suraswal & Shukla, 2022).

5. GLOBAL PRACTICES IN PHYSICAL EDUCATION

Examples of Successful Physical Education Tests Abroad

1. **FitnessGram (USA):** The FitnessGram is a comprehensive fitness assessment tool used in schools across the United States. It measures various components of physical fitness, including aerobic capacity, muscular strength, endurance, flexibility, and body composition. The test

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includes activities such as the PACER (Progressive Aerobic Cardiovascular Endurance Run), push-ups, curl-ups, and the sit-and-reach test.

2. **Eurofit (Europe):** The Eurofit test battery is widely used in European countries to assess the physical fitness of children and adolescents. It includes tests for cardiovascular endurance (20-meter shuttle run), muscular strength (handgrip test), flexibility (sit-and-reach test), speed (10x5 meter shuttle run), and balance (flamingo balance test).
3. **Beep Test (Australia):** The Beep Test, also known as the Multi-Stage Fitness Test or the 20-meter shuttle run test, is commonly used in Australia to assess cardiovascular endurance. Participants run back and forth between two markers 20 meters apart, with the pace increasing at regular intervals. The test continues until the participant can no longer keep up with the required pace.
4. **Physical Activity and Fitness Test (PAFT) (New Zealand):** The PAFT is used in New Zealand to assess the physical fitness of school children. It includes tests for aerobic fitness (20-meter shuttle run), muscular strength (push-ups and sit-ups), flexibility (sit and-reach test), and body composition (BMI measurement).

6. ADAPTATION FOR INDIA

To enhance the effectiveness of PE programs in India, the following best practices can be adapted:

1. **Develop a Comprehensive Curriculum:** Create a curriculum that includes a variety of physical activities, sports, and exercises to cater to the diverse interests and abilities of students.
2. **Focus on Holistic Development:** Incorporate activities that promote mental health, teamwork, and social skills. Emphasize the importance of emotional well-being alongside physical fitness.
3. **Implement Regular Assessments:** Introduce standardized fitness assessments to track students' progress and identify areas for improvement. Use the data to provide personalized feedback and recommendations.
4. **Invest in Teacher Training:** Provide continuous professional development opportunities for PE teachers. Equip them with modern teaching methods and knowledge of sports science.
5. **Engage the Community:** Involve parents and the community in PE programs. Organize events and activities that promote physical activity and create a supportive environment for students.

7. METHODOLOGY

1. **Development of the Standardized PE Test:**
   - ✓ **Criteria for Test Development:** Validity, reliability, and objectivity of the test. Inclusion of various fitness components such as cardiovascular endurance, muscular strength, flexibility, and body composition.
   - ✓ **Components of the Test:** Physical fitness assessments (e.g., 12-minute run/walk test, push-up and sit-up tests, sit and reach test, BMI and skinfold measurements), and mental health assessments (e.g., standardized questionnaires for stress levels, self-report surveys for emotional well-being).
2. **Scoring System:** Each component of the test is scored individually, and scores are then combined to provide an overall fitness score. Scores are categorized into different fitness levels (e.g., excellent, good, average, below average) and interpreted to provide feedback and recommendations for improvement.

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Implementation and Evaluation

1. **Pilot Testing:** Conducted in selected schools across different regions. Data collection on students' performance and feedback from teachers. Analysis of test results to identify trends and areas for improvement.
2. **Feedback and Refinement:** Gathering feedback from students, teachers, and parents on the test and scoring system. Refining the test and scoring system based on feedback.

8. DISCUSSION

1. **Impact on Students:**
   - o **Benefits:** Improved physical fitness and mental health. Enhanced academic performance and overall well-being.
   - o **Challenges:** Potential resistance to change. Need for training and resources for teachers.
2. **Broader Implications for Indian Education:** Alignment with national education goals. Potential for policy changes and wider adoption.

9. CONCLUSION

Key Findings

1. **Current Challenges:** The current PE curriculum in Indian schools faces significant challenges, including lack of infrastructure, limited resources, inadequate emphasis on PE, outdated curriculum design, cultural attitudes, and the absence of standardized assessment and evaluation systems.
2. **Government Initiatives:** Various initiatives like the Khelo India program and the Fit India Movement have been launched to promote physical education and sports in schools. These initiatives aim to revive the sports culture at the grassroots level and encourage regular physical activity among students.
3. **Successful PE Programs Abroad:** Examples of successful PE programs from other countries, such as FitnessGram (USA), Eurofit (Europe), Beep Test (Australia), and PAFT (New Zealand), highlight the importance of a comprehensive curriculum, regular assessment, teacher training, and community engagement.
4. **Need for Change:** There is a pressing need for change to enhance the effectiveness of PE programs in Indian schools. This includes investing in infrastructure, providing professional development opportunities for PE teachers

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THE COMBINED INFLUENCE OF TASK COMPLEXITY AND AUDIENCE PRESENCE ON ANXIETY IN ATHLETES WITH DIFFERENT LEVELS OF ACHIEVEMENT

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ABSTRACT:

The study aimed to systematically investigate the impact of audience presence on anxiety levels among novice and skilled athletes while performing tasks of varying complexity in sports and physical activities. A total of 40 athletes (20 beginners and 20 advanced) aged 18-25 from various districts of Kerala, including both males and females, were selected as subjects. Data were collected using the Sports Anxiety Scale-2 (SAS-2), a validated 15- item questionnaire assessing competitive anxiety across somatic anxiety, worry, and concentration disruption. Responses were rated on a four-point Likert scale. Descriptive statistics (mean, standard deviation) and Analysis of Variance (ANOVA) were employed to analyze the data. The findings reveal the complex interplay of skill level, task complexity, and audience presence in shaping anxiety experiences. These insights provide a foundation for targeted interventions to help athletes manage anxiety and enhance performance, offering valuable implications for future research and practical applications.

Key words: Audience presence, competitive anxiety, novice athletes, skilled athletes, task complexity, somatic anxiety, cognitive anxiety, performance enhancement.

1. INTRODUCTION

Athletes' experiences and results on and off the pitch are shaped by a wide range of internal and environmental circumstances, which collectively contribute to the complex phenomena of athletic performance. Task complexity and audience effect stand out among these variables as important elements that influence the complex terrain of athletes' performance journeys. The relationship among task demands, audience presence, and athletes' psychological reactions-especially anxiety-has received a great deal of attention in the literature on sports psychology.

Task difficulty serves as a foundational element within athletic pursuits, encompassing a spectrum of challenges that athletes encounter throughout their training and competitive endeavours. Whether it involves mastering intricate techniques, confronting formidable opponents, or adapting to adverse environmental conditions, athletes are constantly navigating tasks of varying complexities (Baumeister, 2014). Athletes' sense of task difficulty affects not just the physical and cognitive demands placed on them, but also their psychological state and the results of their following performances (Foster & Weigand, 2017). While some athletes view difficult assignments as chances for improvement and success, others may become more anxious and self-conscious when faced with difficult work (Jones et al., 2016) . According to research, athletes' motivation, self-efficacy, and performance outcomes can all be greatly impacted by their perception of task complexity (Smith & Vargas, 2022).

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Across the field of behavioural research, task complexity is equated with difficult tasks, such that the two terms have been used interchangeably (Gajewski & Falkenstein, 2013; Gorniak, 2019; Olivier et al., 2010; Serrien & Spapé, 2009; Vander Velde & Woollacott, 2008). In terms of performance, complex tasks have been typically viewed as tasks in which there are two or more competing goals (Fait et al., 2011; Gooijers et al., 2013; Krishnan & Jaric, 2010; Richard A. Schmidt, Timothy D. Lee, Carolee Winstein, Gabriele Wulf, Howard N. Zelaznik - Google Books, n.d.; van den Berg et al., 2011). Despite the use of the phrase “task complexity” in over 400 publications, there is no standard definition or method to evaluate how complex a task may be. Instead, we rely on vernacular, custom, and personal experience to say that one task is more complex than another.

The presence of an audience introduces an additional layer of complexity to the athletic experience, embedding social evaluation and scrutiny within the performance context (Cunningham & Turner, 2016). Athletes, spanning from grassroots competitors to elite professionals, often find themselves under the scrutiny of spectators, coaches, and peers across various sporting events and competitions (García-Martínez et al., 2018). The attention of the audience can evoke a plethora of emotions in athletes, ranging from motivation and exhilaration to anxiety and pressure (Castro-Sánchez et al., 2019). Athletes may perceive the expectations and judgments of spectators as additional stressors, impacting their psychological well-being and readiness to perform. Studies have shown that the presence of spectators can influence athletes' performance through mechanisms such as social facilitation and evaluation apprehension (Jekauc et al., 2021).

Research evidence suggests that the presence of an audience significantly influences athletes' performance in sports. A study examining the effects of an audience on the physical performance of both elite and novice rugby players. Results indicated that the presence of spectators led to increased arousal levels among players, which influenced their performance differently based on skill level. While elite players demonstrated enhanced performance under audience pressure, novice players exhibited decreased performance, suggesting a complex interplay between skill level and audience effects.(Theses & Perrin, 2022)

Furthermore, studies have explored the psychological mechanisms underlying the impact of audience presence on sports performance. A study focused on the phenomenon of "choking" in sport, whereby athletes underperform in high-pressure situations. Their analysis revealed that the fear of negative evaluation from the audience contributes to performance decrements, particularly in tasks requiring complex motor skills and decision-making. This suggests that audience-induced pressure can impair athletes' cognitive processing and motor coordination, leading to suboptimal performance outcomes.(Hill et al., 2010)

2. METHODOLOGY

Subject selection

For the purpose of the study 40 athletes (20 beginners and 20 advanced athletes) from various districts of Kerala were selected. The age group of the athletes ranged from 18-25 both male and female.

Selection of Variables

Independent variable:

1. Task difficulty (simple and complex task given based on the discipline or events of the athletes)

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2. Audience impact (simple task with and without audience complex task with and without audience)
3. Level of sports achievement.

Dependent variable: Anxiety

Selection of test items

To attain the objectives of the study, the Sports Anxiety Scale -2 questionnaire was used to collect data from different levels of achievers of various sports.

3. ADMINISTRATION OF THE TEST AND COLLECTION OF THE DATA

The researcher will consider 40 athletes for the study, and they will be undergoing the session of simple tasks with the audience, simple tasks without the audience, complex tasks with the audience, and complex tasks without the audience. After the entire section Sports Anxiety Scale 2 questionnaire will be provided and the data will be collected from the participants.

4. RESULTS

The raw data was computed using IBM -SPSS, and the statistical intervention used was Repeated-Measures ANOVA, the level of significance was set at 0.05 levels.

Table 1

Descriptive Statistics			
	Mean	Std. Deviation	N
BSTWA	31.9000	16.41854	20
BSTWOA	25.5000	16.82573	20
BCTWA	20.8000	10.66031	20
BCTWOA	18.5500	14.83053	20
ASTWA	24.4000	13.27998	20
ASTWOA	22.6000	17.41868	20
ACTWA	25.6000	18.69816	20
ACTWOA	16.1500	14.89710	20

Note:

- **BSTWA**=Beginner athletes' simple task with the presence of the audience
- **BSTWOA**= Beginner athletes' simple task without the presence of the audience
- **BCTWA**= Beginner athletes' complex task with the presence of the audience
- **BCTWOA**= Beginner athletes' complex task without the presence of the audience
- **ASTWA**= Advanced athletes' simple task with the presence of the audience
- **ASTWOA**= Advanced athletes' simple task without the presence of the audience
- **ACTWA**= Advanced athletes' complex task with the presence of the audience
- **ACTWOA**= Advanced athletes' complex task without the presence of the audience

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Fig 1: Level of Anxiety of Beginner level players

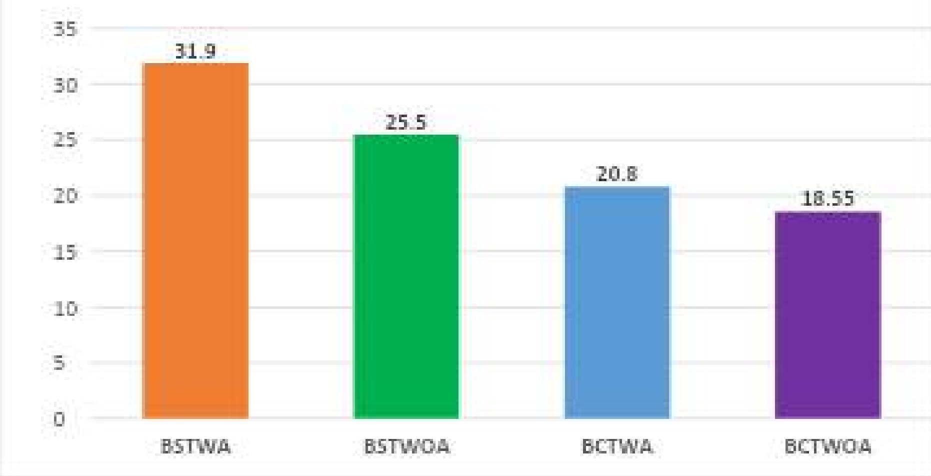

Fig 2:Level of Anxiety of Advanced level players

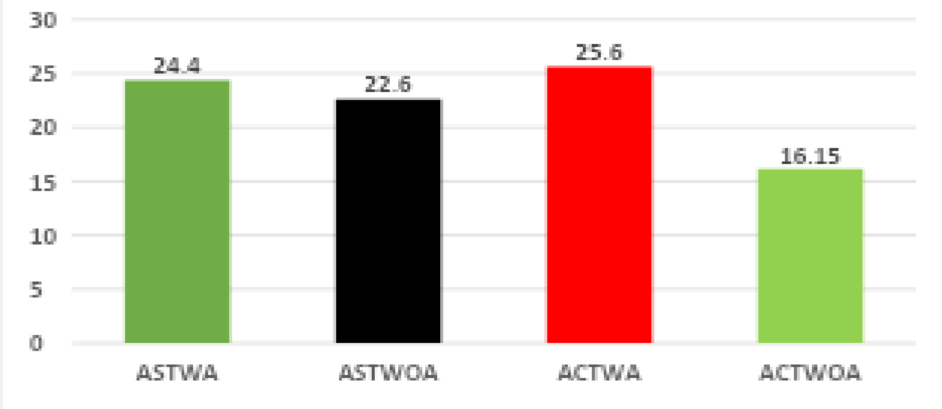

Table 1

MANOVA Omnibus test Indicating a significant difference in the main effect

Effect		Value	F	Hypothesis df	Error df	Sig.	Observed Power[c]
Skill level	Pillai's Trace	.033	.653[b]	1.000	19.000	.429	.120
	Wilks' Lambda	.967	.653[b]	1.000	19.000	.429	.120
	Hotelling's Trace	.034	.653[b]	1.000	19.000	.429	.120
	Roy's Largest Root	.034	.653[b]	1.000	19.000	.429	.120
Task	**Pillai's Trace**	**.200**	**4.754[b]**	**1.000**	**19.000**	**.042**	**.544**
	Wilks' Lambda	**.800**	**4.754[b]**	**1.000**	**19.000**	**.042**	**.544**
	Hotelling's Trace	**.250**	**4.754[b]**	**1.000**	**19.000**	**.042**	**.544**
	Roy's Largest Root	**.250**	**4.754[b]**	**1.000**	**19.000**	**.042**	**.544**
Audience	Pillai's Trace	.131	2.876[b]	1.000	19.000	.106	.363
	Wilks' Lambda	.869	2.876[b]	1.000	19.000	.106	.363
	Hotelling's Trace	.151	2.876[b]	1.000	19.000	.106	.363
	Roy's Largest Root	.151	2.876[b]	1.000	19.000	.106	.363

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Table 2

MANOVA Omnibus test Indicates a significant interaction effect

Effect		Value	F	Hypothesis df	Error df	Sig.	Observed Power[c]
Skilllevel * Task	Pillai's Trace	.094	1.970[b]	1.000	19.000	.177	.266
	Wilks' Lambda	.906	1.970[b]	1.000	19.000	.177	.266
	Hotelling's Trace	.104	1.970[b]	1.000	19.000	.177	.266
	Roy's Largest Root	.104	1.970[b]	1.000	19.000	.177	.266
Skilllevel * Audience	Pillai's Trace	.004	.067[b]	1.000	19.000	.799	.057
	Wilks' Lambda	.996	.067[b]	1.000	19.000	.799	.057
	Hotelling's Trace	.004	.067[b]	1.000	19.000	.799	.057
	Roy's Largest Root	.004	.067[b]	1.000	19.000	.799	.057
Task * Audience	Pillai's Trace	.008	.153[b]	1.000	19.000	.700	.066
	Wilks' Lambda	.992	.153[b]	1.000	19.000	.700	.066
	Hotelling's Trace	.008	.153[b]	1.000	19.000	.700	.066
	Roy's Largest Root	.008	.153[b]	1.000	19.000	.700	.066
Skilllevel * Task * Audience	Pillai's Trace	.073	1.496[b]	1.000	19.000	.236	.213
	Wilks' Lambda	.927	1.496[b]	1.000	19.000	.236	.213
	Hotelling's Trace	.079	1.496[b]	1.000	19.000	.236	.213
	Roy's Largest Root	.079	1.496[b]	1.000	19.000	.236	.213

Table 3

Tests of Within-Subjects Contrasts

Measure: Anxiety

Source	Skilllevel	Task	Audience	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
Skilllevel	Linear			160.000	1	160.000	.653	.429	.653	.120
Error(Skilllevel)	Linear			4655.000	19	245.000				

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Task		**Linear**		**1357.225**	**1**	**1357.225**	**4.754**	**.042**	**4.754**	**.544**
Error(Task)		**Linear**		**5424.775**	**19**	**285.514**				
Audience			Linear	990.025	1	990.025	2.876	.106	2.876	.363
Error(Audience)			Linear	6541.475	19	344.288				
Skilllevel * Task	Linear	Linear		409.600	1	409.600	1.970	.177	1.970	.266
Error(Skilllevel*Task)	Linear	Linear		3950.400	19	207.916				
Skilllevel * Audience	Linear		Linear	16.900	1	16.900	.067	.799	.067	.057
Error(Skilllevel*Audience)	Linear		Linear	4803.600	19	252.821				
Task * Audience		Linear	Linear	30.625	1	30.625	.153	.700	.153	.066
Error(Task*Audience)		Linear	Linear	3797.875	19	199.888				
Skilllevel * Task * Audience	Linear	Linear	Linear	348.100	1	348.100	1.496	.236	1.496	.213
Error(Skilllevel*Task*Audience)	Linear	Linear	Linear	4422.400	19	232.758				

a. Computed using alpha = .05

Table 4
Pairwise Comparisons

Measure: Anxiety

(I) Task	(J) Task	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	5.825*	2.672	.042	.233	11.417
2	1	-5.825*	2.672	.042	-11.417	-.233
Based on estimated marginal means						
*. The mean difference is significant at the .05 level.						

Table 5
Skilllevel * Task

Measure: Anxiety

Skilllevel	Task	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1	1	28.700	2.309	23.867	33.533
	2	19.675	1.885	15.730	23.620
2	1	23.500	2.557	18.147	28.853
	2	20.875	2.696	15.232	26.518

Table 6
Skilllevel * Audience

Measure: Anxiety

Skilllevel	Audience	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1	1	26.350	2.286	21.565	31.135

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	2	22.025	2.451	16.896	27.154
2	1	25.000	2.048	20.713	29.287
	2	19.375	3.140	12.803	25.947

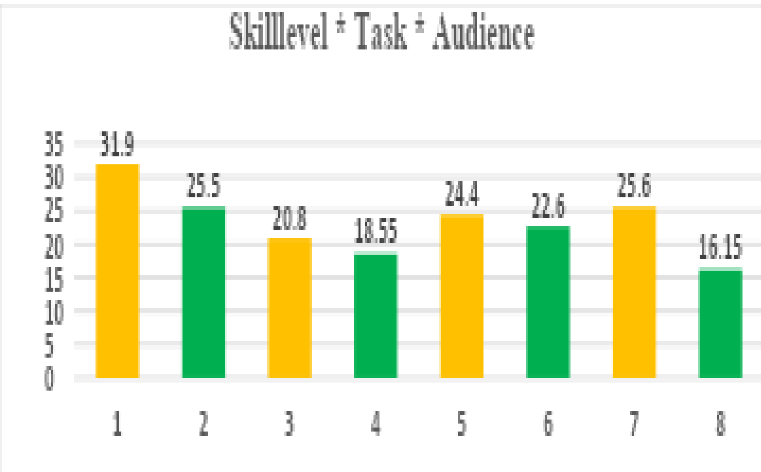
Table 7

Task * Audience

Measure: Anxiety					
				95% Confidence Interval	
Task	Audience	Mean	Std. Error	Lower Bound	Upper Bound
1	1	28.150	2.037	23.887	32.413
	2	24.050	2.767	18.258	29.842
2	1	23.200	2.824	17.289	29.111
	2	17.350	2.280	12.579	22.121

Table 8

Skilllevel * Task * Audience						
Measure: Anxiety						
					95% Confidence Interval	
Skilllevel	Task	Audience	Mean	Std. Error	Lower Bound	Upper Bound
1	1	1	31.900	3.671	24.216	39.584
		2	25.500	3.762	17.625	33.375
	2	1	20.800	2.384	15.811	25.789
		2	18.550	3.316	11.609	25.491
2	1	1	24.400	2.969	18.185	30.615
		2	22.600	3.895	14.448	30.752
	2	1	25.600	4.181	16.849	34.351
		2	16.150	3.331	9.178	23.122



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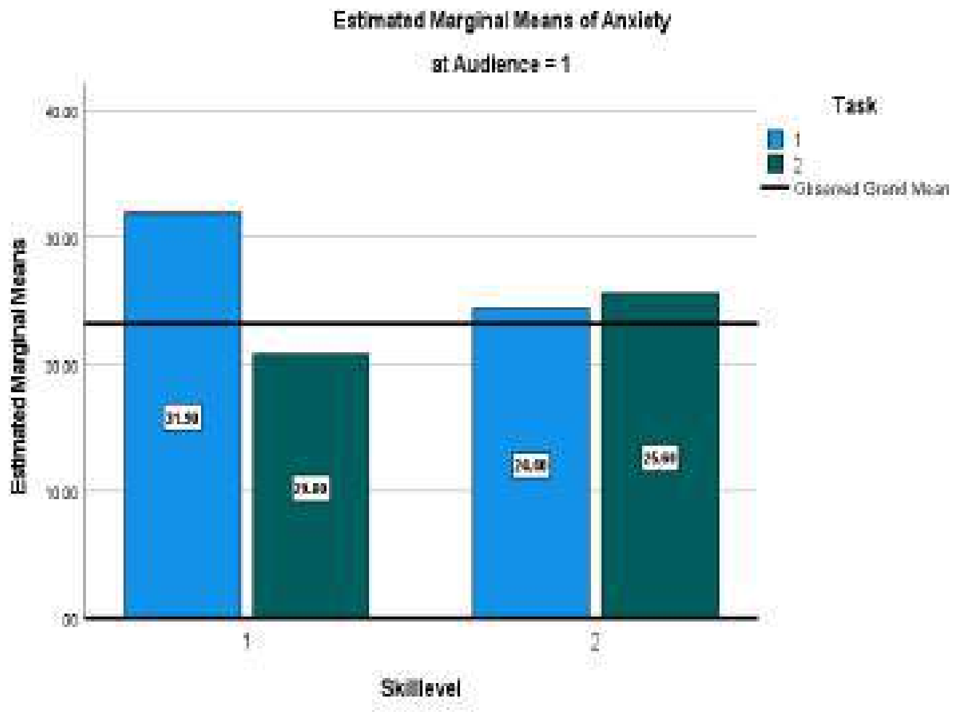

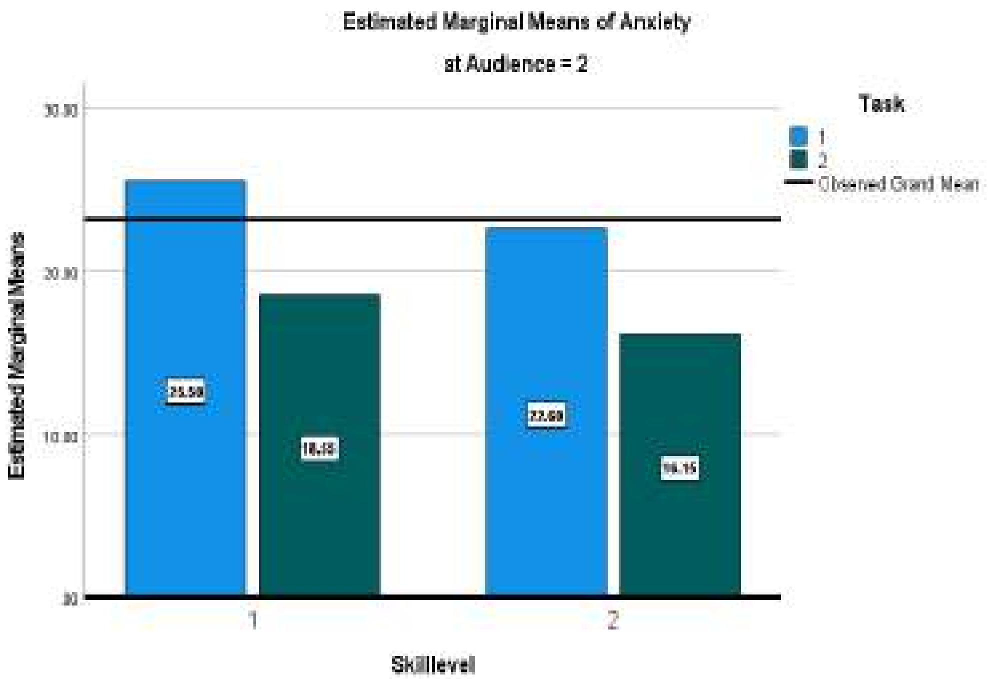

5. CONCLUSION

The study confirms that audience presence increases anxiety levels among athletes, with the extent of this effect influenced by skill level and task complexity. This highlights the significant role of social context in shaping anxiety responses. By understanding these dynamics, tailored strategies can be developed to help athletes effectively manage performance-related anxiety, ultimately enhancing their performance across varied competitive and training scenarios.

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THE CRITICAL ROLE OF SPORTS MANAGEMENT FOR ATHLETES

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ABSTRACT:

Through complete support in performance optimisation, injury management, financial planning, branding, and post-career transition, sports management plays a critical role in shaping the career of athletes. The main duties of sports managers are examined in this article, with an emphasis on how they assist athletes in navigating the challenges of professional sports. Case studies of sportsmen like Virat Kohli, P.V. Sindhu, LeBron James, and Roger Federer highlight the fundamental duties of sports management, which range from handling injuries and legal issues to branding and career sustainability. Furthermore, by guaranteeing fair access and attending to the particular requirements of athletes, including those with disabilities, sports management promotes inclusivity. Sports management provides specialized training, medical and psychological assistance, and adaptive sports programs so that every athlete can realize their potential. To promote public acceptance and acknowledgment of impaired athletes in mainstream sports, it campaigns for resources such as specialized facilities and equipment and organizes inclusive events like the Olympic Games.

Even while sports administration has many advantages, it also has drawbacks. These include moral dilemmas like doping and improper handling of injuries, potential financial hazards, and the problem of striking a balance between immediate success and long-term viability. These difficulties underline the necessity of moral principles, budgetary control, and progressive tactics. This paper highlights how good sports administration ensures career longevity and promotes diversity while also improving athletic performance and creating circumstances where all athletes may thrive.

Keywords: Sports Management, Athletes, support, Performance Optimization, Financial Management, Case Studies.

1. INTRODUCTION

Sports have always been vital to human existence since they offer competitiveness, physical fitness, and enjoyment. Sports management positions are now vital to society since sports have become a big sector in recent years, with billions of dollars spent on goods, sponsorships, and broadcasting rights. Sports management is a billion-dollar sector that oversees and plans different facets of sports teams, events, venues, and organizations. The sports world is here to stay [1]. The area of business that deals with sports and recreation is called sports management. Any set of abilities related to organizing, managing, leading, budgeting, organizing, directing, controlling, or assessing any business or organization in the sports industry is included in sports management. Physical education departments are where the profession of sports management first emerged. Sociology and history are now included in the discipline. The growth of sports management has also influenced export management, which as of 2018 was a 4.5 billion dollar sector. Sports marketing, sports media analytics, sports sponsorships, and sports facility management are now among the more popular options in sports management [2-6].

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The administration of the sports and recreation industries is known as sports management. This indicates that sports managers are those who are concerned with the business aspect of sports and making sure the various players' and teams' careers are successful. Sports managers focus on marketing, public relations, and trade negotiations between teams of all sizes and levels of competition, from leisure groups to professional sports teams. They are usually found working behind the scenes, managing the front office of a sports club or organization, and occasionally acting as a go-between for the players, coaches, and journalists. To guarantee that athletes with disabilities have the opportunity, resources, and support they require to succeed in both competitive and recreational settings, sports management is essential. Good administration improves more than just sports performance [7]. Depending on the size of the club and their particular job description, a sports manager's function can change. The responsibilities necessary to guarantee the success of a team or sports program can differ significantly, even daily. This line of work includes managing athletic training, offering athlete education tools, ensuring coaches and teams follow the rules, and even building and encouraging interest in their club or team in the neighborhood [8]. You can also bet that the sports manager will have a say in what gets done if it has to do with the marketing or financial components of a sports team. To maintain the smooth functioning of sports teams and organizations, sports managers carry out several activities that call for both technical and organizational skills. They plan the team's travel, practices, and games and make sure the staff, players, and coaches follow the schedule. Sports managers also serve as public relations experts, speaking on behalf of the team to the media, coaches, athletes, and other interested parties. The position involves significant financial obligations, as they need to weigh the team's revenue against expenses for travel, equipment, and pay. This requires a business-savvy approach. To increase the team's exposure and marketability, sports managers also plan news conferences, public events, and staff and athlete appearances in the community. Their responsibilities also include organising fundraisers, brand endorsements, and collaborations with donors and businesses, all of which support team marketing initiatives and help secure vital funds. Sports managers also train players and staff on how to interact with the media when they are attending events, so media relations are another area of concentration. Lastly, they manage the distribution and sales of tickets, coming up with plans to boost attendance and earnings during games, protecting the team's or organization's finances and competitive edge [9].

Moreover, sports managers must anticipate and be ready to carry out the following responsibilities [Table1] and functions throughout their careers Plan travel, games, and team practices. Sports managers plan the itinerary for players, coaches, and staff as well as the times of practices and games. In the role of a public relations specialist, they will represent the team to various stakeholders such as the media, coaches, and other members of the athletic staff. Carry out accounting duties and budgeting: Sports managers must thus balance the team's or organization's revenue against salaries, equipment costs, travel expenses, and other financial commitments [10]. This calls for a business-savvy mindset and financial training. Arrange public appearances and activities: Sports managers will also schedule official public appearances, such as press conferences, photo sessions, and community events, for players and other team members. Plan parties, fund-raisers, and sponsorships, Sports managers further support team marketing efforts and community involvement by collaborating with brands, contributors, and team officials for promotional deals, fundraisers, and endorsements. Additionally, this creates and secures funds for the organization as well as team funding. Media and appearances at events: Sports managers will also assist in training players, coaches, and staff members on appropriate media relations

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techniques, including making appearances at events. Supervise the distribution and sales of tickets: A sports manager's responsibility is to guarantee a team's financial and competitive success. To develop plans that guarantee fans attend games and cheer for their team, they will thus keep an eye on ticket sales and distribution initiatives. each of which brings in money for their group or affiliation [11].

Table 1: Presenting the responsibilities of a sports manager

Responsibility	Description
Scheduling Team Practices, Games, and Travel	Coordinating team logistics, including practice sessions, game schedules, and travel arrangements for players, coaches, and staff.
Acting as a Public Relations Professional	Representing the team to media, coaches, and other stakeholders, ensuring positive communication and public relations.
Performing Accounting and Budgeting	Managing the team’s budget, balancing income with salaries, equipment, travel costs, and other financial obligations.
Scheduling Public Events and Appearances	Arranging public appearances for athletes and team members, including press conferences, publicity shoots, and community involvement events.
Organizing Events, Fundraisers, and Endorsements	Collaborating with brands, donors, and team officials for promotional deals, fundraisers, and endorsements to enhance marketing efforts and raise funds.
Media and Event Appearances	Instructing athletes and team members on media interaction and ensuring professional behavior during public events and interviews.
Overseeing Ticket Sales and Distribution	Monitoring ticket sales and implementing strategies to increase attendance and revenue for the team or organization.

2. ESSENTIAL ROLE OF SPORTS MANAGEMENT FOR ATHLETES

Athletes now have to manage their personal and business lives well in addition to performing at their best, as sports have developed into a sophisticated, multibillion-dollar enterprise. The planning, arranging, and carrying out of activities about an athlete's growth, from training regimens to career longevity, is the domain of sports management. Sports management, which includes a broad range of duties that support people's general development and performance in a variety of sports disciplines, is essential to the success of athletes [12]. The key functions that sports management plays in maximizing an athlete's performance are examined in this article. Sports management is vital to athletes' lives since it improves performance and helps with injury prevention, rehabilitation, and finances.

2.1. Performance Optimization: A fundamental component of sports management, performance optimization aims to improve players' physical and mental skills by establishing an organized and productive training environment. Using cutting-edge technology and sports science, this part of sports management is becoming more and more data-driven to monitor and enhance performance. Coaches and sports management can monitor athletes in real-time and obtain extensive insights into their physical condition, skill levels, weariness, and potential injury concerns by using

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techniques like wearable devices, video analysis, and data analytics [13]. This empowers them to make well-informed decisions on everything from modifying training schedules to avoiding overtraining and improving recuperation management. Making highly customized training plans is an essential part of performance optimization. These programs are made to focus on particular areas of improvement based on physiological data from each athlete, such as heart rate, muscle exhaustion, and oxygen consumption. Wearable technology, GPS trackers, and biomechanical evaluations all yield vital information about an athlete's gait, task efficiency, and areas that require more attention. With this tailored strategy, athletes are guaranteed to train smarter and harder, optimizing their performance without raising the risk of injury [14].

The psychological component of sports is also heavily emphasized by performance optimization, which acknowledges the importance of mental toughness on par with physical prowess. Sports psychology includes crucial aspects such as stress management, focus, motivation, and confidence, which are vital during both training and competition. Mental conditioning methods such as cognitive-behavioural approaches, visualization, and meditation assist athletes in overcoming performance anxiety, staying focused during intense situations, and being ready for high-pressure situations [15]. Athletes can maintain their mental toughness and motivation by developing a solid mental framework, which is especially important during crucial competition, recuperation from injuries, or career losses. Performance optimization is essentially a comprehensive strategy that combines technical innovations, psychological training, and physical training to help athletes reach their maximum potential. This methodical, data-driven approach not only enhances athletic performance [16].

2.2. Injury Prevention and Management

Sports managers must be adept at both injury prevention and management since these strategies are critical to extending an athlete's career and maximizing performance. Athletes are subjected to physical demands that can result in a variety of ailments that, if left untreated, might have long-term effects or even end a career. Sports managers collaborate closely with medical specialists, such as physiotherapists, sports physicians, and rehabilitation specialists, to create customized injury prevention plans and recuperation schedules that cater to the unique requirements of the athlete [17]. An athlete's workload needs to be monitored and managed as part of injury prevention. One of the main reasons for sports-related injuries is overtraining, which is defined as pushing the body past its breaking point without enough recovery time. Sports managers can strike a balance between an athlete's workload and required recuperation intervals by using wearable technology and data analytics to track training frequency, intensity, and length. This keeps athletes performing at their best while lowering their risk of overuse problems by minimizing tiredness, muscle strain, and other stress-related injuries [18].

When injuries do occur, having a well-structured rehabilitation protocol is critical for ensuring a full recovery and preventing future recurrences. Rehabilitation plans are customized to address the specific type and severity of the injury, focusing on restoring strength, flexibility, and mobility. Sports managers coordinate with medical teams to monitor the athlete’s progress and adjust the recovery program as needed, ensuring that the return to training and competition is gradual and safe. Effective rehabilitation not only helps athletes regain physical function but also reduces the psychological impact of injuries, such as fear of re-injury, through mental conditioning and confidence-building exercises [19].

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A range of cutting-edge therapies are used in modern injury management to promote healing and hasten recovery. Physiotherapy, which emphasizes movement restoration through exercises and manual therapy, is still the cornerstone of treating injuries. Nonetheless, additional therapies including cryotherapy, hydrotherapy, and hyperbaric oxygen therapy are being utilized more frequently to lessen inflammation, enhance circulation, and hasten the body's inherent healing processes. When these therapies are used in conjunction with conventional techniques, athletes can recuperate faster and compete at their best again. Coordinating these cutting-edge therapies and making sure they are applied successfully and at the right phases of recuperation are major responsibilities of sports managers [20].

Injury prevention and management in sports not only help players recover more quickly but also prolong their careers by lowering the chance of long-term harm. This is achieved by proactively controlling an athlete's workload, using customized rehabilitation programs, and utilizing improved recovery therapies. Maintaining an athlete's health, performance, and competitive longevity requires an all-encompassing strategy.

2.3. Financial and Legal Management:

Athletes must manage their finances and legal affairs efficiently to handle the challenges of their lucrative careers and guarantee their long-term financial stability. Athletes have significant revenue streams from salaries, sponsorships, and endorsements. As their main source of income wanes in retirement, they must handle their money carefully to minimize any potential problems. To ensure athletes' short-term financial success and long-term stability, sports agents and financial consultants are crucial in assisting athletes with contract negotiations, investment strategies, tax preparation, and legal issues [22].

Securing just remuneration through contract negotiations is one of the most important parts of financial management for athletes. Sports agents guarantee that athletes obtain fair conditions that are commensurate with their market value and performance, whether they are negotiating salaries with teams, endorsement agreements, or media rights. To provide players with financial security during their careers, these discussions also include provisions about injuries, performance bonuses, and other contingencies. Sports agents' knowledge of the nuances of contract law helps athletes steer clear of bad deals that could limit their earning potential [22].

Since athletes usually have brief career spans, long-term financial preparation is essential. Athletes who want to continue earning income from their investment portfolios even after their athletic careers are over might receive guidance from financial consultants. This includes making investments in companies, real estate, stocks, and other endeavours that produce passive income. Athletes can avoid financial instability by maintaining their lifestyle after retirement through careful investment preparation. Advisors coach athletes through wealth-building methods that complement their long-term objectives and assist them in making well-informed decisions on high-risk investments. Rich athletes have special tax issues, particularly when they compete in various nations and jurisdictions with differing tax regulations. By making sure they adhere to tax laws and reduce their tax obligations, tax planning assists athletes in navigating these intricacies. Financial advisers handle residency-related tax responsibilities, maximise deductions, and steer clear of typical tax problems in collaboration with tax specialists. An athlete's take-home pay can be considerably increased by strategic tax planning, allowing them to keep a larger portion of their earnings while still adhering to local and international tax regulations [23].

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Professional athletes often deal with legal problems requiring professional advice, ranging from intellectual property rights and contract conflicts to private issues like divorce settlements and estate planning. Athletes receive complete legal support from sports agents and solicitors, who defend their rights in both business and private contexts. These guarantee athletes are protected from contract violations, exploitation, and other legal actions that can jeopardize their financial security. Athletes' intellectual property is managed in large part by legal counsel, who makes sure that their likeness, brand, and image are safeguarded and profitably used [24].

To sum up, an athlete's profession requires sound financial and legal management since it offers the foundation for long-term stability, legal protection, and sustainable wealth building. Sports agents and advisers assist athletes in navigating the complexity of their professions by providing them with professional contract negotiations, investment strategies, tax planning, and legal counsel. This allows athletes to concentrate on their performance while safeguarding their financial future.

2.4. Brand Development and Marketing:

Athletes are more than just rivals in the digital age; they are also powerful brands with the ability to engage sizable audiences and bring in sizable sums of money through clever marketing. Sports management requires brand building because it helps players establish and preserve a personal brand that appeals to media, sponsors, and fans. Athletes can increase their earning potential through endorsements, commercial endeavors, and media appearances with a well-designed brand, not just during their competitive years but even long after they retire. Sports management companies oversee sponsorship agreements, public relations, and social media presence, all of which significantly contribute to the development of this brand [25]. Securing sponsorship arrangements with firms whose values and image coincide with the athlete's persona is one of the most lucrative components of an athlete's brand. Through these collaborations, athletes can promote goods, services, or brands in exchange for payment that frequently exceeds what they would make from just playing sports. These sponsorship deals are negotiated by sports management companies, who make sure athletes are associated with companies that support their ideals and improve their public image. Sports managers assist players in creating a brand that is real and appealing to their fan base by carefully choosing their connections [26]. Maintaining an athlete's reputation and making sure the public, media, and sponsors view them favourably depend on effective public relations management. Sports managers maintain a positive public image for their athletes by handling media relations, setting up press conferences, and scheduling public appearances. Athletes are positioned as role models, influencers, or ambassadors in the public eye through public relations methods, whether they deal with controversy or capitalize on significant career events. To maintain the athlete's brand value and prevent bad press that could harm their marketability, proper image management is essential [27]. An athlete's social media presence is a crucial part of their brand in the connected world of today. Athletes may interact with fans directly, share intimate moments, and advertise their endorsements on social media sites like Instagram, Twitter, and YouTube. Athletes may build a devoted fan base and increase their marketability by creating strategic content and engaging with their fans. Sports management companies help players curate their online identity so that social media posts are consistent with their brand image. Additionally, they help athletes navigate the complexities of interacting with fans, media, and other stakeholders through these platforms, turning social media into a powerful branding tool [28].

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In short, athletes who want to optimize their financial and personal success must focus on brand development and marketing. Sports managers assist athletes in developing a brand that transcends their athletic accomplishments and opens up potential career paths in business, media, and sponsorships. They do this by negotiating sponsorship deals, handling public relations, and establishing a strong social media presence. In addition to increasing an athlete's income potential during competition, a well-managed brand positions them for success beyond it.

2.5. Post-Career Transition:

Leading players through the difficult transition from competitive play to life after retirement is a major duty of sports management. Athletes often have identity issues, financial instability, or difficulties finding a new purpose after their sporting career comes to an end. Athletes who receive effective sports management at this critical juncture are given the resources and direction they require to succeed in their lives after competition. Education and career counselling are two of the main ways sports management helps athletes with their post-career transition. For many players to pursue possibilities outside of athletics, they must learn new abilities and information. Sports managers assist athletes in determining their areas of strength, interest, and possible career options, including business, coaching, and other industries. Sports management makes sure that players are ready for new professional endeavors following retirement by promoting further education, certificates, or vocational training. Numerous athletes use their notoriety, reputation, and background to find lucrative jobs in the media or entrepreneurship. Sports managers support athletes in investigating commercial opportunities, like starting their brands, investing in start-ups, or serving as brand ambassadors for well-established businesses. Athletes also frequently pursue jobs in the media, taking advantage of their experience and prominence, in fields including acting, commentary, and sports broadcasting. Sports management organizations assist in creating these chances by offering athletes strategic counsel, settling contracts, and matching players with suitable partners for prosperous post-sports careers [29]. Another crucial component of the transition is the athletes' post-retirement physical and mental well-being. Many athletes struggle to maintain their physical and mental health as well as their general well-being when they are not involved in the routine of training and competition. When it comes to making sure that athletes have access to the tools they need to continue to be physically and mentally well after retirement, sports managers are essential. This could be individualized treatment programs, getting in touch with mental health specialists, or continuing assistance for injuries they've incurred on the job. Retired athletes can have satisfying, healthy lives by paying proper care to their health and wellness [30].

In conclusion, by offering career counseling, creating chances in media or business, and encouraging health and wellness, sports management plays a critical role in assisting athletes in making the transition from sports to life beyond sports. These programs assist players in overcoming the obstacles of life after retirement, making sure they continue to be prosperous, healthy, and involved in activities outside of sports.

3. CASE STUDIES: REAL-WORLD EXAMPLES OF SPORTS MANAGEMENT UTILIZED BY FAMOUS ATHLETES (BOTH NATIONAL AND INTERNATIONAL):

Several well-known sportsmen have served as prime examples of how crucial sports administration is to their achievement. LeBron James, for example, credits his success off the court to having a solid management group that supports his business endeavors, financial planning, and brand building. In a similar vein, Roger Federer is among the highest-paid athletes in the world

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thanks to the efforts of his management team, which helped him land large endorsement deals. The relevance of sports management has grown, and Indian athletes have profited from it more and more. This has enabled them to become worldwide icons, get sponsorships, and succeed internationally. The achievements of several of India's best athletes, like Virat Kohli, M.S. Dhoni, P.V. Sindhu, Neeraj Chopra, Mary Kom, and others, have been greatly aided by sports management.

1. **Virat Kohli: The Modern Cricket Icon:** Not only for his accomplishments on the pitch but also for his off-field brand management, which has elevated him to the status of the highest-paid athlete in the world, Virat Kohli is one of the most recognizable faces in cricket. Over the years, his management group—headed by Cornerstone Sport [31]—has meticulously built his brand. Prominent companies that Kohli has collaborated with include Puma, Audi, MRF, Tissot, and his fashion label, Wrogn. His carefully curated endorsement portfolio reflects his reputation as a disciplined, health-conscious athlete. The fact that Kohli's management helped him land these contracts, increase his net worth and become one of the highest-paid athletes in India. Additionally, Virat Kohli's management group has positioned him as a fitness advocate. In addition to owning the chain of fitness centers Chisel, he has made investments in startups that support children's health, such as Stepathlon Kids. His foray into the culinary industry with One8 Commune has broadened his commercial reach and secured his financial future after the cricket season. Kohli's public persona has been carefully shaped via strategic PR management to showcase his leadership abilities and charitable endeavors, especially through his Virat Kohli Foundation, which supports young athletes and others from disadvantaged backgrounds. With the support of his management group, Kohli has been able to successfully combine business and cricket, ensuring that his name is known outside of the cricket arena [32].
2. **P.V. Sindhu: The Badminton Star's Global Rise:** One of the most successful badminton players in India, P.V. Sindhu, has gained recognition throughout the world thanks to her management group, which is headed by Baseline Ventures and has made sure that her success on the court is matched by chances off the court but now she moves to Cornerstone sports. Sindhu rose to fame in India after taking home gold at the 2019 World Championships and silver at the 2016 Rio Olympics. Taking advantage of this momentum, her management team signed endorsement contracts with companies including Gatorade, Panasonic, Bank of Baroda, Li-Ning, and Bridgestone. She now ranks among the highest-paid female athletes in the world thanks to these sponsorships, putting her in the same class as elite international competitors. The administration of Sindhu has made sure that her name will always be associated with diligence, self-control, and tenacity. They have also concentrated on showcasing her as a role model for young Indian women and her pioneering work in Indian sports. The management of Sindhu has played a significant role in molding her charitable endeavours, which center on advancing sports in India. She is furthering her legacy by developing the next generation of Indian athletes through her participation in youth badminton programs. With a heavy emphasis on her brand and legacy, P.V. Sindhu's management has effectively made her a global sports superstar by ensuring that her accomplishments go beyond badminton [34].
3. **M.S. Dhoni: The Captain Cool of Indian Cricket:** His sports management company, Rhiti Sports, Mahendra Singh Dhoni, who is frequently praised as one of the greatest cricket captains, has become a prosperous businessman and brand ambassador after retiring [34]. Leading companies that Dhoni has promoted, such as Pepsi, Reebok, TVS Motors, Indigo Paints, Gulf Oil, and Dream11, have helped him financially succeed off the pitch. To further solidify his

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reputation as "Captain Cool," his endorsement strategy centers on partnering with companies that share his cool-headed sense of style. Strategic commercial endeavors have allowed Dhoni's management team to diversify its sources of revenue. He is a co-owner of the Chennai Yin FC football team in the Indian Super League (ISL) and has made investments in fitness centers and sports academies. To further establish himself as a business-savvy athlete, he also started Seven, a lifestyle company that sells athletic wear and footwear. The goal of Dhoni's management group has been to keep him relevant even after his cricket career ends. His ventures into videogames and motorsports with Mahi Gaming and the MS Dhoni Racing Team show how savvy management may facilitate a smooth transition after retirement. In addition to helping him become one of the richest sports celebrities in India, M.S. Dhoni's management has secured his entrepreneurial and charitable legacies, expanding his impact outside of cricket [35].

3.4 Mary Kom: The Iconic Boxer and Role Model:

Six-time world boxing champion Mary Kom is a well-known example of an Indian athlete whose achievements have been carefully considered to create a lasting legacy. Mary Kom has been managed by Infinity Optimal Solutions (IOS) since 2009. Kom, a six-time world champion boxer, has said that IOS manages her commercial work so she can focus on her game [36]. Even though she came from modest origins, her management group has been instrumental in building her brand and obtaining endorsements. Kom has endorsed products from companies including Nestlé, BSNL, and P&G, highlighting her status as a representation of tenacity, fortitude, and resiliency. Her ability to balance her athletic accomplishments with her roles as a mother and member of parliament has allowed her management to establish her as a national icon, especially for women in sports [37]. The 2014 biographical film Mary Kom, which portrayed her ascension to prominence, greatly increased her visibility. Her management played a crucial role in the movie's promotion, making sure that more people saw her life story and solidifying her reputation as an inspiration for aspiring athletes. The management team of Kom has also concentrated on her charitable endeavors, such as her Mary Kom Boxing Academy program to encourage boxing among impoverished youngsters in India. This has improved her legacy and allowed her to give back to the sport that helped her become a household name. Mary Kom's management has expertly managed her career, making sure that her impact goes beyond the ring and that she continues to inspire future generations, philanthropy, and public service [38].

3.5 Neeraj Chopra: India's Golden Boy in Javelin:

Neeraj Chopra, the first-ever Olympic gold medallist from India in track and field, shot to fame with his historic victory in the 2020 Tokyo Olympics. His management group, JSW Sports, has been instrumental in turning his achievement into a recognizable brand. Chopra inked agreements with companies like Nike, Byju's, Tata AIA Life Insurance, Gatorade, and Mahindra after his triumph at the Olympics [39,40]. His management group has carefully matched him with companies that are reflective of his enthusiasm, youthfulness, and dedication to quality. His modest, grounded demeanor has been preserved by Chopra's management, as it appeals to the Indian populace. He has become a relatable character thanks to his straightforward but unwavering approach, which has helped establish his brand as an inspiration for young sportsmen. Chopra's management is putting long-term objectives first because of his comparatively young age and potential for future Olympic success. They are making sure that his brand expands gradually while

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considering the length of his career and his post-retirement goals. The example of Neeraj Chopra shows how sports management may use a single triumphant moment to create a long-lasting and powerful brand [39,40].

3.6. LeBron James: The Business Mogul:

His management group, which includes his childhood buddy Maverick Carter, LeBron James has become not only a basketball legend but also a well-known business magnate across the globe. Together, they have managed every facet of LeBron's extracurricular activities via their business, LRMR Ventures, guaranteeing that his legacy goes well beyond basketball. LeBron's group has placed a strong emphasis on building long-term wealth, guiding him away from endorsement deals and towards stock investments in businesses [41]. Notably, when Beats by Dre was sold to Apple, he received a sizeable compensation for his association with the company. Moreover, his investment in Blaze Pizza has turned out to be a wise one. In addition to being a great player, LeBron has put a lot of effort into developing his brand to showcase his qualities as an entrepreneur and humanitarian [42]. His involvement with SpringHill's content production program. By establishing the LeBron James Family Foundation, which notably provided funding for the establishment of the I PROMISE School, LeBron's management team has also established him as a leader in charity. His influence has grown outside of sports and his reputation as a community leader has been reinforced by this facet of his brand management. LeBron's off-court endeavours have contributed to his projected $1 billion in lifetime earnings through smart judgments, demonstrating how a strong management team can turn an athlete into a multifaceted business magnate [43].

3.7 Roger Federer: The Endorsement King:

The remarkable on-court play and off-court management that have defined Roger Federer's tennis career have made him one of the most marketable athletes in history. Federer's management group, headed by his long-time agent Tony Godsick, was instrumental in arranging his sponsorship contracts, which have continuously ranked him in the top echelon of athletes worldwide. Federer is more than just a tennis player [44]. High-profile endorsements from brands like Nike, Wilson, Mercedes-Benz, Rolex, and Uniqlo have been obtained by his management. Despite being concluding his career, Federer made headlines in 2018 when he signed a $300 million, ten-year contract with Uniqlo. This ongoing partnership shows how an athlete's value can extend beyond the time spent competing. Federer's team has endeavored to augment his renown as a refined, His affiliation with Rolex, in particular, enhances his attractiveness to both sports fans and the broader public by balancing his public character of elegance and success [45]. Similar to LeBron James, Federer’s management team has emphasized philanthropy, particularly through the Roger Federer Foundation, which supports education initiatives in Africa. His worldwide reputation as more than just an athlete has been strengthened by his charitable endeavors, expanding the reach of his brand. Roger Federer's careful brand management has demonstrated a mastery of utilizing worldwide [46].

3.8. Cristiano Ronaldo: The Global Icon:

Throughout his career, Cristiano Ronaldo has always excelled both as a player and as a business mogul. Under the direction of Jorge Mendes, his management group has made Ronaldo a household name outside of the football world. Ronaldo's affiliations with some of the biggest corporations globally, such as Nike, Clear, Herbalife, and his brand, CR7, demonstrate the worth

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of his brand. His almost $1 billion lifetime contract with Nike highlights his exceptional marketability as an athlete [47,48]. Ronaldo is now the most followed athlete on social media sites like Instagram because of his management's strategic use of his enormous worldwide fan following. Sponsors view Ronaldo as a crucial player in expanding into international markets, and his social media popularity is a great asset to them. In addition to endorsements, Ronaldo has started his clothing line, CR7, and expanded into other business endeavors such as gyms, hotels, and perfumes. His management group has established a self-sustaining brand, guaranteeing him revenue streams that last well beyond retirement. The capacity of Cristiano Ronaldo to command international endorsement deals and create a personal empire emphasizes the value of having a well-rounded management staff that can take advantage of an athlete's global marketability [49].

3.9. Serena Williams: The Athlete-Investor:

Sports agent and former professional tennis player Jill Smoller is considered a pioneer for women in the industry. She is best known as the longtime agent to tennis star Serena Williams Serena Williams has gone from being a tennis champion to a shrewd investor and businesswoman, making her an iconic presence in both sports and business. Because of her long-standing endorsement deals with companies like Gatorade, Beats by Dre, Nike, Wilson, and Gatorade, Serena is among the highest-paid female athletes [50]. But Serena's management has made sure she's more than just a spokesperson; through her company Serena Ventures, Serena invests as well, specializing in ventures founded by women. To expand her brand's reach into the lifestyle and fashion domains, Serena has launched her apparel line, S by Serena. Being one of the few athletes to successfully make the move into entrepreneurship is a testament to her business skills and strategic connections [51]. The promotion of gender equality, which has been essential to Serena's brand, has also received attention from her management. Through her advocacy for diversity and women's rights, Serena has built a strong and enduring legacy. Serena Williams' career after retiring from tennis has served as a model for how players can use their success in the game to build a diverse portfolio of business endeavors, endorsement deals, and investments [52].

3.10. Tiger Woods: From Scandal to Redemption:

Throughout sports history, Tiger Woods has had some of the most remarkable ascents, descents, and returns. A key part of Woods' redemption tale was his management group, which included Mark Steinberg. Following his public problems, they made sure Woods kept and regained lucrative endorsement deals. After his scandals, Woods' management group put a lot of effort into restoring his reputation [53]. Nike, Bridgestone, and TaylorMade endorsements continued to be essential to his recovery plan. His victory in the 2019 Masters helped him rebuild his reputation, which led to fresh prospects for endorsements and public favour. Tiger's management team used his inspirational comeback to draw in new sponsors in spite of difficulties [54]. His collaboration with Golf TV and other golf-related businesses serves as examples of how management may transform a career comeback into sustained success. The example of Tiger Woods shows how resilient a well-managed athlete can be [55].

Professional sports management is becoming more and more connected to athletes' success on the national and international stages. These case studies highlight the complex part sports administration plays in an athlete's accomplishments. Effective management teams assist athletes in maximizing their potential, whether it is through financial planning, brand development, or post-career transitions. This ensures longevity and success in their particular sports both on and off the

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pitch, as well as secure long-lasting success beyond their athletic careers [56]. These case studies demonstrate the critical role that efficient sports administration plays in assisting players in navigating the international sports scene and advancing their careers.

4. CHALLENGES IN SPORTS MANAGEMENT:

Sports management is not without its difficulties while being essential to maximizing an athlete's career on and off the pitch. Navigating these difficulties needs a balance between ethical integrity, financial prudence, and long-term planning, all of which are crucial to guaranteeing the athlete’s continuous success. This section explores the main obstacles that sports managers must overcome, emphasizing the need for strategic control as well as potential dangers [57]

4.1 Moral Concerns: Ethical issues are one of the most important issues facing sports managers, especially when the pressure to succeed or keep up one's best work might result in unethical choices.

- **Doping and performance-enhancing drugs:** There is frequently a great deal of pressure to outperform competitors in the cutthroat world of sports, where a win may make or ruin an athlete's career. Athletes who dope by using performance-enhancing drugs (PEDs) to obtain an advantage have resulted from this. Strict adherence to anti-doping regulations and the development of an ethical conduct-focused culture are essential components of effective sports management. Regretfully, management teams occasionally choose to ignore these unethical behaviors out of ignorance or a desire for quick success. If caught, these actions can seriously harm an athlete's career and reputation **[58]**
- **Mismanagement of Injuries:** Taking care of injuries properly presents another ethical dilemma. After an injury, athletes are frequently under pressure to get back on the pitch as soon as possible, which can lead to a hurried recovery and long-term health hazards. The challenge for sports managers and medical staff is to strike a balance between an athlete's desire for competitive success and their physical health. In addition to putting the athlete's career in jeopardy, poor management in this area raises moral questions about putting the athlete's health last and focusing primarily on short-term rewards **[59].**
- **Conflicts of Interest:** When it comes to endorsements or contracts, sports managers may have conflicting interests that put their own money ahead of the athlete's. For example, a manager may, out of self-interest, steer an athlete towards a particular sponsor or agreement rather than what's best for the athlete's brand or career **[60].**

Sports managers must meet these ethical problems with open communication, strict adherence to rules, and a strong feeling of responsibility to protect the athlete's integrity and health**.**

4.2. Mismanagement of finances: Even the most gifted athletes can suffer from bad financial advice or mismanagement, which makes the financial aspect of sports management difficult. Financial decisions made without enough supervision might hurt one's career.

- **Inadequate Financial Planning**: Ensuring an athlete's financial stability throughout and after their playing career is one of a sports manager's main duties. Athletes can, however, end up bankrupt due to bad investment decisions, a lack of financial literacy, and a failure to make long-term financial security plans. Prominent instances of athletes filing for bankruptcy soon after they retired serve as a reminder of the disastrous consequences that can result from poor financial management. Collaborating with financial specialists to develop diversified investment

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portfolios, retirement plans, and savings strategies is essential to effective sports management [61].

- **Overspending:** Athletes tend to splurge, especially those who become well-known and wealthy early in their careers. Without the right direction, they can lead ostentatious lives, buy investments that lose value, or put their trust in people who could take advantage of them financially. Sports managers are essential in helping athletes realize the value of future security and responsible spending by providing them with appropriate financial guidance **[62].**
- **Fraud and Exploitation:** Regrettably, there are many instances of fraud, embezzlement, and exploitation in the sports industry. Athletes are vulnerable to exploitation by unscrupulous managers or financial consultants, particularly those with little financial knowledge. To reduce these risks, open financial transactions, frequent audits, and accountability systems are necessary **[63].**

Financial mismanagement not only impacts an athlete's career but can also taint their reputation, making it vital for sports management to adopt sound financial procedures and safeguard against fraud.

4.3 Juggling Short-Term and Long-Term Objectives:

In sports management, striking a balance between an athlete's short-term success and their long-term health and career sustainability is one of the trickiest problems. Significant disputes may arise as a result of this tension for the athlete and their management group.

- **Pressuring for Instant Success:** In order to optimise an athlete's wages and accomplishments in the short term, there is frequently pressure to take advantage of their prime years. This can entail pressuring a competitor to participate more frequently, sign more endorsement contracts, or do physically taxing tasks. While this can bring about immediate financial rewards, in the long run, it might also result in bodily harm, burnout, or diminished performance **[64].**
- **Prolonged Career:** Concentrating just on the sustainability of the athlete's long-term career may require a more cautious approach, such as restricting competition participation or delaying sponsorship chances until the athlete reaches a more mature or experienced level. This more cautious approach occasionally sacrifices immediate financial gain or notoriety, but its goal is to safeguard **[65].**
- **Managing Expectations:** Managing the expectations of athletes, sponsors, and stakeholders is another part of striking a balance between short- and long-term objectives. Sponsors typically desire high visibility and quick returns on their investments, while athletes may want to compete and perform at the highest levels regularly. Sports managers have to tread carefully when dealing with these expectations to make sure the player is not overworked and that their career is being strategically advanced over time **[66].**
- **Planning for Transitions:** A vital component of long-term planning is getting the athlete ready for life beyond competition. This includes post-career options mentorship, education, and business investments as tactics for career transition. Athletes who don't make plans for life after sports risk being unprepared for the future on a mental and financial level. A sophisticated strategy is needed for effective sports management **[67].**

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Here's a more concise table 2 summarizing the challenges in sports management.

Table 2: highlights the key challenges in sports management.

Category	Challenges	Description
Ethical Concerns	Doping & PEDs	Pressure to succeed may lead to unethical drug use, risking careers.
	Mismanagement of Injuries	Rushing recovery can harm athletes' long-term health.
	Conflicts of Interest	Managers may prioritize their gains over the athlete's best interests.
Financial Mismanagement	Inadequate Financial Planning	Poor planning can lead to bankruptcy post-retirement.
	Overspending	Lavish lifestyles can result in financial instability.
	Fraud & Exploitation	Athletes may be vulnerable to financial fraud or embezzlement.
Balancing Short- & Long-Term Goals	Pressuring for Instant Success	Overworking athletes can cause burnout or physical harm.
	Prolonging Career	Focusing on long-term health can sacrifice immediate gains.
	Managing Expectations	Balancing athlete, sponsor, and stakeholder demands for long-term success.
	Planning for Transitions	Preparing athletes for life after sports ensures financial and mental readiness.

5. CONCLUSION AND FUTURE DIRECTION

In summary, sports management is a crucial component of athletes' lives, assisting with anything from injury prevention to performance optimization to financial and legal administration to post-career transitions. Sports managers provide athletes with the tools they need to succeed in their competitive endeavours and set them up for long-term success once their careers end. Athletes such as LeBron James, P.V. Sindhu, and Virat Kohli are used as case studies to show the revolutionary influence that good management can have on creating sporting brands and ensuring financial stability. In addition, the management of sports has changed to promote inclusivity and guarantee that athletes with disabilities are given fair support and acknowledgment. Sports managers foster settings that are empowering for all athletes by fighting for financing and public awareness, securing medical and psychological resources, and promoting adapted sports programs. The field does, however, confront several difficulties, such as moral conundrums, poor money management, and conflicting short- and long-term objectives. These obstacles must be overcome by effective sports management, which places a strategic emphasis on moral behavior, prudent financial management, and long-term career growth. Sports managers will play an increasingly important role as sports continue to change, especially when it comes to meeting the special

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requirements of all athletes, including those who are disabled. Developing conditions that support peak performance, career longevity, and inclusion will be key to the future of sports management since they will guarantee that every athlete has the chance to thrive and be recognized equally in the world of international sports.

Athletes will undoubtedly receive even more extensive help in the future as artificial intelligence, data analytics, and mental health support are more thoroughly integrated into sports administration. Furthermore, as sports become more commercialized, public relations and brand management will become more important, making it harder to distinguish between athletes who are competitors and those who are worldwide icons.

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COMPARATIVE ANALYSIS OF RESILIENCE AMONGST ATHLETES & NON-ATHLETES

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ABSTRACT

In sport, adversity is typically synonymous with athletic success. Athletes know that winning is in the mind for which the athlete has to endure situations that warrant physical, mental and emotional toughness. Athletes tend to endure a number of crisis situations due to performance issues, injuries, or even balancing academics and sports. To deal with such crisis situations one needs to be resilient. Resilience refers to "positive adaptation or the ability to maintain or regain mental health, despite experiencing adversity." (Wald et al, 2006). The sports atmosphere is replete with examples of athletes being resilient in adversities. However, past studies are inconclusive due to conflicting results. This study includes 175 participants (male and female), comprising 110 athletes and 65 non-athletes between the age group of 18-25 from India. Random sampling is used for the samples. Data collection is based on abbreviated version of the Nicholson McBride Resilience Questionnaire (NMRQ) with12 Questions. The data is tabulated and statistical analysis carried out using Welch's t-test**.** The result indicates that there is no significant difference in the resilience among Athletes and Non-Athletes. However, since there is no clear outcome from this or the previous studies, further research in this area is warranted.

Keywords: Resilience, Athletes, Non-athletes, Adversity, Stress, Adaptation

1. INTRODUCTION

Professional athletes generally tend to reflect a higher level of bounce back after physical injuries or emotional set backs or fatigue. Psychological resilience, or the ability to experience adversity and adapt positively (Luthar & Cicchetti, 2000), has been identified as a desirable characteristic for athletes and coaches in sport (Fletcher & Sarkar, 2012; Galli & Vealey, 2008; Hosseini & Besharat, 2010). Unfortunately, research involving resilience in the sport context is limited (Gucciardi et al, 2011). Understanding resilience in athletes and its difference in individuals who are non-athletes may help us identify the effect of physical activity on resilience. The scope of this study however, is very basic and broad.

2. RESILIENCE

Norm Garmezy, who studied the phenomenon of resilience, initiated "Project Competence," which was devoted to studies of competence, adversities, and resilience. "During the 1970s and 1980s empirical studies reported how some children were able to achieve competency despite their adverse circumstances" (Anthony 1974; Werner & Smith 1982). Resilience was "the ability to readily recover from illness, depression, and adversity" (Abrams 2001). Factors of resilience include: "self awareness, determination, vision, self-confidence, organization, problem solving, interaction and relationships" (Derek Mowbray, 2008).

The American Psychological Association (2014) defines resilience as "the process of adapting well in the face of adversity, trauma, tragedy, threats or even significant sources of stress.

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Fletcher & Sarkar (2013) felt that "all definitions of resilience highlight the individual's ability to overcome adversity and attain successful positive adaptation".

3. STATEMENT OF RESEARCH PROBLEM

Resilience amongst athletes is greater than in non-athletes of India in/ the age group of 18 to 25 years

Hypotheses

- Null Hypothesis - H_0: There is no difference in resilience among athletes and non- athletes
- Alternative Hypothesis - H_1: There is a significant difference in resilience amongst athletes and non-athletes

Operational Definitions

- **Athletes –** An individual who is trained or skilled in exercises, sports, or games requiring physical strength, agility, or stamina.
- **Non-athlete** – All individuals who do not fall in the category of athletes would be considered non-athletes for this research
- **Resilience** - Resilience refers to "positive adaptation or the ability to maintain or regain , despite experiencing adversity." (Wald et al; 2006)

Variable - Resilience

Objectives of Research

a. To assess and compare resilience amongst athletes and non athletes
b. To test the Hypothesis and analyse results of the study
c. To specify gaps in the research for further study

Delimitations

- **Inclusion criteria:** Male and female Indians in the age bracket of 18-25 years are included in the study
- **Exclusion criteria:** Those individuals who do not meet the inclusion criteria and those who are unwilling to participate or returned incomplete questionnaire are excluded.

Limitations

- Reliability of the response cannot be assured. Scope of the research is very wide.

Need and significance of the study

The study is carried out to contribute to research gaps. The study would add to the literature on resilience for further exploration.

4. REVIEW OF LITERATURE

The concept of positive adaptation despite adversity has existed practically since humans began reflecting on their own behaviour. Early resilience studies were concentrated on qualities of the individual child or adolescent — the resilient child who was described as invulnerable (Anthony, 1974) or invincible (Werner and Smith, 1982). Gradually, researchers came to view these terms as misleading for several reasons and have broadened or sharpened the concept of resilience.

Rutter (1987) proposed the model of resiliency. Rutter (1979) then Garmezy et al. (1984) described three levels of protective factors — the individual, the family, and the community

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(Sandler, 2001). The compensatory and protective models of resiliency are the two that have received the most attention in the research literature (Fergus & Zimmerman, 2005).

Hosseini & Besharat (2010) investigation showed that resilience was connected with higher levels of sport accomplishment and psychological well-being, but not with lower levels of psychological distress. Barley, Cerqueira et al., (2012) studied that **sport appears to contribute to the event of a lot of resilient profile and higher quality of life**. Morgan, Sarkar (2015) found five main psychosocial processes underpinning team resilience: transformational leadership, team learning, social identity, and positive emotions. Role of genetic factors as well as personality traits (some of which are the result of social learning) was highlighted by Shastri (2013) in her review of resilience.

Shrivastava & Mishra (2016) found that **non-sports persons exhibited higher levels of grit, resilience and agency as compared to the sportsperson, contrary to expectations**. Doğan, E., (2019) found that **athletes engaged in different team sports had similar psychological resilience**. Cazayoux & Debeliso (2019) found that **Athletes have higher resilience and hardiness** and fewer problems. Dunston, et al, (2020) found that **Vigorous physical exercise was connected with resilience**. Ram et al. (2020) found that there is a significant relationship between Resilience, hardiness and . **Resiliency Athletes and non-athletes both have greater toughness and mental wellness**. The study also suggests the relevance of mental toughness and resilience in predicting in athletes and non-athletes. In a study by Cevada, et al, (2021) the results imply that **regular physical exercise and sports should be promoted to help with enhancing resilience** and resting-state brain cortical function, and consequently, improving .

Prof. Sir Michael Rutter – He defined resilience as “an interactive concept that is concerned with the combination of serious risk experiences and a relatively positive psychological outcome despite those experiences” (Rutter, 2006). His definition has remained stable over time, with his 2013 definition stating that resilience is when, “Some individuals have a relatively good outcome despite having experienced serious stresses or adversities – their outcome being better than that of other individuals who suffered the same experiences” (Rutter, 2013). Rutter takes **a lifespan approach to resilience**, as he states that resilience is “not the chemistry of the moment” but something that may be more evident at different times in one’s life (Rutter, 2007).

Dr. Norman Garmezy - Garmezy defined resilience as “not necessarily impervious to stress. Rather, resilience is designed to reflect the capacity for recovery and maintained adaptive behavior that may follow initial retreat or incapacity upon initiating a stressful event” (Garmezy, 1991a). Garmezy makes the point that all children experience stress at some time” (Garmezy, 1991b). Norman Garmezy was the lead researcher in ‘Project Competence’, one of the landmark studies in the field of resilience (Garmezy, 1987). Garmezy concluded that resilience (or competence) was linked to a low number of risks and higher number of protective factors. Garmezy contended that protective factors at the individual and familial levels, and external to the family, all influence resilience. Garmezy developed three models that explained resilience (Garmezy et al., 1984): Compensatory model, Protective vs. vulnerability model, and model.

Dr. Emmy Werner - Werner defined resilience as, “The capacity to cope effectively with the internal stresses of their vulnerabilities and external stresses (illness, major losses, and dissolution of the family)” (Werner, 1982). She describes resilience as those children who “worked well, played well, loved well, and expected well” (Werner, 1982). Werner identified several individual, family and community factors that correlated with resilience. In 1989 Werner published a follow-up to the Kauai study to trace the long-term effects of protective factors and stressful events

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(Werner, 1989). Werner held an ecological view of resilience, focusing on protective factors that promoted resilience at the individual, family and community level (Werner, 1989). Werner's longitudinal approach provided a window into changes in resilience over time. She proposed that there is a shifting balance at each developmental stage, and that these shifts depend on stressful life events, gender and protective factors (Werner, 1989).

Prof. Suniya Luthar - Luthar et al. (2000) defined resilience as "a dynamic process encompassing positive adaptation with the context of significant adversity". She states that there are two critical conditions that must be met to be resilient: exposure to significant threat or severe adversity and the achievement of positive adaptation. Luthar, similar to other researchers, proposes that resilience is not a personal trait but a product of the environment and the interaction between the child and the environment. She indicated that further work is required to understand the "culture of affluence" (Luthar et al., 2006). She and her colleagues have also emphasised that risk factors and protective factors are not simply polar opposites of the same variable (Luthar et al., 2006). Luthar suggests that researchers need to be cognisant of the multidimensional nature of resilience, and that children can show competence in some domains but not in others (Luthar et al., 2000). She states it is unrealistic to expect children to be successful across all domains consistently. Luthar et al. (2000) is critical regarding the lack of clarity in the use of definitions and terminology within resilience. Luthar questions whether competence should be excellent or average to be considered resilient, and whether some domains are more important than others.

Prof. Ann Masten - Masten defined resilience as, "The capacity of a dynamic system to withstand or recover from significant changes that threaten its stability, viability, or development" (Masten, 2011). His 2014 definition is "the capacity of a dynamic system to adapt successfully to disturbances that threaten system function, viability, or development" (Masten, 2014). This newer definition reflects the perspective that individuals do not withstand risk, but change to accommodate risk. Masten et al. (1999) noted that if reasonably good resources are present, competence outcomes are generally good. Masten indicates there must be two criteria present to be considered resilient, namely a measure of positive adaptation or development and the past or current presence of conditions that threaten to disrupt positive adaptation (Masten et al., 2009). The two models of resilience frequently referred to by Masten are the Variable Focused and Person Focused approaches (Masten et al., 2009, Masten, 2011, Masten, 2001). Masten has developed a list of protective factors that operate at the individual, family and community level (Masten et al., 2009). However, she notes that there have been very few resilience interventions implemented to actually know if current theory can be substantiated (Masten, 2011). Consequently, much of current resilience theory remains untested.

Michael Ungar - Ungar defined resilience as, "more than an individual set of characteristics. It is the structures around the individual, the services the individual receives, the way knowledge is generated, all of which combine with characteristics of individuals that allow them to overcome the adversity they face and chart pathways to resilience" (Ungar, 2005a). He expanded on this definition in 2008. The point he is emphasising is that it is the features of both individuals and the environment that lead to resilience (Ungar, 2013). Ungar et al. (2007) identified seven tensions of resilience. According to Ungar et al. (2007) tensions may exist in all cultures; however, young people will resolve them in a culturally relevant way. Due to the non-linear relationship, Unger asserted that resilience is not a predictable set of developmental processes and positive outcomes. Ungar did not find a valid factor structure for seven tensions of resilience. In 2011, Ungar raised four principles that require consideration, namely decentrality, complexity, atypicality and cultural

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relativity (Ungar, 2011). Ungar emphasises the importance of the environment and proposes a social ecological understanding of resilience (Ungar, 2013).

Limitations and Uncertainties - There are several limitations to current research in resilience, namely the ambiguity in terminology and measurement, methodology, the absence of young people's voices, predominance of western views with the absence of culture and context, and a lack of resilience interventions.

Instruments for assessment of Resilience - There are multiple measures of resilience that have been developed and used across a variety of adult samples. Some of the common instruments include 25 & 14 item resilience scale (Wagnild & Young, 1993); Hardy-Gill Resilience scale (Hardy et al, 2004); Connor–Davidson Resilience Scale (CD RISK, CD RISK 10 & CD RISK 2; Resilience Assessment Questionnaire (RAQ 8 & RAQ 25); Nicholson McBride Resilience Questionnaire (NMRQ) 12 & 40 questions.

Research Gap - There is a contradiction in the findings of various research studies regarding resilience displayed by athletes and non-athletes. The influence of culture on resilience is a very little-explored field within resilience studies.

5. RESEARCH METHODOLOGY

- **Research Design -** Survey research is used in this study. The responses sought are quantitative.
- **Universe of the Study -** The population of the study comprises of males and females from India between the age group of 18- 25 years.
- **Sampling -** Simple random sampling method was used to obtain responses to the questionnaires.
- **Data collection Procedure -** The participants are to be informed about the purpose of the research and the questionnaires are presented through Google forms.

Tools for Research

Data collected is based on an abbreviated version of the Nicholson McBride Resilience Questionnaire (NMRQ) with 12 questions. For each question, the score is between 1 and 5, where 1 = strongly disagree and 5 = strongly agree. [NMRQ Score indicates level of resilience - 0-37 (Developing); 38-43 (Established); 44-48 (Strong); 49-60 (Exceptional)]

- **Data analysis methods -** The data is tested for normality. The mean, standard deviation and the variance of the variables is found. Then, an Independent **Welch's t-Test** is conducted to test the difference between sample means.
- **Research Ethics -** Participation is voluntary (Consent obtained prior to the study). The participants have the right to withdraw from the study. Adequate level of confidentiality of the research data is ensured.

Data interpretation

The data collected is segregated into two independent groups - athletes and non-athletes. The groups are independent and mutually exclusive. Values obtained in one sample do not influence the values of the other sample. The response sought is quantified.

- **Level of significance -** α (Alpha) for the study is 5%.
- **Procedure for analysis -** Mean, standard deviation and variance was calculated for each group. Welch's t-Test is administered for the samples. Null Hypothesis and Alternative Hypothesis are defined. α (Alpha) of 0.05% (level of significance) is defined. Degree of freedom is defined.

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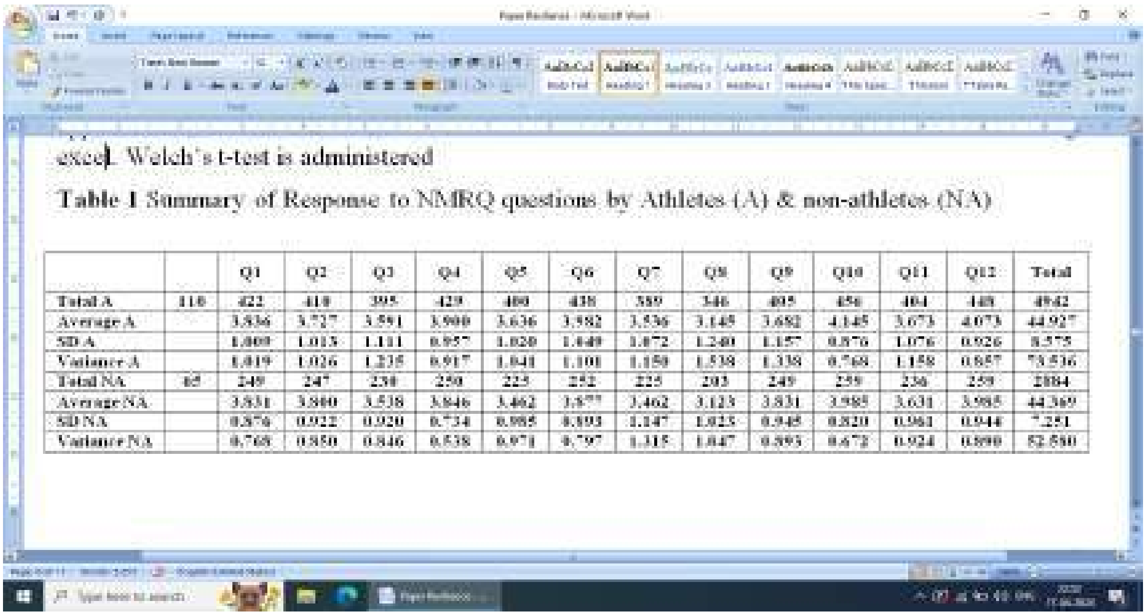
Decision rule defined is to “reject null hypothesis if p value is greater than critical value. Conclusions of the study are drawn.

- **Statistical analysis -** Raw data collected is summarized for easy manipulation for statistical application (refer table below). The mean, standard deviation and variance is calculated using excel. Welch’s t-test is administered



excel. Welch’s t-test is administered

Table I Summary of Response to NMRQ questions by Athletes (A) & non-athletes (NA)

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Total
Total A	110	422	410	395	429	400	438	389	346	405	456	404	448	4942
Average A		3.836	3.727	3.591	3.900	3.636	3.982	3.536	3.145	3.682	4.145	3.673	4.073	44.927
SD A		1.009	1.013	1.111	0.957	1.020	1.049	1.072	1.240	1.157	0.876	1.076	0.926	8.575
Variance A		1.019	1.026	1.235	0.917	1.041	1.101	1.150	1.538	1.338	0.768	1.158	0.857	73.536
Total NA	65	249	247	230	250	225	252	225	203	249	259	236	259	2884
Average NA		3.831	3.800	3.538	3.846	3.462	3.877	3.462	3.123	3.831	3.985	3.631	3.985	44.369
SD NA		0.876	0.922	0.920	0.734	0.985	0.893	1.147	1.023	0.945	0.820	0.961	0.944	7.251
Variance NA		0.768	0.850	0.846	0.538	0.971	0.797	1.315	1.047	0.893	0.672	0.924	0.890	52.580

Response (1 to 5) percentage of Athletes and Non-athletes for each option of NMRQ: For option 1 - 4.17 & 1.03; for 2 – 7.35 & 10.13; for 3 – 26.67 & 29.36; for 4 – 33.56 & 37.05; and for 5 – 28.26 & 22.44 respectively

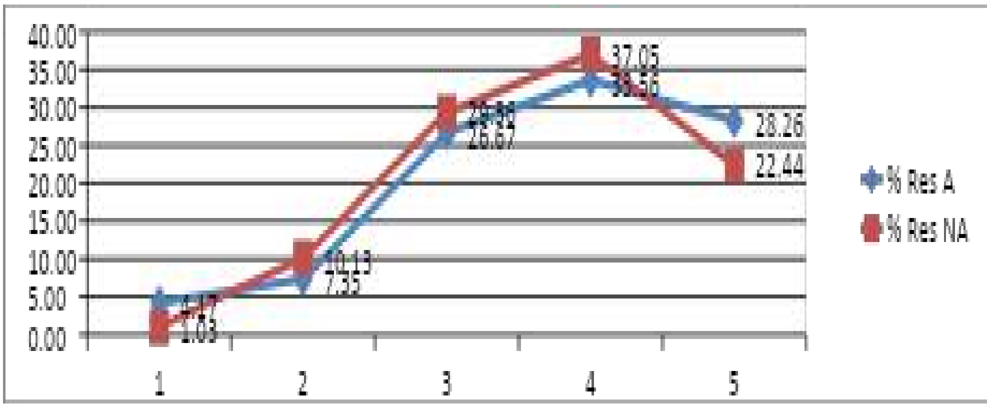
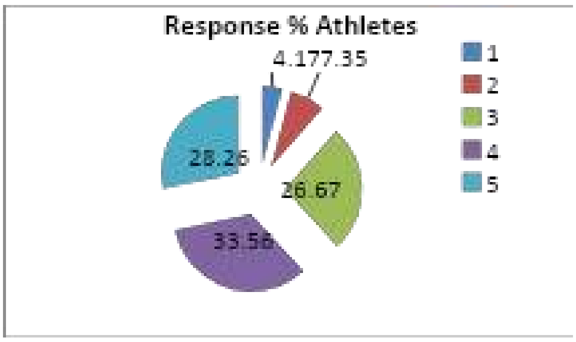
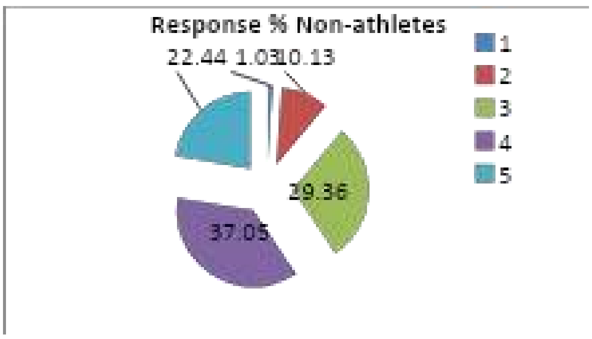


Figure 1 Line and Pie chart of NMRQ score as a percentage of Total Response





Welch’s t-test for two samples with unequal variance was administered using an alpha value of 0.05. The result is appended below.

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Table 3 – Output of Welch's t-Test: Two-Sample Assuming Unequal Variances

t-Test: Two-Sample Assuming Unequal Variances		
Measure of Resilience using NMRQ instrument for athletes & non-athletes	Athletes	Non-athletes
Mean	44.927	44.369
Variance	73.536	52.580
Observations	110.000	65.000
Hypothesized Mean Difference	0.000	
Df	152.000	
t Stat	0.459	
P(T<=t) one-tail	0.323	
t Critical one-tail	1.655	
P(T<=t) two-tail	0.647	
t Critical two-tail	1.976	

- **Hypothesis testing -** T stat value of 0.459 is less than the critical value (1.976) at α of 5%, and the p-value of 0.647 is larger than the significance level of 0.05.
- **Result -** Since the t stat value is less than the t critical value for two tails at 5% α, the null hypothesis is not rejected (Fail to reject H_0)

6. FINDINGS

Mean score for each response lies between 3& 4 (except for Q 11 (A) where it is 4+) implying a "neutral" to "agree" response.

Mean score of response for athletes is 44.927 indicating a strong level of resilience implying an above average score that indicates that you are "pretty good at rolling with the punches and you have an impressive track record of turning setbacks into opportunities"

Mean score of response for non-athletes is 44.369 indicating a similar level of resilience

For athletes minimum score is 18 and maximum score is 60 with a standard deviation of 8.575 (Variance of 73.536)

For non-athletes minimum score is 29 and maximum score is 60 with a standard deviation of 7.251 (Variance of 52.580)

The inter quartile range for Athlete responses is 41 to 52 with a median of 47 and for Non-athletes is 39 to 50 with a median of 44

7. DISCUSSION

The mean values for both the groups fall in the 44-48 group (44.927 & 44.369) indicative of a strong level of resilience amongst the youth between 18 to 25 years. Though the values are very close to the lower margin, further research can comment on the increase or decrease of these values with time or with changing environmental scenarios. Extreme minimum scores of 18 and 29 in athlete and non-athlete groups require further exploration.

Since t stat value is less than the critical value the null hypothesis is not rejected. Also, since the p-value or calculated value is larger than the significance level of 0.05, the null hypothesis is

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not rejected. Thus we conclude that there is no statistically significant difference in Resilience amongst the athletes and non-athletes. However, the analysis of reasons behind the response needs further investigation. Unlike some of the studies of yester years, this study is neutral towards the state of resilience amongst the youth. Role of sports to enhance or address resilience issues cannot be commented upon. Further instruments can be explored to study responses simultaneously to bring out corroborating or conflicting aspects.

8. SUMMARY

The study was conducted among 175 young adults (110 athletes and 65 non- athletes). The data was collected through Google forms following the ethics of research. The results indicate that resilience level amongst the youth in India appears to be strong with no significant difference between Athletes and Non-Athletes. Scope of use of sports for changing the state of resilience cannot be commented upon. Further research needs to be continued on the subject.

9. CONCLUSION

The ability to respond positively to setbacks is essential for any successful athlete. Although resilience has been studied in general psychology for several decades, it is only recently that researchers and practitioners have begun to explore the construct within the sport context. The findings of this research indicate no significant difference in resilience amongst the youth. Knowledge may be enhanced by the development of a sport-specific resilience measure and use of more sophisticated qualitative approaches and advanced statistical modeling procedures.

10. IMPLICATIONS OF THE STUDY

The failures and poor performances that athletes regularly face in their life may affect or support their need to bounce back in performance and their drive to persevere. This may boost/ lower their motive and intent. Effect of sports and physical activity on resilience needs to be understood clearly before its application in society for handling adversities. Hence, further research should be focused and specific in looking at the factors affecting resilience and the effect of physical activity on them.

11. LIMITATIONS OF THE STUDY

The study conducted is with a small sample size. The difference in type of sport is not considered in the study. Affect on response during examination period of academic session is not considered.

12. SCOPE FOR FUTURE RESEARCH

The numbers of Participants can be increased. Researchers can study variables of resilience for better and fruitful outcome. Differentiation of athletes according to their sports can be considered for the study. Comparative studies considering the impact of environment and culture on sport as well resilience can be undertaken. Studies with a focus to improve understanding of what makes the youth more resilient and its connection with physical activity, if any, can be considered

Conflict of Interest - The authors declared no conflict of interest.

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PHYSICAL EDUCATION, PHYSICAL ACTIVITY AND SPORTS: A COMPARATIVE PERSPECTIVE OF THE MINDSET IN INDIA

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ABSTRACT

Physical education,physical activity and sports play a crucial role in overall well being yet their perception and prioritization vary across cultures. In India, despite increasing recognition of sports on international platforms, a deep rooted preference for academics over physical activity persst. This paper explores the mindset surroundings physical activity in India compared to global perspectives,highlighting the challenges,societal perceptions and potential reforms to elevate sports and physical education in Indian society.

Keywords- Physical Education,Physical Activity, Sports,Mindset.

1. INTRODUCTION

Physical activity is more than just sport or professional sport; it is a mindset that integrates movement into daily life. Globally, there is an increasing awareness of its role in health, social interaction, and psychological well-being. However, in India, sports and Physical education (PE) are often secondary to academics. This paper endeavours to look at how education systems can integrate sports more effectively which in turn can change perspectives and positively influence societal well-being. This paper also examines the perceptions regarding Physical education, physical activity, and sports in India as compared to other nations.

2. PHYSICAL ACTIVITY AS A MINDSET

The modern era is marked by social isolation, aggravated by technology and climate change limiting outdoor interactions. Sports provide a platform for social engagement, whether through participation, as spectators, or through community bonding. Additionally, research supports the psychological benefits of movement, showing that regular physical activity enhances resilience, reduces stress, and improves mental health. Unlike the passive consumption of self-help content, sports offer a tangible way to develop discipline, consistency, and teamwork and many other soft skills even at times without consciously trying to achieve these outcomes that benefit personality development

Physical activity is not limited to athletes; it is a habit that promotes a healthier lifestyle. Small actions, such as choosing to walk instead of drive or stretching after prolonged sitting, reflect an active mindset. In countries where physical activity is ingrained in daily life, people naturally incorporate movement into their routines. In contrast, India's increasing urbanization and technology dependence have contributed to a sedentary lifestyle, making it imperative to cultivate an active mindset from an early age.

Two experiments with one-week follow-up periods investigated the effects of viewing recommendations that prescribe a lower (vs. higher) amount of physical activity and provide a liberal (vs. stringent) definition of what counts as physical activity on individuals' mindsets about the adequacy and health consequences of their physical activity, as well as physical activity-related self-efficacy, physical activity behavior, and perceived health. Study 1 (N = 157) showed that

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exposure to low-and-liberal recommendations (vs. high-and-stringent recommendations) caused participants to adopt the mindset that their physical activity was more adequate, which in turn predicted greater engagement in physical activity and perceived health one week later. Study 2 (N = 272) showed that regardless of definition of physical activity (liberal vs. stringent), a lower (vs. higher) amount of recommended physical activity led participants to adopt the mindset that their activity was more adequate. This more adaptive mindset predicted greater self-efficacy and engagement in physical activity in the following week, in addition to better perceived health. Rather than inducing complacency, recommendations prescribing a relatively lower (vs. higher) amount of physical activity may be more effective at promoting physical activity and health by inducing adaptive mindsets.

3. MINDSET ABOUT PHYSICAL ACTIVITY AMONGST NATIONS

India - Despite India's progress in international sports, PE remains undervalued in schools. Parents and educators often prioritize academics over physical activity, reinforcing the belief that sports are secondary to intellectual pursuits. This mindset has led to limited integration of PE into the mainstream curriculum; insufficient infrastructure and resources for sports development and a lack of career opportunities for athletes, that have forced many into unsatisfactory roles without proper systemic support. However, there has been a shift in this approach in the National Education Policy (NEP) 2020. Translation of the policy to execution is going to be a tall order as the education system requires lead time to bring about such a change. The advocators of PE would have to be educated and trained in this field. So far PE had taken a back seat and was not given an opportunity to flourish. Mindset of students, teachers, parents and society should accept the positive role of PE in development of a child. Till now the transition for acceptance of this aspect has been rather slow. Time only will tell how far the efforts of the government succeed in pushing this agenda for a favourable change in our society.

Other nations - It is not feasible to study the perspective of mindset of the general populace of each and every nation towards physical activity. Hence the study is limited to key consideration points of different cultures, from whose study we can draw lessons, and with modifications, can implement in India to the extent possible. Mindset towards physical activity varies significantly across nations, with some cultures placing a strong emphasis on exercise for health and wellbeing, while others may prioritize other aspects like social interaction, leading to different motivations and levels of participation in physical activity. Factors like socioeconomic status, access to green spaces, and cultural norms play a major role in shaping attitudes of nationals. Key points about different national mindsets regarding physical activity are highlighted below.

Countries like Japan and South Korea often view exercise as a way to improve focus, discipline, and mental acuity, with a strong emphasis on structured activities like martial arts, team sports. These are often tied to cultural values of self-improvement. In Japan, physical education is viewed as a holistic approach to well-being, emphasizing both physical fitness and mental development through mindful movement and communal participation. In Korea, the focus tends to be more on achieving positive values and healthy physical development through structured PE classes.

Countries like Sweden and Finland (High-activity cultures) prioritize outdoor activities like hiking, running, and cross-country skiing as a way to connect with nature and promote overall wellbeing. These are often integrated into daily life that is made possible through favourable climate and infrastructure availability. In Sweden and Finland, the mindset towards physical education is strongly focused on promoting overall health and wellbeing through movement,

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emphasizing enjoyment of diverse activities, outdoor engagement, and a holistic approach to physical activity rather than solely competitive sports, with a significant focus on integrating "Friluftsliv" (outdoor life) into the curriculum in Sweden and initiatives like "Finnish Schools on the Move" to increase activity throughout the school day in Finland.

Countries like Italy and Spain may see physical activity as more integrated into daily life through activities like walking, dancing, and social sports, with a focus on enjoyment and community. Both Italy and Spain generally value physical education, but there's a perception that the Italian mindset might place slightly more emphasis on team sports and traditional physical activities within PE, while Spain may show a greater focus on individual sports and leisure-based physical activity, though both countries can face challenges with consistently encouraging active lifestyles among their youth.

North American Countries (USA, Canada) often view exercise as a means to achieve a desired fitness, with a focus on individual fitness goals and competitive sports. In the United States and Canada, physical education is viewed as a way to develop physical fitness, social skills, and lifelong habits of physical activity. Both the United States and Canada recognize that physical education can help children and youth develop lifelong habits of physical activity. Physical education can also help children develop social skills, self-esteem, and emotional intelligence.

Some examples of different mindsets are: In countries like Japan, where work culture can be demanding, exercise is often seen as a way to manage stress and maintain mental health. In many Latin American countries, physical activity is often associated with social gatherings, like neighborhood soccer matches, fostering community bonds. In countries with a strong sports culture, like the US, individuals may be more motivated by achieving athletic goals and competition.

4. SHAPING THE MINDSET ABOUT PHYSICAL ACTIVITY

A positive mindset about physical activity means approaching exercise as a way to improve your overall health and well-being, focusing on the positive benefits like increased energy, better mood, and improved physical capabilities, rather than solely seeing it as a burden, and embracing challenges as opportunities for growth; essentially, viewing movement as something enjoyable and beneficial to your body and mind, not a chore.

To shift the mindset about physical activity, reforms could focus on promoting a holistic view of exercise as a positive lifestyle choice, emphasizing its benefits for mental health, energy levels, and overall wellbeing, while making it accessible and enjoyable through diverse activities, community initiatives, and educational campaigns that address common misconceptions and barriers to participation. Some of the factors that influence national mindset towards physical activity are enumerated below.

Cultural Values/ norms - Traditions and social norms regarding health, fitness, and leisure time significantly impact exercise habits. Some cultures may prioritize physical fitness as a sign of health and vitality, while others may see it as less important or even associated with vanity.

Accessibility to Facilities: Availability of gyms, parks, and outdoor spaces can influence how easily people can incorporate physical activity into their lives.

Government Policies: Public health initiatives and promotion of physical activity through education can play a major role. Initiatives promoting physical activity through education campaigns, funding for recreational facilities and active transportation infrastructure can significantly influence attitudes.

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Socio-economic Factors: Socioeconomic status can affect access to fitness programs and the time people have to dedicate to exercise. Individuals with higher incomes may have greater access to gyms and fitness classes, leading to higher participation rates.

Media influence: Popular trends in fitness and sports can shape public perception of physical activity.

Growing awareness: Increased public understanding of the health benefits of physical activity, driven by medical research and public health campaigns.

Technology integration: Fitness trackers and apps promoting activity tracking to motivate individuals.

Focus on inclusivity: More emphasis on accessible exercise options for people with disabilities and old people etc.

5. POSITIVE MINDSET AND PHYSICAL ACTIVITY

There are a wide range of physical activities beyond traditional gym workouts that include dance, walking, outdoor activities, and community sports. There are various exercise programs for people with disabilities and for old people and children. Shifting the mindset about physical activity requires a multi-faceted approach. Positive mindset can impact the quality of physical activity in many ways. Some of these are highlighted below.

Improved motivation: A positive outlook is likely to increase motivation that makes one more likely to stick to exercise routine. It encourages individuals to identify personal reasons for exercise beyond just weight loss, like stress reduction, improved mood, or better sleep or simply feel better. A positive mindset helps one bounce back from setbacks and stay committed. Using encouraging language and celebrating even small achievements can promote a mindset that emphasizes enjoyment and progress and helps in understanding personal motivations for exercising.

Education and awareness campaigns: These can be used to debunk some myths by addressing common misconceptions about exercise, like the belief that "a little is not enough" or that exercise needs to be strenuous to be beneficial. The campaigns can highlight benefits by communicating wide range of mental and physical health benefits associated with regular activity. Messaging to different demographics, including children, adults, and seniors can be tailored as per need.

Technology integration: Fitness trackers can be utilized for wearable technology to monitor activity levels and provide positive reinforcement. Apps and online platforms can offer accessible virtual exercise classes and personalized workout plans.

Healthcare system involvement: Doctor’s recommendations can be integrated for discussions on physical activity, routine checkups and for providing personalized exercise plans.

School curriculum: Comprehensive PE programs can be created to implement quality physical education that focuses on enjoyment, skill development, and lifelong activity habits. Active learning can be used to integrate physical activity into classroom activities to encourage movement throughout the day.

Reforms for Positive Mindset towards Physical Activity

You can’t rewrite your history, but you can reset your fitness attitude. There are many ways to change your outlook towards fitness. Key aspects of reforms for a positive mindset towards physical activity include, but are not restricted to, the following.

Change your definition of exercise - “Exercise is just moving your body.” Consider the full spectrum of activities that can get you moving.

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Revise your mental script - Research shows that a growth mind-set, which recognizes that improvement is possible, even when you're struggling to learn something new, is more beneficial than a fixed mind-set, which focuses on whether you're naturally "good" at something. Instead of focusing on the past, congratulate yourself for recommitting yourself to a healthier lifestyle and acknowledge your progress. Have a positive view of the Body. Focus on what your body can do rather than how it looks.

Focus on movement over 'exercise' - "The goal is movement and getting more active, and our bodies are designed for that." Ask yourself 'what gets me moving?' All of a sudden, options start to open up. It could be taking the stairs instead of the elevator, parking farther away or taking a 5-minute dance break. Moving really gets us out of our heads and into our body.

Start with the end in mind - Training for a specific goal can keep you motivated. "It helps to have a plan and a destination." Set small and realistic goals. If you haven't been exercising at all, you might aim for just 10 minutes a day. Manageable goals make it more likely you'll get started and stick with it, and small wins build up over time. "The journey of a thousand miles starts with one step." Override negative memories with small wins to build confidence.

Build in accountability - Maybe it's finding a workout buddy or paying for an exercise class; whatever it takes to nudge you into showing up even on those days when you don't feel like it.

Enjoy the process: Find activities you genuinely like and that fit your lifestyle. Embrace challenges. View obstacles as opportunities to adapt and grow stronger. Focus on gradual improvements and celebrate milestones.

Make it a habit - "Getting in regular exercise several times a week is better than being a weekend warrior." "A ball that's stationary is harder to move than a ball that's already in motion. Building new habits is all about consistency. If you wait until you want to exercise, it may never happen."

Try mindfulness - "Notice the sensation of exercise and how your body feels in response." Potential Reforms to Shift Mindset through Policy Interventions

Curriculum Integration: PE should be treated with the same importance as STEM (Science, technology, engineering, and mathematics - it can refer to a group of related academic disciplines, or to a type of education) and arts subjects, with updated methodologies that highlight its cognitive and emotional benefits.

Infrastructure development for physical activity – Though routine physical activity can be undertaken within the available limited resources, organized activity requires special infrastructure. This is warranted to enhance the desired enthusiasm in the society to alter the current mindset towards sports and games.

Holistic Development Approach: Sports should be positioned as a life skill that enhances employability, leadership, and teamwork, similar to any other professional competency.

Career Opportunities in Sports: Creating structured pathways for post-retirement employment in sports management, coaching, and allied fields can change perceptions about its viability as a career.

6. CONCLUSION

The mindset towards physical activity varies significantly across nations, with some cultures placing a strong emphasis on exercise as a vital part of health and wellbeing, while others may view it as more of a leisure activity or have limited access to facilities, leading to lower participation rates. For India to truly embrace physical activity as a lifestyle there needs to be a shift in perception

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at both societal and educational levels. By recognizing the benefits of physical activity beyond professional sports and integrating it meaningfully into education and career planning, India can foster a healthier, more engaged population. The evolution of sports in India must go beyond Olympic success to everyday movement, making an active lifestyle accessible and desirable for all.

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BIOMECHANICAL ANALYSIS OF THE SWIM-START

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ABSTRACT

The swim-start plays a pivotal role in competitive swimming, directly influencing overall race performance. This study explores the biomechanical components that contribute to an effective swim-start, including takeoff, flight phase, water entry, and underwater propulsion. Various kinematic and kinetic parameters are examined to assess their impact on start efficiency. The objective of this research is to provide insights that can aid in optimizing technique to enhance athletic performance. A thorough understanding of these biomechanical principles can help coaches and swimmers refine their training strategies for better results.

Keywords: Swim-start, biomechanics, kinematics, kinetics, propulsion, performance.

1. INTRODUCTION

The swim-start is a fundamental aspect of competitive swimming, where even minor enhancements can lead to significant competitive advantages. A well-executed start contributes to faster race times and improved positioning in the water. The primary biomechanical components involved in the swim-start include reaction time, takeoff force, flight trajectory, and hydrodynamic entry (Vantorre et al., 2014).

2. AIM OF THE STUDY

To examine the biomechanical factors influencing the swim-start and identify optimal techniques for enhancing performance.

3. OBJECTIVES OF THE STUDY

- To analyze the kinematic and kinetic factors that affect the swim-start.
- To compare different starting techniques utilized in competitive swimming.
- To assess the role of reaction time and force generation in improving start effectiveness.
- To provide biomechanical recommendations for optimizing swim-start technique.

4. BIOMECHANICAL ASPECTS OF THE SWIM-START

Kinematics of the Swim-Start

Kinematics focuses on motion analysis without considering the forces that cause movement. In the context of the swim-start, kinematic assessment includes reaction time, takeoff velocity, and flight trajectory. Research indicates that quicker reaction times are strongly associated with improved performance, particularly in sprint events (Tor et al., 2015).

Kinetics and Force Production

Kinetics examines the forces responsible for movement. A forceful push-off from the starting block is crucial for maximizing horizontal velocity. Studies suggest that greater ground reaction

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forces lead to longer flight distances and more efficient water entry angles, thereby enhancing overall start effectiveness (Honda et al., 2012).

5. WATER ENTRY AND UNDERWATER PHASE

An effective water entry reduces drag and facilitates a seamless transition into the underwater phase. Proper hydrodynamic positioning is essential, as excessive splashing or incorrect entry angles can diminish momentum. Additionally, well-executed dolphin kicking during the underwater phase enhances propulsion, significantly contributing to race performance (Marinho et al., 2010).

6. COMPARISON OF DIFFERENT START TECHNIQUES

Grab start vs. Track start

The two primary swim-start techniques are the grab start and the track start. In the grab start, both feet are positioned at the front of the starting block, whereas the track start involves a staggered stance with one foot placed forward. Research findings suggest that the track start generates greater horizontal velocity and improved stability during takeoff (Benjanuvatra et al., 2004).

7. START PERFORMANCE IN ELITE SWIMMERS

Elite swimmers predominantly favor the track start due to its ability to produce higher takeoff forces and facilitate faster reaction times. Strength training and plyometric exercises have been found to enhance start performance by increasing explosive power and reaction efficiency (Slawson et al., 2011).

8. CONCLUSION

The swim-start is a biomechanically complex movement that has a profound impact on competitive swimming performance. Key elements that determine the effectiveness of a start include reaction time, takeoff force, flight trajectory, and hydrodynamic entry. Comparative analyses indicate that the track start is generally more advantageous than the grab start due to its superior stability and force generation. Future research should focus on designing individualized training programs tailored to the specific needs of athletes. Incorporating biomechanical principles into training regimens can optimize performance and provide swimmers with a competitive advantage.

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THE ROLE OF REACTION VS RESPONSE MECHANISMS IN SPORTS PERFORMANCE: A SYSTEMATIC REVIEW OF PSYCHOLOGICAL PERSPECTIVES AND INTERVENTIONS

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ABSTRACT

Athletic performance is profoundly influenced by the interplay between reaction and response mechanisms, which align with Kahneman's dual-process theory of cognition (System 1 and System 2). Reaction mechanisms, driven by fast, automatic processing, are essential for quick decision-making in high-speed sports but are prone to errors and emotional hijacking. In contrast, response mechanisms, involving deliberate and rational processing, support strategic decision

making and emotional regulation but require significant cognitive resources. This paper explores the role of these mechanisms in sports performance, drawing on psychological models such as the Information Processing Model, Perceptual-Cognitive Framework, and Ecological Dynamics Approach. It also examines the critical role of emotional regulation in managing stress, enhancing focus, and building resilience. Evidence-based interventions, including cognitive reappraisal, mindfulness, simulation training, empathy training, and executive function training, are discussed as strategies to strengthen response mechanisms and improve performance under pressure. By shifting from reactive to response-driven approaches, athletes can achieve greater consistency, adaptability, and long-term success in competitive environments.

Keywords: Reaction mechanisms, response mechanisms, emotional regulation, dual-process theory, System 1, System 2, cognitive reappraisal, mindfulness, simulation training, executive function, sports performance, decision-making, psychological interventions

1. INTRODUCTION

Athletic performance is heavily influenced by cognitive processing, particularly in high-pressure environments where decision-making speed and accuracy are critical. Psychological research distinguishes between two fundamental mechanisms; reaction and response that dictate how athletes process information and execute decisions. These mechanisms align with Daniel Kahneman's (2011) dual-process theory of cognition, which differentiates between System 1 (intuitive, automatic processing) and System 2 (deliberative, rational processing). Understanding the interplay between these systems is essential for optimizing sports performance, reducing errors, and enhancing strategic decision-making.

2. REACTION MECHANISM: SYSTEM 1 THINKING

System 1 thinking is fast, automatic, and instinctive, operating without conscious effort (Kahneman, 2011). It is essential in high-speed sports scenarios where quick reflexes are required, relying on pattern recognition, muscle memory, and learned reflexes. This mechanism is mediated by subcortical brain structures like the amygdala and basal ganglia, enabling rapid decision making based on past experiences (LeDoux, 1996). For example, a goalkeeper reacting to a penalty kick or a sprinter responding to a starting gun demonstrates the efficiency of System

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1 thinking. These reflexive actions, honed through repetition, allow athletes to execute complex motor tasks with precision (Schneider & Shiffrin, 1977). However, while efficient, System 1 is also prone to cognitive biases and impulsive errors. Misinterpreting stimuli can lead to premature actions, such as mistimed movements or incorrect defensive reads (Stanovich & West, 2000).

3. RESPONSE MECHANISM: SYSTEM 2 THINKING

In contrast, System 2 thinking is deliberate, analytical, and effortful, supporting strategic decision making and problem-solving (Kahneman, 2011). Unlike System 1, it requires cognitive resources and operates more slowly, making it crucial for evaluating multiple options and anticipating future outcomes. This mechanism is particularly beneficial in sports requiring long-term strategy, such as a quarterback assessing defensive formations before a throw or a chess player planning their next move. System 2 also plays a key role in emotional regulation, helping athletes manage impulsive reactions and execute well-thought-out decisions (Miller & Cohen, 2001). However, it

4. THE ROLE OF REACTION VS RESPONSE MECHANISMS IN SPORTS PERFORMANCE:

A Systematic Review of Psychological Perspectives and Interventions has limitations: it is resource-intensive, prone to fatigue, and less effective in fast-paced gameplay where rapid responses are needed (Shiffrin & Schneider, 1977).

The Interplay between System 1 and System 2 in Sports Performance Elite athletes seamlessly transition between automatic reactions and rational responses, engaging System 1 for instinctive actions and System 2 for strategic decision-making based on situational demands. Through deliberate practice and cognitive training, they refine System 1 for rapid execution while reserving System 2 for complex problem-solving (Ericsson et al., 1993). For instance, basketball players rely on System 1 for reflexive dribbling but engage System 2 when deciding whether to pass or shoot. Similarly, tennis players instinctively react to fast serves but use System 2 to plan return strategies. A race car driver utilizes System 1 for high-speed maneuvering while employing System 2 to strategize overtakes (Vickers, 2007). Beyond Kahneman's dual-process theory, other psychological models further explain how athletes process information, make decisions, and execute actions under varying conditions, highlighting the intricate balance between reaction and response mechanisms.

The Information Processing Model

The Information Processing Model conceptualizes cognitive mechanisms in three stages: stimulus identification, response selection, and response programming (Schmidt & Wrisberg, 2008). In sports, athletes first detect environmental cues, select an appropriate action, and then execute the movement. This model distinguishes between reaction- rapid, stimulus-driven actions and response, which involves deliberate decision-making. For example, a soccer defender reacting to an opponent's sudden movement demonstrates stimulus-response compatibility, while a midfielder deciding between passings or dribbling based on multiple cues exemplifies response mechanisms requiring cognitive effort.

The Perceptual-Cognitive Framework

This framework emphasizes attention, anticipation, and pattern recognition in sports decision making, highlighting that expert athletes develop superior perceptual-cognitive skills through practice (Mann et al., 2007). Reaction mechanisms in this model rely on implicit learning,

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enabling athletes to instinctively recognize patterns and execute movements. Response mechanisms,

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However, involve conscious processing, where athletes analyze situational variables before making decisions. For instance, a tennis player reacting to a serve relies on reaction mechanisms, whereas planning a drop shot or lob requires response-oriented cognitive engagement (Vickers, 2007).

Fitts and Posner's Three-Stage Model of Motor Learning

Fitts and Posner's model outlines skill acquisition in three stages: cognitive, associative, and autonomous (Fitts & Posner, 1967). The cognitive stage involves conscious processing, where response mechanisms dominate as athletes analyze and refine technique. In the associative stage, movement patterns become more fluid, reducing cognitive load. Finally, in the autonomous stage, skills become automatic, allowing athletes to rely on reaction mechanisms for rapid decision making. For example, a beginner learning to dribble in basketball focuses on technique (response mechanism), while an expert instinctively adjusts to defenders using reaction mechanisms.

5. THE ECOLOGICAL DYNAMICS APPROACH

This approach integrates perception, action, and environmental interactions, emphasizing adaptability in decision-making (Davids et al., 2008). Unlike models that separate reaction and response mechanisms, it suggests that both emerge dynamically based on task constraints. In combat sports, for instance, fighters react instinctively to fast-paced attacks while simultaneously adapting their responses to exploit weaknesses.

Each of these models provides a unique perspective on reaction and response mechanisms. The Information Processing Model and Perceptual-Cognitive Framework emphasize structured decision-making, while Fitts and Posner's model explains the progression from deliberate control to automaticity. The Ecological Dynamics Approach highlights the fluid interplay between perception and action. Incorporating these frameworks into training programs can optimize both reaction efficiency and strategic response capabilities. Coaches and sports psychologists can design drills that balance instinctive skill execution with cognitive decision-making, enhancing overall athletic performance.

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Role of Reaction and Response in Emotional regulation

Emotional regulation is crucial in sports performance, enabling athletes to manage their emotions, maintain focus, and perform under pressure. Reaction and response mechanisms influence how athletes perceive, process, and adapt to emotional stimuli, shaping their ability to stay composed and make strategic decisions.

Reactions are primarily driven by the autonomic nervous system, triggering physiological responses such as increased heart rate, sweating, or muscle tension. While heightened alertness can amplify performance, unchecked emotional reactions can lead to anxiety-induced performance declines. A major drawback of reaction mechanisms is emotional hijacking

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(Goleman, 1995), where intense emotions override logical thinking, leading to impulsive decisions. For instance, an athlete frustrated by a missed shot may lose focus, negatively affecting subsequent plays. Stress can also cause athletes to perceive challenges as threats rather than opportunities, increasing anxiety and impairing performance (Stanovich & West, 2000). In contrast, response mechanisms involve cognitive processes such as appraisal, self-talk, and decision-making, allowing athletes to regulate their emotions and maintain stability under pressure. Effective response mechanisms enable athletes to stay composed, refocus, and execute strategies even in high-stress situations. A tennis player, for example, who controls their frustration after a bad call is more likely to maintain concentration and win the next point.

Athletes who regulate their emotions effectively are better able to focus, reducing cognitive distractions that might otherwise hinder performance. Studies suggest that cognitive reappraisal reframing stressful situations in a positive light helps individuals perform better under pressure (Gross, 2002). Furthermore, emotional regulation promotes resilience, allowing athletes to recover quickly from setbacks. Psychological resilience, which is closely tied to response mechanisms, is a common trait among elite athletes who remain motivated despite failures (Fletcher & Sarkar, 2012). Maintaining optimal arousal levels is another key benefit of emotional regulation. Athletes who struggle with excessive anxiety may experience performance drops, while those who lack sufficient arousal might become disengaged. Effective response mechanisms help in maintaining this balance, ensuring athletes remain alert and in control without becoming overwhelmed (Jones et al., 2002). In the long term, strong emotional regulation skills also contribute to psychological well-being by preventing burnout and sustaining motivation, ultimately promoting long-term

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Athletic success (Gould & Dieffenbach, 2002). A well-developed response mechanism strengthens decision-making by reducing impulsive actions and ensuring clarity in high-pressure situations. By developing response-focused emotional regulation strategies, athletes can heighten their performance, build resilience, and sustain mental well-being throughout their careers.

Interventions and Strategies to Improve Response Mechanisms for Enhanced Emotional Regulation in Athletes

Training athletes to shift from reaction-based emotional responses (System 1) to a response-driven approach (System 2) is essential for improving emotional regulation, problem-solving, and decision-making. Repeated engagement in structured interventions helps response mechanisms become automatic, enhancing performance consistency under pressure. The following evidence-based strategies focus on strengthening these mechanisms, ensuring they become ingrained in an athlete's cognitive framework.

Cognitive Reappraisal Training

Cognitive Reappraisal Training helps athletes reinterpret stressful situations positively, reducing anxiety-driven reactions and enhancing performance. Rooted in Gross's Process Model of Emotion Regulation (2002), this strategy involves altering interpretations of events before emotional responses are triggered. Research shows that athletes using cognitive reappraisal experience lower stress levels and improved decision-making under pressure (Moore et al., 2012). Techniques like journaling, where athletes document emotionally challenging

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experiences and reframe thoughts positively, encourages self-awareness and emotional regulation. Cognitive restructuring, using thought records to replace negative automatic thoughts with constructive interpretations, further supports this process (Beck, 2011). Pre-performance reframing, guided by coaches, helps athletes view high-pressure situations as growth opportunities rather than threats, boosting confidence and focus.

Mindfulness-Based Emotional Regulation Training

Mindfulness-Based Emotional Regulation Training aims to improve attentional control, reduce emotional reactivity, and enrich decision-making under stress. This training helps athletes develop meta-awareness, enabling them to recognize and observe their emotions without reacting

Impulsively (Kabat-Zinn, 2003). Research, such as studies on Mindfulness-Based Stress Reduction (MBSR), shows that mindfulness practices reduce anxiety and emphasizes performance in competitive sports (Josefsson et al., 2014). Focused breathing exercises, practiced for 10 minutes daily, cultivate self-awareness and prevent emotional hijacking. Body scanning, a progressive relaxation technique, helps athletes identify and release physical tension. Mindful performance routines, such as taking deep breaths before a free throw or putt, maintain composure under pressure.

Simulation Training

Simulation Training complements cognitive flexibility and problem-solving skills, enabling athletes to make better decisions under pressure. According to Attentional Control Theory (Eysenck et al., 2007), anxiety impairs decision-making by reducing attentional flexibility. Decision-Making Simulation Training (DMT) counteracts this by improving cognitive control. One effective implementation of DMT is through Virtual Reality (VR) training that simulates high pressure game scenarios, allowing athletes to practice quick, calculated decisions. Video review and self-reflection help athletes analyze past performances to identify areas for improvement. Tactical board games, like chess, develop anticipatory and adaptive thinking. Additionally, Modified Perceptual Training (Hadlow et al., 2018) classifies sport-specific training into explicit, guided, and discovery-based methods, refining perception-action coupling and decision-making. Integrating these techniques equips athletes with the mental tools to perform effectively under pressure, ultimately enhancing their overall performance on the field or court.

Empathy training

Empathy Training improves team dynamics, emotional intelligence, and leadership skills. Athletes who practice compassion-focused therapy (Gilbert, 2010) and mindfulness demonstrate lower anxiety, improved resilience, and better emotional regulation. Loving-Kindness Meditation (LKM) cultivates compassion for oneself and others, reducing stress-related amygdala activation (Hölzel et al., 2011). When athletes develop a deeper understanding of themselves and those around them, they are less likely to engage in detrimental social comparisons. Even in moments of loss, empathy allows them to recognize that their opponents have also worked hard to reach the competition stage and are equally deserving of success. This perspective can help mitigate feelings

The role of reaction vs response mechanisms in Sports performance:

A Systematic Review of Psychological Perspectives and Interventions of jealousy, enabling athletes to move forward with a growth mindset rather than dwelling on defeat. By

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improving an ability to consider multiple viewpoints, empathy encourages athletes to think from a broader perspective, allowing for greater emotional adaptability and resilience in high-pressure situations. Role-playing and group discussions encourage perspective-taking and reduce aggression (Mahmoudi et al., 2022). Shifting focus from external validation to personal progress cultivates emotional adaptability and mitigates the negative effects of social comparison.

Self-Awareness and Confidence Building Training

Self-awareness in sports refers to an athlete's ability to recognize and understand their emotions, thoughts, and behaviors, and how these factors influence their performance. Confidence, on the other hand, pertains to the belief in one's abilities under competitive pressure. Traditional reliance on external comparisons often leads to fluctuating self-esteem. This external dependency often leads to fluctuating self-esteem and inconsistent performance. To address this, shifting focus inward by acknowledging personal strengths and weaknesses fosters a stable, intrinsic confidence, reducing the impact of external comparisons. Reflective journaling helps athletes document emotional responses and actions, identifying patterns and areas for improvement. While positive self-talk has been advocated to boost confidence, discrepancies between positive affirmations and actual performance can lead to disillusionment. Adopting neutral and realistic self-talk encourages athletes to maintain a balanced perspective, acknowledging both strengths and weaknesses without exaggeration. This approach aligns self-perception with reality, promoting consistent confidence and emotional stability. Studies have shown that self-talk, when tailored appropriately, can influence athletes' thoughts, feelings, and behaviors, impacting performance outcomes (Walter et al., 2019). Furthermore, reducing social comparison and focusing on personal progress mitigates the negative effects of external pressures, developing stable, intrinsic confidence.

Executive Function Training in Sports Performance

Executive function (EF) refers to a set of cognitive processes that enable goal-directed behavior, including working memory, cognitive flexibility, and inhibitory control (Diamond, 2013). One key component of EF training is working memory training, which enables athletes to retain and manipulate information in real time, a skill essential for decision-making in dynamic sports environments (Furley & Memmert, 2010). Interventions such as dual-task training, where athletes

8. THE ROLE OF REACTION VS RESPONSE MECHANISMS IN SPORTS PERFORMANCE:

A Systematic Review of Psychological Perspectives and Interventions simultaneously perform cognitive and physical tasks, have been shown to improve working memory and adaptability (Walton et al., 2018). Cognitive flexibility training, such as video-based decision training, helps athletes adapt to changing game scenarios (Mann et al., 2007). Additionally, inhibitory control training helps athletes resist impulsive reactions, maintaining discipline and focus under stress. Techniques such as stop-signal training and Go/No-Go tasks have been shown to improve impulse control, reducing unforced errors in sports (Verbruggen & Logan, 2008). Integrating these EF tasks into game-specific cognitive drills ensures that cognitive improvements translate to actual performance (Vestberg et al., 2017). By strengthening executive function, athletes develop better emotional regulation, strategic thinking, and adaptability, ultimately improving their overall performance and resilience in sports.

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Reducing Rumination and Enhancing Present-Moment Awareness in Sports Rumination, characterized by repetitive negative thinking about past mistakes or future uncertainties, can significantly impair athletic performance and mental well-being. Athletes who fixate on past failures often experience cognitive distortions that diminish confidence and hinder focus. According to Flow Theory (Csikszentmihalyi, 1990), peak performance arises when individuals are fully immersed in the present moment, free from self-doubt and overthinking. Grounding techniques, like the 5-4-3-2-1 method, anchor attention to the present. Mindfulness practices, including meditation and body awareness, reduce anxiety and rumination (Colzato & Kibele, 2017). Shifting from post-game rumination to constructive reflection, focusing on "What can I learn and improve?" rather than "What went wrong?" encourages growth and reduces the tendency to dwell on mistakes. Furthermore, Attention Control Training (ACT) redirects focus toward task-relevant cues, enhancing performance under pressure (Ducrocq et al., 2016). Practices like focus-shifting meditation train athletes to deliberately shift their focus, improving their ability to manage multiple stressors and maintain concentration on what is pertinent at any given moment during competition. Such training can improve attentional control, allowing athletes to better manage multiple stressors and maintain performance under pressure.

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Psychological Strategies in Sports Injury Rehabilitation enhancing Recovery through Response mechanisms

Incorporating psychological strategies into sports injury rehabilitation can significantly amplify recovery outcomes. Cognitive flexibility enables athletes to adapt to setbacks, cultivating resilience during rehabilitation (Moen et al., 2015). Self-awareness allows individuals to recognize their emotional responses to injury, facilitating effective coping mechanisms (Ridder et al., 2008). Building confidence through realistic goal-setting and acknowledging progress is vital for motivation, aligning with Bandura’s (1997) self-efficacy theory. Mindfulness practices, such as meditation, help athletes maintain present-moment focus, reducing anxiety and promoting healing (Kaufman et al., 2018). Attention control training encourages concentration on rehabilitation tasks, improving efficacy (Vine et al., 2014). Reflective journaling provides insights into recovery progress and emotional states, aiding in mental adjustment (Schön, 1983). Adopting neutral and realistic self-talk prevents negative thought patterns that may hinder recovery (Todd et al., 2010). Decision-making simulation training prepares athletes for return-to-play scenarios, enhancing readiness (Faubert, 2013). Compassion-focused therapy addresses self-criticism, fostering a supportive internal environment conducive to healing (Gilbert, 2014). Flow theory emphasizes complete immersion in rehabilitation activities, enhancing engagement and effectiveness (Csikszentmihalyi, 1990). Cognitive-behavioral therapy (CBT) identifies and restructures maladaptive thoughts related to injury, promoting a positive outlook (Beck, 2011). Focus-shifting meditation trains athletes to manage attention, reducing rumination on pain or limitations (Jha et al., 2010).

All these psychological interventions play a crucial role in shifting athletes from a reaction-based approach to a response-based approach in injury rehabilitation. Reaction mechanisms often stem from impulsivity, frustration, and emotional distress, leading to negative behaviors such as avoidance, self-doubt, or overexertion, which can delay recovery (Baumeister et al., 2007).

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In contrast, response mechanisms involve deliberate, conscious, and controlled decision-making, allowing athletes to approach rehabilitation with patience, resilience, and adaptability (Carver & Scheier, 2011). By incorporating response-based strategies, athletes develop a balanced, process-oriented mindset, improving adherence to rehabilitation protocols, reducing stress-related physiological responses, and ultimately accelerating recovery.

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10. CONCLUSION

Understanding and optimizing the balance between reaction and response mechanisms can significantly increase sports performance. By integrating psychological models and evidence-based interventions, athletes can improve decision-making, emotional regulation, and strategic execution, ultimately leading to greater success in competitive sports.

11. SCOPE FOR FURTHER RESEARCH

More research is needed to understand how psychological strategies affect athletes over time. Studies should explore how mindfulness and cognitive techniques improve performance and emotional control in the long run. Individual factors like personality, culture, and sport type may also influence the success of these methods. New technologies like virtual reality and neurofeedback could help athletes train well by simulating real-game pressure. Additionally, research should focus on how these strategies can be integrated into coaching and team dynamics. Combining psychological techniques with physical training, such as biofeedback and heart rate monitoring, could create more effective training programs.

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RAW RED SEAWEED (JANIA RUBENS) AS SPORTS SUPPLEMENT- A CRITICAL ANALYSIS

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ABSTRACT

Seaweed, or macroalgae, is a diverse group of marine plants found in various aquatic environments. The present study aimed to conduct proximate composition analysis of Red Seaweed (Jania rubens) collected from the Mandapam region coast, Rameshwaram, Tamil Nadu, India. and finding the suitability of the same as sports supplement. The results obtained shows that Red Seaweed (Jania rubens) has ash (23.41% DW), Protein (19.74% DW), lipid (8.59% DW), crude fibre (27.06% DW), carbohydrate (30.91 % DW), Total Dietary Fiber (5.91% DW), (3.03%) and (6.76% DW).The composition of monosaccharides present is fucose (21.34 µg/ml) %, mannose (0.65(µg/ml)%), galactose (<0.81 (µg/ml)%), Xylose 1.29 (µg/ml)% and rhamnose (0.59 (µg/ml)%. The chlorophyll-A: 150.83 µg/100 g DW; chlorophyll-B: 112.74 µg/100 g DW; Iodine 248.72 µg/100 g DW. Phytochemical analysis of steriods, phenols, tannins, saponins, flavonoids, terpenoids, and glycosides shows that all components are present. Mineral contents are Na (8857.35 Mg/100g DW), K (1728 Mg/100g DW), Mg (229.49 Mg/100g DW), Ca (1085.71 Mg/ 100g DW), Fe (307.41 Mg/100g DW), Se (4.75 Mg/100g DW), Mn (4.68 Mg/100g DW), P (19,561.20 Mg/100g DW) were observed. The findings shows that it has rich quantities of macro nutrients as well as have favourable antifungal, anti-bacterial and anti-inflammatory qualities. Also, the heavy metal content of the seaweeds as well within in the recommended level for human conception. Taking these in to consideration it is recommended to consider Jania rubens (Red seaweed) as a potential supplement to sports person subjected human trial and validation

KeyWords: Supplementation, Sea weed, Jania rubens, Proximate composition analysis

1. INTRODUCTION

The importance of nutrition in sports performance has been recognized since the dawn of civilization. Along with Sumerians, Egyptians, the Chinese, and other ancient cultures, the Indian people were among the first to pursue a nutritious diet and a meaningful lifestyle in the face of environmental obstacles. Sports nutrition has gotten a lot of attention in the last few decades, and it's only going to gain more attention in the future since it's so critical to an athlete's performance, and it may even be life or death. Sports nutrition, a specialized field within nutrition, integrates knowledge of physiology and exercise science to optimize Physical performance and overall health. It involves developing practical daily eating plans that provide fuel for physical activity, facilitate post-exercise recovery, and enhance competitive performance. While often associated with elite athletes, sports nutrition principles apply to anyone regularly active, from fitness enthusiasts to competitive amateurs and professionals. Individualized plans are essential due to varying nutrient needs across this spectrum.

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Adequate food and fluid intake is vital to ensure athletic performance at its peak . Macro nutrients & micronutrients play an important role in energy production, lean mass & haemoglobin synthesis, maintenance of bone health, adequate immune functioning, and protection against oxidative damage. Active adults and competitive athletes turn to sports nutrition to help them achieve their goals. The successful participation in extreme events greatly depends on adequate nutrition and hydration strategies. The relationship between diet and athletic performance is significant, with nutrition playing a key role in an athlete's success (Williams & Patel, 2017). Adequate intake of energy, micronutrients, and fluids is essential, as food provides the energy necessary for physical activity (Lupton et al., 2002). Protein intake exceeding 1.7g/kg of body weight/ day during stable training periods can lead to increased protein oxidation. Therefore, top athletes with high training loads are advised to consume 1.5-1.7g/kg of body weight per day (Tarnopolsky 1999). Recommended protein intake for female athletes performing endurance activities is 65-90 grams per day, while active males typically require 95-120 grams daily. While carbohydrates are the main fuel source for power sport athletes, fat also plays a vital role, particularly during endurance training. Intramuscular triglyceride, stored in skeletal muscle, serves as an important fuel source during prolonged moderate-intensity exercise up to approximately 85% VO2max (Stellingwerff et al., 2007). Appropriate energy intake aids optimal bodily functions, influences macronutrient and micronutrient intake, and aids in managing body composition in athletes. Maintaining energy balance and weight stability, both short-term and throughout the training and competitive season, is crucial for endurance athletes, who often aim for a low body mass and/or body fat percentage for performance benefits.

Concerns for health, animals and the environment are among the most common reasons for following a plant-based diet. Vegans eat only plant foods such as grains, beans, fruits, vegetables, nuts and seeds. Flexitarians or semi vegetarians, to decrease the amount of meat they eat primarily for health reasons and they will occasionally eat red meat. An estimated two billion people worldwide live on an animal-based diet, while an estimated four billion people live primarily on a plant-based diet (Pimentel & Pimentel, 2003). The reason why more people live on a plant-based diet rather than on an animal-based one is the shortage of fresh water and energy resources. In the twentieth century, not many individuals accepted veganism, vegetarianism, and a plant-based diet as a healthy diet, even though people knew eating more vegetables was essential for better health. Non vegetarian athletes can benefits, too by learning how to incorporate more health and performance promoting plant foods into their meals and snacks. Vegans consume only plant-derived foods such as grains, beans, fruits, vegetables, nuts, and seeds. Flexitarians, or semi-vegetarians, primarily reduce their consumption of non vegetarian foods for health reasons, occasionally consuming red meat. The term "vegetarian" encompasses a variety of dietary variations. While many athletes thrive on well-balanced vegetarian diets, others struggle to obtain adequate nutrients from overly restrictive diets that lack sufficient Fiber and tend to be rich in fat and cholesterol. Athletes may eliminate animal products from their diets for various reasons, including improving health, enhancing performance, or adhering to spiritual or cultural guidelines.

The influence of supplements on human health and performance constitutes a significant area of inquiry within sports nutrition. While dietary supplements can contribute to achieving adequate calorie, carbohydrate, and protein intake, they should be viewed as complements and not as replacements for, a balanced diet. Supplements use with the intent to improve sports performance among athletes especially young athletes is common. Some research findings suggests

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that specific nutrients and dietary supplements may enhance athletic training and performance, yet not stand true for the majority of supplements currently marketed to athletes. For athletes engaged in performance-enhancing training, sufficient caloric intake, along with adequate macronutrient and micronutrient consumption, is essential for maintaining health and well-being.

Seaweeds are a group of photosynthetic, non-flowering plant-like organisms (called macroalgae) that live in the marine environment. They belong to three major groups based on their dominant pigmentation: Red (Rhodophyta- 1000 Species), Brown (Phaeophyta- 4500 species), and Green (Chlorophyta- 900 Species). Seaweed has been historically and is still used as a food source in China, Japan, and the Republic of Korea. Approximately 33 genera of seaweeds, primarily red and brown, are professionally harvested and farmed However, locally, over 500 species from roughly 100 genera are gathered and exploited (Mouritsen, 2013). For an extended period, it has been used for sustenance, fertilizer, and therapeutic purposes. Seaweeds, like other plants, contain a variety of inorganic and organic compounds that may potentially have positive effects on human health. Seaweed has been shown to contain significant amounts of minerals, vitamins, vital amino acids, indigestible carbohydrates, and dietary fiber, as reported by Jiménez-Escrig and Goni in 1999. The coastal regions of India are renowned for their extensive variety of algae.

The nutritional value of seaweeds is highly regarded due to their rich content of proteins (containing all essential amino acids), polyunsaturated fatty acids (specifically omega-3 fatty acids), vitamins, minerals (such as magnesium and calcium), dietary fibers (such as alginates, agar, and carrageenan), pigments (including carotenes, xanthophylls, and chlorophylls), and secondary bioactive metabolites (such as phytosterols and polyphenols). This has generated significant interest in utilizing seaweeds as a valuable source of nutrition. Seaweed proteins exhibit comparable quality to other plant protein sources, including peas, soy, and tree nuts. Moreover, proteins derived from several seaweed species possess mutually beneficial Essential Amino Acid (EAA) profiles. They may be combined to create protein blends that are nutritionally equivalent to animal-based products like milk and whey. Seaweed proteins include all the necessary amino acids (Diniz et al. 2011). However, their composition may vary depending on the species, seasons, and geographic location (Circuncisão et al., 2020). The purpose of this study was to investigate the feasibility of raw red seaweed (Jania rubens) as a potential supplement through a critical analysis of various factors like macro and micro components as well as antifungal and anti-inflammatory qualities

2. MATERIALS AND METHODS

Sampling site and Collection of samples

In the present study, seaweed samples were collected from the Rameshwaram Coast of the Gulf of Mannar of the Indian Ocean. The Gulf of Mannar is a large shallow bay forming part of the Laccadive Sea in the Indian Ocean with an average depth of 5.8 m (19 ft. It lies between the south-eastern tip of India and the west coast of Sri Lanka, in the Coromandel Coast region. For the study the methanolic seaweed extract of Red algae (Jania rubens) collected along the Rameshwaram Coast of the Gulf of Mannar of the Indian Ocean. Samples were collected using the traveller's boat with the help of the local fishermen. The collected seaweed samples were identified using standard manuals

Analysis

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The samples underwent a comprehensive rinsing process using fresh water to eliminate salt and other substances, such as epiphytes, shells, sand, etc. The seaweeds that had been washed were subjected to a drying process in an air oven at a temperature of 60°C until they reached a state of equilibrium weight. After grinding the samples into a fine powder capable of passing through a 0.5 mm mesh filter, the resultant material was kept in airtight containers at ambient temperature in preparation for further examination. Dry matter, ash content, crude fat (extracted using ether), crude protein, and total dietary fiber underwent analysis using the approved techniques outlined by the Association of Approved Analytical Chemists (AOAC, 2006). The concentration of monosaccharide in extracts was determined using the technique followed by Dische (1955) using calorimetric method and phytochemical analysis was conducted using established protocols.

Mineral and Amino acid analysis

The minerals potassium (K), magnesium (Mg), calcium (Ca), iron (Fe), and manganese (Mn) were quantified using an atomic absorption spectrophotometer (AAS) model Hitachi Z-5000 from Tokyo, Japan, and an air-acetylene burner. The elements sodium (Na), phosphorus (P), and selenium (Se) were analyzed using inductively coupled plasma mass spectrometry (ICP-MS) using a Perkin Elmer ELAN 9000 instrument located in Wellesley, MA, USA. The concentrations of the elements were derived using the calibration curves of the standard elements. The data were reported in milligrams per 100 grams of dry weight (mg/100 g DW), and each measurement was conducted three times. The Proteins of seaweed extracts such of Red algae (Jania rubens) was hydrolysed in 6 N HCL at 110°C for 24 h under a vacuum. The amino acid composition was determined using a JEOL-300 automatic amino acid analyser (United Kingdom). Corrections were made to destroy threonine and serine during hydrolysis (Tettamanti and Pigman, 1968).

Antibacterial and anti-inflammatory activity Analysis.

Antibacterial activity against human pathogens such as a-Staphylococcus aureus, b-Staphylococcus epidermidis, c-Pseudomonas folliculitis, d-Streptococcus agalactiae, e- Salmonella enterica, f- Listeria monocytogenes, g- Vibrio cholerae, h- Streptococcus pyogenes. using method recommended by Milletteet al., 2007. Antibacterial activity and the MIC were measured as previously mentioned (CLSI, 2007). The antifungal activity was assessed using the well diffusion method on sterilized Petri plates. Furthermore, the MIC (0.25-128µg/ml) was measured as previously described (CLSI, 2007). Total antioxidant activity was measured using the method followed by (Pour Morad et al., 2006). The measurement of scavenging activity for DPPH free radicals was conducted using the methodology described by Zhao et al. in 2006.

3. RESULTS AND DISCUSSION

Results of the proximate Analysis of Red algae (Jania rubens)					
Sl.No	Component	Content	Sl.No	Component	Content
1.	Amino Acid	71.97 mg /g Dw	13.	Mannose	0.65(µg/ml)
2.	Sodium	8857.35 mg/dw	14.	Galactose	<0.81 (µg/ml)
3.	Potassium	1085.71 Mg/ 100g DW	15.	Xylose	1.29 (µg/ml)
4.	Magnesium	1085.71 Mg/ 100g DW	16.	Rhamnose	0.59 (µg/ml)

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5.	Calcium	1085.71 Mg/ 100g DW	17.	Moisture	11.6 (%DW)
6.	Selenium	4.75 Mg/100g DW	18.	Ash	<23.41 (%DW)
7.	Manganese	5.2	19.	Protein	<19.74 (%DW)
8.	Phosphorus	19,561.20	20.	Carbohydrate	30.91 (%DW)
9.	Carotenoids	44.52 (µg/100 mg)	21.	Crude Fiber	27.06 (%DW)
10.	Chlorophyll	150.83(µg/ml)	22.	Dietery Fiber	5.91 (%DW)
11.	Chlorophyll- B	112.74(µg/ml)	23.	Lipid	8.59 (%DW)
12.	Monosaccharides	21.34(µg/ml)	24.	Iron	307.41 Mg/100g DW

Making nutritional choices can be challenging for athletes because they need to ensure adequate muscle growth and development, as well as improve their sports performance. Therefore, athletes often tend to use nutritional supplements to meet their nutritional needs (Campa F,Coratella, 2021). A Nutritional and dietary practices of Indian athletes are reportedly subnormal (Moreira A, Delgadol, 2009). Very few Indian studies on supplement use amongst athletes have been reported. Inadequate nutrition, specifically low energy availability, has been placed firmly in the spotlight recently as a risk factor for infection in elite athletes (Thomas Erdman and burke,2016). Micronutrients play important roles in nucleotide and nucleic acid synthesis (e.g. iron, zinc and magnesium) and antioxidant defences that limit tissue damage (e.g. vitamins C and E). Antioxidant availability (e.g. vitamin C) may be particularly important during heavy exertion or infection when oxidative stress increases (Hemila H,2017). In recent years, nutritionists and food scientists have noticed a notable increase in the importance of assessing the nutritional value of edible seaweeds (Kumari et al., 2010; Arporn and Chirapart, 2006). Most research has focused on red seaweeds since they have shown higher nutritional content than brown and green edible seaweeds (Arasaki and Arasaki, 1983; Marinho-Soriano et al., 2006; Wong and Cheung, 2000).

Seaweeds are well-known for their high concentration of minerals, vitamins, and polysaccharides. Brown seaweeds have a comparatively low protein level, whereas most red seaweeds have a high protein content. Lipid concentrations are generally moderate. Brown seaweeds often have lower amounts of protein (averaging 5-15% of the dry weight), whereas green and red seaweeds have higher protein levels (averaging 10-30%). Seaweed's predominant free amino acids are alanine, aminobutyric acid, taurine, omithine, citrulline, and hydroxy-proline, in varying quantities depending on the species. Algae often contain lipids that constitute 1-3% of their dry weight, suggesting their role as a dietary energy source is insignificant (Arasaki & Arasaki, 1983). The present study showed that the methanolic extracts of Red algae (Jania rubens) collected along the Rameshwaram Coast of the Gulf of Mannar of the Indian Ocean have rich nutritional contents such as protein, carbohydrate, lipid and dietary fiber. They are also rich in different monosaccharides, pigments like carotenoids, and other vital phytocompounds such as flavonoids, terpenoids, tannins, and saponins. Moreover, they are rich in various minerals, including sodium, potassium, magnesium, ferrous, and calcium, and are also rich in both essential and non-essential amino acids. The seaweed extract displayed potential antibacterial and antifungal activities against various human bacterial and fungal pathogens, including pathogens causing infections in athletes. The seaweed extracts also displayed potential antioxidant activities against various enzymatic and non-enzymatic free radicals. Hence, the present study clearly satisfied all the objectives laid out. The study resulted in the isolation of highly nutritious seaweeds such as green, brown, and red

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algae that could be used as nutritional supplements that are essential for sportspersons but also have potential antimicrobial activities against athletic infections and antioxidant activities.

4. CONCLUSION

The quest for finding an ideal supplement for sportsmen which can adequately fulfil the energy and nutrient gap in regular diet is on for quite some time. Traditional supplements no matter whether is natural or commercially available has its pros and cons as demonstrated by numerous studies. With more and more athletes turning in to vegetarians there is an urgent need to find out plant-based alternatives with Ergogenic, Antifungal and anti-inflammatory qualities as supplements. In the present study we have focused on Jania rubens (red seaweed) present in the Gulf of mannar of Tamil Nadu, India and the findings shows that it has rich quantities of macro nutrients as well as have favourable antifungal, anti-bacterial and anti-inflammatory qualities. Also, the heavy metal content of the seaweeds as well within in the recommended level for human conception.

In addition to this, those seaweeds (in dried state) can be incorporated into the day meal as component of full meal, or serves as starters (Soups) as snacks (Biscuits, Cookies, Nutritional bars) and as drinks (Shakes, smoothies). An added advantage is these specimens has no smell or taste which substantiate as a quality addition to regular dishes. Taking these in to consideration it is recommended to consider Jania rubens (Red seaweed) as a potential supplement to sports person subjected human trial and validation

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A COMPARATIVE STUDY ON SHOULDER STRENGTH AND EXPLOSIVE STRENGTH BETWEEN HANDBALL AND BASKETBALL PLAYERS

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ABSTRACT

The study's purpose was to compare the explosive strength and shoulder strength of handball and basketball players. A total of 40 participants, consisting of 20 handball players and 20 basketball players, were selected from Alva's Education Foundation using simple random sampling. Explosive strength was assessed using the standing broad jump test, while shoulder strength was evaluated using the pull-up test. The data underwent rigorous statistical analysis, including the application of the t-test. The study revealed significant differences between handball and basketball players in explosive strength and shoulder strength. The findings suggest that basketball players exhibited superior explosive strength, while handball players demonstrated greater shoulder strength. These results provide valuable insights into the unique physical demands of each sport and highlight the need for sport-specific training programs. This research contributes to the existing body of knowledge on athletic performance, particularly in the context of handball and basketball. The study's findings have practical implications for coaches, athletes, and fitness enthusiasts, offering guidance on the development of targeted training programs to enhance performance and optimize physical attributes. Ultimately, this research aims to inform evidence-based practice in sports training and promote excellence in athletic performance.

Keywords: Strength, Handball, Basketball, Explosive, Athletic etc.

1. INTRODUCTION

Sports have become an integral part of human and social life, with physical activities being a necessity for survival. They have been passed down through generations and have become an integral part of the educational process, with physical education and sports being included in the regular curriculum of education. Today, every form of sport requires a certain amount of fitness, skill level, physique, and body composition.

Physical fitness is the most popular and frequently used term in physical education, with the primary components identified by the United States President's Council on physical fitness and sports being muscular strength, muscular endurance, cardio respiratory endurance, agility, speed, flexibility, and balance. However, the author has not included speed, agility, power, and balance as essential components of basic physical fitness.

Strength is one of the fundamental pillars upon which athletes build their prowess in sports, with the ability to harness and maximize physical power transcending time, culture, and discipline. Explosive strength, often referred to as power, represents the fusion of speed and strength, resulting in rapid, forceful movements that propel athletes to unparalleled heights of achievement. This comprehensive exploration delves into the intricacies of explosive strength, shoulder strength, handball, and handball-related practices, as well as the intricate interplay between mental fortitude and physical might.

Handball, a popular game worldwide, was introduced in Germany by gymnastics teacher Max Heiser in 1917. Its growing popularity is due to its healthy competitive nature, simple rules, and simple equipment needed. Understanding and working on shoulder muscles can bring significant benefits to athletes, fitness enthusiasts, and those seeking better functional strength.

Significance of the study

1. The study may assist players in determining their explosive and shoulder strength.
2. The study may provide guidelines to the physical education teachers and coaches in preparing the training programme for the handball and basketball players.
3. The study may help the physical education teachers and coaches to identify the individual efficiency in explosive and shoulder strength.

2. METHODOLOGY

The study's title is "A Compare on the Shoulder Strength and Explosive Strength between Handball and Basketball Players," and the participants were chosen from the Alva's Education Foundation. Since every research project involves a systematic approach and a set protocol to be followed, we will discuss the subjects chosen for the study, the sources of data used, the variables that were taken into consideration, the study's tools, administration, and data collection, among other things.

Selection of subjects

A total of forty (40) participants were carefully selected to fit the scope of the study. Twenty (20) handball players and twenty (20) basketball players made up this group. The selection procedure was carried out among subjects of Alva's Education Foundation and followed the rules of simple random sampling. This deliberate choice was made with the intent of identifying and examining any potential differences between these two sports in terms of shoulder strength and explosive strength.

Test administration

Standing broad jump

1. At begin by selecting a suitable flat and non-slip surface for performing the jump. Make sure there is enough space to perform the jump safely.
2. Mark the take off line on the ground. This is where the jumper's feet will be positioned before the jump. Ensure that the starting position is consistent for all participants.
3. If applicable, provide a clear demonstration of the standing broad jump technique.
4. The participant stands behind the marked take off line. The feet should be hip-width apart, and the toes should be just behind the line.

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5. To perform the jump, the participant swings their arms backward for momentum while simultaneously bending their knees slightly.
6. Explosively push off the ground with both feet, swinging the arms forward for additional propulsion. The goal is to jump as far forward as possible.
7. The participant lands on both feet, focusing on maintaining balance and stability. The distance is measured from the take-off line to the closest point of contact on the landing. 8. Measurement: Measure the distance covered by the participant's jump using a measuring tape.
8. Record the measured distance in a standardized manner, ensuring accuracy and consistency.

Pull-ups

1. Choose a sturdy horizontal bar that can support the participant's weight. The bar should be high enough to allow the participant to hang freely with their feet off the ground.
2. Participants can use an overhand grip (palms facing away) or an underhand grip (palms facing towards). Choose the grip that is most comfortable for the participant.
3. Stand underneath the bar and grasp it with the chosen grip. Arms should be fully extended, and the body should hang freely. Keep the feet off the ground.
4. Begin by pulling the body upward using the arms. Focus on engaging the back, shoulders, and arms muscles. The movement should be controlled, and the body should rise as a single unit.
5. Continue pulling until the chin passes above the level of the bar. This indicates that the pullup has been successfully executed.
6. Lower the body back down in a controlled manner, fully extending the arms. Avoid sudden dropping or jerking motions.
7. Record the number of successful pull-ups performed by the participant.

3. DISCUSSION ON FINDINGS

The study compares explosive strength and shoulder strength between basketball and handball players, finding that basketball players have higher mean values in both areas. This is consistent across measures, indicating the distinct physical demands of the sports. Basketball players benefit from enhanced explosive strength for rapid movements and superior shoulder strength for shooting, passing, and dribbling. These findings have implications for training and performance strategies, but acknowledge individual variability and need careful consideration.

4. SUMMARY

This study compares explosive strength and shoulder strength in handball and basketball players aged 18-27. The research aims to understand the unique physical demands of each sport and provide insights for training, performance enhancement, and sport-specific strategies. Explosive strength is crucial for rapid movements, while shoulder strength supports daily tasks and upper body movements. The findings could inform tailored training regimens and optimize performance. The study contributes to the body of knowledge surrounding athletic performance and offers practical insights to help athletes, coaches, and fitness enthusiasts achieve excellence in their chosen sport.

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5. CONCLUSION

In conclusion, this study successfully confirmed the hypotheses by demonstrating significant differences in both shoulder and explosive strength between handball and basketball players. These findings provide valuable insights for players, coaches, and educators to tailor training programs and enhance performance. The study's limitations, including uncontrollable external factors and the omission of participants' prior training backgrounds, must be acknowledged. Nevertheless, the observed disparities underscore the specific physical demands of each sport, with basketball emphasizing explosive power and handball requiring robust shoulder strength. Overall, this research contributes to a better understanding of the distinct strength profiles of these athletes, facilitating informed training strategies and improving athletic outcomes.

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INFLUENCE OF LOW- IMPACT PLYOMETRIC TRAINING ON PAIN AND PERFORMANCE LEVEL AMONG STATE LEVEL KABADDI PLAYER WITH MEDIAL MENISCAL INJURY- A CASE REPORT

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ABSTRACT

Introduction: Kabaddi players are most commonly prone for Medial meniscal tears due to the high- intensity nature of sport which involves rapid change in directions, sudden stops and contact with the prevalence rate of 68.42%. Plyometric exercise involves dynamic movements such as jumps, bounds, and quick contractions, utilizing the stretch-shortening cycle to maximize force production, lower- limb strength and performance outcome. This case study aims to influence the effect of Low- impact plyometric training on pain and performance level among state level kabaddi player with medial meniscal injury.

Objective: To determine the effectiveness of Low- Impact Plyometric Training on Pain and Performance level among State level kabaddi player with Medial Meniscal Injury

Method: A 21- year old female state level kabaddi player with On- field medial meniscal injury (grade 1) was selected for this study. She underwent an 6 weeks of intervention program consisting of Ultrasound therapy for pain reduction and Low- impact plyometric exercises i.e., 5- 10 mins of warm- up session followed by Squat to Heel Raise, Lateral Skater Jumps, Box Step- ups (with knee raise), Reverse Lunge to Knee Drive, Lateral Band Walks and 5- 10 mins of cool down session. Pre and Post-intervention assessments includes NPRS and Illinois Agility Test.

Results: Post- test results showed a significant pain reduction (from 5 to 3 on Numerical Pain Rating Scale) and enhanced performance level, as reflected in increased Illinois Agility Test Score (from 21 to 19.5 sec). Thus the findings indicated that the given training program reduced pain and improved the performance level in a player with medial meniscal injury.

Conclusion: Low- impact plyometric exercises effectively reduce pain and improve performance in State level kabaddi player with medial meniscal injury (grade- 1). Integrating these exercises into training programs can optimize knee function and prevent injuries. Further research with larger sample sizes is recommended.

Keywords: Menisci medial, Plyometric exercises, Athletic performance, Sports Rehabilitation, kabaddi injuries.

1. INTRODUCTION:

Kabaddi is a traditional sport originating from ancient India that has gained global recognition and popularity. It is a homegrown game with deep roots in history. The sport demands exceptional physical endurance, agility, personal skill, neuromuscular coordination, lung capacity, fast reflexes, strategic thinking, and mental alertness from both the attackers and defenders [(1)]. Kabaddi is a widely popular sport in India and serves as the state game of Tamil Nadu, Karnataka, Punjab, Maharashtra, Bihar, Telangana, and Andhra Pradesh. It is also the national sport of Bangladesh and Nepal. On the international stage, Kabaddi has been included in the Asian Games since 1990 and features an annual World Cup event for both men and women, in addition to various professional leagues and other global tournaments[(2)].

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Kabaddi is a combative team game that is played with absolutely no equipment, in a rectangular court with seven players on each side of the ground. The athlete score points by entering into the opponent's court and touching as many defense players as possible without getting caught in a single Breath[3]. Sudden turning and twisting movements are required by a Raider to free him/her from the stoppers. These quick and reflexive movements of starting, stopping, bending, twisting and changing direction exert extreme force on the knee resulting in injuries to the ligaments. Injury to the ligament is known as sprain. This study found that the most common injury was ACL tear (89.47%), followed by meniscus tears which were noted in 68.42% of the players. And the common cause was contact mechanism (72.37 %)[4]. One of the most frequently damaged joints in kabaddi is the knee. It raises attention to the significant morbidity rate linked to knee injuries in Kabaddi [5].

The most frequent injury type suffered by both "Raiders" and "Stoppers/Defenders" is a knee injury. A Raider must make abrupt twisting and turning motions in order to escape the stoppers. This stance, which is also known as an active waiting position, requires the player to react to another player by either touching the defender with his or her entire knee or twisting and turning the knee to change direction and aid in his or her escape from the defender or raider [6,7]. Plyometric training is a specialized form of exercise that focuses on rapid contraction and extension of muscles to enhance explosive power, strength, and agility. It involves dynamic movements such as jumps, bounds, and quick contractions, utilizing the stretch-shortening cycle to maximize force production.

Plyometric training enhances neuromuscular efficiency, particularly by targeting fast-twitch muscle fibers, allowing athletes to generate peak force in minimal time. In Kabaddi, where agility and explosiveness are crucial, plyometrics play a vital role in improving performance. The sport demands quick movements, abrupt directional shifts, and powerful lunges during raids. By incorporating plyometric exercises, players can develop the muscular strength and explosiveness needed to launch into rapid raids, maneuver past opponents with agility, and execute forceful defensive techniques effectively [8]. There are many factors contributed to the popularity of PT, one of them is that plyometric training can be performed at any intensity levels, ranging from low-intensity exercise such as double-leg hops to high intensity unilateral drills [9] .

The meniscal injury represent with pain, swelling, or mechanical symptoms and often requires surgical intervention for symptom resolution. Treatment of such injuries relies on understanding the gross and microanatomic features of the meniscus that are important in maintaining meniscal function. The ability of the meniscus to participate in load bearing, shock absorption, joint lubrication, and joint stability depends on the maintenance of its structural integrity. The diagnosis of meniscal injury often can be made by clinical evaluation utilizing the history, physical examination, and plain radiographs. Magnetic resonance imaging can be useful in confirming the diagnosis when clinical findings are inconclusive. Treatment depends on tear pattern, vascularity, and an assessment of tissue quality. Surgical decision making for the treatment of meniscal injury is based on patient factors and understanding of the meniscal structure, function, and pathology [10].

2. CASE DESCRIPTION:

A 21-year-old female kabaddi player presented with a grade 1 medial meniscal injury sustained during a recent match. The patient had been actively playing kabaddi for six years and was well-versed in the physical demands of the sport, which included rapid pivots, directional

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changes, and frequent impact on the knees. During the match, she experienced a sudden, sharp pain in her right knee after a quick twist and pivot while trying to avoid an opponent's tackle. Immediately following the incident, she felt a dull ache in the medial (inner) aspect of the knee, accompanied by mild swelling and discomfort.

The pain was primarily localized around the medial joint line of the knee and became more pronounced during weight-bearing activities. The player also experienced occasional stiffness and mild swelling after matches. While there were no locking or catching sensations, she reported slight difficulty in fully extending or flexing the knee.

There was no history of prior knee injuries or significant discomfort before this episode. However, following the injury, the player noticed a decline in her ability to perform usual on-court activities, particularly lateral movements and quick directional changes.

Clinical examination of the knee revealed minimal swelling and tenderness along the medial joint line, a common indicator of a meniscal injury. The range of motion was somewhat restricted due to pain, but there was no significant instability. Special tests, including the McMurray test, elicited a positive response, with the patient's symptoms and pain location suggesting a meniscal injury.

A detailed MRI scan confirmed a Grade 1 medial meniscal injury, characterized by mild fraying of the meniscal cartilage without significant tearing or displacement. A Grade 1 injury typically represents a minor, localized issue that is unlikely to require surgical intervention but may still lead to pain and functional limitations.

3. ASSESSMENT PROCEDURE

1. Numeric Pain Rating Scale (NPRS): Pain intensity was assessed using the NPRS, an 10 point scale ranging from 0 (no pain) to 10 (worst imaginable pain). The participant rated her current pain level at rest and during activity.
2. Illinois agility Test: Starting Position: The participant starts by lying face down behind the starting line (Cone 1) with their hands by their sides. The test begins when the timer is started and they are instructed to get up and sprint forward to Cone 2, Weave through Cones 2, 3, and 4 in a zigzag pattern and run forward to Cone 5 and cut around it, heading diagonally toward Cone 6. Run through the final shuttle section (Cones 5 and 6), and then cut back to Cone 7. Turn sharply around Cone 7, run diagonally to Cone 8, and turn around Cone 8 before sprinting to the finish line (the starting line). The participant must complete the course as quickly as possible while maintaining agility and control of their movements. The timing is noted after the completion of task, the pre-test and post-test scores are monitored.
3. Clinical Examination of Medial meniscal injury; McMurray's Test: The patient was in supine with the knee fully flexed. The foot and tibia was externally rotated while applying a valgus stress (pressure toward the midline). Then the knee was extended while maintaining the pressure. The reproduction of pain along the medial joint line indicates a positive test for a medial meniscal tear.

4. PRE- INTERVENTION ASSESSMENT

Before the intervention, the participant underwent baseline assessments, including the Numeric Pain Rating Scale (NPRS) and the Illinois Agility Test. The NPRS was used to measure knee pain, with the participant reporting a pain score of 5. The Illinois Agility Test assessed

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performance, specifically speed and directional changes, with a recorded time of 21 seconds. Additionally, MRI findings confirmed a Grade 1 medial meniscal injury.

5. INTERVENTION:

A 21 year old female state level kabaddi player with On- field medial meniscal injury (grade 1) was selected for this study. It is confirmed by performing McMurray test. She underwent an 6 weeks of intervention program consisting of Ultrasound therapy for pain reduction and Low-impact plyometric exercises i.e., 5- 10 mins of warm- up session followed by Squat to Heel Raise, Lateral Skater Jumps, Box Step- ups (with knee raise), Reverse Lunge to Knee Drive, Lateral Band Walks and 5- 10 mins of cool down session. Pre and Post- intervention assessments includes NPRS and Illinois Agility Test.

Ultrasound therapy protocol

Treatment frequency - 3 times/week followed for 6- weeks

Treatment duration – lasts between 8-10 mins

Frequency – 1 MHz with the intensity of 2.5W/cm²

6-week intervention protocol for low-intensity plyometric training with the following exercises mentioned: Squat to Heel Raise, Lateral Skater Jumps, Box Step-ups, Reverse Lunge to Knee Drive, and Lateral Band Walks.

Weeks 1-2: Foundation Phase

The first two weeks aim to develop basic strength, stability, and technique. The focus will be on controlled movements with low intensity.

Frequency: 2-3 sessions per week with at least one day of rest between sessions.

Sets and Reps: 2 sets of 8-10 repetitions for each exercise.

Rest: 45-60 seconds between sets to ensure proper recovery.

Intensity: Focus on slow, controlled movements to establish proper technique.

Exercise Progression:

1. Squat to Heel Raise: Perform with slow and controlled squat depth and a deliberate calf raise at the top.
2. Lateral Skater Jumps: Emphasize soft landings and minimal jump height, with a focus on balance and control.
3. Box Step-ups: Step up and down with control, focusing on proper knee alignment and engaging the glutes.
4. Reverse Lunge to Knee Drive: Perform the reverse lunge with controlled descent, driving the knee up to a 90-degree angle at the top.
5. Lateral Band Walks: Perform with a resistance band around the knees, maintaining a squat position and stepping side-to-side with slow, controlled movements.

Weeks 3-4: Strength and Endurance Phase

In weeks 3 and 4, the focus shifts slightly to endurance and strength building with an emphasis on form and consistency.

Frequency: 3 sessions per week.

Sets and Reps: 3 sets of 10-12 repetitions for each exercise.

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Rest: 45 seconds between sets.

Intensity: Gradually increase intensity by adding more repetitions and slightly reducing rest periods.

Exercise Progression:

1. Squat to Heel Raise: Increase squat depth and speed up the heel raise while maintaining control.
2. Lateral Skater Jumps: Increase jump distance and height slightly, with controlled landings.
3. Box Step-ups: Use a higher box or platform (8-12 inches), focusing on stepping up with proper form and controlled descent.
4. Reverse Lunge to Knee Drive: Increase the speed of the knee drive while maintaining a stable lunge.
5. Lateral Band Walks: Increase the resistance of the band, performing quicker steps while maintaining control of the squat position.

Weeks 5-6: Power and Performance Phase

The final phase introduces more dynamic movement with faster tempo, but still emphasizing controlled landing and proper technique to avoid injury.

Frequency: 3-4 sessions per week.

Sets and Reps: 3-4 sets of 12-15 repetitions for each exercise.

Rest: 30-45 seconds between sets to challenge endurance and power.

Intensity: Increase intensity by performing exercises with greater speed and power while maintaining control.

Exercise Progression:

1. Squat to Heel Raise: Perform with a quicker squat and more explosive calf raise.
2. Lateral Skater Jumps: Increase jump height and distance, adding more lateral movement for greater agility and power.
3. Box Step-ups: Incorporate a slight jump or explosive step-up, focusing on maximum height and controlled landings.
4. Reverse Lunge to Knee Drive: Perform with greater speed in the knee drive and more explosive upward motion.
5. Lateral Band Walks: Increase tempo and resistance, engaging the glutes and hips more dynamically.

Warm-up and Cool-down:

Warm-up: 5-10 minutes of dynamic stretches and mobility drills, focusing on the hips, knees, and ankles.

Cool-down: 5-10 minutes of static stretching, focusing on the quads, hamstrings, calves, and hip flexors to improve flexibility and reduce soreness

This protocol focuses on building foundational strength and explosiveness with the intention of progressing safely while increasing power and stability in the lower body over six weeks.

6. POST- INTERVENTION ASSESSMENT

After completing the six-week exercise program, the participant underwent a post-intervention assessment using the same measures as the pre-intervention phase. The NPRS score was 3. The

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Illinois agility test score was 19.5sec. And McMurray's test was negative. The results were compared to the baseline data to assess the effectiveness of the Low- impact plyometric training program.

7. RESULT:

The case study results showed significant improvements in both pain reduction and performance levels among Kabaddi players following a six-week low-impact plyometric training program. The participant reported noticeable pain relief after completing the program, with her Numeric Pain Rating Scale (NPRS) score decreasing from 5 to 3 during activity. This pain reduction aligned with her self-reported experience of improved ability to perform sport-specific movements, such as directional changes and pivot turns, without discomfort.

The Illinois Agility Test results also reflected enhanced performance, with the completion time improving from 21 seconds to 19.5 seconds post-intervention. This improvement was attributed to better joint function and refined sport-specific movements. The increased agility score indicated that the participant's ability to execute defensive skills had strengthened due to low-impact plyometric exercises.

In conclusion, the post-intervention findings demonstrated a significant reduction in knee pain and enhanced Kabaddi performance. These improvements highlight the effectiveness of low-impact plyometric exercises in managing medial meniscal injuries in state-level Kabaddi player.

8. DISCUSSION:

The findings of this case study align with existing literature, reinforcing the significance of low-impact plyometric exercises in managing medial meniscal injury and improving performance among kabaddi players. This case report demonstrated that an six -week intervention program effectively reduced knee pain and enhanced performance level in a state-level kabaddi player. The noted enhancements in pain relief and improved performance scores highlight the significance of focused rehabilitation approaches in correcting biomechanical deficiencies linked to medial meniscus injuries

In contact sports like Kabaddi, injuries, particularly knee injuries, are quite common. The high incidence of sports-related injuries significantly affects individuals, their careers, and the healthcare system. A literature review on common injuries and their prevention in kabaddi by Sajjan Pal et, al., (2021) [11].

The findings of Venkatesha Murthy BS (2016) focused on the qualitative analysis of human movement patterns in Kabaddi sport. They outlined movements in the sagittal plane and briefly addressed those in the frontal and horizontal planes. They then explored the constraints-led approach to studying human movement and examined examples of walking, running, jumping, and throwing, while also suggesting injury prevention strategies. Research indicates that altered knee biomechanics can impair force generation, coordination, and endurance, ultimately impacting sports performance [4].

This article specifies that Plyometric training has been shown to enhance sports-specific physical fitness in male Kabaddi players by improving explosive power, flexibility, agility, and trunk-lower extremity muscle strength. These improvements are believed to positively impact both raiding and defensive performance. Hence, it is recommended that plyometric training be

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integrated with conventional training to enhance the performance of Kabaddi players. (Dharod R, Shetty T, 2020) And Similarly (Hewett, T. E., 1999) reported that plyometric training may have a significant effect on knee stabilization and prevention of serious knee injury among female athletes [12,13].

Previous studies have established that after the 8 weeks of low intensity plyometric training and low intensity plyometric training combined with aerobic training have produced the increase in performance of explosive power in kabaddi players. However, low intensity plyometric training combined with aerobic training have produced greater effect on explosive power than the low intensity plyometric training. (Dr. Baljit Singh Sekhon 2023). The result of the present case report explains the enhancement of performance level among kabaddi players with medial meniscus injury [14,15].

The clinical implications of this case study emphasize the importance of incorporating low-impact plyometric exercises into training and rehabilitation programs for Kabaddi players. The notable reduction in pain and improvement in performance indicate that these exercises should be an essential part of strength and conditioning protocols.

From a rehabilitation perspective, the findings further support the use of ultrasound therapy as a non-invasive intervention for managing knee pain. Since Kabaddi players are highly prone to knee injuries due to repetitive motions, early integration of low-impact plyometric exercises in rehabilitation may serve as a preventive measure, reducing the risk of recurrent Grade 1 meniscal injuries.

9. LIMITATION AND RECOMMENDATION:

This study has some limitations that should be acknowledged when analyzing the results. Firstly, the research is based on a single case, making it difficult to generalize the findings to a wider population of state-level Kabaddi players with medial meniscal injuries. Additionally, variations in factors such as individual pain tolerance, compliance with the training program, and differences in injury severity may have influenced the results.

Another limitation is the absence of long-term follow-up data to determine the lasting effects of the intervention on pain reduction and performance enhancement. Future studies should consider including a larger sample size along with a control group to confirm the effectiveness of low-impact plyometric training. Furthermore, incorporating advanced biomechanical evaluations could provide a more comprehensive understanding of the physiological changes associated with this training method. Longitudinal research focusing on reinjury rates and performance maintenance would also be beneficial in strengthening the evidence for integrating plyometric exercises into rehabilitation programs for Kabaddi players.

10. CONCLUSION:

This case report provides evidence that Low impact plyometric exercise can be an effective intervention for reducing knee pain and improving performance in state-level kabaddi player with medial meniscal injury. The six-week exercise program led to significant improvements in both pain levels and performance, as assessed by the Numeric Pain Rating Scale and the Illinois agility test. These findings suggest that Low impact plyometric training exercises can be integrated into rehabilitation programs to optimize knee function and prevent injuries in kabaddi players.

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Given the positive outcomes observed in this case study, it is recommended that Low impact plyometric exercises be incorporated into training and rehabilitation programs for athletes with medial meniscal injury. Further research is needed to expand on these findings and establish more comprehensive guidelines for the use of Low impact plyometric exercises in sports rehabilitation.

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EFFECTIVENESS OF BLACKBOARD MOBILIZATION BARS TRAINING VS BOSU BALL TRAINING IN FUNCTIONAL ABILITY AND BALANCE AMONG UNIVERSITY BADMINTON PLAYERS WITH ANKLE INSTABILITY

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ABSTRACT:

Background: Balance and functional ability are critical components for optimal performance in elite badminton players. Instability training methods, such as Blackboard Mobilization Bars (BBMB) and BOSU ball training, are widely used to enhance these parameters. However, comparative evidence on their effectiveness remains limited.

Objective: This study aimed to compare the effectiveness of Blackboard Mobilization Bars training versus BOSU ball training in improving functional ability and balance among elite badminton players.

Methods: A randomized controlled trial was conducted with 30 university badminton players, randomly assigned into two groups: Blackboard Mobilization Bars training (n=15) and BOSU ball training (n=15) along with conventional training. Both groups underwent a structured four-week intervention for five days a week. Functional ability was assessed using the Foot Function Index (FFI), and balance was evaluated using the Static Y Balance Test (SYBT) at baseline and post-intervention.

Results: Both groups demonstrated significant improvements in Static Y Balance Test and Foot Function Index scores post-intervention ($p<0.001$). However, the BBMB group exhibited greater improvement in functional ability and overall balance performance compared to the BOSU ball group.

Conclusion: While both training modalities effectively enhance balance and functional ability, Blackboard Mobilization Bars training along with conventional training provides superior benefits in functional ability and overall balance. Incorporating Blackboard Mobilization Bars exercises may offer an advantage in sport-specific performance enhancement for elite badminton players.

Keywords: joint instability, racquet sport, ankle joints, physical therapy modalities, rehabilitation, exercises therapy

1. INTRODUCTION:

Ankle instability represents a significant concern in badminton, affecting players' performance, safety, and long-term athletic career [1]. The dynamic nature of badminton, characterized by rapid directional changes, jumping, and landing movements, places substantial stress on the ankle joint, making it part

icularly susceptible to injuries and subsequent instability [2] . Chronic ankle instability (CAI) not only impairs athletic performance but also impacts daily functional activities, necessitating effective rehabilitation strategies [3].

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Among university-level badminton players, the prevalence of ankle instability ranges from 20% to 40%, highlighting the magnitude of this problem in competitive sports [4]. The condition often manifests as recurrent ankle sprains, decreased proprioception, and compromised balance control, leading to reduced confidence and athletic performance [5]. Traditional rehabilitation approaches have shown varying degrees of success, prompting the exploration of alternative training methodologies [6].

Recent years have witnessed the emergence of innovative training tools and techniques aimed at addressing ankle instability [7]. Blackboard mobilization bars, a relatively new intervention in rehabilitation science, have gained attention for their potential in improving ankle stability and functional performance [8]. These bars provide a controlled environment for progressive resistance training while simultaneously challenging proprioceptive mechanisms [9]. The unique aspect of blackboard mobilization bars lies in their ability to facilitate multi-directional movements while maintaining joint stability [10].

Conversely, BOSU ball training has been a well-established method in rehabilitation and performance enhancement [11]. The unstable surface created by the BOSU ball challenges the neuromuscular system, promoting enhanced proprioception and balance control [12]. Research has demonstrated its effectiveness in improving postural stability and reducing the risk of ankle injuries in various athletic populations [13]. Studies have shown significant improvements in dynamic balance and functional performance following BOSU ball intervention [14].

While both interventions show promise, there is limited comparative research examining their relative effectiveness, particularly in the context of badminton players [15]. Understanding the optimal training approach is crucial for developing evidence-based rehabilitation protocols [16]. Previous studies have primarily focused on general athletic populations [17]. Sport-specific applications require further investigation to establish optimal protocols [18].

The integration of functional training elements is particularly relevant for badminton players, given the sport's unique demands [19]. The ability to maintain balance during rapid movements and recover quickly from perturbations is essential for competitive success [20]. Therefore, rehabilitation strategies must address both the mechanical and functional aspects of ankle stability [21].

Recent evidence suggests that targeted interventions can significantly improve functional outcomes in athletes with ankle instability [22]. The Static Y Balance Test (SYBT) has emerged as a reliable tool for assessing dynamic balance and functional performance in athletes with ankle instability [23]. Additionally, the Foot Function Index (FFI)provides valuable insights into both sports-specific function and activities of daily living [24]. These validated outcome measures offer comprehensive assessment of intervention effectiveness [25].This study aims to improve the knowledge gap by comparing the effectiveness of blackboard mobilization bars training versus BOSU ball training in improving functional ability and balance among university-level badminton players with ankle instability. The findings will contribute to the development of more effective, evidence-based rehabilitation protocols for this specific athletic population [26].

2. MATERIALS AND METHODS:

Materials required: Black board mobilization bars, Bosu ball

The study employed an experimental design with 30 university level badminton players with ankle instability randomly divided into conventional (n=15) and experimental (n=15) groups. Male badminton players aged between 17-25yrs with ankle instability were included, while those with

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recent fracture and surgeries were excluded. The study compared two rehabilitation approaches for players with ankle instability, both conducted for 20 minutes, five times weekly over four weeks. The primary outcome measures used were the Static Y Balance Test (SYBT) for dynamic balance assessment and the Foot Function Index (FFI) questionnaire to evaluate functional performance during daily activities and sports. Group A underwent blackboard mobilization bars training while Group B received BOSU ball training interventions.

EXPERIMENTAL GROUP (n=15)

- **Single-leg Stance**: Patients were made to stand with one leg while sliding the alternate foot along the horizontal bars. This exercise challenged their balance and proprioception while maintaining controlled movement patterns along the bars.
- **Forward and Backward Walking**: This exercise involved walking along the bars while maintaining balance. Participants gradually increased their speed and movement complexity as they gained confidence and control.
- **Side-stepping Exercises**: Lateral movements were performed while using the bars for support. This enhanced lateral stability and control, particularly important for quick directional changes in badminton.
- **Heel Raises and Lowering**: While holding the bars for support, patients performed controlled heel raises and lowering movements. This strengthened the ankle plantar flexors and dorsiflexors through full range of motion.
- **Single-leg Squats**: Performed with bar support, this exercise helped improve lower limb strength and stability. The bars provided necessary support while challenging balance on a single leg.
- **Dynamic Reaching**: This involved controlled arm movements while maintaining stability through bar support. Participants reached in various directions while maintaining balance, challenging multi-directional control.
- **Lateral Weight Shifts**: Controlled lateral weight transfers were performed using the bars as support. This improved weight distribution and transfer abilities essential for badminton movements.

3. CONVENTIONAL GROUP (n=15)

- **Double-leg Stance**: Initial exercise performed on the dome side of the BOSU ball. Participants maintained balance while standing with both feet on the unstable surface.
- **Single-leg Stance**: Progressing from double-leg stance, this was performed on both dome and flat sides of the BOSU ball. This significantly challenged balance and proprioception.
- **Dynamic Weight Shifts:** Participants performed controlled movements in all directions while maintaining balance on the ball. This enhanced multi-directional stability and control.
- **Mini Squats**: These were performed on both sides of the BOSU ball, with controlled descent and ascent movements. This improved lower limb strength and control while on an unstable surface.
- **Forward and Backward Rocking**: Controlled rocking movements on the ball helped develop ankle strategy and dynamic stability. Participants maintained balance while moving in the sagittal plane.
- **Side-to-side Movements**: Lateral movements on the BOSU ball improved lateral stability and control. This was particularly beneficial for badminton-specific lateral movements.

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- **Sport-specific Movements**: Advanced exercises including lunges and jumping movements were performed on the BOSU ball. These directly addressed the dynamic requirements of badminton play and challenged functional stability.

4. OUTCOME MEASURES:

STATIC Y BALANCE TEST (SYBT): By measuring a person's reach in three different directions—anterior (ahead), posterior lateral (backward and outward), and posterior-medial (backward and inward)—the Static Y Balance Test evaluates a person's stability and balance. The participants were made to stand on one leg in the middle of a Y-shaped grid, with their free leg behind them, to administer the test. Next, while keeping their balance on the standing leg, the person stretches as far as they can in each of the three directions, touching the ground with their toes. The distances are noted and each reach is measured. Usually, the test is retaken to ensure correctness, and the results are examined to assess stability and balance.

FOOT FUNCTION INDEX (FFI): The **Foot Function Index (FFI)** is a self-reported questionnaire used to assess the **effect of foot disorders on function.** It helps measure pain level, disability in daily activities and activity limitation. The FFI consists of **three subscales (**Pain, Disability, and Activity Limitation), with each item scored on a **0 to 10 scale.** A **higher total score** indicates **greater foot impairment. (**0-30% – Minimal foot dysfunction, 31-60% – Moderate foot dysfunction, 61-100% – Severe foot dysfunction).

5. STATISTICAL ANALYSIS:

The data collected were organized and analysed through descriptive and inferential statistics. Each measurement was shown as the mean along with the standard deviation (SD). To compare test measurements taken before and after the intervention, Significant differences were identified using the paired t test. A p-value of <0.001 was established as the threshold for statistical significance.

6. DATA ANALYSIS

TABLE 1: COMPARISION OF POST-TEST MEAN VALUES OF STATIC Y BALANCE TEST WITHIN THE EXPERIMENTAL AND CONVENTIONAL GROUPS

TEST	GROUP	MEAN ± SD	T VALUE	P VALUE
ANTERIOR REACH TEST	Experimental group	40.32 ± 1.52	12.845	<0.001
	Conventional group	34.26 ± 1.60		
POSTEROMEDIAL REACH TEST	Experimental group	37.82 ± 1.56	15.273	<0.001
	Conventional group	29.80 ± 1.48		
POSTEROLATERAL REACH TEST	Experimental group	38.92 ± 1.79	13.962	<0.001

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	Conventional group	31.90 ± 2.59		

GRAPH 1: COMPARISION OF POST-TEST MEAN VALUES OF STATIC Y BALANCE TEST WITHIN THE EXPERIMENTAL AND CONVENTIONAL GROUPS

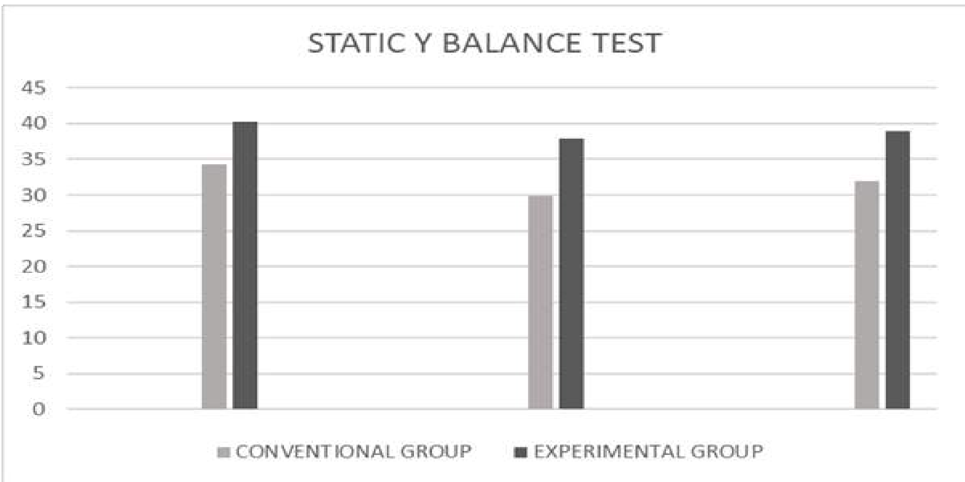
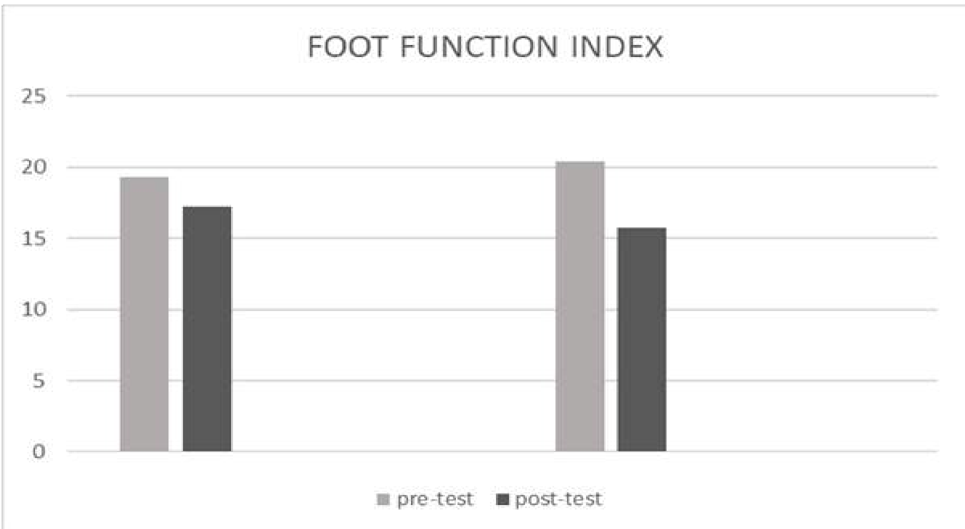


TABLE 2: COMPARISION OF PRE AND POST-TEST MEAN VALUES OF FOOT FUNCTION INDEX WITHIN THE EXPERIMENTAL AND CONVENTIONAL GROUPS

TEST	GROUP	PRE-TEST MEAN± SD	POST-TEST MEAN ± SD	T-VALUE	P-VALUE
FFI	Experimental group	20.41± 1.680	15.79 ± 1.634	8.532	<0.001
	Conventional group	19.28± 1.925	17.24 ± 1.883	3.456	<0.001

GRAPH 2: COMPARISION OF PRE AND POST-TEST MEAN VALUES OF FOOT FUNCTION INDEX WITHIN THE EXPERIMENTAL AND CONVENTIONAL GROUPS



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7. RESULTS:

The results of the pre-test and post-test evaluations for the Y Balance Test reveal significant improvements in balance and reach following the intervention, suggesting that the intervention effectively enhanced participants' balance and stability across multiple dimensions. In the Y Balance Test which assessed participants' reach capabilities in multiple directions, similarly notable improvements were observed: Anterior Reach, the Conventional group's mean reach distance was 34.26 cm (SD =1.60), whereas the Experimental group improved significantly to a mean of 40.32 cm (SD = 1.52). The large increase in reach distance, with a t-value of 12.845 and a p-value of <0.001 suggests enhanced forward stability and control. The slight decrease in SD indicates more consistent performance across participants, reflecting better anterior stability after the intervention. Posteromedial Reach This direction showed one of the most substantial improvements, with the mean of Conventional group as 29.80cm (SD = 1.48) and Experimental group increasing to 37.82 cm (SD = 1.56), The highest t-value of 15.273 and p-value of <0.001 indicates the significance of this improvement, implying considerable gains in stability and control when reaching Postero medially. This result is particularly important as it indicates improved balance in a challenging direction that combines elements of lateral and backward reach. Posterolateral Reach In the posterolateral direction, participants' mean in conventional group was 31.90cm (SD = 2.59), and the Experimental group increased to a mean of 38.92 cm (SD = 1.79). The corresponding t-value of 13.962 and a p-value of <0.001 shows the statistically significant enhancement in reach distance. The substantial improvement in reach and reduced SD shows better control and reduced variability in this difficult balance direction, which requires both backward and lateral stability. Overall, the statistically significant improvements across all measures demonstrate that the intervention effectively enhanced participants' balance and reach capabilities. The marked increases in mean values of Experimental group in each dimension, coupled with the consistent decreases in SD, indicate both an improvement in balance skills and a more reliable balance performance among participants. This improvement in balance and reach in different directions suggests a comprehensive enhancement in dynamic stability and functional reach, which may translate to better overall stability and movement control in daily activities.

The Foot Function Index (FFI) assessment revealed significant improvements in both groups following intervention, with notably superior outcomes in the experimental group.

Statistical analysis using paired t-tests demonstrated that the experimental group (N=15) exhibited a substantial reduction in FFI scores from pre-test (20.41 ± 1.680) to post-test (15.79 ± 1.634), representing a decrease of 4.62 points (t=8.532, p<0.001). This marked reduction indicates a clinically meaningful improvement in foot function, pain levels, and activity capability. The Conventional group (N=15) also showed improvement with FFI scores decreasing from 19.28 ± 1.925 at pre-test to 17.24 ± 1.883 at post-test, a reduction of 2.04 points (t=3.465, p<0.001). While statistically significant, this improvement was less pronounced than in the experimental group.

These results strongly suggest that the both interventions produced statistically significant improvements in foot function (p<0.001), the experimental protocol demonstrated substantially greater improvements in reducing FFI scores and enhancing overall foot functions and ability among the badminton players.

8. DISCUSSION:

The present study investigated the comparative effectiveness of Blackboard Mobilization Bars (BMB) training versus BOSU Ball training in improving functional ability and balance among

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university badminton players with ankle instability. The findings demonstrate significant improvements in both intervention groups, with distinct advantages observed in specific aspects of performance and rehabilitation outcomes.

Analysis of the Static Y Balance test (SYBT) results revealed that both training methods effectively enhanced dynamic balance control. The BMB group showed particularly significant improvements in the posterolateral and posteromedial reach directions, suggesting enhanced neuromuscular control in these challenging planes of movement. These findings align with previous research indicating that targeted ankle mobilization techniques can improve proprioceptive awareness and pain control in athletes with chronic ankle instability. The systematic progression of BMB training, which emphasizes controlled movement patterns and precise foot positioning, may have contributed to these improvements in directional control.

The Foot Function Index (FFI) scores demonstrated meaningful improvements in both groups, with the BMB group reporting higher levels of confidence during sport-specific movements. This outcome suggests that the structured, progressive nature of BMB training may provide a more systematic approach to developing functional stability. Participants in the BMB group reported feeling more secure during rapid changes of direction and landing maneuvers, which are crucial components of badminton performance. However, the BOSU Ball group exhibited superior performance in maintaining balance during rapid directional changes, which is particularly relevant to the demands of badminton.

A notable finding was the differential impact of the training methods on specific aspects of performance. While BMB training appeared to excel in developing foundational stability and movement confidence, BOSU Ball training showed advantages in sport-specific agility and reactive balance control. This suggests that both training methods may have complementary benefits in rehabilitation protocols for ankle instability. The unstable surface training provided by the BOSU Ball may better simulate the dynamic requirements of match play, while BMB training appears to establish a stronger foundation of basic stability and control.

The neurophysiological mechanisms underlying these improvements may be attributed to enhanced proprioceptive feedback and motor control adaptation. The BMB training's emphasis on controlled movements likely facilitates better neuromuscular coordination, while the BOSU Ball's unstable surface challenges the proprioceptive system in ways that mirror real-game situations. This dual approach to rehabilitation suggests that combining elements of both training methods might optimize outcomes for athletes recovering from ankle instability.

These results have important clinical implications for sports physiotherapists and trainers working with badminton players. The findings suggest that an individualized approach, potentially incorporating elements of both training methods, might be optimal for addressing ankle instability in this athletic population. Clinicians might consider initiating rehabilitation with BMB training to establish foundational stability before progressing to BOSU Ball exercises for sport-specific training.

The study also highlights the importance of sport-specific considerations in rehabilitation protocols. Badminton's unique movement patterns and balance demands require targeted interventions that address both basic stability and dynamic control. The positive outcomes observed in both training groups suggest that either method could be effectively implemented, depending on the athlete's specific needs and stage of rehabilitation.

Future studies should look at the possible advantages of a combined training regimen and how well these gains hold up over time in competitive play scenarios. Additionally, examining the

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timing and progression of these interventions within the athletic season could provide valuable insights for optimal implementation in training programs. Studies investigating the potential preventive effects of these training methods on ankle instability in healthy athletes would also be valuable for developing comprehensive injury prevention strategies.

The study's concentration on athletes at the university level and its very brief follow-up period are among its limitations. More thorough information on the long-term efficacy of these training techniques would be provided by future research with longer follow-up times and a range of skill levels.

ACKNOWLEDGEMENT: We would like to acknowledge all the participants participated in this study.

DECLARATION OF INTEREST: The authors declare no conflict of interest.

9. CONCLUSION:

The study findings demonstrated that both blackboard mobilization bars training and BOSU ball training led to significant improvements in dynamic balance and functional ability among university badminton players with ankle instability. The SYBT scores showed notable improvements in all reaching directions for both groups, while the FFI scores indicated enhanced functional performance in both daily activities and sports-specific tasks. The BOSU ball training group demonstrated slightly superior outcomes in dynamic balance parameters, particularly in the posterolateral and posteromedial reaching directions of the SYBT. Meanwhile, the blackboard mobilization group showed comparable improvements with particularly strong results in the anterior reaching direction and activities of daily living section of the FFI. These results suggest that both training methods are effective rehabilitation tools for ankle instability, with each offering unique benefits. The study recommends incorporating either or both training methods into rehabilitation programs for athletes with ankle instability, based on individual needs and available resources. Future research with larger sample sizes and longer follow-up periods would be valuable to further validate these findings and establish long-term effectiveness of these training approaches.

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EFFECT OF PROGRESSIVE SKILL DRILLS ON AGILITY AMONG COLLEGIATE BASKETBALL PLAYERS WITH HAMSTRING PULL

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ABSTRACT

Background: Hamstring injuries are one of the most common injuries in basketball, often resulting in decreased performance, prolonged recovery, and a high risk of recurrence. These injuries can significantly affect player's ability to perform at peak levels particularly in a sport like basketball, which demands explosive movements, agility, and sport-specific skills. In combination of agility and skill- specific drills, basketball players can achieve faster recovery, improved performance, and a reduced risk of future injuries. This study aims to improve the performance level on progressive skill drills among players and minimizing the risk of re-injury.

Objective: To determine the effect of progressive skill drills on agility among collegiate basketball players with hamstring pull.

Method: A total of 15 samples was selected, for pre and post-test values was measured by using progressive Illinois agility test. The player will be trained for 8 weeks by progressive skill drills on agility. The post values were obtained and measured in same manner as the pre-test. The values are evaluated statistically and analysed in paired T-test.

Results: From statistical analysis made with the quantitative data revealed statistically significant difference between pre and post test of intervention group, with P value of <0.0001.

Conclusion: The study on this progressive skill drills on agility is effectively enhanced the player's speed, change of direction, and overall performance among basketball players while minimizing the risk of re-injury on hamstring pull. These drills not only help along recovery but also come up with better functional movement and athletic performance.

Keywords: Basketball, performance, hamstring muscles, speed, agility.

1. INTRODUCTION:

Basketball players perform a number of multidirectional motions at different speeds and intensities, including dribbling, shuffling, sprinting, and rebounding [1]. These specific movements are related to the functional performance that requires well-developed fitness and exercise programs for achieving better performance and success [2]. Players jump, turn, and run both forward and backward during the game. They also alter their running path several times [3].The number of injuries among basketball players has been constantly increasing [4].

Muscle strains are among the most frequently treated conditions by physicians. Lengthening contractions under high force can generate extreme stress, leading to pain and tissue damage, making them the primary cause of muscle injuries. Hamstring strains are particularly common among basketball players due to the sport's sprinting demands. A hamstring injury, often referred to as a pulled hamstring, involves a strain affecting one or more muscles at the back of the thigh. Common factors contributing to hamstring injuries include inadequate warm-ups, poor physical

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conditioning, excessive exertion, muscle weakness, improper running form, and resuming activity too soon after an injury.

Most hamstring injuries can be managed at home using rest, ice, compression, elevation, and light stretching. The recovery period varies based on the severity of the injury, ranging from a few days to several months. Hamstring muscles are especially vulnerable because they span two joints and frequently undergo lengthening contractions while running. These injuries often cause prolonged symptoms and extended recovery times, restricting an athlete's ability to compete [5,6,7,8]. Hamstring strains have a high likelihood of recurrence. Professional and collegiate basketball players are particularly susceptible to these injuries, as explosive movements such as jumping and sprinting are frequent contributors to hamstring strains [11,12,13].

Levels of hamstring strain: Grade 1: Pressure. The back of the thigh hurts suddenly and radiatingly. Although strength won't be impacted, leg movement will be challenging. Grade 2: A partial tear. more painful than grade 1. There may be some bruising, edema, and limb weakness. Grade 3: Severe rupture. worsened edema, pain, and tenderness.

Agility often involves sprinting in a straight line and making quick, intentional changes in direction. In basketball, it encompasses several key elements, such as reaction speed, precise movements, swift directional shifts, and fast decision-making skills. Therefore, agility is a highly complex and defining athletic quality in basketball. Assessment and training typically involve comprehensive discussions on speed, strength, reaction time, and other related qualities [14,15,16]. Progressive training ensures athletes develop foundational skills before advancing to more complex movements, here are some drills: linear run ,3 cone drills/L drill, high knees, shuttle runs, side shuffle.

Illinois Agility Test the IAT was used to test running agility on various turns and movements [17,18,19,20,21].

2. AIM:

The aim is to find the effect of progressive skill drills on agility among collegiate basketball players with hamstring pull.

3. MATERIALS AND METHODS:

A six-week quasi-experimental study was conducted with a total of 15 subjects who were recruited based on the inclusion and exclusion criteria. All participants were collegiate basketball players aged 18 to 25 years and had been actively training for at least six months prior to the study. The study aimed to assess the effect of progressive skill drills on agility among collegiate basketball players with hamstring pull.

1. Side shuffle:

Standing with feet hip-distance apart, the participant performed the side shuffle exercise by bending their knees slightly and hunching forward at the hips, making sure their spine was neutral and their chest was raised, moving quickly to the right with shuffle steps, pausing momentarily after reaching the desired distance or number of steps, and then repeating the shuffle motions to the left.

The targeted muscles for side shuffle is glutes, hips, thighs and calves and benefit of this exercise is to improve the lateral movement boosts metabolism.

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2. Linear Run:

The participant performed a linear running exercise, starting from a standing position at the starting line. They sprinted in a straight line and had to come to a sudden stop as instructed by the instructor.

The linear run primarily targets the glutes and quadriceps. The main benefit of this exercise is improving response and reaction time, enhancing overall speed and agility.

3. Cone Drill/L Drill:

The participant performed the 3-cone drill (L-drill) by setting up three cones in an L-shape, each placed 5 yards apart. Considering the middle cone as 2 and the others as 1 and 3, the drill began at cone 1. The participant sprinted to cone 2, touched it, then sprinted back to touch cone 1. They then sprinted around cone 2, weaving toward the inside of cone 3, turned around cone 3, looped back around cone 2, and returned to cone 1. The drill was then repeated in the opposite direction, with cone 3 now acting as cone 1.The targeted muscles for 3 cone drill/L drill is quads, hamstrings and benefit of this exercise is to improve balance and direction change.

4. High Knees:

The participant performed high knee in Standing at starting line Run forward, staying on toes, driving knees high up, and swinging arm, Concentrate on the height of knees rather than length of stride, Think "short and sharp"

The targeted muscles for calves, glutes, quads and benefit of this exercise to improves balance and increases speed.

5. Shuttle Run:

The participant performed the shuttle run by standing at the starting line, sprinting to the finish line and back, completing six repetitions as quickly as possible. After finishing, they rested for five minutes before repeating the drill.

The targeted muscles for calves, glutes, quads and benefit of this exercise to increases speed and improves quick turns.

Each exercise was performed for three sets of 4-5 repetitions, with progressive increases in intensity as tolerated. The progressive skill drills on agility exercise were performed four to five days per week. For players recovering from a hamstring pull, skill drills intensity increases gradually in intensity while minimizing strain on the injured muscle. This exercise focusses to improve change of directions, jumping skills and increases speed on basketball players to maintain the sports specific movements without aggravating injury.

4. STATISTICAL ANALYSIS:

For data analysis statistical methods were used to evaluate the Effect of progressive skill drills on agility among Collegiate basketball players with Hamstring pull.

Means and standard deviations were calculated for the Illinois agility test, for pre- and post-intervention.

The paired t-tests for both show significant reductions in Illinois agility test scores ($p < 0.001$), confirming that the intervention had a statistically significant effect. Additionally, the strong correlations between pre- and post- scores suggest consistency in the measurement. The independent t-test between groups, however, shows significant difference, indicating that post training was effective.

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Table 1: Comparison of pre- and post-test values for Illinois agility test:

Agility T test	Mean	Standard deviation	T value	P value
Pre test	22.4000	0.38730		
Post test	21.5600	0.68222	7.228	<0.0001

In Table 1 There is a statistically significant improvement in agility after the intervention.

5. RESULTS:

The results of this study demonstrated a significant improvement in agility and functional performance following a six-weeks progressive skill drills on agility exercises. The paired samples t-test comparing pre-test and post-test agility scores showed a statistically significant reduction in agility time, ($t = 7.228$, $p < 0.001$). The post-test mean agility time (21.5600 seconds) was significantly lower than the pre-test mean agility time (22.4000 seconds), indicating enhanced movement efficiency. These results suggest that progressive skill drills exercise effectively enhanced functional performance, power, and agility in collegiate basketball players.

6. DISCUSSION:

The purpose of this study was to analyze how progressive skill drills influence agility in collegiate basketball players recovering from hamstring pull injuries. Agility is a critical component of basketball performance, as it enables players to change direction quickly, react to opponents, and maintain movement patterns on the court. However, hamstring injuries can significantly obstruct agility by limiting speed and flexibility.

Progressive skill drills involve a step-by-step training approach that gradually increases in intensity. In this study, these drills were targeted to improve movement efficiency while minimizing stress on the recovering hamstring muscles. The drills focused on controlled lateral movements, acceleration-deceleration patterns, and multidirectional changes.

The results indicate that players who underwent structured progressive skill drills showed significant improvements in agility compared to those who followed usual exercises. Progressive drills incorporated strength-building exercises that targeted the hamstrings and surrounding muscle groups, reducing the risk of reinjury. Engaging in sport-specific drills helped players regain confidence in their movements, which is essential for competitive performance.

In their 2018 study, Carlos Vicente Andreoli et al. emphasized that understanding the general epidemiology of basketball injuries is crucial for developing effective strategies to reduce injury rates and their associated costs, such as medical expenses, hospital visits, and athlete downtime. The study found that lower limb injuries are the most common among basketball players, regardless of gender or age group, with knee and ankle injuries being the most frequently occurring. Additionally, injuries to the hands, fingers, and wrists showed a consistent probability across children, adolescents, and professional adults. Notably, the study also observed a higher incidence of head and neck injuries among children and adolescents compared to other age categories.

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In their 2021 study, Takashi Nagai et al. found that male high school basketball players demonstrated greater strength but less flexibility compared to their female counterparts. Additionally, younger male athletes were found to be weaker than older males, a trend not observed in female athletes. The authors suggested that future research should investigate whether these differences are linked to the occurrence of hamstring strains in athletes. Their findings contribute to the existing knowledge on hamstring strength and flexibility in high school basketball players. These normative data could help sports medicine professionals design more effective screening procedures, interventions, and return-to-sport protocols for this group.

Weicheng Li, Yongfeng Liu, Jiaxin Deng, and Tong Wang Medicine 103 (6), e37124 (2024) claims that..Basketball players' agility can be significantly increased by combining sophisticated training methods, such as enhanced training, thorough speed training, and a variety of approaches like small-sided games (SSG), TRX suspension training, and Bulgarian bag exercises. These strategies increase muscle explosiveness, core stability, and brain plasticity, which improve performance in fast decision-making, fast direction changes, and high-intensity motions. Consequently, tailored and organized training regimens are essential for optimizing basketball players' gains in agility.

Through the development of standardized instructions and execution methods, Roozen (2008) demonstrated the dependability of the Illinois Agility Test (IAT) in a population of male SMs. Assuring the validity of these tests gives medical professionals a useful instrument for assessing uniplanar, biplanar, and multiplanar motions, providing a thorough examination of agility. Furthermore, each test's quantifiable results are used as reference data by fitness professionals and physicians that engage with this demographic, supporting program development and performance evaluation.

The study explains about the enhancing performance of basketball players with hamstring pull among female athletes. In this study Some of progressive skill drills on agility exercise like side shuffle, lateral ladders, linear run, high knees, shuttle run are used to improve reaction time, speed, direction change, response and lateral movement boosts metabolism for players.

The outcome measure that used for this study is IAT [Illinois Agility Test], the purpose is to test running agility using various turs and movemrnts.an excellent score is under 15.2 seconds for a male, less than 17 seconds for a female. This markable increase in the outcome measure shows the significance of the progressive skill drills on agility.

7. CONCLUSION:

The study on the effect of progressive skill drills on agility among collegiate basketball players with hamstring pulls indicates that structured and gradual skill-based training significantly enhances agility while promoting recovery. Progressive drills that focus on controlled movements, neuromuscular coordination, and gradual intensity improvements help players regain functional mobility, reduce reinjury risk, and enhance overall performance. Incorporating agility-focused rehabilitation programs tailored to basketball-specific movements can optimize recovery outcomes and allow athletes to return to peak performance efficiently.

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A RELATIONSHIP STUDY BETWEEN ANKLE INSTABILITY IN WITH AND WITHOUT ANKLE SPRAIN INJURIES IN BASKETBALL PLAYERS

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ABSTRACT

The purpose of the study was to find out the relationship between ankle instability in basketball players with and without ankle sprain injuries. The total 60 (N=60) subjects selected for data collection were Mangalore University intercollegiate men basketball players with their ages ranging between 18 and 25 years. The MC Gill core endurance test and one-leg stance test were used to measure core endurance and balance of a player. Descriptive statistics such as Mean and Standard Deviation and comparative statistics such as independent t-test were used for analysing the data. The study found that there is no discernible change in MC Gill core endurance for trunk flexor and extensor strength but there is a significant difference in MC Gill core endurance trunk's lateral flexor and balance between ankle instability in with and without ankle sprain injuries in basketball players.

Keywords: Basketball, MC Gill core endurance test, Mangalore university, Intercollegiate, etc.

1. INTRODUCTION

Dr. James Naismith invented basketball as we know it today in Springfield, Massachusetts, in December 1891 as a way to keep young players in shape during the chilly winters. At the YMCA International Training School in Springfield, Massachusetts, which is now Springfield College, Naismith taught physical education. To assist athletes in staying in condition throughout the winter, Naismith was requested by his supervisor to develop an indoor sports game.

There was a soccer-style ball and peach baskets included. For the novel game, he released 13 rules. He split his class of 18 students into two teams, each with nine players, and started by explaining the fundamentals of his new game to them. The basketball had to be thrown into the fruit baskets that were nailed to the gym balcony's lower railing in order to win the game. The game was stopped after each goal to allow the janitor to get a ladder and get the ball. Soon, the fruit baskets' bottoms were taken off. On March 11, 1892, Springfield, Massachusetts, hosted the inaugural basketball match for the general public.

2. REVIEW OF REALTED LITERATURE

Amira A Abdullah, et al (2019). the purpose of this study was to compare core muscle endurance and hip muscle strength between soccer players who experienced non contact lower extremity sprain and/or strain injury during their season and those who did not. Additionally, the frequency of injury was correlated with core muscle endurance and hip strength, and endurance was used for predicting the risk for injury. Lower extremity sprain and strain injury constitutes a large percentage of lower extremity injuries experienced by soccer players. Yet, very limited data exists on the association between core strength and endurance and this injury Prone-bridge and side-bridge hold times were significantly longer in the non-injured players when compared with the times of the injured players (p=0.043 & 0.008 for the prone-bridge and side-bridge, respectively). There were significant negative correlations between the frequency of injury and both prone-bridge (r=-0.324, p=0.007) and side-bridge (r=-0.385, p=0.003) hold times. Logistic regression analysis revealed that side bridge hold time was a significant predictor of injury (OR=0.956, CI=0.925-0.989).

Rumaisah Pathan, et al (2021). this study was undertaken to compare core muscle endurance, balance and ankle instability in basketball players with and without ankle sprain injuries (age group 18-25years.) To reduce the risk of injuries and to increase the endurance and balance sport specific physical therapy can be helpful. The McGill core endurance test is used to assess the endurance of core muscles- trunk flexors, trunk extensors and lateral musculature. One leg stance test for balance and Foot and Ankle Ability Measure for ankle instability. Statistical analysis was done based on data received from 50 participants. According to this study we concluded that there is no significant difference between trunk flexors and extensors and balance in players with and without ankle sprain injuries, there is a significant difference in lateral musculature and there is a significant difference in ankle stability in players with ankle injuries affecting ADLs and sports activities.

Elvira Pauda, et al (2017). ankle joint is the most common site of injury for basketball athletes. An effective warm-up (WU) is a period of preparatory exercise to improve training performance and reduce sports injuries. Continuous examination of effective WU routines in basketball players is a necessity. The aim of this study was to investigate the effects of general and combined warm up on ankle injury range of motion (ROM) and balance in young female basketball players. Materials and Methods: A sample of 28 young female basketball players were randomly allocated to either global warm up control group (GWU) (n = 11) or combined warm up experimental group (CWU) (n = 17). All participants performed 7-min of run. The CWU group performed a single leg stance barefoot with eyes closed, plank forearm position and triceps sural stretching. Participants in GWU performed walking ball handling and core stability using a Swiss ball. Both WU routines were conducted 3 times per week for 10 weeks. Outcome measurements were the Stabilometric platform and dorsiflexion lunge test. Results: Twenty-eight young female basketball players completed the study. Participants in the experimental group improved significantly in the range of motion (ROM) in right and left ankle and the center of pressure displacement (CoP). The control group did not show any changes in ankle dorsiflexion and a significant reduction in all body balance parameters. Conclusions: An 8-min combined warm-up routine for 10 weeks improves the ankle dorsiflexion ROM and CoP displacement that plays a key role in ankle injuries prevention in basketball players. Further studies are strongly needed to verify our findings.

3. METHODOLOGY

Selection of the subjects

A total of 60 participants in that 30 each of with and without ankle sprain injured men basketball players respectively were selected as subjects for the current investigation. The age range of the chosen subject was 18 to 25 years old, and they took part in inter collegiate participation the subjects were chosen in Mangalore University colleges.

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Procedure for administration of the collection of data

Core muscle endurance

The investigator measured the core muscle endurance of Basketball players with and without ankle sprain injuries with the help of Trunk flexor endurance test, Trunk extensor endurance test, Trunk lateral endurance test.

Trunk flexor endurance

The flexor endurance test is the first that assesses muscular endurance of the deep core muscles of Basketball players with and without ankle sprain injuries.

Procedure

The starting position requires the subject to be seated, with the hips and knees bent to 90 degrees, aligning the hips, knees, and instruct the subject to fold his arms across the chest, touching each hand to the opposite shoulder, lean against a board positioned at a 60- degree incline, and keep the head in a neutral position second toe. to press the shoulders into the board and maintain this open position throughout the test after the board is removed the subject to engage the abdominals to maintain a flat-to-neutral spine. The back should never be allowed to arch during the test the goal of the test is to hold this 60-degree position for as long as possible

Trunk extensor endurance test

The trunk extensor endurance test is used to assess muscular endurance of the torso extensor muscles of Basketball players with and without ankle sprain injuries

Procedure

The starting position requires the subject to be prone, positioning the iliac crests at the table edge while supporting the upper extremity on the arms, which are placed on the floor or on a riser While the subject is supporting the weight of his or her upper body, anchor the client's lower legs to the table using a strap. The goal of the test is to hold a horizontal, prone position for as long as possible. Once the subject falls below horizontal, the test is terminated.

Trunk lateral flexor endurance test

The trunk lateral endurance test, also called the side-bridge test, assesses muscular endurance of the lateral core muscles of Basketball players with and without ankle sprain injuries

Procedure

The starting position requires the subject to be on his or her side with extended legs, aligning the feet on top of each other or in a tandem position (heel-to-toe). Have the client place the lower arm under the body and the upper arm on the side of the body. When the subject is ready, instruct him or her to assume a full side-bridge position, keeping both legs extended and the sides of the feet on the floor. The elbow of the lower arm should be positioned directly under the shoulder with the forearm facing out (the forearm can be placed palm down for balance and support) and the upper arm should be resting along the side of the body or across the chest to the opposite shoulder. The hips should be elevated off the mat and the body should be in straight alignment The goal of the test is to hold this position for as long as possible. Once the client breaks the position, the test is terminated.

Balance

The balance test is to measure the whole-body balance of Basketball players with and without ankle sprain injuries

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Procedure

The aim of the test is for the participant to stand on one leg for as long as possible. Give the subject a minute to practice their balancing before starting the test. When ready, they lift one foot off the ground, and the timing starts. The timing stops when the elevated foot touches the ground or the person hops or otherwise loses their balance position.

Statistical Techniques

The selected data will be analysed by using MS Excel statistical programme. The statistics test including mean, standard deviation and t-test to determine nature of the data.

4. ANALYSIS OF DATA AND RESULT OF STUDY

This content contains analysis of data, finding and discussion with regard the study on ankle instability in with and without ankle sprain injured basketball players in Mangalore university.

Analysis of data

The raw score for the core muscle endurance, balance ankle instability between with and without ankle sprain injured basketball players were subjected for statical analysis by Mean, Standard Deviation according to 't'test. The scores of the data to the ankle instability were analysed the result were systematically arranged through tabular analysis.

Table 4.1 Shows that statistical value of Mc Gill core endurance test for trunk flexor and trunk extensor in group A subjects with ankle injuries and group B subjects without ankle sprain injuries basketball players of Mangalore university.

	GROUP A		GROUP B		'T'- TEST
VARIABLES	MEAN	SD	MEAN	SD	0.58
Flexor	1.18	SD 0.51	Mean 1.29	SD 0.83	
Extensor	1.19 1.33	0.51 0.59	1.41	0.83 0.63	

The table 4.1shows that the trunk flexor with mean ankle sprain is 1.19 and SD of 0.51 and without mean ankle sprain is 1.29 and SD of 0.83, respectively. The mean and standard deviation values of trunk extensor with an ankle sprain are 1.33 and 0.59 and without ankle sprain are 1.41 and 0.63. The t value is 0.58 shows that there is no difference in trunk flexor and extensor in with and without ankle sprain injured in basketball players.

Table 4.2 Shows that statistical value of Mc Gill core endurance Trunk lateral flexor test in group A subject with ankle injuries and group B subjects without ankle sprain injuries basketball players of Mangalore university.

	GROUP A		GROUP B		'T'-TEST
VARIABLES	MEAN	SD	MEAN	SD	
Trunk flexor					
Right	1.08	0.39	1.59	0.83	3.18

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Left	0.39	0.19	1.39	0.99	5.45

The table 4.2 shows that he mean and standard deviation values of core muscle endurance trunk lateral bend with ankle sprain right side are 1.08 and 0.39 and left side 0.39 and 0.19 respectively. The mean and standard deviation values of trunk lateral bend without ankle sprain on the right side is 1.59 and 0.81 left side is 1.39. The obtained t- test is 3.1 based on the left side the t- test is 5.45 shows that the without ankle sprain injured players have the more trunk lateral endurance than the with ankle sprain injured basketball players.

Table 4.3: Shows that the statistical value of balance one leg stance test in group A subjects with ankle in and group B subjects without ankle sprain injuries of basketball players of Mangalore university.

	GROUP A		**GROUP B**		**'T'-TEST**
VARIABLES	**MEAN**	**SD**	**MEAN**	**SD**	4.20
Balance	0.83	SD0.58	Mean1.62	SD 0.85	

The table 4.3 shows that the mean and standard deviation values of the balance test with an ankle sprain are 0.83 and 0.58 respectively and the mean and standard deviation values without ankle sprain injury are 1.62 and 0.85. Table 3 indicates that observed t- value is 4.20 which shows that the without ankle sprain injured players have the more balance than with ankle sprain injured basketball players.

5. DISCUSSION ON HYPOTHESIS

1. The formulated hypothesis is accepted because there was no discernible change in trunk flexor and extensor strength between basketball players with and without ankle sprain injuries in the current investigation.
2. This study found a substantial difference in the trunk's lateral flexor between players with and without ankle sprain injuries; as a result, the formulated hypothesis is accepted. Basketball players without ankle sprain injuries have greater lateral flexor than players with ankle sprain injuries.
3. In the study, we found that there is a significant difference between balance in basketball players with and without ankle sprain injuries; players without ankle sprain injuries have better balance than players with ankle sprain injuries, therefore the formulated hypothesis is accepted.

6. CONCLUSION

The study concluded that without ankle sprain injury player have a good balance than with ankle sprain injuries and in core muscle endurance there was no significant difference between trunk flexor and extensor between basketball players with and without ankle sprain injuries but there was a significant difference in lateral flexor endurance between basketball players with and without ankle sprain injuries.

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IMPACT OF RESISTANCE TRAINING ON SELECTED SKILL PERFORMANCE VARIABLES AMONG FEMALE HANDBALL PLAYERS

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ABSTRACT

The purpose of the study was to find out the impact of resistance training on selected skill performance variables among female handball players. It was hypothesized that there would be significant differences on selected skill performance variables due to the effect of resistance training among female handball players. For the present study the 30 female handball players from Shrimati Indira Gandhi College, Tiruchirappalli, Tamilnadu, India were selected at random and their age ranged from 18 to 23 years. For the present study pre test – post test random group design which consists of control group and experimental group was used. The subjects were randomly assigned to two equal groups of fifteen each and named as Group ‘A’ and Group ‘B’. Group ‘A’ underwent resistance training and Group ‘B’ has not undergone any training. The data was collected before and after six weeks of training. The data was analyzed by applying dependent test. The level of significance was set at 0.05. The results of the study showed that the resistance training had positive impact on dribbling and shooting abilities among handball players.

Key words: Resistance Training, Dribbling, Shooting & Handball.

1. INTRODUCTION

Resistance training produces increased strength, superior movement performance and general fitness, including enhanced function of the respiratory, cardiac and metabolic systems. Other improvements include an increase in muscle mass, strengthening of connective tissue and supportive tissue as well as improvements in posture and physique. Structuring a resistance training program with Burke Spencer’s Fitness Partner encourages the lifetime physical activity in students ages 8+ to improve neural motor skills and strength, to improve bone development by increasing bone density, to improve the strength of bone connective tissue to strengthen the heart muscle and to improve muscle energy capacity **(Baechle, 1994)**.

2. METHODOLOGY

The purpose of the study was to find out the impact of resistance training on selected skill performance variables among female handball players. It was hypothesized that there would be significant differences on selected skill performance variables due to the effect of resistance training among handball players. For the present study the 30 female handball players from Shrimati Indira Gandhi College, Tiruchirappalli, Tamilnadu, India were selected at random and their age ranged from 18 to 23 years. For the present study pre test – post test random group design which consists of control group and experimental group was used. The subjects were randomly assigned to two equal groups of fifteen each and named as Group 'A' and Group 'B'. Group 'A' underwent resistance training and Group 'B' has not undergone any training. The data was collected before and after six weeks of training. The data was analyzed by applying dependent't test. The level of significance was set at 0.05.

Table –I

Skill Variables and Test

S.No	Variables	Tests
1	Dribbling	Subjective Ratings for 100 points
2	Shooting	

3. RESULTS

The findings pertaining to analysis of dependent't' test between experimental group and control group on selected skill performance variables among handball for pre-post test respectively have been presented in table II to III.

Table –II

Significance of Mean Gains & Losses between Pre and Post Test Scores on Selected Skill Performance Variables of Resistance Training Group

S.No	Variables	Pre-Test Mean	Post-Test Mean	Mean difference	Std. Dev (±)	σ DM	't' Ratio
1.	Dribbling	54.12	68.23	14.11	3.34	0.86	7.66*
2.	Shooting	53.26	70.16	16.90	0.47	0.12	15.18*

* Significant at 0.05 level

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Table II shows the obtained 't' ratios for pre and post test mean difference in the selected variable of dribbling (7.66) and shooting (15.18). The obtained ratios when compared with the table value of 2.14 of the degrees of freedom (1, 14) it was found to be statistically significant at 0.05 level of confidence. It was observed that the mean gain and losses made from pre to post test were significantly improved in skill performances thus the formulated hypothesis is accepted.

Figure- I

Comparisons of Pre- Test Means and Post–Test Means for Experimental Group in Relation to Selected Skill Performance Variables

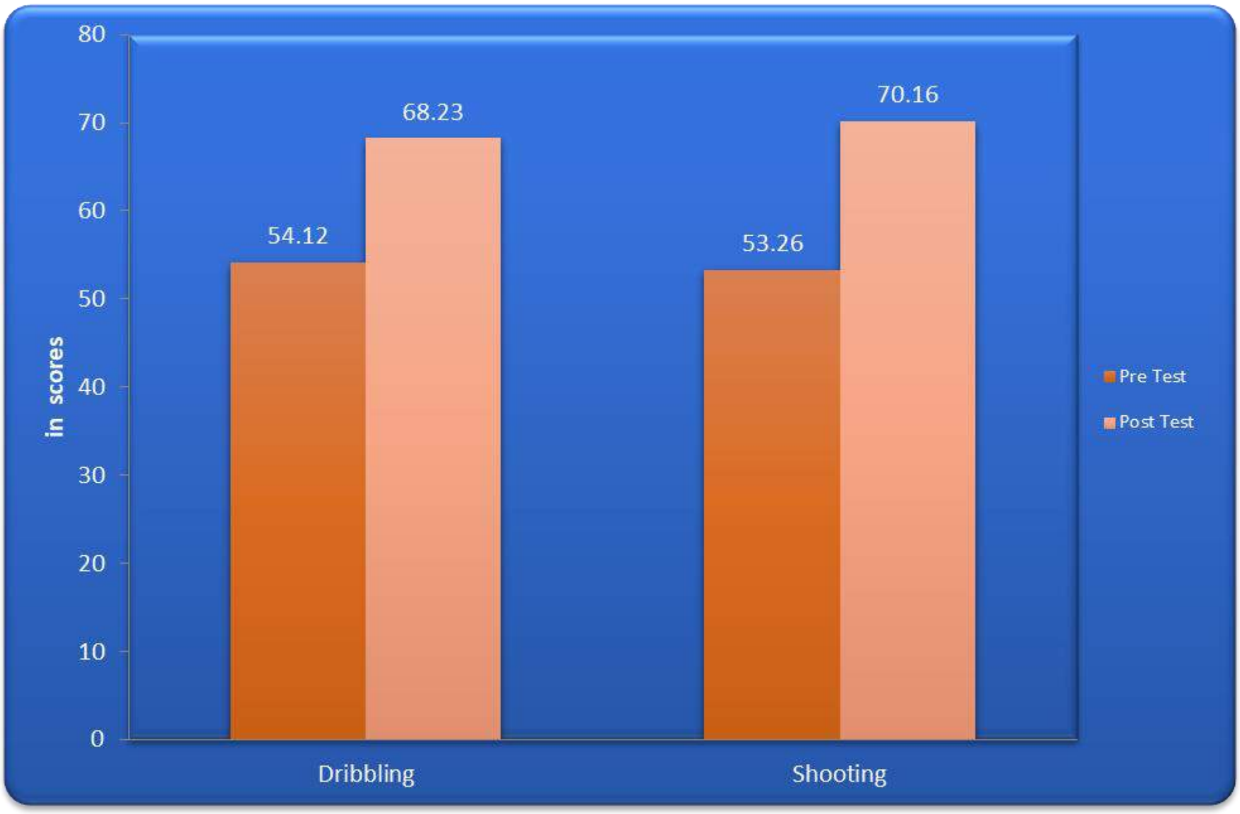

Table – III

Significance of Mean Gains & Losses between Pre and Post Test Scores on Selected Skill Performance Variables of Control Group (CG)

S.No	Variables	Pre-Test Mean	Post-Test Mean	Mean difference	Std. Dev (±)	σ DM	't' Ratio
1.	Dribbling	55.76	57.12	1.36	3.28	0.84	0.54
2.	Shooting	56.45	57.65	1.20	0.35	0.09	0.28

* Significant at 0.05 level

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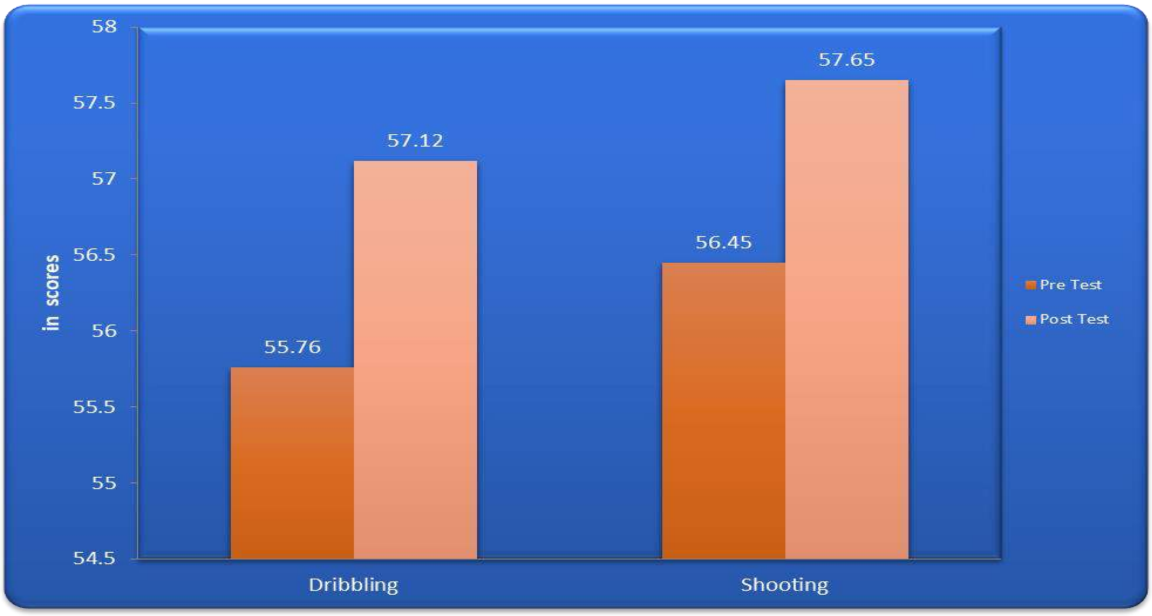
Table III shows the obtained 't' ratios for pre and post test mean difference in the selected variable of dribbling (0.54) and shooting (0.28). The obtained ratios when compared with the table value of 2.14 of the degrees of freedom (1, 14) it was found to be statistically significant at 0.05 level of confidence. It was observed that the mean gain and losses made from pre to post test were not significantly improved in skill performance variables.

Figure II

Comparisons of Pre–Test Means and Post–Test Means for Control Group in Relation to Selected Skill Performance Variables



4. CONCLUSION

The resistance training had positive impact on dribbling and shooting abilities among female handball players.

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INCLUSIVE PHYSICAL EDUCATION AND ATHLETE DEVELOPMENTBENEFITS OF PHYSIOTHERAPY REHABILITATION IN PARALYMPIC ATHLETES: A LITERATURE REVIEW

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ABSTRACT

Background: Paralympic athletes are the individuals with physical disabilities who compete in sports at the Paralympic games. A physiotherapist plays a crucial role in supporting paralympic athletes by preventing injuries, rehabilitating existing ones, optimising performance through tailored exercise programs while considering the unique challenges presented by athlete's disability**.**

Aim: This review aims to find the benefits of Physiotherapy rehabilitation in Paralympic athletes.

Methodology: This literature search was conducted using Google Scholar, PubMed and Science Direct databases, examining the Benefits of Physiotherapy rehabilitation in Paralympic athletes. Studies from the year 2020 – 2025 were considered. Selection criteria was based on the keywords chosen.

Results & Dissemination: This Literature review stated that Physiotherapy provides numerous benefits by improving their flexibility, strength, endurance and also preventing injuries. This search mainly focuses on various physiotherapy interventions that are benefiting the Paralympic athletes. It is shown that physiotherapy is helpful in sports injury and enhancing post-training muscle recovery and strength in paralympic athletes. However there are limited studies regarding the role of a physiotherapist and physiotherapy benefits in paralympic athletes. In the light of these considerations Randomised controlled trials are needed to establish the causality between physiotherapy interventions in paralympic athletes.

Conclusion: This review states the benefits of physiotherapy treatment and rehabilitation in overall outcomes, injury prevention and sports performance of paralympic athletes.

Keywords: Paralympic athletes, physiotherapy treatment, disabled athletes, physiotherapy rehabilitation.

1. INTRODUCTION:

The interest and development of Para sport continues to increase around the globe. As Para athletes performnces and professionalism are steadily improving, there is also an increasing need and interest for athlete health and (para-)medical support. The term Para athlete refers to individuals with an impairment that participate in a sport that has classification rules as defined in the International Paralympic Committee (IPC) Athlete Classification Code[1] . Para athletes report higher rates of sports injuries and illnesses compared to able-bodied athletes. For an athlete with an impairment, a sports injury or illness may not only affect sporting participation and performance, but also exacerbate the existing, underlying disability and compromise the athlete's ability to perform activities of daily life[1].

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Especially for individuals with a disability, sports practice has a positive impact on cardiovascular fitness, self- efficacy, self- perceived quality of life and community participation. Although sport participation is beneficial, it also comes with a risk of musculoskeletal injuries[6].

Sports physiotherapists must engage in increasing Para sport opportunities and share knowledge with fellow colleagues within the medical field. By nature of their qualification and skills, sports physiotherapists act as classifiers alongside physicians and sports experts across almost all Para sports[1].

Powerlifting is a sport that involves lifting weights in exercises such as bench press, deadlift, and free squat using the heaviest load possible within the proper technique. In the Paralympic modality, powerlifting is limited only to the adapted bench press, where the difference is that the athlete performs the exercise with the upper limbs on the bench. Consequently, training in this sport typically involves heavy loads and high training intensity. High loads tend to cause an increase in muscle micro injuries , which increases the athlete's recovery time between training sessions and affects the initially planned volume. This type of impairment is not desired when it comes to achieving high performance . Training tends to promote fatigue, muscle damage, and an increased risk of musculoskeletal injuries, so for an athlete to maintain their training rhythm, aiming to improve performance, it becomes imperative that they recover adequately between training sessions. This context requires that we create post-workout strategies to accelerate the recovery, aiming to keep all planned training[5].

Cold water immersion (CWI) is commonly used to relieve pain, particularly inflammatory diseases, injuries, and overuse. Furthermore, recovery in post-workout CWI in athletes has been widely used, with positive effects on physiological aspects, the inflammatory process, and metabolic and nerve transmission. However, although athletes have widely used CWI, this type of recovery is not yet used in Paralympic athletes due to the fact that these athletes have difficulties in being inserted/removed from the place of the recovery process[2].

The use of dry needling (DN) in recovery has been proposed to reduce muscle pain . This technique acts through a local inflammatory process by increasing blood supply to the injured area. However, there are no reports of its application to alleviate late muscle pain symptoms .Dry needling is a relatively new technique for recovery, which already shows good results in recovery overuse, which is common in sports[2].

Swimming is a cyclical sport with high quantitative base such as energetic cost and power than qualitative base and it is characterized by continuous repetitions of stereotyped cycles of movements carried out in a stable environment, such as the stroke. The techniques to minimize the action-reaction forces acting on the vertical plane used by not-disable swimmers are not equally

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applicable to disable swimmer due to structural modifications and joint and dynamic body differences. For this reason, each different handicap requires an individualized technical project, which considers the anatomical and functional characteristics of each individual athlete[3].

Despite the importance of high standard and quality of physiotherapy care, there is a dearth of information on the epidemiology of sports injury and related physiotherapy services at the WPG in current literature. However, some sports injury and physiotherapy services can be predicted for certain sports-specific disciplines and equipment modifications (e.g. wheelchair curling, sledges) and prosthetics (e.g., stump socket) which predispose elite athletes to unique injuries which predispose elite athletes to unique injuries. Epidemiological injury surveillance has been done for every PG, but there is a limited number of WPG physiotherapy service-related studies reporting the epidemiology (onset time) of the sports injuries, especially with details about the anatomical region, number of injuries, high-incidence sports disciplines, nature of injury (acute or overuse), and treatment (number of treatments and modalities)[4].

The adequate post-exercise recovery strategy is an essential aspect of any physical conditioning program and consists of restoring the body's systems to their basal conditions . Monitoring of post-exercise recovery is important to ensure better quality in all subsequent training sessions. The inadequacy between volume and intensity in training sessions and rest periods can go beyond the individual limit of athletes, resulting in unnecessary wear and tear . Therefore, it is necessary to give equal importance to both training and recovery before submitting the athlete to a new training session or competition to maintain a healthy balance, avoid performance restriction, and decrease injury risk[2].

The physiotherapist play a critical role in providing treatment and rehabilitation for clients, along with initial assessments and evaluations to maximize performance of the para-athletes and prevent further injuries[3]. This calls for further scientific knowledge and professional competencies. We believe that physiotherapists are crucial partners in this regard[1].

2. METHDOLOGY:

This literature search was conducted using Google Scholar, PubMed and Science Direct databases, examining the Benefits of Physiotherapy rehabilitation in Paralympic athletes. Studies from the year 2020 – 2025 were considered. Selection criteria was based on full text articles, abstracts and keywords chosen such as Paralympic athletes, physiotherapy treatment, disabled athletes, physiotherapy rehabilitation.

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	1.	2.	3.	4.
TITLE	Physiological and Biochemical Evaluation of Different Types of Recovery in National Level Paralympic Powerlifting	Disability and inclusion: Swimming to overcome social barriers	Sports Injury and Physiotherapy Services in the 2018 PyeongChang Winter Paralympic Games: Considerations and Potential Recommendations for Future Paralympics	Enhancing Post-Training Muscle Recovery and Strength in Paralympic Powerlifting Athletes with Cold-Water Immersion, a Cross-Sectional Study
AUTHOR	Wélia Yasmin Horacio dos Santos, Felipe J. Aidar , Dihogo Gama de Matos, Roland Van den Tillaar , Anderson Carlos Marçal, Lázaro Fernandes Lobo, Lucas Soares Marcucci-Barbosa, Saulo da Cunha Machado NunoDomingosGarrido, Paulo Francisco de Almeida-Neto , Victor Machado Reis, Érica Leandro Marciano Vieira, Breno Guilherme de Araújo Tinoco Cabral , José Vilaça-Alves and Walderi Monteiro	Pasquale Imparto , Italo Sannicandro, Riccardo Izzo, Sara Aliberti, Tiziana D'isanto	Haeun Park, PT, BPT, Joon Young Chang, MSc, PT, Jongseok Hwang, PhD, PT, Young Hee Lee, PhD, MD, Joshua (Sung) Hyun You, PT, PhD	Felipe J. Aidar, Wélia Yasmin Horacio dos Santos Albená Nunes-Silva, Érica Leandro Marciano Vieira, Saulo da Cunha Machado, Diego Ignácio Valenzuela Pérez Esteban Aedo-Muñoz, Ciro José Brito andPantelis T. Nikolaidis

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	da Silva Júnior , Albená Nunes-Silva			
AIM	Evaluates different post – workout recovery methods in national level Paralympic powerlifting athletes	To investigate if disabled and not-disabled athletes can derive performance benefits and if it is possible to reduce the gap between the competition times between athletes, through a single, performance and training activity	To evaluate the demographic and clinical characteristics of injured athletes and non-athletes and analyse the Physiotherapy services provided	To assess the effects of various post-training recovery methods on muscle damage and strength indicators in Paralympic powerlifting athletes
METHODS	P – 12 male National - level Paralympic powerlifters I - Passive recovery (PR), Dry needling (DN), Cold – Water immersion (CWI). C – Effectiveness of these recovery methods in comparison to one another. O – Changes in physiological and biochemical markers including maximal isometric force, muscle thickness,	P – 12 athletes including 6 with disabilities (S2 category) and 6 non – disabled athletes skilled in backstroke swimming. I – an 8 week training program combining High – Intensity Interval Training (HIIT), Tabata training and Pilates with additional physiotherapy sessions for disabled athletes to improve joint range of motion.	P – Athletes and non – athletes (coaches, Paralympic family members, staff) at PyeongChang 2018 Winter Paralympic Games who utilized Physiotherapy services. I – Physiotherapy services including manual therapy, Transcutaneous electrical nerve stimulation (TENS), massage, therapeutic exercise and Cryotherapy. C – Different injury types and Ph	P - Paralympic powerlifting athletes. I – Cold – water immersion (CWI) as post – training recovery method. C - Passive recovery (PR) O – Improved post – training muscle recovery, reduction in pro –inflammatory blood immune markers, increased anti – inflammatory markers and better maintenance of static strength indicators (MIF).

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	cytokine levels and pain thresholds over 48 hours post – exercise. T - Measurements taken before, immediately after and at 2, 24 and 48 hours post – recovery intervention.	C – performance differences before and after training between disabled and non – disabled athletes. O - although performance improved in all athletes, the time gap between disabled and non – disabled swimmers remained significant. Stroke efficiency was the most influential factor in swimming performance. T – the study lasted 8 weeks with pre- and post-training performance assessments.	ysiotherapy treatments among athletes and non – athletes. O – chronic injuries were most common (51% in athletes, 47% in non – athletes). The most frequently injured sites were the spine and shoulder. Physiotherapy services particularly manual therapy were widely utilized. T – data were collected from March 1 to March 20, 2018 covering the pre – competition and post – competition periods.	T – Assessments before, immediately after and at 2, 24, and 48 hours post –recovery intervention.
RESULTS AND DISSEMINATION	CWI helped restore strength levels faster than PR or DN, with an increase in force 24 hours after training. CWI and DN increased Interleukin 2 (IL-2) levels from 24 to 48 hours. After	All athletes showed improvements in swimming times. Disabled athletes showed greater motivation and better progress than non – disabled athletes. However the performance	The physiotherapy treatment service analysis demonstrated that manual therapy was most commonly utilized, followed by transcutaneous electrical nerve stimulation/interference current therapy (TENS/ICT),	CWI significantly improved post – training muscle recovery with better maintenance of maximum isometric force after 48 hours compared to passive recovery.

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	DN, muscle thickness did not increase significantly in any of the muscles and after 2 h, muscle thickness decreased significantly again in the major pectoralis muscle. After CWI, pain pressure stabilized after 15 min and increased significantly again after 2 h for acromial pectoralis. Thus it emphasizes the benefits of CWI in Paralympic powerlifting recovery protocol.	gap between disabled and non – disabled athletes remained substantial. Therefore this study indicated that while all athletes improved their performance, the stroke rate remained the most influential factor in time differences.	therapeutic massage and therapeutic exercise. However the study underscores the importance of preventive physiotherapy services in managing and reducing injuries in Paralympic athletes.	Thus the findings emphasize the potential of CWI as an effective recovery strategy for paralympic athletes.
CONCLUSION	CWI was the most effective recovery method for maintaining maximal force levels 24hours post – exercise. DN significantly increased IL – 2 levels and showed moderate effects on pain and muscle thickness, while PR was less effective overall.	While the training program improved performance for both groups, it did not eliminate the performance gap. However disabled athletes reported increased and engagement highlighting the psychosocial benefits of inclusive training programs.	The study highlights the importance of preventive physiotherapy services to reduce injury risks in Paralympic athletes as there is high prevalence of chronic injuries. Therefore the study suggested that pre – competition physiotherapy may have contributed to a lower incidence of traumatic injuries during games.	CWI demonstrated significant benefits in maintaining strength levels and reducing muscle damage at 24 and 48 hours post – exercise compared to Passive recovery. This suggests that CWI can be an effective method for enhancing recovery in Paralympic athletes.

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3. RESULTS AND DISSEMINATION

This Literature review stated that Physiotherapy provides numerous benefits by improving their flexibility, strength, endurance and also preventing injuries. This search mainly focuses on few physiotherapy interventions that are benefiting the Paralympic athletes. Studies on CWI and DN suggested the targeted recovery strategies can enhance muscle recovery and pain management in power lifters. Similarly, the research on inclusion in swimming indicates that performance gaps exist and combined training programs improve physical and psychological outcomes in disabled athletes. Finally, the Physiotherapy framework from PyeongChang Paralympics underscores the need for proactive Physiotherapy to minimize injury risks.

However there are limited studies regarding the role of a Physiotherapist in team functioning and athletic performance in paralympic athletes. Also there is limited exploration of benefits of Physiotherapy for specific disabilities. In the light of these considerations Randomised controlled trials are needed to establish the causality between physiotherapy and its benefits in paralympic athletes. Research on novel physiotherapy interventions such as virtual reality and gaming and long – term follow – up studies are needed to investigate the sustainability of physiotherapy interventions in paralympic athletes.

4. CONCLUSION

This review states the benefits of physiotherapy treatment and rehabilitation in overall outcomes, injury prevention and sports performance of paralympic athletes. Thus sports recovery and Physiotherapy play a crucial role in improving performance in Paralympic and adaptive sports. Cold water immersion and dry needling are effective recovery methods to strengthen athletes, while Physiotherapy services are essential in Paralympic athletes.

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IMPACT OF COMBINED LOW-INTENSITY PLYOMETRIC AND AEROBIC TRAINING ON POWER PERFORMANCE

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ABSTRACT

The present study aimed to examine the effects of low-intensity Plyometric Training combined with Aerobic Training on power performance. To achieve this objective, forty-five schoolboys from The Madurai Diraviyam Thayumanavar Hindu College Higher Secondary School, Tirunelveli, were randomly selected as subjects. Their age group ranged between 13 to 17 years. The study followed a pre-and post-test random group design, dividing the forty-five participants into three equal groups. The experimental group-1 (n=15, LI-PT) underwent low-intensity Plyometric Training, while experimental group-2 (n=15, LI-PT-AT) participated in low-intensity Plyometric Training combined with Aerobic Training. The third group, serving as the control group (n=15, CG), did not engage in any specific training. In this study, two training programs—low-intensity Plyometric Training and low-intensity Plyometric Training combined with Aerobic Training—were introduced as independent variables. Power was selected as the dependent variable, measured through the standing broad jump, with performance recorded in meters. Both experimental groups followed their respective training programs three times a week for eight weeks, alternating between low-intensity Plyometric Training and the combined training regimen. The power performance of the participants was assessed before and after the training period. The collected pre- and post-test data were analyzed using Analysis of Covariance (ANCOVA) to determine significant adjusted post-test mean differences among the three groups. Additionally, Scheffe's post hoc test was applied for pairwise comparisons between the groups. To test the hypothesis, a 0.05 level of significance was established in this study. The results demonstrated that the selected training interventions led to a significant improvement in power performance compared to the control group, which did not show any notable enhancement.

Key Words: Plyometric Training, Aerobic Training, Low Intensity, ANCOVA, Power.

1. INTRODUCTION

Athletics is a collection of sports that includes competitions such as running, jumping, throwing, and walking. The most common types of athletics competitions include track and field, road running, race walking, cross-country running, mountain running, and trail running. An athlete is an individual who excels in a sport and competes in one or more events that demand physical strength, speed, and endurance. Given the significance of athletic performance, the researcher aimed to investigate the effects of low-intensity plyometric training combined with aerobic training on power performance. Plyometrics consists of training drills designed to enhance an athlete's ability to bridge the gap between sheer strength and the power required for explosive, reactive movements. This is particularly evident in activities such as jumping, throwing, and sprinting. Plyometric drills involve quick, powerful movements using a pre-stretch or countermovement that utilizes the stretch-shortening cycle. Classical plyometric exercises include various types of jump

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training and upper body drills using medicine balls (Baechle, 2000). Aerobic metabolism plays a crucial role in human performance and is fundamental to all sports, primarily due to its role in recovery. Metabolically, the Krebs cycle and electron transport chain serve as the primary pathways for energy production. Aerobic metabolism produces significantly more ATP energy compared to anaerobic metabolism and utilizes fats, carbohydrates, and proteins as energy sources (Dudley, 1985). Power is a key factor in achieving optimal performance and is defined as the ideal combination of speed and strength required for movement (Chu, 1998). It is the ability to propel the body or an object through space (or to perform work within a given time). Power is essential in jumping activities (projecting the body), throwing and putting events (projecting an object), as well as maximum striking and sprinting. Increased strength enhances the ability to apply force; therefore, if velocity remains constant, an increase in strength contributes to greater power (Jensen, Schultz, & Bangerter, 1984).

2. METHODOLOGY

This study aimed to examine the effects of low-intensity Plyometric Training combined with Aerobic Training on power performance. To accomplish this, forty-five schoolboys from The Madurai Diraviyam Thayumanavar Hindu College Higher Secondary School, Tirunelveli, Tamil Nadu, were selected as subjects. Their age group ranged between 13 to 17 years.The participants were randomly divided into three equal groups of fifteen each. Experimental group-1 (n=15, LI-PT) underwent low-intensity Plyometric Training, while experimental group-2 (n=15, LI-PT-AT) engaged in low-intensity Plyometric Training combined with Aerobic Training. The third group, serving as the control group (n=15, CG), did not undergo any specific training.The selected two treatment groups followed their respective training programs three days a week for a period of eight weeks, adhering to the structured training regimen outlined below.

TRAINING APPROACHES EXPERIMENTAL GROUP I: LOW INTENSITY PLYOMETRIC TRAINING (LI-PT)

Exercise	Repetition	Set	Recovery in between exercise	Recovery in between sets
1-2 Weeks				
1. Box jump 2. Lateral Bound 3. Broad Jump 4. Split Squat Jump 5. Single – leg - Hop	Each 6	2	1 minute	3 minutes
3-4 Weeks				
1. Box jump 2. Lateral Bound 3. Broad Jump 4. Split Squat Jump 5. Single – leg - Hop	Each 8	2	1 minute	3 minutes
5-6 Weeks				
1. Box jump 2. Lateral Bound 3. Broad Jump	Each 10	2	1 minute	3 minutes

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4. Split Squat Jump 5. Single – leg - Hop				
7-8 weeks				
1. Box jump 2. Lateral Bound 3. Broad Jump 4. Split Squat Jump 5. Single – leg - Hop	Each 12	2	1 minute	3 minutes

EXPERIMENTAL GROUP II LOW INTENSITY PLYOMETRIC TRAINING COMBINED WITH AEROBIC TRAINING (LI-PT-AT)

Exercise	Repetition	Set	Recovery in between exercise	Recovery in between sets
1-2 Weeks				
Plyometric Training 1. Box jump 2. Lateral Bound 3. Broad Jump 4. Split Squat Jump 5. Single – leg - Hop	Each 6	2	1 minute	3 minutes
Aerobic Training 1 minute jog and 1 minute walk	5	2	2	3 minutes
3-4 Weeks				
Plyometric Training 1. Box jump 2. Lateral Bound 3. Broad Jump 4. Split Squat Jump 5. Single – leg - Hop	Each 8	2	1 minute	3 minutes
Aerobic Training 1.5 minute jog and 1.5 minute walk	5	2	2	3 minutes
5-6 Weeks				
Plyometric Training 1. Box jump 2. Lateral Bound 3. Broad Jump 4. Split Squat Jump 5. Single – leg - Hop	Each 10	2	1 minute	3 minutes
Aerobic Training 2 minute jog and 2 minute walk	5	2	2	3 minutes
7-8 Weeks				
Plyometric Training 1. Box jump	Each 12	2	1 minute	3 minutes

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2. Lateral Bound 3. Broad Jump 4. Split Squat Jump 5. Single – leg - Hop				
Aerobic Training 2. 5 minutes jog and 2.5 minutes walk	5	2	2	3 minutes

3. ANALYSIS OF THE DATA

To determine any significant differences among the adjusted post-test means for the selected criterion variables, **Analysis of Covariance (ANCOVA)** was employed. When the F-ratio for the adjusted post-test mean was found to be significant, **Scheffe's test** was conducted as a post-hoc test to identify specific group differences. For statistical analysis, the level of significance was set at **0.05 level of confidence**, ensuring the validity of the F-ratio obtained through ANCOVA.

TABLE I THE RESULTS OF ANALYSIS OF COVARIANCE AND "F" RATIO ON POWER OF DIFFERENT GROUPS (Scores in seconds)

Test Conditions		G- 1 LI-PT	G- 2 LI–PTAT	G- 3 CG	SV	SS	Df	MS	F Ratio
Pre test	Mean	2.21	2.20	2.22	Between	0.002	2	.001	0.74
	S.D ±	.10053	.10077	.10365	Within	.434	42	010	
Post test	Mean	2.35	2.33	2.21	Between	.161	2	.081	10.82
	S.D ±	.07181	.7689	.10629	Within	.313	42	.007	
Adjusted post test	Mean	2.351	2.336	2.208	Between	.184	2	.092	24.02
					Within	.035	41	.004	

*Significant at .05 level of confidence. The required table value for test the significance was 3.22and 3.21, with the df of 2 and 42, 2 and 41.

4. RESULTS - I

Table – I shows that the pre test mean and standard deviation on powerscores G1, G2, and G3 were 2.21 ± .10053, 2.20 ± .10077 and 2.22± .10365 respectively. The obtained pre test F value of .074 was lesser than the required table F value 3.22. Hence the pre test means value of low intensity plyometric training, low intensity plyometric training combined with aerobic training and control group on the performance of power before start of the respective treatments were found to be insignificant at 0.05 level of confidence for the degrees of freedom 2 and 42. Thus this analysis confirmed that the random assignment of subjects into three groups were successful. The post test mean and standard deviation on power of G1, G2 and G3 were 2.35 + .07181, 2.33 + 0.42 and 2.21 + .10629 respectively. The obtained post test F value of 10.82 was higher than the required table F value of 3.22. Hence the post test means value of low intensity plyometric training, low intensity plyometric training combined with aerobic training on the performance of power were found to be significant at 0.05 level of confidence for the degrees of freedom 2 and 42. The results prove that selected two training interventions were produced significant improvement rather than the control group. The adjusted post test means on power scores of G1, G2 and G3 were 2.351, 2.336 and

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2.208 respectively. The obtained adjusted post test F value of 24.04 was higher than the required table F value of 3.21. Hence the adjusted post test means value of low intensity plyometric training, low intensity plyometric training combined with aerobic training on the performance of power were found to be significant at 0.05 level of confidence for the degrees of freedom 2 and41. The results confirm that the selected two training interventions were produced significant difference among the groups. In order to find out the superiority effects among the treatment and control groups the Seheffe‘s post hoc test were administered. The outcomes of the same are presented in the table I (a).

TABLE - I (a) SCHEFFE"S POST HOC TEST MEAN DIFFERENCES ON POWER AMONG THREE GROUPS (Scores in seconds)

G-1 LI-PT	G- 2 LI-PT-AT	G- 3 C G	Mean Differences	Confidence Interval Value
2.351	2.336		.015	0.03
2.351		2.208	.143*	0.03
	2.336	2.208	.128*	0.03

* Significant at .05 level of confidence.

5. RESULT – II

Table I (a) shows the paired mean differences of low intensity plyometric training, low intensity plyometric training combined with aerobic training and control group on power. The paired wise comparisons results as follows. First comparison: Group1 and 2: The pair wise mean difference of group 1 and group 2 values .015 was lesser than the confidential value of 0.03 Hence the first comparison was insignificant. The results of this comparison clearly proved that both training have produced similar effects on power. Second comparison: Group 1 and 3: The pair wise mean difference of group 1 and group 3 values .143 was higher than the confidential value of 0.03. Hence the second comparison was significant. The results of this comparison clearly proved that low intensity plyometric training, have produced greater improvements on power than the control group. Third comparison: Group 2 and 3: The pair wise mean difference of group 2 and group 3 values .128 was higher than the confidential value of 0.03. Hence the third comparison was significant. The results of this clearly proved that low intensity plyometric training combined with aerobic training have produced greater improvements on power than the control group.

6. DISCUSSION ON FINDINGS

The results of the present study demonstrate a positive effect of low-intensity plyometric training and low-intensity plyometric training combined with aerobic training on power performance. These findings align with previous research studies that have investigated the impact of plyometric and agility training on athletic performance.

Supporting Studies:

1. Ahmed Fadhil Farhan (2014) conducted a study on the impact of a plyometric training program on physical performance in girls aged 12 to 15 years. The results showed that a six-week plyometric training program significantly enhanced physical performance in the experimental group, whereas the control group, following a usual training program, exhibited no significant improvements in performance.

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2. Young et al. (2001) examined the effects of agility, plyometric, and sprint training on speed, endurance, and power in high school soccer players. Their findings indicated that straight speed and agility training methods are highly specific and result in limited transfer effects to other physical attributes. These findings emphasize the importance of designing targeted power and agility training programs to optimize athletic performance.

Implications of the Study:

- The results confirm that both low-intensity plyometric training and low-intensity plyometric training combined with aerobic training are effective strategies for improving power performance in adolescent athletes.
- The combined training approach (LI-PT-AT) did not significantly differ from LI-PT alone, suggesting that both methods are equally beneficial for power enhancement.
- The findings support the need for structured plyometric training programs in youth athletic development, reinforcing their role in enhancing explosive strength and overall performance.

7. CONCLUSIONS

The findings of this study indicate that both low-intensity plyometric training (LI-PT) and low-intensity plyometric training combined with aerobic training (LI-PT-AT) significantly improved power performance in school-going athletes compared to the control group.Furthermore, both experimental groups demonstrated similar levels of improvement**,** suggesting that plyometric training alone is as effective as its combination with aerobic training in enhancing power**.** In contrast, the control group did not show any significant improvement, confirming the necessity of structured training interventions for developing power performance in young athletes. These results emphasize the importance of incorporating plyometric training into athletic programs to enhance explosive strength and overall sports performance.

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OPTIMIZING YOUTH FOOTBALL TRAINING: A SYSTEMATIC REVIEW OF SMALL SIDED GAMES AND IMPACT ON PERFORMANCE

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ABSTRACT

Small-sided games (SSGs) are widely utilized in youth football training to enhance both technical and physical performance. These modified game formats increase ball interaction, promote high-intensity play, and improve skill execution by replicating real-match conditions. Despite their widespread use, the specific effects of different SSG formats on performance outcomes in youth players remain unclear. This systematic review examines the impact of SSGs on technical (passing, dribbling, shooting) and physical (speed, endurance, agility) performance in youth football players (U12-U18). A systematic literature search was conducted in PubMed, Web of Science, Google Scholar, and Semantic Scholar, identifying 136 studies. After screening based on inclusion and exclusion criteria, 16 studies were selected for analysis. Study selection followed the PRISMA 2020 guidelines, and methodological quality was assessed using the Revised Cochrane Risk of Bias Tool (RoB 2). 10 studies were classified as low risk of bias, while 6 had some concerns. Findings indicate that smaller SSG formats (2v2, 3v3) significantly improved passing accuracy, ball control, and dribbling, while larger formats (5v5) enhanced structured gameplay and endurance. Speed and agility gains were highest in younger players (U12-U14), whereas older players (U16-U18) showed greater strength improvements. Endurance benefits varied across studies, suggesting a need for further investigation. SSGs are an effective training method for developing both technical and physical attributes in youth football. Coaches should tailor SSG formats to age-specific needs and training objectives to maximize player development. Future research should explore long-term adaptations to SSG training and the impact of rule modifications on performance outcomes.

Keywords: Small-Sided Games, Youth Football, Technical Performance, Physical Performance, Football Training.

1. INTRODUCTION

Background:

Small-sided games (SSGs) are a key training method in modern football, especially for youth development, enhancing skill acquisition, decision-making, and fitness through fewer players, smaller pitches, and adapted rules. Unlike full-sized matches, SSGs increase ball touches, game-related scenarios, and individual involvement while replicating match conditions. Coaches and sports scientists use them to improve skills and conditioning in a controlled setting, adjusting pitch size, player numbers, and constraints to target specific technical and physical aspects.

Importance of Youth Football Development:

Youth football is a critical stage for skill acquisition and physiological development, where structured training programs significantly impact long-term performance outcomes. Developing technical abilities such as passing, dribbling, and shooting at a young age enhances a player's ability to progress through competitive levels. Similarly, physical attributes like speed, endurance, and agility play a vital role in determining match success.

Traditional training methods often focus on isolated drills that lack the dynamism of real game scenarios. SSGs bridge this gap by integrating technical, tactical, and physical demands into a single format. Players engage in repeated high-intensity actions, develop situational awareness, and refine decision-making skills—all within an environment that mimics actual match play.

Theoretical Foundations and Technical-Physical Demands of SSGs

SSGs in football training are supported by various theories. The Ecological Dynamics Theory highlights how player-environment interactions shape skill development, while Nonlinear Pedagogy emphasizes adaptable learning environments where constraints like pitch size and player numbers foster creativity. Empirical research reinforces these benefits—

Clemente et al., (2021) found that smaller formats (e.g., 3v3) enhance technical skills through increased ball involvement, whereas larger formats (e.g., 5v5) improve tactical awareness and aerobic capacity.

The technical and physical demands of SSGs vary with format. Smaller games (e.g., 2v2, 3v3) promote tight-space play, rapid decision-making, and frequent ball touches, while larger formats (e.g., 5v5, 6v6) mirror traditional match conditions, enhancing off-the-ball movement, positioning, and teamwork. SSGs also develop endurance, agility, and quick transitions through high-intensity movement patterns, making them an effective training tool for holistic player development.

This paper systematically reviews the impact of SSGs on youth football development, outlining the methodology for data collection, inclusion criteria, and bias assessment. The results section presents key findings, followed by a discussion comparing them with existing literature, and a conclusion highlighting practical training implications and future research directions. Despite widespread use, a comprehensive analysis of SSG effects on both technical and physical performance across age groups is limited. By consolidating existing research, this study provides valuable insights to help coaches optimize training for player development.

2. RESEARCH OBJECTIVES

This systematic review aims to:

1. Analyze the impact of SSGs on technical performance (e.g., passing, dribbling, shooting). 2. Evaluate the physical fitness benefits of SSGs (e.g., endurance, speed, agility). 3. Identify the most effective SSG formats for different age groups in youth football. 4. Provide evidence-based recommendations for coaches and sports scientists.

3. METHODOLOGY

Search Strategy

A systematic literature search was conducted using four major academic databases: PubMed, Web of Science, Google Scholar, and Semantic Scholar. The search included studies focused on the effects of small-sided games (SSGs) on technical and physical performance in youth football players.

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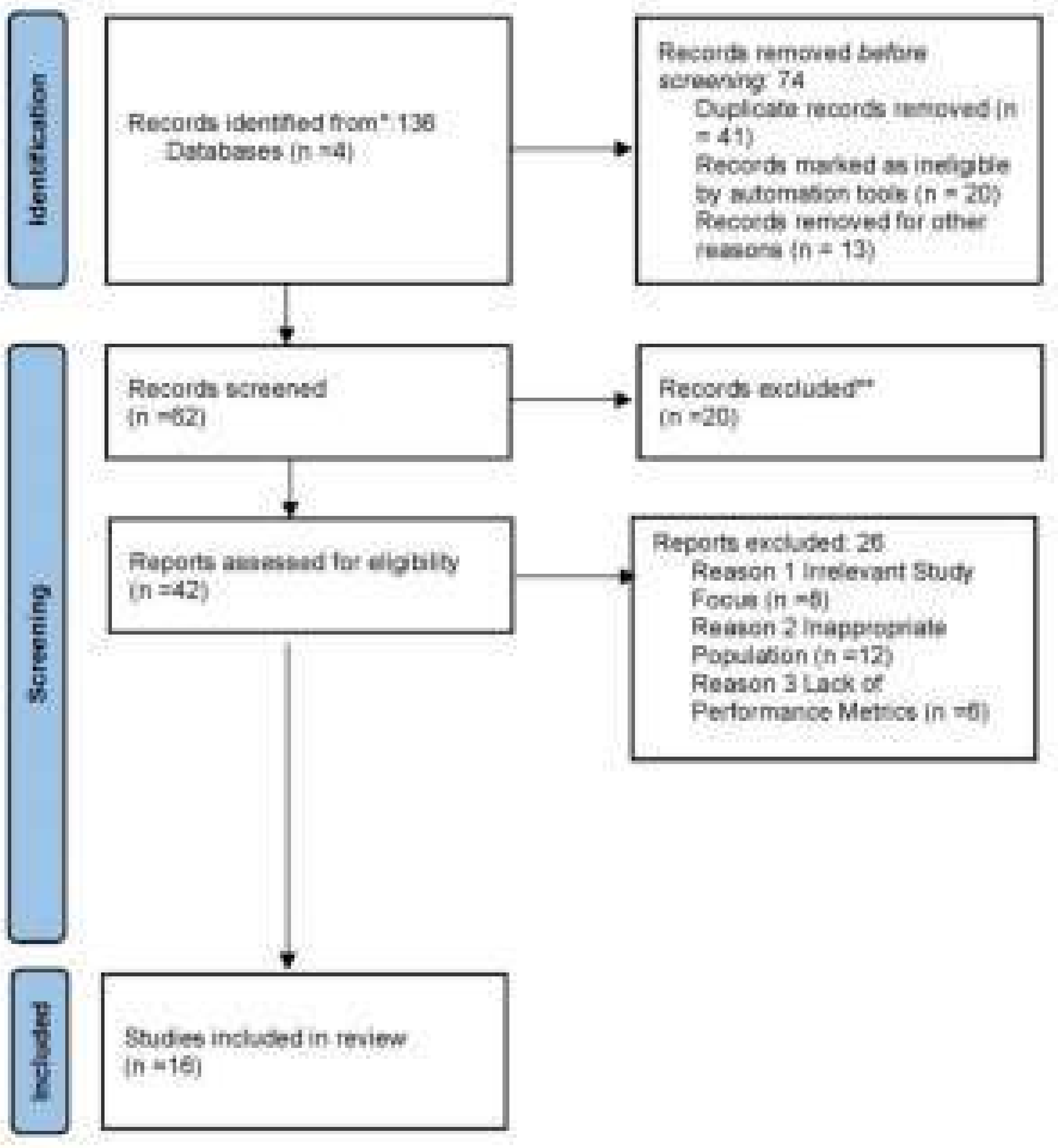
Study Selection and Eligibility Criteria

A total of 136 studies were identified, with 16 meeting the inclusion criteria after screening and eligibility assessment. Exclusions were based on study focus, population, and lack of performance metrics. The selection process is detailed in the PRISMA 2020 flow diagram



Data Extraction and Synthesis

A structured data extraction table was created to summarize key study characteristics, including study design, sample size, age group, SSG format, technical performance outcomes physical performance outcomes, and key findings. Extracted data were analyzed to identify common trends and patterns in technical and physical adaptations to SSG training.

Table 1: Summary of Key Study Characteristics

Authors (Year)	Sample Size	Age Group	SSG Format	Technical Performance	Physical Performance	Key Findings

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Práxedes A, et al. (2018)	19	10 – 12	3v3, 4v4, 5v5	Passing		Improved passing skills
Young & Warren (2023)	36	14-16	1v1, 2v2, 3v3	Dribbling, Ball control, Passing	Agility, Sprint speed, Explosive Power	Improved agility, Sprint speed, Explosive power
Clemente et al. (2021)	38	15 - 18	2v2, 3v3, 4v4	Ball control	Sprint speed, Jumping ability, Agility, Endurance, Balance	Improvement in Sprint speed, Jumping ability, Agility, Endurance, Balance
Ben Rached Yacine, Rabouh Salah (2021)	20	Under 17	5v5	Offensive movements, Passing		Enhanced Offensive movements and Passing
Chaouachi et al. (2014)	36	13 - 15	1v1, 2v2, 3v3	Ball control	Sprint times, Change of direction, Jumping ability, Reactive agility	Improved Sprint times, Change of direction, Jumping ability
Bahtra et al. (2023)	20	Under 15	5v5		Endurance	Improved aerobic endurance
Putra et al. (2024)	80	Under 12	5v5	Passing, Dribbling, Shooting	First touch, passing, and shooting accuracy	First touch, passing, and shooting accuracy improved
Jumareng et al. (2024)	24	16 - 18	3v3	Dribbling, Passing, Shooting	Sprint, Agility, Endurance	Improved in both technical and Tactical Performance
Athanasios Katis, Eleftherios	34	12 - 14	3v3, 6v6	Dribbling, Shooting,	Sprint speed, Jump	3v3 had more short passes,

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Kellis (2009)				Heading, Tackling, Passing	Performance, Agility, Endurance	dribbles and tackles
Jorge López Fernández et al. (2020)	63	U14, U16, U18	3v3		Acceleration	Older players (U16, U18) performed better than U14
M. Karahan (2020)	22	12 - 18	5v5		Sprint, Agility, Countermovement Jump	SBT showed greater improvements
Wang et al. (2024)	24	15 - 17	2v2, 4v4	Passing Accuracy		2v2 better passing accuracy than 4v4
Yiannis Michailidis (2024)	16	14 - 16	2v2, 3v3, 4v4	Total Distance Covered	Acceleration, Aerobic conditioning	4v4 and 3v3 SSGs are optimal for aerobic conditioning
Ansori et al. (2024)	30	15 - 17	2v2, 3v3, 4v4, 5v5		Anaerobic Endurance	Both SSG and HIIT significantly improved anaerobic endurance
Clemente et al. (2022)	20	15 - 17	3v3, 5v5	Peak Speed, Acceleration, Distance Covered		SSGs had more acceleration
Clemente et al. (2022)	40	15 - 17	2v2, 4v4	Sprint Speed, 420Agility	Aerobic fitness	SSG improved agility and change-of-direction more than HIIT

Risk of Bias Assessment

The Revised Cochrane Risk of Bias Tool (RoB 2) was applied to assess the methodological quality of the included studies. Of the 16 included studies, 10 were classified as low risk of bias, while 6 had some concerns, primarily due to issues with randomization and deviations from intervention protocols. No studies were classified as high risk of bias, ensuring that all included studies maintained a reasonable level of methodological rigor.

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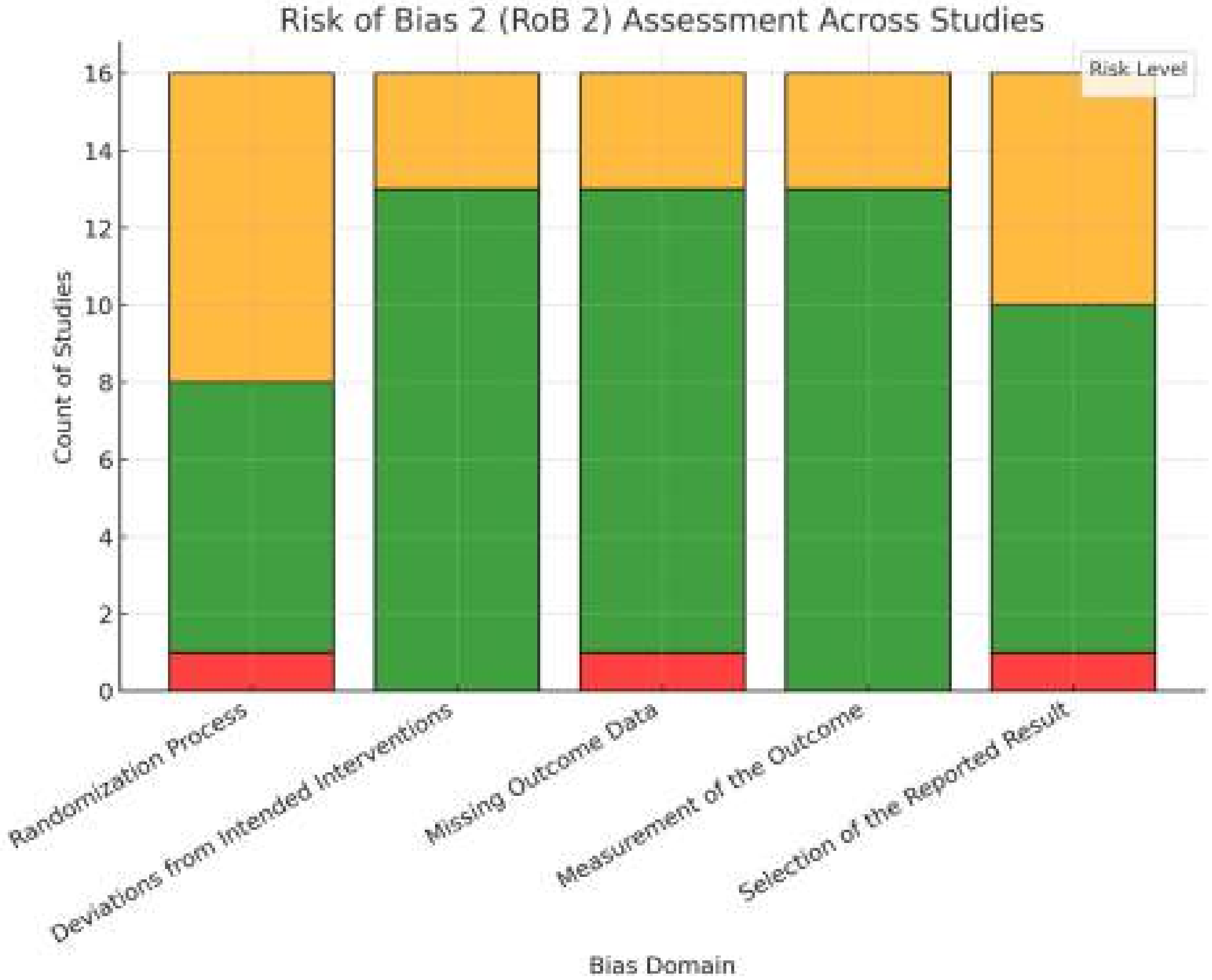
Figure 1 Risk of Bias 2 (RoB 2) Assessments Across Studies



This structured approach ensured a transparent and reproducible methodology for evaluating the effectiveness of SSGs in youth football training.

4. DISCUSSION

The analysis of 16 studies highlights consistent benefits of small-sided games (SSGs) on both technical and physical performance in youth football players.

Technical Performance: Smaller formats (2v2, 3v3) significantly improved passing accuracy and ball control due to increased touches and decision-making. Dribbling was enhanced in 3v3 and 4v4 games with frequent one-on-one situations, while shooting accuracy improved in 5v5 formats, where structured play simulated real match conditions.

Physical Performance: High-intensity movements in smaller SSGs (2v2, 3v3) led to better acceleration and agility, whereas larger formats (5v5) improved endurance through prolonged ball possession and positional play. Strength and power gains were noted in studies incorporating multidirectional sprints within SSG training.

A risk of bias assessment found 10 studies to be low risk, with six showing minor concerns due to unclear randomization or deviations in intervention protocols. No studies were classified as high risk, ensuring reliable findings.

These results align with previous research. Clemente et al., (2021) and Sarmento et al., (2018) confirm SSGs enhance passing and dribbling due to frequent ball involvement and decision-making. Hill-Haas et al., (2011) highlight how rule modifications, such as touch restrictions, refine

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shooting and control. For physical development, Jones et al., (2013) found small formats improve agility, while Rebelo et al., (2016) showed that 5v5 games boost aerobic conditioning. Additionally, Young et al., (2013) emphasize multidirectional sprints enhance power and acceleration.

However, variability in study methodologies—such as differences in training protocols, session durations, and player fitness levels—limits direct comparisons. Endurance improvements were inconsistent, suggesting that while SSGs contribute to aerobic conditioning, supplementary fitness training may be necessary.

Future Research Directions:

· Assess long-term adaptations to SSG training.

· Identify optimal SSG formats for different age groups.

· Explore rule modifications to enhance skill transfer and fitness adaptation. Overall, SSGs provide an effective and adaptable training method. Coaches should strategically implement different formats to optimize youth player development based on age and training objectives

5. CONCLUSION

This review confirms that small-sided games (SSGs) are an effective training tool for enhancing technical and physical performance in youth football. Smaller formats (2v2, 3v3) improved passing accuracy, ball control, and dribbling, while larger formats (5v5) enhanced shooting accuracy and decision-making.

SSGs also contributed to agility, speed, and endurance, with younger players (U12-U14) adapting better to endurance-based training and older players (U16-U18) showing greater strength and sprint improvements. However, endurance benefits varied, highlighting the need for further research on long-term conditioning effects.

Methodological quality was strong, with 10 studies rated as low risk and 7 with minor concerns, mainly related to randomization. While SSGs are highly effective, variability in formats and assessment methods limits broad conclusions. Future research should examine long term impacts and rule modifications to optimize training outcomes.

Overall, SSGs offer a flexible and efficient approach to youth football training. Coaches should tailor formats to player age and training goals, while continued research will help refine methodologies and enhance development programs.

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A STUDY ON SERVICE EFFECIENCY TESTS FOR VOLLEYBALL MEN PLAYERS OF MANGLORE UNIVERSITY

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ABSTRACT

Volleyball game is a very prominent game played all over the world. It is an excellent all round team sports and it has been widely accepted as a highly competitive and recreation game throughout the world. It can be played by men, women and children of all ages with a minimum of expense and effort. The game itself is stimulating mentally and physically, and it combines the values of an individual and team sports. The purpose of the study is to find out the service efficiency of volleyball men players under the Mangalore University. The total numbers of samples 30 and the age of the subject were ranged from 18 to 25. The collected data were tabulated for the purpose of analysis. Mean, standard deviation and coefficient of variation was used, and results were represented by using appropriate figures and tables. The researcher found that the overhead service is better than the Jump and service and Floating service, under arm service, because of service are the Advance skills of the volleyball.

Keywords: volleyball, service efficiency.

1. INTRODUCTION

The game of Volleyball plays an important role in the development of fitness. It is an excellent all round team sports and it has been widely accepted as a highly competitive and recreation game throughout the world. It can be played by men, women and children of all ages with a minimum of expense and effort. The game itself is stimulating mentally and physically, and it combines the values of an individual and team sports.Most of the games played now-a-days nationally give enjoyment but also help to develop physical fitness and skills. Most Indian people in our country have become sick due to lack of physical fitness. Volleyball is an Olympic sport in which two teams separated by a high net, hit a ball back and forth over the net between the teams. Each team is allowed three hits to get the ball over the net to the other team. A point is scored if the ball hits the ground in the opponent's court, if the opponent's commit a fault, or if they fail to return the ball properly. Keith Nicholas (1973) observed that volleyball is an action-oriented game with none of the players acting as an involuntary spectator for a part of the game as in the other team games such as football, Volleyball and netball.

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2. METHODOLOGY

This study examines the service efficiency of Mangalore University male volleyball players.

Selection of subject & test items

A total of 30 players representing the university were selected for the study. The AAHPER service efficiency test was used, where each player had 10 attempts to serve into designated scoring zones on a standard volleyball court. The test included:

1. Jump Serve
2. Underarm Serve
3. Overhead Serve
4. FloatingServe

Procedure for Data Collection & Test Administration

The researcher, with a trained assistant, collected data from 25 selected colleges under Mangalore University. The study followed an empirical approach, and prior permission was obtained from institutional authorities. The AAHPER service efficiency test was used to assess players' serving abilities.

Test Administration

• Each player had 10 service attempts from behind the service line.
• The ball had to be served over the net into designated scoring zones. • Scoring: Points were awarded only for serves landing in the scoring areas. No extra points were given for merely hitting the ball or sending it over the net.
• Total Score: The sum of points from all 10 serves determined the player's service efficiency

Service

Objective; to measure the ability to serve the volleyball low and deep into the Opponent's court.

Equipment: Well inflated approved size of volleyballs, net, chalk powder, measuring tape and scoring sheets are required for data collection.

Test area: Standard volleyball court.

Description of Markings: the standardized volleyball court is chose. The court is divided into 9 zones, with 3X3 meter square as shown in figure – 1 Score: Maximum scoring points is 50.

Scoring: Players earned points based on successful serves landing in scoring areas, with a maximum score of 50 points.

Statistical Analysis

The study utilized Mean, Standard Deviation, and Coefficient of Variation to analyse service efficiency among Mangalore University men's volleyball players. These statistical techniques were used to test the hypothesis and determine significant differences in service efficiency. The collected data were systematically tabulated and analysed using appropriate formulas.

3. ANALYSIS AND INTERPRETATION OF DATA

The study aimed to develop skill tests for different volleyball service techniques, including jump serve, floating serve, underarm serve, and overhead serve. The objective was to assess and standardize service efficiency among intercollegiate men's volleyball players aged 18

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to 27 years from Mangalore University. Data were collected from 30 players under identical conditions using well-constructed skill and criterion tests

Table 4.1

The statistical value for service efficiency test of volleyball men players of Mangalore University

Service Type	Mean Score	Standard Deviation	Coefficient of Variation
Jump Serve	30.666	4.716	15.379
Floating Serve	31.417	3.204	10.198
Underarm Serve	34.545	2.769	8.018
Overhead Serve	35.636	2.203	6.55

Table 4.1 reveals that among the four service types, overhead service has the highest mean value, indicating better performance. It also has the lowest coefficient of variation, making it the most efficient and consistent among the tested service techniques.

4. CONCLUSIONS

1. The overhead service is better than the Jump and service and Floating service, under arm service, because of service are the Advance skills of the volleyball.
2. The Jump and service and Floating service skills are very poor it can be improved through the training and coaching the students.

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A STUDY ON CONTRIBUTION OF COASTAL KARNATAKA WRESTLING CLUBS TOWARDS KARNATAKA STATE WRESTLING

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ABSTRACT

This research paper examines the contributions of coastal Karnataka wrestling clubs to the overall performance of wrestlers in Karnataka state. The study begins with an extensive historical overview of wrestling, tracing its origins and evolution across various cultures, particularly highlighting Indian wrestling traditions and their significance. It identifies the Wrestling Federation of India (WFI) and state-level associations, such as the Karnataka State Wrestling Association (KSWA), as key governing bodies in the sport's administration. The methodology includes the selection of 15 wrestling clubs from three districts in coastal Karnataka namely Dakshina Kannada, Udupi, and Uttar Kannada. The collection of data through a self-constructed questionnaire focused on performance metrics and training dedication. The analysis employs descriptive statistics and ANOVA to evaluate the data, revealing that Dakshina Kannada wrestlers exhibit the highest performance scores on average. However, the study finds no statistically significant differences in performance across the districts, suggesting uniform contributions to the state's wrestling development. The findings underscore the need for improved support from the Karnataka State Wrestling Association to enhance the uniformity of resources and training across all districts, thus facilitating the production of wrestlers capable of competing at national and international levels.

Keywords: Wrestling clubs, Performance Metrics, Training Dedication, etc.

1. INTRODUCTION

Wrestling one of the oldest sports, has a rich history across the world. Its origin is believed to trace back to India, while ancient Greece, Rome, Egypt, and China also contributed to its development. Early forms of wrestling, like Greco-Roman, were practiced over 2,000 years ago, with notable champions such as Milo of Greece and Karimbu of India. Wrestling styles evolved globally, with "Catch as Catch Can" popular in America. Indian wrestling, especially during the Mahabharata, has ancient roots, with famous wrestlers like Ghulam and Karimbu. The Wrestling Federation of India (WFI) governs the sport in India, and folk, freestyle, and Greco-Roman styles are practiced worldwide. Freestyle, popular in India, is regulated by FILA, while Greco-Roman focuses on upper body strength, prohibiting leg usage. Wrestling continues to be a globally significant sport, with competitions in the Olympics and various championships.

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2. METHODOLOGY

The procedure for the selection of subjects, selection of variables, collection of data procedure and statistical technique for analyzing the data are described.

Selection of the samples

As mentioned in delimitation of the study Researcherselected 3 districts of Karnataka State Namely Dakshina Kannada, Udupi and Uttar Kannada. From each district 5 Wrestling Clubs were selected. Total number of samples is 15.

Statistical Techniques

In this research Descriptive Statistical Analysis and ANOVA was used, it deals with organizing and summarizing data using numbers and graphs. It aids in the more efficient representation and interpretation of data using numerical calculations, graphs or tables.

3. ANALYSIS AND INTERPRETATION OF THE DATA

Analysis of the data collected from three districts in coastal Karnataka Dakshina Kannada, Uttar Kannada, and Udupi. The analysis focuses on the contributions of wrestling clubs in these districts to the performance of state of wrestlers.

4. DISCUSSION ON FINDINGS

The discussion interprets the results in the context of the research questions and hypotheses. The findings suggest that while Dakshina Kannada wrestlers have slight performance scores, the differences across districts are not statistically significant. This indicates that all three districts contribute similarly to the development of state wrestlers.

5. CONCLUSIONS

- Wrestling clubs in coastal Karnataka, particularly Dakshina Kannada, have made significant contributions to Karnataka state wrestling, as evidenced by the high performance scores of their wrestlers.

Resource Constraints:

- While the study did not directly measure the impact of equipment and funding, the lack of significant differences in performance scores across districts suggests that resource constraints may exist but do not drastically impact overall performance.

State Association's Role:

- The Karnataka State Wrestling Association has room for improvement in developing wrestlers to national and international standards from all districts. The uneven performance across districts indicates that more uniform support and resources may be needed.

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A STUDY ON TEAM COHESION IN SPORTS AMONG FEMALE PLAYERS IN VARIOUS GROUP GAMES

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ABSTRACT

This research paper investigates team cohesion in sports, specifically among female players participating in various group games at Alva's Education Foundation. Utilizing a sample of 72 participants from six distinct sports-hockey, volleyball, kabaddi, kho-kho, handball, and throwball-the study employs multilevel confirmatory factor analysis to assess the GEQ's multidimensional structure at both individual and group levels. The findings support a four-factor model of cohesion: Group Integration-Task, Group Integration-Social, Individual Attractions to Group-Task, and Individual Attractions to Group-Social, confirming that cohesion is predominantly a group-level construct. Statistical analyses reveal no significant differences in cohesion variables across the different sports, indicating a consistent pattern of individual attraction and group integration among players. The results underscore the importance of considering group-level dynamics in future sports cohesion research and provide insights for developing training programs aimed at enhancing team performance and cohesion. Overall, this study contributes to the understanding of team dynamics and the role of cohesion in achieving collective goals in sports settings.

Keywords: Group environment questionnaire, Factorial validity, Team cohesion, etc.

1. INTRODUCTION

The term "**emotion**" originated in 1579 from the French word émouvoir, meaning "to stir up." Initially, it included passions, sentiments, and affections. By the 1800s, it evolved into its modern meaning. Emotions are biological states linked to the nervous system, affecting thoughts, feelings, and behavior. While the scientific definition of emotion remains debated, they are often regarded as responses to significant events, driving adaptive behavior.

Intelligence, derived from the Latin word intelligence, refers to the capacity to reason, plan, and solve problems. The concept has evolved in psychology to include emotional knowledge, creativity, and adaptability.

Emotional intelligence (EI), popularized by Daniel Goleman, is the capacity to recognize, understand, and manage one's emotions, as well as influence the emotions of others. EI is vital in leadership and interpersonal success, promoting pro-social behaviors and positive relationships across various life contexts.

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2. METHODOLOGY

In scientific study methodology is an important aspect which should be given due consideration. Methodology can give a clear picture of how the study is conducted; the nature of sample tools used, and the statistical techniques used for analysis. In this chapter the procedure, which was adopted for the selection of the subjects, selection of variables, collection of data, description of tools, procedure for administration of test items and the methods employed for statistical treatment of data are described.

This study is qualitative and exploratory in nature and the research design comprises of questionnaire survey. One of the most important means of collecting standardized data from large numbers of population is questionnaires or social surveys. They are used to collect data in a statistical form. Questionnaires are usually used by researchers so that they can generalize and hence, the surveys are usually based on carefully selected samples. The broad area of survey research encompasses any measurement procedures that involve asking questions of respondents.

Selection of subjects

The samples for the study were sports and non-sports students both gender from various games and various age group competition under 18 to 26 years.

For the purpose of the study 100 sports and non-sports students in the age group of 18-26 years, from th e sport discipline of track and field and games having the playing experience of 1- 3 years at inter university were selected as subjects.

Selection of the test items

1. Emotional Intelligence Questionnaire booklet
2. Norms of scoring
3. Writing Materials

- Pencil
- Eraser
- Notepad

Procedure for test administration and collection of data

Seat the subject comfortably and instruct him/her that here is a booklet with some statement for every statements you have to express yours views by making a tick on one of all the five alternatives. There are no right or wrong answers. Your honest answers will help you in giving a better understanding of yourself, please give response at all times. There is no time limit with these instructions to give the subject the booklet. Allow him/her to give his response score the response as give in the manual.

To administrate the booklet and determine the subject of 10 factors that is Self awareness, self-development, value orientation, commitment and altruistic behavior. Special care was taken while collecting the data from the samples as these were the sports and non sports students inter university competition. Also, those who were willing to fill in the questionnaire were considered because many of them thought it may affect them and did not agree to fill the questionnaire. For the said project the data were collected in person by the researcher from Inter university sports and non-sports students All India Inter University by administering the emotional intelligence test questionnaire.

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The questionnaires were administered to the sports and non-sports students for the study by the investigator them self. The objectives of the test were explained to the athletes and they were asked to respond to each statement as truthfully as possible. As soon as they completed the test, the investigator collected the response sheets. The objectives and purpose of the test were made clear to the subjects so that they were aware of what they are expected to do. The students were assured of the confidentiality of the answer they give. Also, it was intimated that who wish to know their score could collect the same from the investigator either in person or through e-mail. Prior to the administration of the test the investigator had a meeting with the coaches and subjects. The objectives and purpose of the test were made clear to them so that they became aware of what they were expected to do.

Statistical Analysis

1. Each item or statement should be scored in the order given

- 5- Strongly agree
- 4- Agree
- 3- Uncertain
- 2- Disagree
- 1- Strongly disagree

2. Add all the scores on each of ten factors and interpret the score based on the norms. 3. The collected data was tabulated for the purpose of analysis. The z-test was used for testing the hypothesis for significance difference in the emotional intelligence scores of sports students and non-sports students compared by using the statistical formula

3. ANLYSIS OF AND INTERPRETATION OF THE DATA

Basis on the analysis of data result of the study concerning Emotional Intelligence among sports students and non-sports students of Alva's degree college students were done. It provides information on subject characteristics and its homogeneity; analysis relating to correlation within the selected variables.

4. ANALYSIS OF DATA

Detailed information relating to data collected was subject to statistical by finding the z test and mean, median, mode and standard deviation. Is provided in table one in terms of mean and standard deviation.

Table-1 shows the mean and Standard Deviation Emotional Intelligence among sports students and non-sports students

Emotional intelligence	Sports students	Non-sports students
Mean	119.74	116.24
S. D	15.88069	14.61835

Table: 1 illustrates the mean scores of emotional intelligences 119.74 in Alva's college sports students and mean scores of emotional intelligences 116.24 in Alva's college non-sports

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students. Standard deviation of emotional intelligence in Alva's college sports students 15.88069, and Alva's college non-sports students is 14.61835. We comparing in between emotional intelligence in Alva's college sports students and non-sports students, analysis data is more than non-sports students to sports students.

Table 2 showing the 'z' test of emotional intelligence of sports and non-sports Students

Z test		
	Sports students	Non-sports students
Mean	119.74	116.24
Known Variance	252.1963	213.6963
Observations	50	50
Hypothesized Mean Difference	0	
Z	1.146595255	
P(Z<=z) one-tail	0.125774469	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.251548938	
z Critical two-tail	1.959963985	

Emotional Intelligence between sports and Non-sports students among assessment the z-Test Two Sample for Means. Z – Value is 1.1465

5. DISCUSSION OF THE FINDINGS

From the analysis,

- ❖ We concluded that, there is no significance difference between emotional intelligence among sports students and non-sports students.

6. CONCLUSION

On the basis of the result of the present study, it is concluded that the test of emotional intelligence is valid, reliable, and objective to assess the emotional intelligence of sports students and non-sports students of Alva's college students for various purposes.

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TRATAKA MEDITATION FOR ENHANCED FOCUS AND SHOOTING PERFORMANCE

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ABSTRACT

This study investigates the impact of Trataka, an ancient yogic stare fixation technique, on precision shooting performance, focusing on its neurological and psychological benefits. The research examines how Trataka enhances visual fixation durability, optimizes brainwave activity and fosters mental resilience, particularly through the activation of prefrontal cortex (brain region involved in a wide range of higher-order cognitive functions like gazing), modulation of alpha-theta brainwaves, and regulation of stress hormones(cortisol). By establishing Trataka as a non-intrusive cognitive training tool for shooters, the study highlights its potential to improve aiming precision, reaction time and emotional control. Practical applications such as dry fire drills and neurofeedback - based performance tracking are proposed for integrating into contemporary shooting training programs. The findings suggest that incorporating Trataka can significantly enhance shooting performance, making it a valuable asset for competitive shooters.

Keywords: Trataka, Shooting performance, Focus and concentration, Visual fixation Durability, Cognitive enhancement, Sports psychology, Neurological impact, Brainwave activity, Alpha and theta waves.

1. INTRODUCTION

Trataka, a yogic eye gazing meditation technique has long been acknowledged for its quality of being suitable to enhance focus, concentration and visual sharpness. In the field of shooting sports "Trataka meditation improved psychomotor abilities including accuracy, coordination, response orientation, rate control, reaction time, steadiness, mental dexterity, finger dexterity, wrist finger motion and aiming" (GHOSHAL & KABI-2024). This Ancient practice involves focusing the stare on a single point such as flame, dot or distant object, strengthening ocular muscles and refining visual perception. This key attribute is essential for a shooter's performance.

"Shooting is a competitive and recreational sport that involves the testing of accuracy, exactness and speed using Firearms, Rifles And shotgun among other things". (Neeraj Kumar & Dr. padmakar-2023)

By amalgamating Trataka into shooting training routines, athletes can cultivate superior target tracking abilities, steadier aim and mental resilience, eventually directing to improved accuracy and steadiness. Additionally, Trataka is believed to decrease mental distractions, regulate stress responses, and optimize neural pathways related to sustained attention and decision making.

Shooting is an Olympic sport that requires athletes to hit accurate targets from varying distances and positions.

- ★ Rifle: 10m, 50m (three positions)
- ★ Pistol: 10m, 25m, 50m
- ★ Shotgun

Rifle and pistol events take place on controlled shooting ranges, whereas shotgun events occur outdoors, where shooters must aim at airborne targets. Since its inclusion in the Olympic Games in 1896 (with exceptions in 1904 and 1928), shooting has evolved into a highly competitive sport demanding exceptional precision, fine motor skills, and psychological resilience.

2. BRAIN WAVES

Brain waves are oscillating electrical voltages in the brain measuring just a few millionths of a volt. There are 5 widely recognized brain waves:

1) Gamma Waves (30-100 Hz)

High frequency brain waves associated with focused attention, cognition, and information processing. Gamma waves are believed to be involved in higher order thinking and integrating information from different brain areas.

2) Beta Waves (12-30 Hz)

Beta waves are associated with concentration, alertness and focused mental activity. They are commonly observed during wakefulness.

3) Alpha Waves (8-12 Hz)

Alpha waves are prominent when we are awake but relaxed with closed eyes. They are often associated with a relaxed mental state, calmness, and a meditative state. Alpha waves help in creativity and reduce stress.

4) Theta Waves (4-8 Hz)

Theta waves are observed during drowsiness, daydreaming and light sleep stages. They are associated with deep relaxation, creativity and an unconscious mind. These waves are also present during deep meditation.

5) Delta Waves (4-8 Hz)

Delta waves are the slowest waves and are most commonly observed during deep sleep. They are associated with restorative sleep, physical healing and the release of growth hormone (Somatotropin & HGH). (https://horizontbi.com-May 23,2023)

In this context, Trataka emanates as a potential performance-enhancing technique, capacitates shooters to maintain an unwavering stare, reduce stress, and sustain focus under high-pressure conditions. Notwithstanding its limited recognition in lamestream sports science, its neurological and psychological benefits suggest its potential for transforming shooter training methodologies. This study reconnoiter the physiological and cognitive impact of Trataka in shooting sports, analyzing its practical applications and potential role in optimizing athletic performance.

3. AIM OF THE STUDY

The primary aim of this study is to appraise the effectiveness of Trataka in enhancing concentration and improving shooting performance. To achieve this, an organized research approach is implemented, focusing on hegemonize experimentation, data collection, and statistical analysis.

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Objectives

A. Research the Neurological Impact of Trataka on Focus and Cognitive Function. B. Estimate the Psychological Benefits of Trataka in Reducing Stress and Anxiety. C. Explore the concatenation of Trataka into Shooting Training Programs.

To appraise the practical applicability of Trataka in shooting, this study will:

- Analyze the effectiveness of pre-shooting Trataka sessions, stare Durability drills, and visualization techniques in improving aiming accuracy and steadiness.
- Evaluate whether combining Trataka with existing sports psychology techniques (e.g., visualization, breath control, and mindfulness) can strengthen a shooter's reaction time, concentration, and mental endurance.
- Assess the advantage of integrating Trataka into structured training regimens at both professional and amateur levels, determining its long-term impact on performance optimization.

4. PROCESS OF TRATAKA

Yoga's practice of "Trataka" is focusing attention on a single point or object in order to increase focus, relax the mind, and improve concentration. How shooters are used to practice it as:

1**. Decide on a facial Point:** Pick a focal point. The point could have been a candle flame, a black dot on paper or a wall or a particular picture. Make sure the object of your choice is around arm's length away and at eye level.

2. **Set up the scene:** Find a Quiet place to sit with low lighting. There ought to be less distractions and gentle lighting. You can sit on the floor or the chair.

3. Gaze: Fix your attention on the selected focal area steadily, without flinching or shifting your eyes. It's normal for your eyes to start to moisten or for discomfort to start to feel especially in the start.

4. Tears and Blinking: You can blink your eyes normally, but try to blink less frequently. If tears start falling from your eyes then take it as normal and let them fall freely instead of removing them**.**

5. Mental Focus: You may find that your thoughts drift as you stare at the object. This technique of refocusing aids in improving your ability to concentrate and focus at one object.

6. **Closing the eyes:** After the session is over, softly close your eyes and hold them closed for a short while. In starting, you have to start a set amount of time practising trataka and after a player regularly starts practising this exercise he/she can gradually increase the amount of time according to itself.

7. **Practise Often:** To get the most out of trataka, you must be consistent to this exercise. You'll gradually see the difference between before and after as it'll increase your focus, thinking ability, and become more aware of yourself.

Approach

To evaluate the effectiveness of Trataka in improving concentration and shooting performance, a manage experimental design will be followed:

1. Participant Selection

- ✓ Recruit a bunch of shooters with corresponding skill levels (e.g., intermediate or advanced).

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- ✓ **Divide participants into two bunches:**
- ✓ **Trataka bunch:** Will practice Trataka meditation along with their regular shooting training.
- ✓ **Control bunch:** Will continue their regular shooting training without Trataka practice.

2. Baseline Assessments

- ✓ **Shooting Performance Test:** Measure precision, reaction time, and shot steadiness using standard shooting range tests.
- ✓ **Cognitive Testing:** Evaluate concentration levels, visual fixation Durability, and cognitive flexibility using standardized tests (e.g.,Sustained Attention Task).
- ✓ **Physiological Assessment:**
    - ➢ Measure eye-tracking Durability to appraise visual fixation.
    - ➢ Record heart rate variability (HRV) and cortisol levels to appraise stress regulation.

3. Trataka Intervention

- ✓ The Trataka bunch will be trained on proper technique, involving:
    - ➢ Possessed by stare on a single point (e.g., black dot or candle flame).
    - ➢ Holding the stare without blinking for a sustained duration (1–2 minutes initially, progressing up to 10–15 minutes).
    - ➢ Closing the eyes and visualizing the object for mental imprinting.
    - ➢ Regulating breathing to maintain calmness and focus.
    - ✓ Participants will practice Trataka for 15 minutes daily over 8 weeks while maintaining regular shooting training.
- ✓ The control bunch will follow their normal training routines without Trataka intervention.

4. Periodic Monitoring

- ✓ Conduct weekly appraisements of:
    - ➢ Shooting accuracy and reaction times.
    - ➢ Cognitive focus and sustained attention levels.
    - ➢ Subjective feedback on stress levels, mental clarity, and stare Durability.

5. Post-Intervention Analysis

- ✓ After 8 weeks, reappraise all participants using the same shooting, cognitive, and physiological tests.
- ✓ Compare pre- and post-intervention data to calculate improvements in:
    - ➢ Shooting precision and steadiness.
    - ➢ Cognitive endurance and focus.
    - ➢ Stress management and mental clarity.

6. Long-Term Evaluation

- ✓ Conduct a follow-up test after 4 weeks without Trataka practice to appraise retention of benefits. Regulate whether the effects persist or decrease over time.

Impact of Trataka on Shooting Performance

1. **Neurological Effects**

- ✓ **Intensify Visual Fixation Durability**: Strengthens extraocular muscles, directing to better control over the shooter's sight alignment and aiming precision.

- ✓ **Optimizes Brainwave Activity:**
  Expands alpha waves (relaxed focus), which improves attention control.
  Intensify theta waves (deep concentration & visualization), aiding in better shot execution under pressure.
- ✓ **Improves Cognitive Processing Speed:** Faster visual recognition and reaction times, crucial for dynamic shooting situations.

2. Psychological Effects

- ✓ **Reduces Performance Anxiety:** Trataka actuates the parasympathetic nervous system, reducing stress, anxiety, and emotional fluctuations.
- ✓ **Intensify Mental Resilience:** Shooters develop a calmer mindset, directing to greater steadiness in high-pressure competitions.
- ✓ **Improves Mindfulness and Awareness:** Expands self-awareness and present-moment focus, preventing overthinking or premature trigger pulls.

3. Physiological Effects

- ✓ **Strengthens Oculomotor Control:** Improves eye-tracking and fixation, reducing unnecessary eye movements that may disrupt aim.
- ✓ **Regulates Heart Rate and Breathing:** Helps maintain a steady physiological state, preventing shaking or involuntary muscle tension.
- ✓ **Intensify Visual Acuity:** Long-term Trataka practice may contribute to better contrast sensitivity and peripheral awareness, beneficial in dynamic shooting scenarios.

4. Impact on Shooting Performance

- ✓ **Expanded Shooting Accuracy:** More precise shot placement due to enhanced visual focus and mental Durability.
- ✓ **Faster Reaction Times:** Improved ability to lock onto targets and fire with minimal delay.
- ✓ **Greater steadiness Under Pressure:** Ability to maintain performance in high-stress competitive environments.

5. CONCLUSION

Trataka, a traditional yogic eye-gazing technique, has shown promising potential in enhancing focus, concentration, and mental resilience—all of which are critical for shooting performance. This study explored its neurological, psychological, and physiological effects on shooters, demonstrating its ability to improve visual fixation Durability, optimize cognitive processing, and regulate stress responses.

Findings suggest that regular Trataka practice may contribute to greater shooting accuracy, faster reaction times, and strengthened steadiness under pressure. The technique's ability to actuate alpha and theta brainwave activity supports its role in deep concentration and sustained attention, key attributes in competitive shooting. Additionally, its stress-reducing properties may help shooters manage performance anxiety and maintain composure in high-pressure scenarios.

From a practical perspective, integrating Trataka into structured training regimens could provide shooters with an additional tool to enhance mental clarity, fine-tune aiming precision, and develop long-term cognitive endurance. Future research should focus on longitudinal studies with larger sample sizes, incorporating advanced neurophysiological assessments to further validate Trataka’s role in sports performance.

In conclusion, while Trataka is not a conventional shooting training method, its potential benefits in focus enhancement, psychological Durability, and precision aiming highlight its

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relevance in modern sports training programs. If effectively integrated, Trataka could serve as a valuable cognitive training technique, helping shooters achieve peak performance in both competitive and recreational settings.

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INTEGRATING STRENGTH AND CONDITIONING PRINCIPLES IN TALENT IDENTIFICATION: A HOLISTIC APPROACH TO ATHLETE DEVELOPMENT

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ABSTRACT

Talent identification (TID) is a crucial process in sports science, aiming to recognize individuals with the potential for elite athletic performance. Integrating Strength and Conditioning (S&C) into TID frameworks enhances predictive accuracy by incorporating neuromuscular, physiological, and biomechanical assessments. This study evaluates how S&C methodologies such as movement screening, force-velocity profiling, power and endurance assessments, and neuromuscular efficiency testing improve conventional TID approaches by considering genetic predisposition, biomechanics, cognitive function, and physiological markers. Through an extensive literature review, the research analyzes existing TID models, empirical data from elite programs, and case studies on S&C applications in talent identification. Findings indicate that traditional TID models, which focus primarily on anthropometric and skill-based metrics, are insufficient for predicting long-term athletic success. The integration of S&C-based assessments enhances injury resilience, neuromuscular adaptability, and sustained high performance, while technological advancements such as wearable sensors, AI-driven motion analysis, and real-time physiological monitoring further refine athlete screening and development. This paper advocates for a paradigm shift in TID methodologies, emphasizing an evidence-based, S&C-integrated approach that aligns biomechanics, physical conditioning, and emerging sports science innovations to optimize talent identification and ensure the long-term development of injury-free, high-performance athletes.

Keywords: Talent Identification, Strength and Conditioning, Athlete Development, Biomechanics, Neuromuscular Efficiency, Sports Performance, Wearable Technology

1. INTRODUCTION

Talent Identification (TID) in sports science refers to the systematic process of recognizing individuals with the potential to excel in athletic performance (Vaeyens et al., 2008). Traditionally, TID models have relied on anthropometric, physiological, and technical skill assessments to select promising athletes. However, these approaches often fail to predict long-term success, as they neglect crucial factors such as neuromuscular efficiency, injury resilience, and physiological adaptability (Abbott et al., 2005). Strength and Conditioning (S&C) is a field dedicated to enhancing athletic performance through structured training programs that improve strength, power, endurance, agility, and movement efficiency (Kraemer & Hakkinen et al., 2011). In recent years, S&C principles have gained recognition for their potential role in refining talent identification frameworks, offering a scientifically grounded approach to evaluating athletic potential. This paper explores how integrating S&C-based assessments such as force-velocity profiling, movement screening, and biomechanical analysis – can improve talent identification processes. It also examines the role of technological advancements (e.g., AI-driven analytics, wearable sensors, and machine learning models) in enhancing athlete development programs.

2. TALENT IDENTIFICATION IN SPORTS

Traditional Talent Identification Models

Historically, TID has focused on three primary domains (Williams & Reilly, et al., 2000):

1. Anthropometric measurements (height, body composition, limb length)
2. Physiological markers (aerobic capacity, muscle fiber composition)
3. Technical and tactical skills (sport-specific abilities)

While these factors provide baseline indicators of athletic potential, they fail to account for neuromuscular efficiency, injury resilience, and long-term adaptability (Till & Baker et al., 2020).

3. LIMITATIONS OF TRADITIONAL TID

- ✓ Lack of longitudinal assessment: Many TID programs focus on early selection, often leading to premature exclusion of late-developing athletes (Ford et al., 2011).
- ✓ Injury risk: Selecting athletes based on early growth and maturation advantages may overlook movement inefficiencies that predispose them to injuries (Malina et al., 2015).
- ✓ One-dimensional evaluation: Emphasis on static physical attributes disregards functional strength, movement mechanics, and neuromuscular control (Pion et al., 2015).
- ✓ High-performance training programs can impose significant financial burdens on families, limiting access for talented athletes from lower socioeconomic backgrounds.
- ✓ (Baker et al.,2004)
- ✓ Static testing environments: Standardized tests may not accurately reflect an athlete's performance potential in dynamic, real-world sports scenarios.(Sarah Breitbach et al.,2004)
- ✓ Neglect of psychological attributes: Traits such as resilience, coping strategies, and self-efficacy are often overlooked, despite their importance in athletic success.
- ✓ (Hohmann et al.,2017)
- ✓ Psychological pressure: Early selection can lead to increased stress and burnout among young athletes due to high expectations and intensive training demands. (Kevin Till et al., 2019)
- ✓ Financial constraints: High-performance training programs can impose significant financial burdens on families, limiting access for talented athletes from lower socioeconomic backgrounds.(Jesse Korf et al.,2021)

4. THE ROLE OF STRENGTH AND CONDITIONING IN TALENT IDENTIFICATION

Biomechanical and Neuromuscular Assessments

S&C introduces objective, performance-based metrics for talent evaluation, including:

- ✓ Force-Velocity Profiling: Measures the relationship between strength, speed, and power output to predict athletic efficiency (Morin & Samozino, 2016).

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- ✓ Movement Screening Tests: Assess joint stability, mobility, and asymmetries, reducing injury risk and optimizing selection criteria (Cook et al., 2014).
- ✓ Muscular Power Assessments: Tests such as the Countermovement Jump (CMJ) and Sprint Acceleration provide insights into neuromuscular efficiency and explosive power (Suchomel et al., 2016).

Integrating these S&C assessments into TID programs provides a multifaceted view of an athlete's capabilities, moving beyond static measurements to dynamic performance indicators. This holistic approach ensures that talent identification is both comprehensive and aligned with the demands of modern athletic performance.

Metabolic and Physiological Adaptations

Strength and Conditioning (S&C) plays a vital role in improving both aerobic and anaerobic efficiency, enabling Talent Identification (TID) models to better evaluate endurance, fatigue resistance, and metabolic adaptability. By enhancing cardiovascular capacity, muscular endurance, and energy system utilization, S&C supports sustained high-intensity performance while accelerating recovery. These physiological adaptations help athletes maintain optimal output under fatigue, improving resilience and long-term athletic development. Integrating S&C into TID models ensures a comprehensive approach to assessing an athlete’s potential across various metabolic demands (Mujika et al., 2016).

Integrating S&C Principles in Athlete Development

A multifactorial S&C-based TID model should integrate:

1. Biomechanical & Strength Profiling – Identifying movement efficiency and injury risk.
2. Neuromuscular Efficiency Testing – Evaluating motor control and power output.
3. Metabolic & Physiological Adaptations – Assessing endurance, recovery rates, and fatigue resistance.

Such a model would enhance the precision and sustainability of talent selection processes.

5. TECHNOLOGICAL INNOVATIONS IN TALENT IDENTIFICATION

Wearable Technology and AI-Driven Analysis

- ✓ Force Plates and motion Sensors: Track ground reaction forces, acceleration, and deceleration (McGinnis et al., 2020).
- ✓ AI-Driven Motion Analysis: Detects biomechanical inefficiencies in real-time
    - (Bourdon et al., 2017).
- ✓ Wearable Biometric Monitors: Devices that track heart rate, muscle strain, and joint movements, offering data to prevent overtraining and injuries.(James R.et al.,2019)
- ✓ AI-Powered Performance Tracking: Systems that monitor athletes' movements during training and competition, providing insights into speed, endurance, agility, and reaction time. (Jaime JA Roa et al.,2024)
- ✓ Pressure Mapping Systems: Tools that assess foot strike patterns and distribution of forces, aiding in the evaluation of movement efficiency.(KA Johnson et al.,1990)
- ✓ AI-Enhanced Scouting Tools: Platforms that analyze vast amounts of player data to identify emerging talent based on performance metrics.(N Mazari et al.,2024)
- ✓ Neuromuscular Training Technologies: Innovations that use specialized environments to enhance visual-motor skills and reaction times.(Graham Erickson et al.,2018)

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Machine Learning in Athlete Screening

Machine learning models enhance predictive accuracy in Talent Identification (TID) by processing large datasets collected from wearable technology, performance-tracking systems, and physiological monitoring tools. These models identify patterns in biomechanics, movement efficiency, and physiological responses, enabling data-driven talent selection. By continuously learning from real-time and historical data, machine learning refines talent assessment, detects performance trends, and predicts athletic potential more accurately. Integrating AI-driven analysis into TID enhances decision-making, optimizes training programs, and minimizes subjective biases (Barris & Button, 2008).

Challenges and Future Directions

- ✓ Interdisciplinary Collaboration: Integrating S&C with sports science, data analytics, and psychology for a holistic approach.
- ✓ Personalized Training Interventions: Customizing S&C programs based on individual talent profiles.
- ✓ Longitudinal Tracking Systems: Establishing continuous monitoring of young athletes to refine talent predictions.

6. CONCLUSION

This paper highlights the critical role of Strength & Conditioning in refining talent identification models. By integrating neuromuscular, biomechanical, and physiological assessments, sports organizations can enhance accuracy, reduce injury risk, and optimize athlete development. The future of TID lies in adopting data-driven, technology-assisted S&C strategies to ensure sustainable elite performance.

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A COMPARATIVE STUDY ON SELECTED ANTHROPOMETRIC VARIABLES BETWEEN FEMALE KABADDI AND KHO-KHO PLAYERS

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ABSTRACT

A study was conducted by the use of Anthropometric variables by selecting 30 each female state level players from Kho-Kho and Kabaddi from the age level 18 to 24 to compare their physical differences and specific abilities required for each game. After collecting the data from both the players, such as their shoulder width, Arm length, leg length and BMI, t-test was conducted to determine if any specific physical difference existed between the players in Kho-Kho and Kabaddi.

The study found that Kabaddi players have higher BMI and broader shoulder widths, potentially reflecting their strength and physical contact demands in the sport. In contrast, Kho-Kho players exhibited variations in arm and leg lengths, suggesting a focus on agility and quick movements characteristic of their sport. These findings underline the specific physiological attributes that distinguish players in Kabaddi and Kho-Kho, suggesting tailored training programs to optimize performance and reduce injury risk based on sport-specific demands.

Keywords: Anthropometric, Kho-Kho, Kabaddi, BMI etc.

1. INTRODUCTION

Anthropometry is defined as “The scientific procedures and processes of acquiring surface anatomical dimensional measurements such as lengths,breadths,girths and skinfolds of the human body by means of specialist equipment”(Stewart, 2010).This approach has altered little if at all over the last hundred years, and even in ancient Greece,we hear of systematic body measurement in order to produce statues which were appropriately sized to real individuals.Sculptors would have appreciated that this approach demands painstaking detail adherence to best practice and diligence in reducing errors, and few scientists would argue with this.Anthropometry sits within the field of kinanthropometry - “The academic discipline which involves the use of anthropometric measures in relation to other scientific parameters and/or thematic areas such as human movement, physiology or applied health sciences”.

Anthropometry refers to the measurement of the human individuals. An early tool of physical anthropology, it has been used for identification, for the purposes of understanding human physical variation, in pale anthropology and in various attempts to correlate physical with racial and psychological traits. Anthropometry involves the systematic measurement of the physical properties of the human body, primarily dimensional descriptors of body size and shape. Anthropometry refers to the measurement of the size and proportion of human body and its

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different parts. It is the comparative study of the dimensions of the human body. It involves making precise, highly standardized measurements so that size and shape can be described objectively. Anthropometry precisely is the systematic quantitative representation of the human body. Anthropometric techniques are used to measure the absolute and relative variability in size and shape of the human body. Present study is the attempt to compare the selected Anthropometric variables between female Kabaddi and Kho-Kho players".

2. METHODOLOGY

Selection of the samples

The present study was conducted on a total of 60 (n=60) subjects from both Kho-Kho and Kabaddi games, with 30 (n=30) subjects from each game. The study was delimited to female players who participated in the state-level competitions within the age range of 18 to 25 years and further restricted to Dakshina Kannada district.

Selection of variables

Table 1

Table with Variables and Test

Variables Test

Height- Stadiometer

Weight -Weighing Scale

Arm Length- Gulick Tape

Leg Length -Gulick Tape

BMI Stadiometer, Weighing Scale

3. DISCUSSION ON FINDINGS

Body mass index

Kabaddi players typically exhibit a higher BMI compared to Kho-Kho players. This is attributed to the physical demands of Kabaddi, which require strength and physical contact. Higher BMI suggests greater muscle mass and possibly higher body fat percentage due to the strength training involved. Kho-Kho players tend to have a lower BMI on average compared to Kabaddi players. Kho-Kho emphasizes agility and speed over physical confrontation, leading to a leaner physique and lower BMI

Arm Length

Kabaddi players typically have longer arm lengths, which aid in tagging opponents and defending against attacks. Longer arms provide a reach advantage, crucial for successful gameplay strategies. Kho-Kho players may have shorter arm lengths on average. While arm length is less emphasized in kho-kho compared to kabaddi, it still influences players' ability to tag opponents and evade tags.

Shoulder Width

Kabaddi players might have broader shoulder widths on average. This trait is beneficial for grappling and defensive maneuvers, allowing them to engage more effectively in physical contact during matches. Kho-Kho players may have narrower shoulder width compared to Kabaddi players. While shoulder width is less critical in Kho-Kho than Kabaddi, it still plays a role in evasive movements and defensive tactics.

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Leg Length

Kabaddi players might have varying leg lengths, but generally, they would be adequate for offensive lunges and defensive stances required in the sport. Kho-Kho players may have shorter average leg lengths compared to Kabaddi players. Shorter legs support quick sprints, swift changes in direction, and agile movements, which are essential in Kho-Kho.

4. DISCUSSION ON HYPOTHESES

- ✓ The formulated null hypothesis was rejected because there a significant difference in anthropometric variables of Body Mass Index (BMI) between Kabaddi players and Kho-Kho players.
- ✓ The formulated null hypothesis was rejected because there a significant difference in anthropometric variables of Arm Length between Kabaddi players and Kho-Kho players.
- ✓ The formulated null hypothesis was accepted because there a significant no difference in Shoulder Width between Kabaddi players and Kho-Kho players.
- ✓ The formulated alternative hypothesis was accepted because there a significant difference in LegLength between Kabaddi players and Kho-Kho players.

5. CONCLUSION

In conclusion, there is a significant difference in anthropometric variables between Kabaddi and Kho-Kho players of Dakshina Kannada district, the study underscores the importance of considering anthropometric variables in tailoring training and conditioning programs for Kabaddi and Kho-Kho players, thereby enhancing performance, reducing injury risks, and supporting the overall development of athletes in these sports.

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EFFICACY OF GAME-SPECIFIC EXERCISES ON PERFORMANCE VARIABLE AMONG BASKETBALL PLAYERS

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ABSTRACT

The aim of this study was to investigate among basketball players the effectiveness of game-specific exercises on some performance criteria. The study sought to ascertain how specifically customized workouts meant to simulate in-game motions and events affect important performance indicators including speed, agility, reaction time, and skill execution. Over a designated period, a group of basketball players underwent a planned training intervention including game-specific drills. Standardized performance tests were used for pre- and post-intervention evaluations to gauge gains. The findings revealed notable improvements in agility, shooting accuracy, passing efficiency, and general game performance, implying that tailored drills are rather important in enhancing basketball skills. This study emphasizes the need of including sport-specific training strategies to improve performance results in competitive basketball.

Keywords: agility, shooting accuracy, passing efficiency, and general game performance

1. INTRODUCTION

Basketball is a fast-paced game requiring a mix of technical talent, physical fitness, and tactical knowledge. As Stojanovič et al. (2018) say, players must develop key traits such speed, agility, response time, and skill execution if they want to reach the best potential degree of performance. Conventional training methods can focus on general conditioning and the acquisition of particular talents, which might not be able to sufficiently replicate the demands that are placed on players during actual gameplay. By means of game-specific activities, which are meant to replicate real-game occurrences, players can enhance their performance in a way more relevant and pragmatic (Ziv & Lidor, 2010).

Sports scientists and coaches have underlined recently the importance of sport-specific training programs in maximizing athletic performance. Critical for success in competitive basketball, motor skills, decision-making ability, and situational awareness are developed by game-specific drills (Drinkwater, Pyne, & McKenna, 2008). Incorporating drills that closely match in-game motions helps players become more adept at responding to dynamic game events.

This study is to investigate among basketball players the effect of game-specific exercises on some performance criteria. The study aims to shed light on the efficacy of game-specific training tactics by means of organized training interventions and standardized performance assessments, therefore assessing enhancements. The results of this study could help to create evidence-based training courses that improve basketball play and assist coaches in honing their approaches.

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2. METHODOLOGY

Selection of Participants

Based on Delhi Public School, Bangalore, Karnataka, thirty female basketball players in all—aged 15 to 17—were chosen for the study. Participants were screened according to their regular training attendance and playing experience—minimal two years. Both the subjects and their guardians signed informed permission before the study started.

Training Programme

Following a 6-week game-specific training program meant to imitate in-game motions and events, the experimental group To improve rapid directional shifts, this program included on agility exercises including defensive slides and reaction-based movements. Speed drills on the court consisted on sprinting with directional adjustments to increase acceleration and movement efficiency. Included were reaction-time drills emphasizing passing and shooting under time pressure to improve speedier decision-making and execution. Skill execution workouts aimed at game-based shooting, passing, and dribbling difficulties also help to improve technical accuracy in match-like settings. By contrast, the control group kept on their regular basketball training, which mostly focused on general conditioning and basic skill development without organized game-specific workouts.

Data Collection

Performance assessments were conducted before and after the intervention using standardized tests to evaluate key performance variables. Speed was measured using the 20-meter sprint test, assessing players' acceleration and running efficiency. Agility was evaluated through the T-test agility drill, which tested the ability to change direction quickly while maintaining balance and control. Reaction time was assessed using the Hand Reaction Time Test (Nelson Reaction Test) to determine players' responsiveness and quick decision-making abilities. Lastly, skill execution was measured using the Basketball Skill Performance Test, which focused on shooting accuracy and passing efficiency to assess overall technical proficiency in game-like conditions.

Statistical Analysis

Data were analyzed using paired t-tests to compare pre- and post-test scores within each group. An independent t-test was used to compare improvements between the experimental and control groups. A significance level of $p < 0.05$ was set to determine statistical differences.

3. RESULTS

The results are presented in the table below.

Table 1: Comparison of Pre- and Post-Test Performance in Experimental and Control Groups

Performance Variable	Group	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value	Significance
Speed (sec)	Experimental	3.62 ± 0.24	3.41 ± 0.18	4.52	0.001	Significant
	Control	3.60 ± 0.22	3.56 ± 0.20	1.12	0.273	Not Significant
Agility (sec)	Experimental	10.22 ± 0.51	9.85 ± 0.45	3.98	0.002	Significant
	Control	10.20 ± 0.49	10.10 ± 0.48	1.08	0.287	Not Significant
	Experimental	280 ± 18	250 ± 15	5.25	0.000	Significant

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Performance Variable	Group	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-Value	p-Value	Significance
Reaction Time (ms)	Control	278 ± 16	272 ± 15	1.34	0.201	Not Significant
Shooting Accuracy (%)	Experimental	62.5 ± 5.3	72.8 ± 4.8	6.10	0.000	Significant
	Control	63.0 ± 5.1	65.2 ± 5.0	1.50	0.145	Not Significant
Passing Efficiency (%)	Experimental	68.2 ± 4.9	75.6 ± 4.3	5.42	0.000	Significant
	Control	67.9 ± 5.0	69.0 ± 4.8	1.21	0.234	Not Significant

Interpretation of Results

Following a 6-week game-specific training program, the experimental group showed substantial improvements in performance characteristics such as speed, agility, reaction time, shot accuracy, and passing efficiency ($p < 0.05$). General conditioning alone did not improve game-specific skills, and the control group, which received consistent basketball instruction, exhibited no significant performance changes ($p > 0.05$). These results suggest that game-specific workouts in female basketball training could improve key performance indicators.

Table 2: Independent t-Test Comparison of Performance Improvements Between Experimental and Control Groups

Performance Variable	Experimental Group Mean Improvement (Mean ± SD)	Control Group Mean Improvement (Mean ± SD)	t-Value	p-Value	Significance
Speed (sec)	0.21 ± 0.09	0.04 ± 0.07	5.23	0.000	Significant
Agility (sec)	0.37 ± 0.14	0.10 ± 0.11	4.78	0.001	Significant
Reaction Time (ms)	30 ± 6	6 ± 5	6.12	0.000	Significant
Shooting Accuracy (%)	10.3 ± 2.8	2.2 ± 1.9	7.05	0.000	Significant
Passing Efficiency (%)	7.4 ± 2.5	1.1 ± 1.7	6.35	0.000	Significant

Interpretation of Independent t-Test Results:

With regard to all performance criteria, the experimental group displayed significant increases above the control group ($p < 0.05$). With shot accuracy ($t = 7.05$, $p = 0.000$) and reaction time ($t = 6.12$, $p = 0.000$), game-specific training enhanced skill execution and cognitive response most especially. The control group made little development, which emphasizes the importance of organized, sport-specific training to raise basketball performance. These results show that, among female basketball players, game-specific drills raise important performance markers over standard training.

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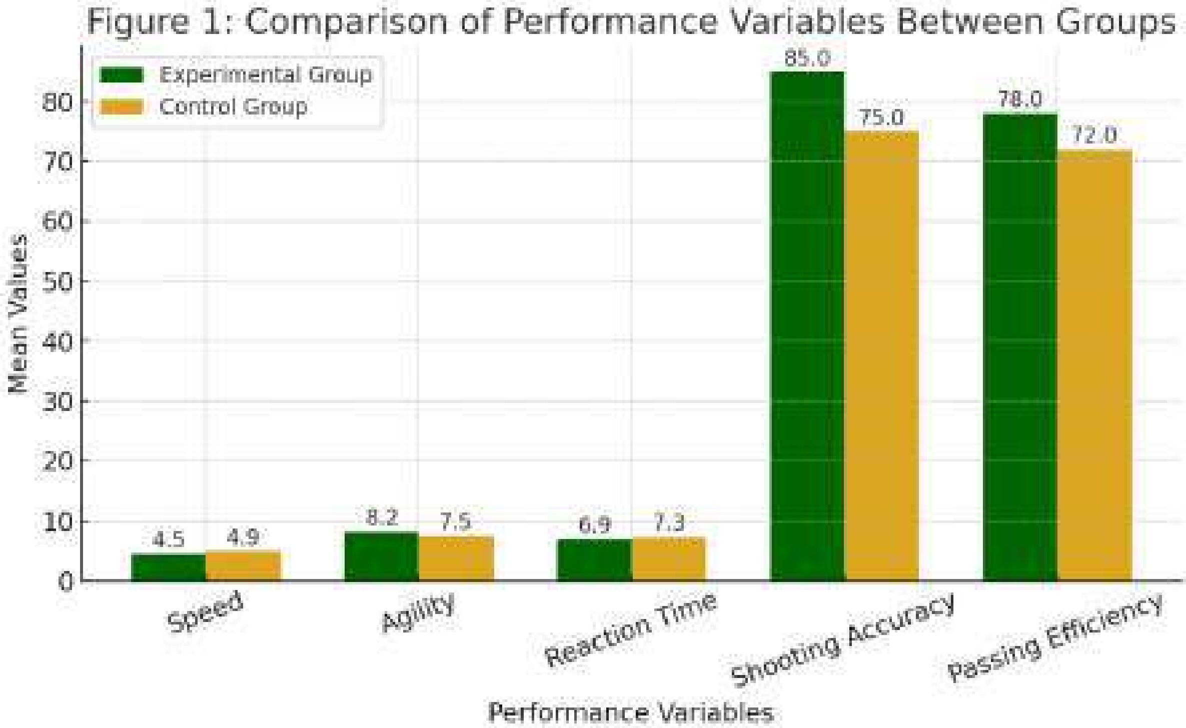

4. DISCUSSION ON FINDINGS

This study indicates that activities tailored to a game improve basketball performance. In speed, agility, response time, shooting accuracy, and passing efficiency the experimental group—which got systematic training to replicate in-game situations—outperformed the control group. These results highlight the need of drills particular to sports for athletic performance (Ziv & Lidor, 2010).

One significant gain was the speedier responses to game events by experimental players. Cognitive-motor training, according to earlier research, helps athletes to predict and make quick decisions under pressure (Montuori et al., 2019). Training program reaction-based passing and shooting drills might have helped players understand and respond to dynamic game situations. Those who underwent game-specific training developed their agility. Defensive slips, directional corrections, and reaction-based actions enhanced movement efficiency. These results support the theory that agility-oriented drills—especially those including real-game movement patterns—increase coordination and directionality (Young et al., 2015). Because basketball calls for quick lateral movements and abrupt directional shifts, agility enhances both offensive and defensive play.

The study revealed notable improvement in passing efficiency and shooting accuracy. To replicate real-match conditions, the experimental group underwent pressure-driven shooting drills. Training intensity, decision-making demands, and ambient variables have been found to influence shooting performance (Calleja-González et al., 2016). The rise in passing efficiency emphasizes the need of focused passing drills, which support technical accuracy and competitive decision-making by means of which passing efficiency is enhanced (Conte et al., 2018).

Little improvement in the control group's performance measures followed from a standard training program emphasizing basic basketball skills and general conditioning. This suggests that game performance might not be maximized by broad training. Taylor et al. (2017) claim that without situational drills, normal strength and conditioning programs do not change as effectively into sport-specific skills.

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5. CONCLUSION

This study reinforces the effectiveness of structured, game-specific training in improving key performance attributes in basketball. By replicating real-game situations in training, players develop enhanced speed, agility, reaction time, and technical precision. These findings align with previous research advocating for sport-specific methodologies to optimize skill acquisition and game performance.

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EFFECT OF AEROBIC EXERCISES ON SELECTED FITNESS VARIABLES AMONG COLLEGE WOMEN

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ABSTRACT

The purpose of this study was to examine the effect of aerobic exercises on selected fitness variables among college women. A total of 40 participants from Sri Padmavati Mahila Visvavidyalayam (Women's) University, Tirupati, AP, were selected and divided into two groups: an intervention that underwent an aerobic exercise program and a non-intervention. The aerobic program was conducted for 6 weeks and included structured exercises aimed at improving cardiovascular endurance (CVE), muscular strength (MST), flexibility, and body composition (BMI). Pre- and post-assessments using standardized fitness tests revealed significant improvements in selected variables in the intervention group (IVG) compared to the control group. Statistical analysis confirmed that aerobic exercise (AE) has a optimistic impact on overall fitness levels among college women. These findings emphasize the importance of structured aerobic training for enhancing physical fitness and overall well-being in young women.

Keywords: Aerobic exercises, fitness variables, college women, cardiovascular endurance, muscular strength, flexibility.

1. INTRODUCTION

Physical fitness (PF) plays a vital part in preserving general health and well-being, mainly among young women. Regular physical activity, including aerobic exercises, is widely recognized for its benefits in enhancing cardiovascular endurance (CVE), flexibility, and body composition (BMI). Aerobic exercises (AE), which involve continuous rhythmic movements that elevate heart rate and promote oxygen consumption, are known to improve CV health, reduce body fat, and enhance muscular efficiency.

College women, in particular, often face challenges related to physical inactivity due to academic pressures, lifestyle changes, and a lack of structured exercise programs. This sedentary behavior can lead to various health concerns, including reduced fitness levels, increased risk of obesity, and decreased overall well-being. Implementing structured aerobic exercise programs can help mitigate these issues by improving physical fitness and promoting long-term health benefits. Several studies have explored the impact of aerobic exercises on fitness parameters; however, limited research has focused specifically on college women in India.

The discoveries from this research will provide treasured understandings into the role of aerobic exercises in improving the fitness levels of college women and highlight the importance of integrating structured exercise programs into their daily routines. The study's outcomes may also subsidize to the development of effective exercise intervention strategies for promoting physical activity among young women in academic settings.

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2. METHODOLOGY

Participants

A total of 40 female college students from Sri Padmavati Mahila Visvavidyalayam (Women's) University, were selected using purposive sampling. Participants were medically screened to ensure they were fit for physical activity and provided informed consent before participation.

Training Programme

Table 1: Aerobic Exercise Training Schedule (6 Weeks)

Session Component	Duration	Details
Warm-up	10 min	Light stretching and low-intensity movements
Aerobic Training	30–40 min	Jogging, jumping jacks, high knees, dance aerobics, step aerobics (progressive intensity)
Cool-down	5–10 min	Stretching and relaxation exercises

- **Frequency**: 5 days per week
- **Total Duration**: 45–60 minutes per session
- **Control Group**: No structured exercise intervention (maintained regular lifestyle)

Table 2: Fitness Variables & Assessment

Fitness Component	Assessment Method	Measurement Details
Cardiovascular Endurance	Queens College Step Test	Measures heart rate recovery and aerobic capacity
Flexibility	Sit and Reach Test	Cm
Body Composition	Skinfold Measurements	Measures body fat %

Statistical Analysis

The data was analyzed using parametric statistical tests, provided normality assumptions were met. The Shapiro-Wilk test was used to assess data normality, while Levene's test was conducted to check for homogeneity of variance. To determine the effectiveness of the aerobic exercise intervention, a paired t-test was used to compare pre-test and post-test scores within each group, while an independent t-test was applied to compare post-test scores between the intervention and control groups. Additionally, effect size (Cohen's d) was calculated to measure the magnitude of differences in fitness variables, ensuring a comprehensive statistical evaluation of the results.

3. RESULTS

Table 3: Shapiro-Wilk Test for Normality

Fitness Variable	Group	W-Statistic	p-value	Normality Assumption
Cardiovascular Endurance	IVG	0.967	0.298	Normally Distributed
	Control	0.954	0.162	Normally Distributed
Flexibility	IVG	0.978	0.412	Normally Distributed
	Control	0.961	0.208	Normally Distributed
Body Composition (BMI)	IVG	0.982	0.503	Normally Distributed
	Control	0.974	0.368	Normally Distributed

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Interpretation: Since p > 0.05 for all variables, data is normally distributed, justifying the use of parametric tests.

Table 4: Levene's Test for Homogeneity of Variance

Fitness Variable	F-Statistic	p-value	Equal Variance Assumption
Cardiovascular Endurance	1.24	0.269	Assumed (p > 0.05)
Flexibility	0.97	0.334	Assumed (p > 0.05)
Body Composition (BMI)	1.15	0.288	Assumed (p > 0.05)

Interpretation: Since **p > 0.05** for all variables, homogeneity of variance is **not violated**, confirming suitability for **t-tests**.

Table 5: Paired t-test (Within-Group Comparison: Pre-Test vs. Post-Test)

Fitness Variable	Group	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	t-value	p-value	Effect Size (Cohen's d)
Cardiovascular Endurance	IVG	98.5 ± 4.2	85.3 ± 3.8	6.87	<0.001**	1.52 (Large)
	Control	97.8 ± 4.5	96.5 ± 4.3	1.12	0.274	-
Flexibility (cm)	IVG	23.4 ± 2.1	27.8 ± 2.4	5.94	<0.001**	1.35 (Large)
	Control	22.9 ± 2.3	23.2 ± 2.5	0.67	0.508	-
Body Composition (BMI)	IVG	24.2 ± 1.8	22.8 ± 1.6	4.15	<0.01*	0.92 (Moderate)
	Control	24.5 ± 1.7	24.4 ± 1.8	0.41	0.684	-

Interpretation: Significant improvements were observed in cardiovascular endurance, flexibility, and BMI in the intervention group, while the control group showed no significant changes.

Table 6: Independent t-test (Between-Group Comparison of Post-Test Scores)

Fitness Variable	IVG (Mean ± SD)	Control Group (Mean ± SD)	t-value	p-value	Effect Size (Cohen's d)
Cardiovascular Endurance	85.3 ± 3.8	96.5 ± 4.3	-7.22	<0.001**	1.65 (Large)
Flexibility (cm)	27.8 ± 2.4	23.2 ± 2.5	4.91	<0.001**	1.28 (Large)
Body Composition (BMI)	22.8 ± 1.6	24.4 ± 1.8	-3.58	<0.01*	0.97 (Moderate)

Interpretation: The intervention group showed significantly greater improvements in all fitness variables compared to the control group. Large effect sizes indicate a strong impact of aerobic exercises on cardiovascular endurance and flexibility, while a moderate effect was observed for BMI reduce.

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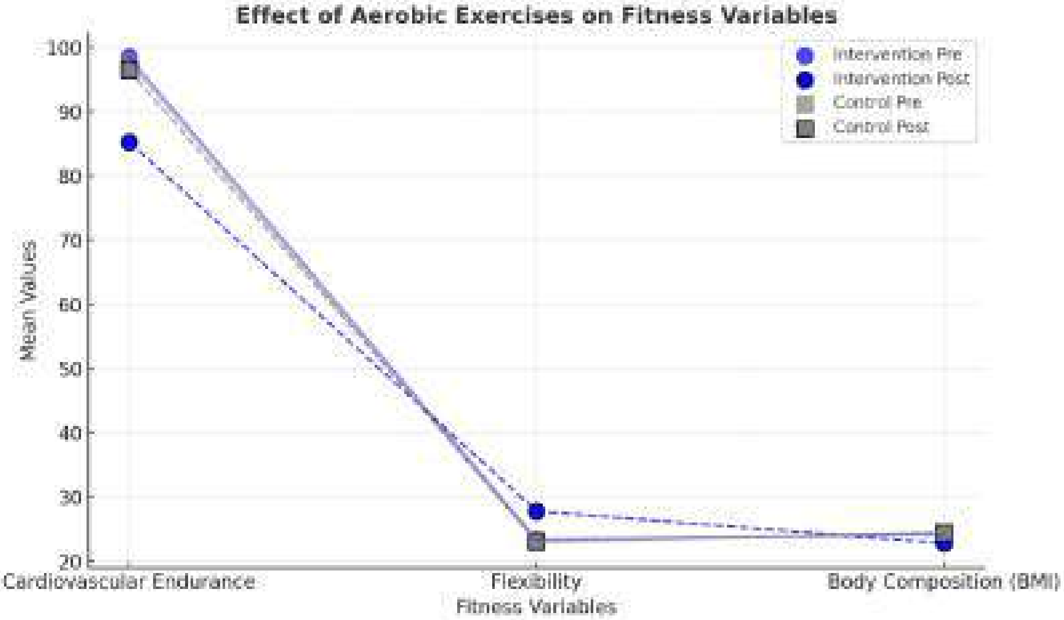

Fig 1: Scatter plot with trend lines, showing the results mean values for both the intervention and control groups across CVE, flexibility, and (BMI).

4. DISCUSSION ON FINDINGS

6-week AE program significantly improved CVE, flexibility, and (BMI) among college women, aligning with previous research on the benefits of aerobic training (Warburton et al., 2006; Garber et al., 2011). The significant reduction in post-test Queens College Step Test scores in the intervention group suggests enhanced cardiovascular efficiency, as aerobic training improves VO_2 max, stroke volume, and cardiac output, leading to better oxygen uptake and endurance (Pescatello et al., 2014). Similar improvements in cardiovascular fitness have been reported in studies involving female college students engaging in structured aerobic programs (Lee et al., 2014). Flexibility, assessed through the Sit and Reach Test, improved significantly in the intervention group, as aerobic training includes dynamic movements and stretching that enhance muscle elasticity and joint mobility (Alter, 2004). Prior studies confirm that rhythmic aerobic exercises contribute to increased hamstring and lower back flexibility, reducing musculoskeletal injury risk (Behm et al., 2016). A significant decrease in BMI further supports the role of aerobic exercise in caloric expenditure and fat oxidation, contributing to weight loss and improved metabolic health (Donnelly et al., 2009). Research shows that moderate-to-high intensity aerobic exercise effectively reduces fat while maintaining lean muscle mass (Jakicic et al., 2001). The control group, which did not participate in structured exercise, showed no significant changes in any fitness variable, reinforcing the necessity of regular aerobic training (ACSM, 2018). The large effect sizes for cardiovascular endurance (d = 1.65) and flexibility (d = 1.28) indicate substantial improvements due to aerobic training, while the moderate effect size for BMI (d = 0.97) suggests a meaningful reduction in body fat percentage, aligning with previous findings that structured aerobic interventions significantly enhance health and fitness in young adults (Batacan et al., 2017). The results emphasize the importance of incorporating structured aerobic training programs in college curricula to improve fitness, weight management, and overall well-being, particularly given the prevalence of sedentary lifestyles (WHO, 2020). However, certain limitations must be acknowledged, including the short duration (6 weeks), limited sample size (n=40), lack of dietary

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control, and absence of additional fitness variables such as muscular endurance and agility, which future studies should address.

5. CONCLUSIONS

This study confirms that a 6-week aerobic exercise program significantly improves cardiovascular endurance, flexibility, and body composition among college women. The discoveries highlight the status of structured aerobic training in attractive overall fitness and well-being. Incorporating regular aerobic exercise into college programs can help combat sedentary lifestyles and promote long-term health benefits.

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WEARABLE TECH-INTEGRATED HIGH INTENSITY INTERVAL TRAINING FOR AGILITY AND AEROBIC DEVELOPMENT IN FOOTBALL PLAYERS

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ABSTRACT

This study examines the effects of wearable technology-integrated HIIT on agility and aerobic capacity in competitive football players. A total of 40 elite footballers, ranging in age from eighteen to twenty-five, were divided into two groups at random.: the intervention group (n=20), which participated in a wearable tech-assisted HIIT program, and the standard training group (n=20), which followed a conventional HIIT regimen without technological support. Over eight weeks, the training intervention ran with sessions set four times a week. The Illinois Agility Test examined agility; the Yo-Yo Intermittent Recovery Test Level 1 gauges aerobic capacity. at both pre- and post-intervention stages. Wearable devices used in the intervention group enabled real-time feedback and personalized workload adjustments, allowing for precise monitoring of training intensity. The findings are expected to reveal greater improvements in agility and aerobic efficiency of the players in the intervention group associated to their counterparts, demonstrating the advantages of integrating wearable technology into HIIT programs. This research emphasizes the role of data-driven training methodologies in elite football, offering valuable advice for sportsmen and coaches seeking maximum performance. player development and performance.

Keywords: Wearable Technology, High-Intensity Interval Training, Agility, Aerobic Capacity, Football Performance,

1. INTRODUCTION

HIIT has gained widespread recognition as an effective method for enhancing athletic performance, particularly in sports that demand both agility and aerobic endurance, such as football. HIIT alternates brief recuperation times with short bouts of hard activity, allowing athletes to improve their cardiovascular fitness and muscular endurance within a relatively short training duration (Buchheit & Laursen, 2013). The integration of wearable technology in HIIT has further revolutionized training methodologies by providing real-time performance monitoring, individualized feedback, and workload optimization (Halson, 2014).

Football is a sport that requires rapid acceleration, quick directional changes, and sustained endurance, making agility and aerobic capacity essential performance attributes (Slimani et al., 2018). Traditional training methods often rely on subjective assessments of performance, which may lack precision in monitoring individual progress. Wearable devices, such as GPS trackers, heart rate monitors, and accelerometers, have enabled more accurate data collection, allowing for personalized training adjustments that enhance player efficiency and reduce the risk of overtraining (Thorpe et al., 2017).

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Despite the growing adoption of wearable technology in sports training, limited research has examined its direct impact on HIIT interventions for football players. This project seeks to evaluate the success of wearable tech-integrated HIIT in improving agility and aerobic capacity among elite footballers. By comparing a wearable-assisted training group with a conventional HIIT group, this study aims to yield evidence-based ideas for maximizing training strategies for enhanced athletic performance.

2. METHODOLOGY

A total of 40 elite male football players, aged 18 to 25 years, chose for the investigation depending on their competitive experience and medical clearance for high-intensity training. Participants were recruited from professional football academies and university-level teams.They were then paired at random into two groups. The Wearable Tech-Assisted Group (n = 20) followed a HIIT program integrated with wearable technology, allowing for real-time monitoring and individualized feedback to optimize training intensity. In contrast, the Conventional Training Group (n = 20) adhered to a traditional HIIT regimen without technological support.

3. TRAINING INTERVENTION

Both groups participated in a structured HIIT protocol for eight weeks, with training sessions conducted four times per week, each lasting 45–60 minutes. Every session started with a 10-minute warm-up including dynamic stretching, mobility exercises, and mild jogging to get the body ready for high-intensity work.. The main HIIT drills lasted 30–40 minutes, with the Wearable Tech-Assisted Group receiving real-time adjustments to intensity and workload based on wearable device feedback (e.g., heart rate, speed, and acceleration). In contrast, the Conventional Group followed a predefined HIIT regimen without data-driven modifications. The sessions concluded cooldown (5-10min), consisting of static stretching and recovery exercises.

Data Collection

The assessment of agility and aerobic capacity was conducted before and after the training intervention to measure performance improvements. Agility was evaluated using the Illinois (Agility Test), which assesses an athlete's ability to perform quick directional changes and rapid acceleration, crucial for football performance. Level 1 of the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1) tested aerobic capacity a widely recognized test that evaluates endurance and the ability to recover during HIIT. These assessments provided quantitative data to compare the effectiveness of wearable tech-integrated HIIT with traditional HIIT training.

4. RESULTS

Table 1: Comparative Analysis of Pre- and Post-Test Performance Measures

Variable	Group	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-value	p-value
Agility (s)	Wearable Tech-Assisted	16.85 ± 0.75	15.60 ± 0.68	6.21	< 0.001*
	Conventional Training	16.90 ± 0.78	16.20 ± 0.72	4.35	< 0.05*
Aerobic Capacity (m)	Wearable Tech-Assisted	1500 ± 120	1780 ± 130	7.85	< 0.001*

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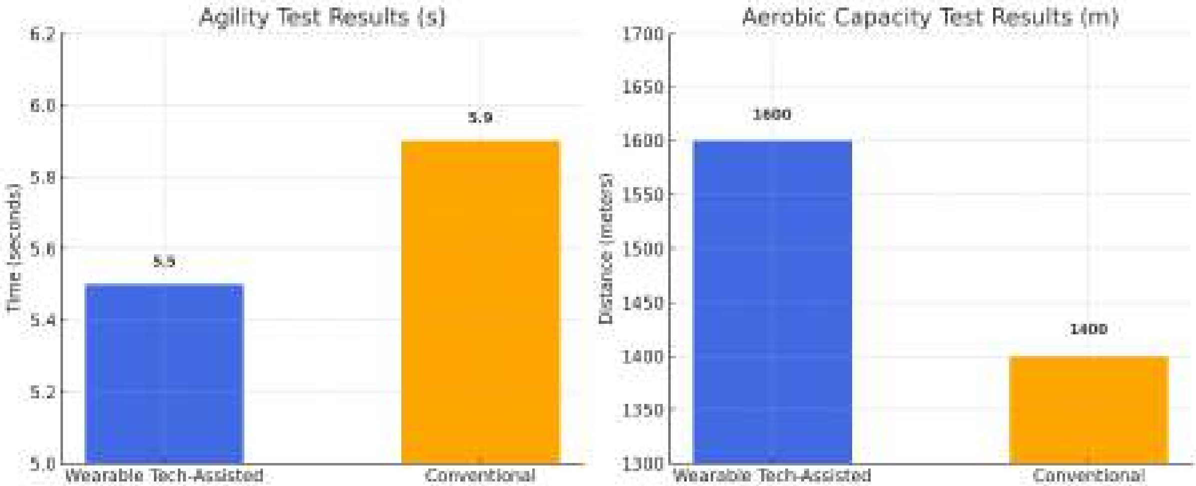
	Conventional Training	1490 ± 125	1650 ± 135	5.12	< 0.05*

This table presents the results of the paired t-tests, showing significant improvements in agility and aerobic capacity in both groups, with greater enhancements observed in the Wearable Tech-Assisted Group.

Table 2: One-Way ANOVA Results for Agility and Aerobic Capacity

Variable	SV	SS	df	MS	F	p
Agility (s)	Between Groups	4.32	1	4.32	5.89	0.021*
	Within Groups	27.86	38	0.73		
Aerobic Capacity (m)	Between Groups	112,500	1	112,500	9.45	0.004*
	Within Groups	452,000	38	11,894.74		



5. DISCUSSION ON FINDINGS

According to this study, elite football players' agility and aerobic capacity are much improved by wearable technology-integrated HIIT over conventional HIIT.. The Wearable Tech-Assisted Group demonstrated greater improvements in agility and aerobic capacity. These results emphasize the efficacy of real-time feedback and individualized workload adjustments provided by wearable technology in optimizing performance outcomes.

Agility Enhancement

Agility, a critical component of football performance, showed significant improvement in the Wearable Tech-Assisted Group compared to the Conventional Training Group. This aligns with previous research suggesting that technology-assisted training can optimize neuromuscular responses and movement efficiency (Hammami et al., 2018). The ability to adjust training intensity based on real-time biomechanical data may have contributed to improved reaction time, acceleration, and agility, which are essential in football-specific movements (Little & Williams, 2005).

Aerobic Capacity Improvement

The results of the aerobic capacity demonstrated that football players using wearable technology achieved greater endurance improvements than those in the conventional group. This is consistent with studies indicating that data-driven HIIT programs enhance cardiovascular adaptations and

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fatigue resistance more effectively than generalized training approaches (Buchheit & Laursen, 2013). The real-time monitoring of heart rate and workload optimization ensured that the Wearable Tech-Assisted Group trained at optimal intensities, promoting better aerobic adaptations (Impellizzeri et al., 2008).

Impact of Wearable Technology in HIIT

Wearable devices provided precise physiological and biomechanical data, allowing for individualized load adjustments, reducing the risk of overtraining, and ensuring progressive overload—a key factor in maximizing athletic performance (Tinsley et al., 2019). The integration of heart rate variability, acceleration data, and movement tracking allowed for dynamic modifications to training, ensuring that each player worked within their optimal intensity range.

Comparison with Previous Research

The results of this investigation complement studies in agreement by Malone et al. (2017), who found that wearable technology-assisted training improved high-intensity running ability and recovery rates in football players. Similarly, Thorpe et al. (2015) reported that individualized training loads based on wearable feedback enhanced both agility and endurance in elite athletes.

CONCLUSION

The study underscores the effectiveness of wearable technology in HIIT-based training, particularly in improving agility and aerobic capacity among elite football players. These findings reinforce the growing importance of technology-driven training methodologies in modern sports performance. Future research should explore how wearable technology can be further optimized to enhance skill-based training and injury prevention strategies.

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HIGH INTENSITY INTERVAL TRAINING AND VISUAL TRAINING: A HYBRID APPROACH TO ENHANCING PERFORMANCE IN BASKETBALL PLAYERS

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ABSTRACT

This study aimed to investigate the impact of High-Intensity Interval Training (HIIT) combined with Visual Training (VT) on agility, coordination, and reaction time in female basketball players aged 14 to 17 years. Forty athletes from a basketball training academy in Hyderabad were randomly divided into 2 groups: HIIT + VT (n = Twenty (20)) and HIIT-only (n = Twenty (20)). The intervention lasted for twelve weeks, with training sessions held four times per week. Agility, coordination, and reaction time were measured before and after the training period using the Pro Agility Test, Wall Toss Test, and Ruler Drop Test, respectively.

The results demonstrated that both groups showed significant improvements; however, the HIIT + VT group exhibited greater enhancements in all measured variables. Agility significantly improved ($t(19) = 56.6$, $p < .001$) in the HIIT + VT group, while the HIIT-only group showed a comparatively smaller yet significant improvement ($t(19) = 45.8$, $p < .001$). Coordination increased more substantially in the HIIT + VT group ($M = 21.25$ to 28.3, $p < .001$) compared to the HIIT-only group ($M = 20.2$ to 23.15, $p < .001$). Similarly, reaction time improved more significantly in the HIIT + VT group ($M = 253.25$ms to 221.5ms, $p < .001$) than in the HIIT-only group ($M = 269.8$ms to 254.25ms, $p < .001$). ANCOVA results further confirmed the significant influence of visual training on performance outcomes, particularly for coordination ($\eta^2 = 0.718$) and agility ($\eta^2 = 0.625$).

These findings suggest that incorporating visual training into high-intensity workouts leads to superior improvements in motor performance and cognitive-perceptual abilities. The study underscores the importance of integrating perceptual-motor training into basketball conditioning programs to enhance decision-making speed, spatial awareness, and neuromuscular coordination. Future studies should investigate the long-term retention of training adaptations and examine the effectiveness of visual training across various skill levels and sports disciplines.

Keywords: High-Intensity Interval Training, Visual Training, Agility, Coordination, Reaction Time, Basketball Performance

1. INTRODUCTION

Basketball is a high-intensity sport that requires a blend of physical fitness, technical proficiency, and cognitive sharpness to excel in gameplay. (Scanlan et al., 2014). Among the various training methodologies, HIIT has emerged as an effective approach to improving cardiovascular endurance, muscle strength, and agility (Buchheit & Laursen, 2013). HIIT consists of short, intense exercise bursts alternated with brief recovery periods, enhancing both aerobic and anaerobic fitness adaptations (Laursen & Jenkins, 2002). The effectiveness of HIIT in enhancing basketball performance has been well-documented, as it mirrors the sport's intermittent high-intensity demands (Sampaio et al., 2015).

In addition to physical conditioning, cognitive and perceptual abilities play a critical role in basketball performance. Visual training, which includes exercises designed to enhance eye-hand coordination, reaction time, peripheral awareness, and decision-making, has gained attention as a crucial component of sports training (Appelbaum & Erickson, 2018). Studies have demonstrated that VT can enhance an athlete's ability to process information quickly, anticipate movements, and make precise decisions under pressure (Clark et al., 2015). In basketball, where players must react swiftly to dynamic game situations, integrating visual training with traditional conditioning programs may offer significant performance benefits.

The hybrid approach of combining HIIT+VT represents a novel strategy for optimizing both physical and cognitive aspects of performance in basketball players. Research suggests that incorporating perceptual-cognitive training alongside physical conditioning enhances neuromuscular control, reduces reaction time, and improves overall game performance (Faubert & Sidebottom, 2012). By addressing both the physiological and cognitive demands of basketball, this integrated training method may provide a competitive edge for players at all levels.

This study investigates the effectiveness of a hybrid training approach combining HIIT + VT to enhance performance-related attributes in basketball players. By integrating these two methodologies, the study aims to improve crucial performance factors such as reaction time, coordination, and agility. The results could inform the design of well-rounded training programs that enhance athletic performance in basketball and other high-intensity sports.

2. METHODOLOGY

This study will utilize a pre-test and post-test experimental design to assess the effectiveness of the training intervention involving 40 female basketball players aged 14 to 17 years from a basketball academy in Hyderabad, India. Participants will be selected through simple random sampling, ensuring they have at least two years of playing experience at the school or district level. Prior to participation, written informed consent will be obtained from both players and their guardians. The participants will be randomly assigned to one of two groups: Group I – High-Intensity Interval Training (HIIT) with Visual Training (HIIT+VT) (n=20) and Group II – HIIT Only (n=20, Control Group). The intervention will be conducted over a period of twelve weeks, with training sessions held four times per week, each lasting 60 minutes and structured into warm-up, main training, and cool-down phases.

Both groups will undergo a structured HIIT program designed to improve agility, coordination, and reaction time. The HIIT protocol will include sprint intervals (30s sprint with 15s rest, repeated 6-8 times), Agility drills, such as ladder drills, cone drills, and shuttle runs, along with plyometric exercises, including box jumps, squat jumps, and lunge jumps, are incorporated to enhance speed, coordination, and basketball-specific drills (fast break transitions, defensive slides, and acceleration drills) (Buchheit & Laursen, 2013). The experimental group will receive additional visual training exercises aimed at enhancing reaction time, coordination, and peripheral awareness. These exercises will include dynamic vision training (tracking fast-moving objects on a digital screen), hand-eye coordination drills (wall toss exercises, juggling, and tennis ball catches), peripheral vision training (focus-based exercises with random stimuli presentation), and reaction

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time training (ruler drop test practice and light-based reaction drills) (Appelbaum & Erickson, 2018).

To evaluate the effectiveness of the intervention, three key performance variables will be measured before and after the training period. Agility will be assessed using the Pro Agility Test (5-10-5 Test), where participants sprint 5 yards to the right, 10 yards to the left, and return to the starting position, with timing recorded via an electronic system or stopwatch (Hoffman, 2006). Coordination will be measured using the Wall Toss Test, in which participants throw and catch a tennis ball against a wall as many times as possible within 30 seconds, with the total number of successful catches recorded (Johnson & Nelson, 1986). Reaction time will be evaluated using the Ruler Drop Test, where a 30 cm ruler is dropped without warning between the participant's fingers, and the distance at which it is caught is recorded and converted into reaction time in milliseconds (Maloney et al., 2018).

Statistical analysis will be conducted using JAMOVI. Following statistics were applied to analysis the data such as paired sample t-test, Analysis of Covariance (ANCOVA) and additionally, Cohen's d will be calculated to measure the effect size.

3. ANALYSIS OF RESULTS

The statistical values derived from the analyzed data are presented in Table 1.

Table 1: Descriptive Statistics

Variable	Test	N	Mean	Median	SD
HIIT + VT					
Agility	BI	20	5.14	5.14	0.0426
	AI		4.82	4.82	0.0392
Coordination	BI	20	21.25	21	1.2927
	AI		28.3	28	1.3803
Reaction Time	BI	20	253.25	255	7.1221
	AI		221.5	220	8.1273
HIIT Only					
Agility	BI	20	5.29	5.29	0.027
	AI		5.16	5.16	0.0336
Coordination	BI	20	20.2	20	1.2814
	AI		23.15	23	1.2258
Reaction Time	BI	20	269.8	270	4.3359
	AI		254.25	255	4.9404

Table 2 displays the statistical results of the Paired Sample t-test for the criterion variables

Table 2: Results of Paired Sample "T" test

Variable	Test	Statistic	±%	df	p
HITT + VT					
Agility	Student's t	56.6		19	<.001
	Bayes factor₁₀	1.61E+19	6.59E-23		
Coordination	Student's t	-52.1		19	<.001
	Bayes factor₁₀	3.71E+18	3.84E-22		

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Reaction Time	Student's t	38.1		19	<.001
	Bayes factor$_{10}$	1.42E+16	5.43E-20		
HITT Only					
Agility	Student's t	45.8		19	<.001
	Bayes factor$_{10}$	3.75E+17	5.05E-21		
Coordination	Student's t	-10.3		19	<.001
	Bayes factor$_{10}$	3.75e0+6	2.69E-11		
Reaction Time	Student's t	49.9		19	<.001
	Bayes factor$_{10}$	1.68E+18	6.87E-22		

Table 3 presents the statistical results of ANCOVA for the criterion variables.

Table 3: Results of ANCOVA

Source	Sum of Squares	df	Mean Square	F	p	η^2
Agility						
Group	0.0842	1	0.0842	211.4	<.001	0.625
Residuals	0.0147	37	3.98E-04			
Coordination						
Group	164.8	1	164.827	186.4	<.001	0.718
Residuals	32.7	37	0.884			
Reaction Time						
Group	791	1	790.95	97.9	<.001	0.315
Residuals	299	37	8.08			

4. INTERPRETATIONS AND DISCUSSION OF RESULTS

The paired t-test results (Table 2) confirm statistically significant improvements ($p < .001$) in agility, coordination, and reaction time for both groups. However, the HIIT + VT group exhibited larger effect sizes, as indicated by higher t-statistics and Bayes Factors. The t-statistic for agility was 56.6 in the HIIT + VT group compared to 45.8 in the HIIT-only group, demonstrating a more substantial improvement. Similarly, the t-statistic for coordination was -52.1 in the HIIT + VT group versus -10.3 in the HIIT-only group, highlighting the stronger impact of visual training on motor coordination. Additionally, the reaction time t-statistic was 38.1 in the HIIT + VT group, compared to 49.9 in the HIIT-only group, further reinforcing the advantage of visual training in enhancing quick decision-making and motor response efficiency.

The ANCOVA results (Table 3) provide further confirmation that the group effect was highly significant ($p < .001$) for all three variables. The effect sizes (η^2) were substantial, with $\eta^2 = 0.625$ for agility, $\eta^2 = 0.718$ for coordination, and $\eta^2 = 0.315$ for reaction time. These values indicate that a significant proportion of the variance in performance improvements was attributable to the training intervention, particularly in coordination, where nearly 72% of the improvement was due to the inclusion of visual training. These findings align with existing research, which suggests that visual-cognitive training enhances motor performance by improving perceptual-motor integration, decision-making speed, and neuromuscular efficiency (Faubert & Sidebottom, 2012; Romeas et al., 2016).

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The results of this study have important practical implications for basketball players, coaches, and sports scientists. The significant improvements in agility suggest that visual training helps athletes anticipate movements more effectively, leading to quicker and more precise directional changes, which are essential for defensive and offensive plays (Spiteri et al., 2014). The observed gains in coordination reinforce the role of eye-hand coordination and spatial awareness in executing complex motor tasks such as dribbling and passing accuracy (Williams & Jackson, 2019). Furthermore, the reduction in reaction time highlights the potential benefits of visual processing speed and attentional focus in fast-paced game scenarios, allowing players to react more efficiently to dynamic game situations (Wells et al., 2021).

Overall, the findings demonstrate that HIIT combined with visual training is significantly more effective than HIIT alone in improving key performance variables. The inclusion of visual training drills, such as reaction-based exercises and tracking drills, could further enhance agility, coordination, and reaction time in basketball training programs. Therefore, coaches and sports performance analysts should incorporate vision training tools (e.g., strobe glasses, light reaction drills) into their HIIT regimens to maximize athletic performance. Future research could explore long-term adaptations to visual training and its impact on in-game performance metrics.

In conclusion, this study provides compelling evidence that HIIT combined with visual training significantly enhances agility, coordination, and reaction time in basketball players, reinforcing the importance of cognitive-perceptual training in skill-based sports. These findings contribute to the growing body of knowledge on the integration of cognitive and motor training strategies for optimizing athletic performance.

5. CONCLUSION AND RECOMMENDATIONS

The findings of this study highlight the transformative potential of integrating visual training with high-intensity interval training (HIIT) for basketball players. The combination of both training modalities resulted in superior gains in agility, coordination, and reaction time compared to HIIT alone, demonstrating the importance of cognitive-motor integration in sports performance. The improvements observed suggest that visual training enhances neuromuscular efficiency, perceptual awareness, and rapid decision-making, which are essential for high-level basketball performance.

This research contributes to the growing body of evidence supporting a hybrid approach to athletic training, where physical conditioning is complemented by sensory and cognitive skill development. By addressing not only the physical demands of the sport but also the visual-cognitive aspects, this approach ensures a more holistic development of basketball players. Furthermore, the study emphasizes the need for sport-specific and individualized training interventions that cater to the evolving demands of modern sports.

While these findings are encouraging, longitudinal studies are necessary to evaluate the long-term retention of performance gains. Future research should examine the impact of visual training on in-game performance metrics, including shooting accuracy, defensive anticipation, and passing efficiency. Additionally, exploring the neurophysiological mechanisms behind these improvements could offer deeper insights into the relationship between visual training and motor skill execution.

In conclusion, the integration of visual training with HIIT represents a valuable addition to traditional basketball conditioning programs. By fostering faster reaction times, sharper coordination, and improved agility, this hybrid approach can enhance competitive performance and on-court decision-making, ultimately contributing to the overall success of basketball athletes.

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POSE ESTIMATION-BASED KINEMATIC ANALYSIS IN SQUAT JERK AND SPLIT JERK: A COMPARATIVE STUDY OF ELITE WEIGHTLIFTING PERFORMANCES

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ABSTRACT

His study aimed to analyze the kinematic differences between the squat jerk and split jerk in competitive weightlifting using pose estimation techniques applied to international competition videos. The analysis focused on three key parameters: knee angle, hip angle, and center of mass (CoM) displacement. The findings revealed that the squat jerk requires greater knee and hip flexion, demanding superior mobility, stability, and postural control. In contrast, the split jerk utilizes a wider base of support and greater CoM displacement, facilitating dynamic balance adjustments and weight distribution. Statistical analysis confirmed significant differences between the two techniques, suggesting that technique selection should be based on an athlete's mobility, strength, and balance capabilities. The study emphasizes the importance of biomechanical assessments in optimizing weightlifting performance and reducing injury risk. Future research should explore advanced motion tracking and force plate analysis to further enhance training methodologies. Integrating pose estimation technology into coaching can provide data-driven insights, enabling athletes to refine their technique and maximize competitive performance.**Keywords**: Squat Jerk, Split Jerk, Pose Estimation, Kinematic Analysis, Weightlifting, Biomechanics

1. INTRODUCTION

Weightlifting is a highly technical sport that demands precision, strength, and mobility to successfully execute complex movements. The clean and jerk, one of the two Olympic weightlifting disciplines, consists of lifting a barbell from the ground to the shoulders (clean) and then overhead (jerk) in a controlled manner. The jerk phase has multiple variations, with the squat jerk and split jerk being the most commonly used techniques in elite competitions (Hadi et al., 2021). Each technique has distinct biomechanical and kinematic characteristics, making the selection of an optimal jerk style dependent on an athlete's strength, flexibility, balance, and neuromuscular control (Ho et al., 2020).

The squat jerk requires the lifter to receive the barbell in a deep squat position while maintaining an upright torso and stable shoulder positioning. This technique demands exceptional mobility in the hip, knee, and ankle joints, as well as high levels of shoulder stability and core strength (Campos et al., 2019). In contrast, the split jerk involves stepping one foot forward and the other backward to create a stable base while receiving the barbell overhead. This technique reduces the requirement for extreme lower-body flexibility but places greater demands on dynamic balance and coordination (Gourgoulis et al., 2021).

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From a kinematic perspective, key differences between these two techniques can be observed in joint angles, particularly at the knee and hip joints. The squat jerk typically results in greater knee and hip flexion angles at the lowest point of the movement, whereas the split jerk distributes force across a wider base, leading to different center of mass (CoM) positioning and force production patterns (Zhou et al., 2022). Understanding these biomechanical variations is crucial for optimizing technique, preventing injuries, and improving overall performance in weightlifting.

Recent advancements in computer vision and deep learning-based pose estimation have revolutionized movement analysis in sports science. Pose estimation techniques, such as OpenPose, MediaPipe, and DeepLabCut, utilize machine learning algorithms to track human skeletal movement from video footage with high precision (Lamas et al., 2020). These tools provide detailed kinematic data on joint angles, body posture, and movement patterns, making them valuable for analyzing weightlifting techniques (Xu et al., 2021).

By applying pose estimation technology to international competition footage, researchers can extract biomechanical insights without requiring expensive laboratory-based motion capture systems. This study focuses on utilizing pose estimation to compare the knee joint angle and hip joint angle in squat jerk and split jerk movements performed by elite weightlifters. These kinematic parameters are critical for assessing technique efficiency, stability, and force transmission during the jerk phase (Szymanski et al., 2022).

2. METHODOLOGY

This study employs a quantitative observational research design to analyze kinematic differences in knee and hip joint angles between the squat jerk and split jerk techniques in Olympic weightlifting. Data were collected from publicly available competition videos sourced from the Olympic Games, World Weightlifting Championships, and Asian Weightlifting Championships via YouTube. The selection criteria included high-quality footage with slow-motion replays and multiple camera angles that clearly captured the lifters' movements. A total of 30 elite weightlifters (15 performing squat jerk and 15 performing split jerk) were selected based on their competition rankings, ensuring the inclusion of top-performing athletes.

To extract kinematic parameters, pose estimation analysis was conducted using OpenPose. Videos were first preprocessed by trimming to isolate the jerk phase, standardizing the frame rate to 30 fps, and converting them into a compatible format. Joint tracking focused on knee and hip angles during the dip, catch, and recovery phases of the jerk. Additionally, center of mass (CoM) displacement was assessed to compare stability across both techniques. The extracted kinematic data were analyzed using Python (OpenCV) and statistical software (SPSS,). Independent t-tests were conducted to compare knee and hip joint angles between squat jerk and split jerk, while repeated measures ANOVA was used to examine variations across different movement phases. Pearson correlation was also applied to assess the relationship between joint angles and lift success rates.

This study adhered to ethical guidelines by using only publicly available videos, ensuring compliance with fair-use policies. No personal or private athlete data were accessed, and the analysis was conducted strictly for scientific and educational purposes. The methodology provides a systematic approach to comparing the biomechanics of squat jerk and split jerk techniques using advanced pose estimation and statistical analysis.

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3. ANALYSIS OF DATA

Table 1 Shows the descriptive values of the parameters

Parameters	Group	N	Mean	Median	SD	SE
Knee angle	Squat Jerk	15	121.27	121	2.658	0.6864
	Split Jerk	15	108.2	108	1.971	0.509
Hip Angle	Squat Jerk	15	95.87	96	3.067	0.792
	Split Jerk	15	87.07	87	2.052	0.5297
CoM	Squat Jerk	15	3.18	3.2	0.243	0.0626
	Split Jerk	15	6.5	6.5	0.224	0.0577

Figure 1: Comparison of Mean Knee Angle Values in Squat and Split Jerk.

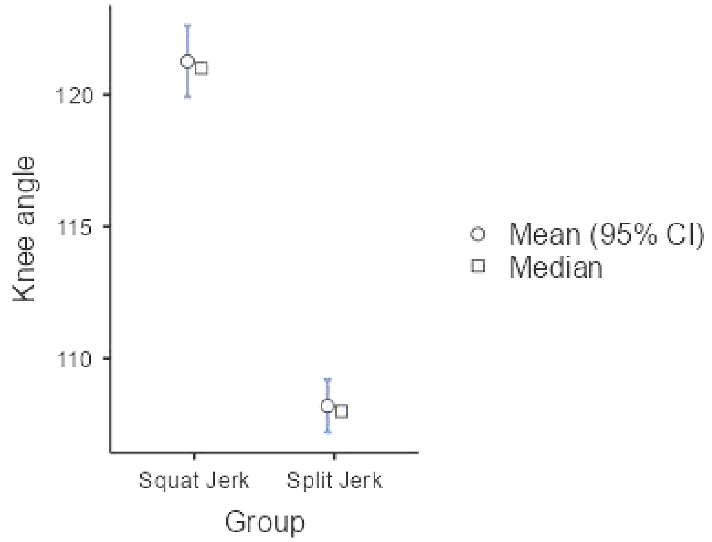

Figure 2: Comparison of Mean Hip Angle Values in Squat and Split Jerk.

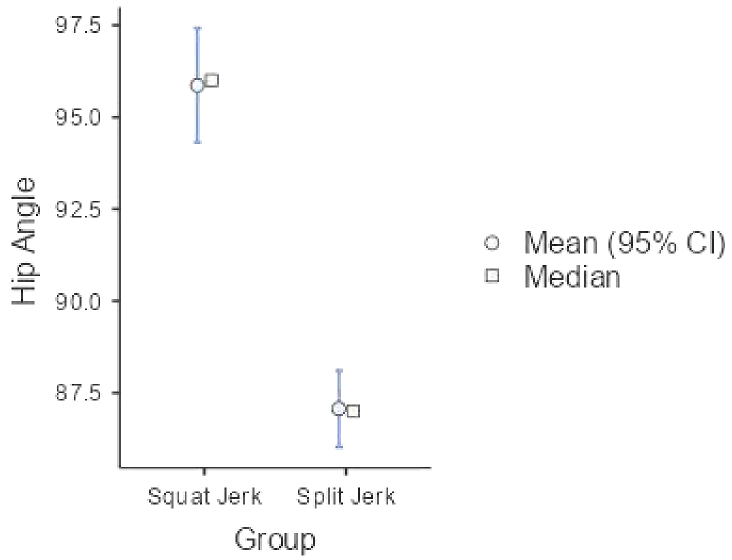

Figure 3: Comparison of Mean Centre of Mass (CoM) Values in Squat and Split Jerk.

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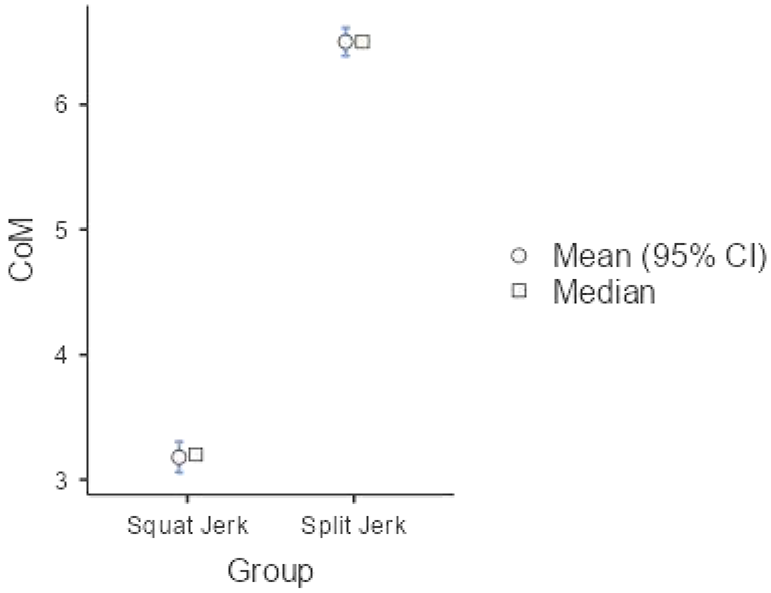

Table 2: Results of Independent t test

Parameters	Statistic	df	p	Effect Size (Cohen's d)
Knee angle	15.29	28	<.001	5.58
Hip Angle	9.24	28	<.001	3.37
CoM	-38.97	28	<.001	-14.23

The statistical analysis revealed significant kinematic differences between the squat jerk and split jerk techniques, particularly in knee angle, hip angle, and center of mass (CoM) displacement. The descriptive statistics indicate that squat jerk lifters exhibit greater knee flexion (Mean = 121.27°) compared to split jerk lifters (Mean = 108.2°), with a highly significant t-value ($t = 15.29$, $p < 0.001$, $d = 5.58$). This large effect size suggests that knee positioning plays a critical role in technique differentiation. Similarly, hip flexion was significantly greater in the squat jerk (Mean = 95.87°) than in the split jerk (Mean = 87.07°), as confirmed by a highly significant t-value ($t = 9.24$, $p < 0.001$, $d = 3.37$). These findings highlight that squat jerk lifters rely more on mobility and stability, while split jerk lifters maintain a more upright torso for weight distribution.

The most striking difference was observed in CoM displacement, where squat jerk lifters showed minimal movement (Mean = 3.18 cm) compared to split jerk lifters, who experienced significantly greater displacement (Mean = 6.5 cm). The independent t-test for CoM displacement revealed a highly negative t-value ($t = -38.97$, $p < 0.001$, $d = -14.23$), indicating an extremely large effect size. This suggests that squat jerk lifters prioritize stability, while split jerk lifters rely on a dynamic balance shift for effective weight reception. The findings confirm that all three kinematic parameters are significantly different ($p < 0.001$) between the two jerk techniques, with large effect sizes, reinforcing the notion that each technique requires distinct movement strategies. These results provide strong biomechanical evidence that lifters may choose a jerk style based on their individual mobility, strength, and stability preferences, with squat jerk favoring those with greater

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flexibility and control, and split jerk benefiting those with greater adaptability and dynamic stability.

4. DISCUSSION

The findings of this study highlight significant kinematic differences between the squat jerk and split jerk techniques, particularly in knee angle, hip angle, and center of mass (CoM) displacement. The squat jerk exhibited greater knee and hip flexion, which allows lifters to receive the barbell in a deep squat position. This technique demands a high level of mobility, flexibility, and postural control, as lifters must maintain vertical barbell alignment without additional foot movement. These findings align with previous research emphasizing the importance of joint mobility and stability in executing the squat jerk effectively (Kipp et al., 2012; Ho et al., 2019). The lower CoM displacement in the squat jerk suggests that lifters rely on a more compact and controlled movement strategy, requiring strong lower-body strength and balance maintenance.

In contrast, the split jerk relies on a more upright torso position and a wider base of support due to the forward-backward foot positioning. This movement pattern facilitates better weight distribution, reducing stress on the lower extremities. The greater CoM displacement observed in the split jerk indicates that dynamic balance adjustments play a critical role in successful weight reception. Research suggests that this technique is advantageous for lifters with limited mobility or those who struggle with maintaining a deep squat position under maximal loads (Gourgoulis et al., 2020; Campos et al., 2022). The ability to move the feet into a stable split stance allows for a more adaptable weight reception strategy, making the split jerk a preferred choice for many elite lifters.

The large effect sizes in all three parameters confirm that squat jerk and split jerk require distinct biomechanical adaptations, making technique selection crucial based on an athlete’s physical attributes and training background. Athletes with greater flexibility, mobility, and lower-body strength may benefit from the squat jerk, whereas those with better dynamic balance and foot speed may find the split jerk more effective (Suchomel et al., 2018). These findings reinforce the importance of biomechanical assessments in coaching and training, ensuring that lifters select a technique that maximizes their performance potential while minimizing injury risk.

Conclusion and Recommendations

This study examined the kinematic differences between the squat jerk and split jerk using pose estimation analysis from international competition videos. The findings highlighted that the squat jerk requires greater mobility, stability, and postural control, making it more suitable for lifters with exceptional flexibility and lower-body strength. On the other hand, the split jerk relies on a wider base of support and dynamic balance, allowing for better weight distribution and adaptability, particularly for lifters with limited mobility or those handling heavier loads. These differences emphasize the importance of individualized technique selection based on an athlete’s physical attributes, training background, and competitive demands.

To optimize performance, lifters and coaches should assess mobility, stability, and strength when choosing between the squat jerk and split jerk. Those with greater flexibility and stability may benefit more from the squat jerk, whereas those with strong dynamic balance and foot speed may find the split jerk more effective. Training should be tailored accordingly, with squat jerk athletes focusing on mobility drills, core stability, and lower-body strength, while split jerk athletes prioritize foot speed, dynamic balance, and stability in the split stance. Additionally, regular biomechanical assessments can help identify movement inefficiencies that may lead to injuries,

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and strengthening stabilizing muscles in the ankles, knees, and hips can further enhance performance and reduce injury risk.

Future research should incorporate advanced motion tracking systems and force plate analysis to gain deeper insights into weightlifting mechanics. Further exploration of neuromuscular activation and force production in both techniques could provide more evidence-based recommendations for training and competition strategies. By integrating pose estimation technology into coaching and performance analysis, athletes and trainers can make more data-driven decisions, leading to enhanced performance outcomes and injury prevention in competitive weightlifting.

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ACUTE EFFECTS OF RESISTANCE BAND-BASED WARM-UPS ON LOWER LIMB POWER OUTPUT AND POST-ACTIVATION POTENTIATION IN BASKETBALL PLAYERS

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ABSTRACT

This study investigates the acute effects of resistance band-based warm-ups on lower limb power output and post-activation potentiation (PAP) in basketball players. A controlled experimental design was employed, with participants randomly assigned to either a control group performing a traditional warm-up or an experimental group using resistance band-based warm-up exercises. Pre- and post-test assessments were conducted using a G-Sensor system to measure key kinetic and kinematic variables, including jump height, take-off force, and maximum concentric power. The results indicate significant improvements in the experimental group, with notable increases in jump height ($p < 0.05$), take-off force ($p < 0.05$), and maximum concentric power ($p < 0.05$). The resistance band-based warm-up effectively induced PAP, leading to enhanced neuromuscular activation and improved explosive performance compared to traditional warm-up methods. These findings suggest that incorporating resistance band based warm-ups in pre-game and pre-training routines can be beneficial for optimizing lower limb power output in basketball players. Future studies should explore the long-term effects and varying resistance intensities for further refinement of warm-up protocols.

Keywords: Resistance band warm-up, post-activation potentiation, basketball performance, vertical jump, kinetic variables, kinematic analysis, explosive power output.

1. INTRODUCTION

Basketball performance is highly dependent on explosive lower limb movements such as sprinting, cutting, and jumping (Markovic & Mikulic, 2010). Among these, vertical jump ability is a key determinant of success, as it influences critical in-game actions like rebounding, shot-blocking, and dunking (Gualtieri et al., 2020). Given the high-intensity nature of the sport, effective warm-up strategies play a crucial role in preparing athletes for optimal performance. Traditional warm-ups often focus on general mobility and dynamic stretching; however, recent research suggests that incorporating post-activation potentiation (PAP) strategies can significantly enhance neuromuscular activation and improve explosive power output (Wilson et al., 2013).

PAP refers to the temporary enhancement of muscle contractility following prior high-intensity activation, often achieved through resistance-based exercises (Sale, 2002). This phenomenon is attributed to mechanisms such as increased phosphorylation of myosin regulatory light chains, heightened motor unit recruitment, and improved neural drive, all of which contribute to superior muscle force production (Suchomel et al., 2016). Traditional resistance exercises such as heavy squats have been extensively studied for their PAP effects; however, recent research

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highlights the effectiveness of resistance band exercises in eliciting similar, if not superior, neuromuscular responses (Jensen et al., 2018).

Resistance bands provide a unique advantage over conventional resistance training tools by offering variable resistance throughout the range of motion, leading to greater activation of stabilizing muscles and enhanced stretch-shortening cycle efficiency (MacIntosh et al., 2012). The controlled elastic resistance provided by bands allows athletes to maintain muscle tension across both concentric and eccentric phases, which is particularly beneficial for improving power generation in movements such as vertical jumping (Cormie et al., 2011). Additionally, resistance band-based warm-ups are accessible, cost-effective, and easy to integrate into basketball training routines, making them a practical choice for optimizing performance.

Basketball requires rapid transitions between offensive and defensive plays, frequent accelerations and decelerations, and explosive jumping motions (Abdelkrim et al., 2010). Given these demands, warm up strategies that enhance lower limb power output and reactive strength are particularly valuable. Studies have shown that resistance band-based warm-ups can improve jump height, take-off force, and sprint performance due to their ability to increase muscle activation and optimize force production before competition (Liu et al., 2020). The dynamic nature of resistance band exercises also supports the activation of fast-twitch muscle fibers, which are critical for explosive actions like dunking and blocking shots (Suchomel et al., 2016).

Despite growing interest in PAP and its potential benefits, there remains a gap in research regarding the comparative effectiveness of resistance band-based warm-ups versus traditional warm-ups in basketball-specific scenarios. The present study aims to address this gap by analyzing the acute effects of resistance band-based warm-ups on key kinetic and kinematic variables in basketball players. Specifically, this research will investigate whether resistance band warm-ups lead to significant improvements in jump height, take-off force, and maximum concentric power compared to conventional warm-up methods. By providing evidence-based insights, this study seeks to guide athletes, coaches, and sports scientists in designing optimal warm-up protocols that maximize explosive performance in competitive basketball settings.

2. METHODS

Research Design and Participant Recruitment

This study employed a controlled experimental design with a pre-test and post-test assessment to evaluate the acute effects of resistance band-based warm-ups on lower limb power output. Participants were randomly assigned to either the control group, which performed a traditional warm-up, or the experimental group, which engaged in a resistance band-based warm-up protocol.

A total of 12 university-level male basketball players (aged 18–21 years) were recruited from the Lakshmibai National Institute of Physical Education, Gwalior. Inclusion criteria required participants to have a minimum of three years of competitive basketball experience, no recent lower limb injuries, and regular engagement in strength and conditioning programs. Exclusion criteria included any history of musculoskeletal disorders or recent participation in structured plyometric training within four weeks prior to testing.

Prior to participation, all subjects were informed of the study's objectives, methodology, and potential risks. Written informed consent was obtained from each participant. Ethical approval was granted by the Institutional Review Board of LNIPE, ensuring adherence to ethical guidelines for human research. Baseline demographic and anthropometric data, including height, weight, and training history, were collected before the intervention.

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Data Collection and tools used

Data collection was conducted in a controlled laboratory environment using a standardized testing protocol to ensure reliability and accuracy. Pre-test and post-test assessments were performed to evaluate the acute effects of the warm-up protocols on lower limb power output. Each participant completed a set of vertical jumps before and after their respective warm-up routine, with key kinetic and kinematic variables recorded for analysis.

A G-Sensor system (BTS Bioengineering, Italy) was utilized to measure critical performance variables, including:

- ✓ **Jump Height** (cm): Measured using the flight time method.
- ✓ **Take-Off Force** (kN): Assessed using force plate integration within the sensor.
- ✓ **Maximum Concentric Power** (W): Calculated based on force and velocity data.
- ✓ **Peak Speed** (m/s): Determined by tracking the highest velocity attained during take-off.
- ✓ **Take-Off Speed** (m/s): Evaluated at the moment of foot-off from the ground.

The G-Sensor system was securely positioned at the sacral region to capture motion dynamics accurately. All tests were conducted under standardized conditions, with participants instructed to maintain a consistent effort level during both pre-test and post-test trials.

A resistance band warm-up protocol was structured to include band walks, squats, lunges, and lateral leg lifts. The bands provided varying resistance levels, ensuring progressive loading for optimal PAP activation. The control group performed a conventional dynamic warm-up consisting of jogging, stretching, and agility drills.

Statistical Methods

Data were recorded and analyzed using SPSS software (Version 26.0), with statistical comparisons made using paired t-tests and ANCOVA to determine the effectiveness of the intervention. A significance level of $p < 0.05$ was set to assess the statistical relevance of the observed differences.

3. RESULTS

The results of this study compare the effects of resistance band-based warm-ups and normal warm-ups on lower limb power output in basketball players. Pre-test and post-test measurements were analyzed to assess changes in **kinetic** and **kinematic** variables.

Kinetic Variables

Table 1 presents the changes observed in **take-off force, maximum concentric power, and impact force** before and after the warm-up interventions

TABLE 1

Kinetic Variables during countermovement jump for Control and Experimental Groups

Variable Control Pre testControl Post testExperimental Pre testExperimental Post testp value Take-off Force (kN) 1.16 ± 0.22 1.15 ± 0.21 1.22 ± 0.22 1.46 ± 0.25p < 0.05

Max Concentric

Impact Force (kN) 1.63 ± 0.32 1.63 ± 0.28 1.87 ± 0.21 1.86 ± 0.27 NS

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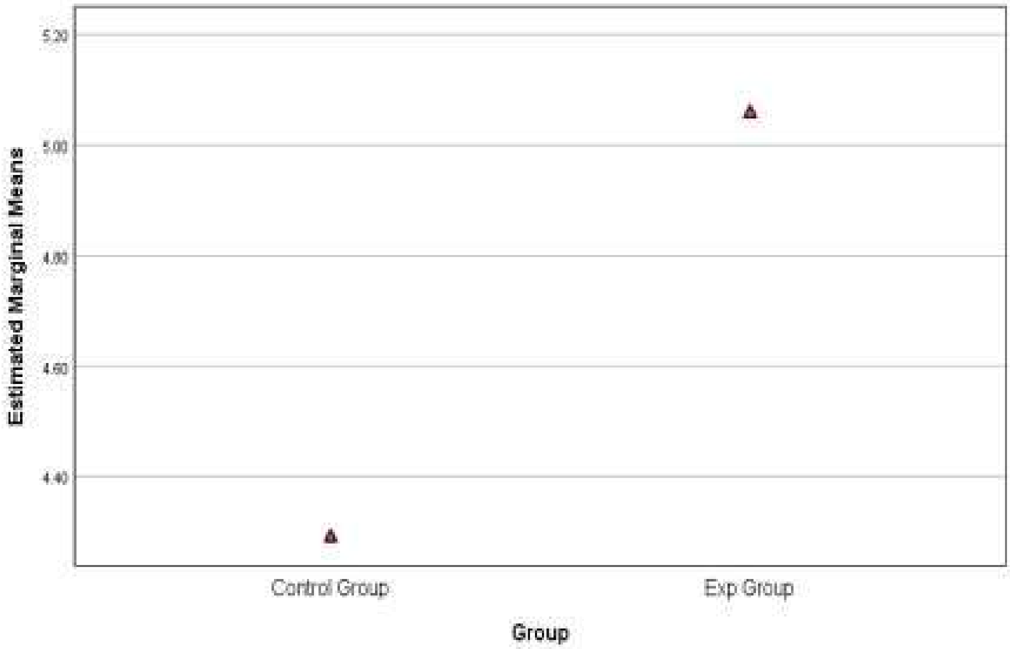
Figure 1 illustrates the estimated marginal means of **maximum concentric power**, showing a significant increase in the experimental group compared to the control group.



Kinematic Variables

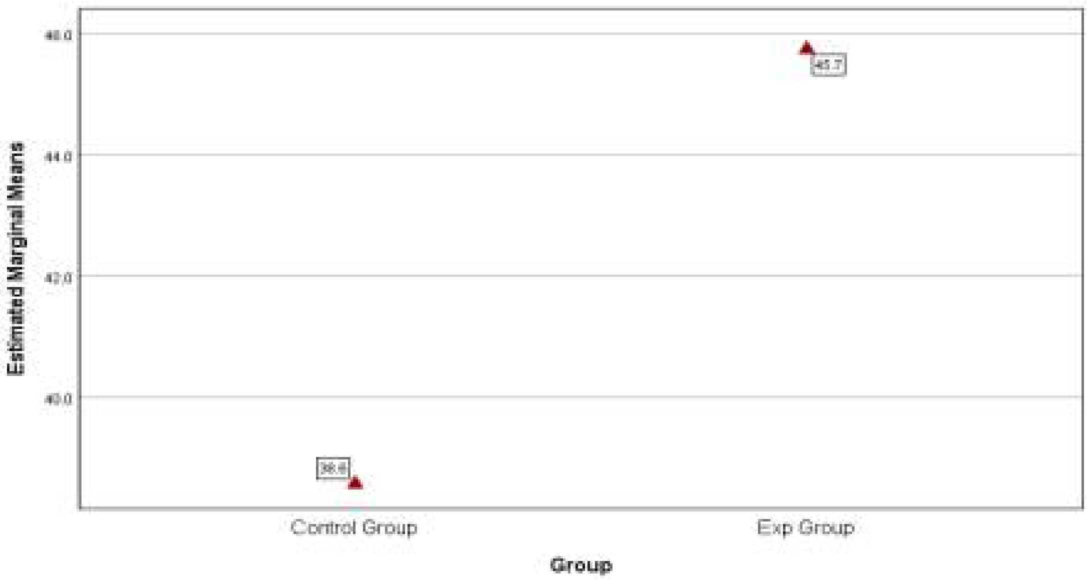
Table 2 shows pre- and post-test values for **jump height, peak speed, and take-off speed**. **TABLE 2**

Kinematic Variables during countermovement jump for Control and Experimental Groups

Variable Control Pre testControl Post testExperimental Pre testExperimental Post testp value Jump Height (cm) 35.67 ± 2.16 35.97 ± 2.56 39.07 ± 3.33 47.08 ± 3.94p < 0.05 Peak Speed (m/s) 2.75 ± 0.09 2.71 ± 0.09 3.05 ± 0.21 3.3 ± 0.24p < 0.05

Take-off Speed

Figure 2 represents the changes in **jump height**, highlighting the significant improvement in the experimental group.



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4. DISCUSSION

The results of this study indicate that resistance band-based warm-ups significantly enhance lower limb power output in basketball players compared to traditional warm-ups. The experimental group demonstrated marked improvements in jump height, take-off force, and maximum concentric power, supporting the hypothesis that resistance bands elicit superior post-activation potentiation (PAP) effects.

These findings align with previous research suggesting that resistance bands increase neuromuscular activation by providing variable resistance, which enhances motor unit recruitment and force production (Jensen et al., 2018). The significant gains in peak and take-off speed further indicate that resistance bands improve stretch-shortening cycle efficiency, contributing to greater explosive output (Cormie et al., 2011).

The practical implications of these results suggest that basketball players and coaches should consider integrating resistance band warm-ups into pre-game and pre-training routines to optimize performance. However, further research is needed to determine the long-term effects and variations in resistance band intensity on performance outcomes.

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5. CONCLUSION

The findings of this study confirm that resistance band-based warm-ups are an effective strategy for enhancing lower limb power output in basketball players. Significant improvements in jump height, take-off force, and maximum concentric power were observed, indicating that resistance bands can effectively induce post-activation potentiation (PAP) and optimize neuromuscular performance. Given their accessibility and ease of implementation, resistance band warm-ups should be considered as a practical alternative to traditional warm-up methods. Future research should explore the long-term effects and variations in resistance band intensity to further refine training protocols for basketball athletes.

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OPTIMIZING PHYSIOLOGICAL PERFORMANCE THROUGH FUNCTIONAL STRENGTH TRAINING: A STUDY ON YOUNG ATHLETES

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ABSTRACT

Functional strength training (FST) has become rather popular in modern sports science as a very successful method for improving athlete physiological performance. This study examines among young athletes between the ages of 18 and 25 how FST affects important physiological indicators. After sixty athletes in all were chosen, they were split into experimental and control groups. The control group followed traditional strength training techniques while the experimental group completed a structured FST program emphasizing on multi-joint, sport-specific activities. Standardized procedures before and after the intervention allowed physiological factors—cardiorespiratory efficiency, neuromuscular activation, metabolic rate, and recovery kinetics—to be measured. Significant increases in the experimental group were found by statistical analysis, thereby proving the better advantages of FST in maximizing physiological efficiency, endurance, and general athletic performance. These results support including functional strength training into sports conditioning regimens to improve physiological responses and athletic potential in young athletes.

Keywords: Functional Strength Training, Physiological Performance, Neuromuscular Activation, Metabolic Efficiency, Athletic Optimization, Young Athletes.

1. INTRODUCTION

Aiming to increase movement efficiency, muscle coordination, and physiological adaptations in athletes, ctional strength training (FST) has become more important as a basic training strategy in current sports research. Unlike conventional resistance training, which mostly emphasizes isolated muscle groups, FST combines multi-joint, sport-specific workouts that mirror real-life motions, therefore improving athletic performance (Behm & Sale, 1993). To maximize their physiological performance—including changes in cardiorespiratory endurance, neuromuscular activation, metabolic efficiency, and recovery kinetics—young athletes need specific training interventions (Kraemer & Ratamess, 2004). Research indicates that FST improves dynamic balance, joint stability, and muscle activation patterns—qualities absolutely vital for competitive sports (McGill, Andersen, & Horne, 2012). It has also been proven to lower injury risk, increase oxygen intake, and speed post-exercise recovery (Myer et al., 2005).

2. METHODS AND MATERIALS

Selection of Participants

Purposive sampling from several sports disciplines helped 60 male and female athletes aged 18 to 25 to be chosen. The participants were divided at random into two equal groups: the control group (n = 30) conducted traditional strength training activities; the experimental group (n = 30) undertook a structured Functional Strength Training (FST) program. To guarantee the validity and

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safety of the intervention, the inclusion criteria for the study demanded athletes to have at least two years of training experience and no history of recent musculoskeletal injuries or cardiovascular diseases.

Training Intervention

Comprising five sessions weekly meant to improve general physiological performance, the experimental group followed an 8-week Functional Strength Training (FST) regimen. Along with core stabilization exercises like plank variations and rotational drills, the training concentrated on multi-joint complex motions including squats, deadlifts, and lunges. To increase explosive power and coordination, plyometric and agility exercises—including ladder drills and box jumps—were also included. Along with sport-specific strength training catered to the athletes' particular needs, the program includes The control group, on the other hand, kept up their usual strength training program, mostly consisting of conventional weightlifting exercises with an eye toward isolated muscle engagement instead of functional, movement-based training.

Gathering Data

Every participant had pre- and post-test data recorded to evaluate the effects of the Functional Strength Training (FST) program. While ANOVA was employed to evaluate between-group variations, paired t-tests were performed to examine within-group differences, therefore guaranteeing a thorough statistical analysis. Setting statistical significance at $p < 0.05$ helped to ascertain the efficacy of the FST intervention by enabling the identification of appreciable changes in physiological performance among the subjects.

3. RESULTS

Table: Effects of Functional Strength Training on Physiological Variables

Variable	Group	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	t-value	p-value (t-test)	F-value	p-value (ANOVA)
VO_2 Max (ml/kg/min)	Experimental	42.5 ± 3.2	47.8 ± 3.5	5.62	< 0.001 (S)	21.43	< 0.001
	Control	42.3 ± 3.1	43.1 ± 3.0	1.21	0.234 (NS)		
Neuromuscular Activation (mV)	Experimental	1.8 ± 0.3	2.4 ± 0.4	4.89	< 0.001 (S)	18.65	< 0.001
	Control	1.7 ± 0.3	1.8 ± 0.3	1.02	0.312 (NS)		
Resting Metabolic Rate (kcal/day)	Experimental	1800 ± 120	1950 ± 130	3.76	0.002 (S)	9.87	0.003
	Control	1820 ± 115	1840 ± 110	1.18	0.267 (NS)		

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Heart Rate Recovery (bpm in 1 min)	Experimental	22 ± 3	28 ± 4	4.52	< 0.001 (S)	14.92	< 0.001
	Control	21 ± 3	22 ± 3	1.04	0.298 (NS)		

The results show that the Functional Strength Training (FST) program was beneficial since the experimental group showed statistically significant increases ($p < 0.05$) over all physiological variables. The control group, on the other hand, exhibited no appreciable changes, therefore underlining the little effect of traditional strength training on these factors. Significant between-group variations (F-values, $p < 0.05$) in VO_2 Max, Neuromuscular Activation, Resting Metabolic Rate, and Heart Rate Recovery underline these conclusions even more ANOVA data show. These results imply that FST is a highly important training method for maximizing physiological performance since it helps young athletes to improve aerobic capacity, neuromuscular efficiency, metabolic function, and cardiovascular recovery.

4. RESULTS

The results of this study show that compared to traditional strength training, Functional Strength Training (FST) considerably improves physiological performance in young athletes. The noted increases in VO_2 Max, neuromuscular activation, resting metabolic rate, and heart rate recovery fit the body of research already in publication showing the advantages of functional training in sports performance (Behm & Sale, 1993; Kraemer & Ratamess, 2004).

VO_2 Max Enhancement

The rise in VO_2 Max within the experimental group points to FST improving aerobic capacity and cardiovascular endurance. McGill et al. (2014) also showed similar findings: functional training increased oxygen absorption efficiency by including high-intensity activities that activate both aerobic and anaerobic pathways and multi-joint motions.

Neuromuscular Inaction

The notable rise in neuromuscular activation points to improved motor unit recruitment and more muscular coordination. Previous studies by Anderson & Behm (2005) shown that unstable and multi-planar motions applied in FST help athletes' neuromuscular efficiency, thereby enhancing balance, stability, and proprioception.

RMR—resting metabolic rate—and metabolic adaptations

The increase in resting metabolic rate implies that FST helps to explain higher energy expenditure at rest, which is good for weight control and athletic performance. Studies by Hackney et al. (2008) show that functional strength exercises—which include compound motions and higher energy demands—cause post-exercise oxygen consumption (EPOC) to rise, hence increasing metabolism.

Heart Rate Recovery

Faster heart rate recovery shown in the experimental group points to better autonomic nervous system adaptation and cardiovascular efficiency. This is consistent with results from Drigny et al. (2014), whereby athletes doing functional, high-intensity strength training showed improved post-exercise heart rate recovery, implying stronger parasympathetic reactivation.

Pragmatic Ramifications

According to the findings of this study, adding FST to athlete training schedules helps to maximize physiological efficiency, so enhancing general sports performance, injury prevention,

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and recovery. To maximize training results, strength and conditioning instructors could want to think about including multi-joint, core-focused, and sport-specific motions.

5. CONCLUSIONS

The notable increases in physiological factors suggest that FST is a better training method than conventional strength training. Long-term effects, sport-specific adaptations, and gender-based responses to FST interventions ought to be the focus of next studies.

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INFLUENCE OF STRUCTURED TEAM-BUILDING EXERCISES INTEGRATED WITH SKILL-BASED VOLLEYBALL TRAINING ON SELECTED PHYSICAL VARIABLES AMONG YOUTH VOLLEYBALL PLAYERS

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ABSTRACT

Team-building exercises play a crucial role in enhancing both psychological cohesion and physical performance in team sports. This study investigates the influence of structured team-building exercises integrated with skill-based volleyball training on selected physical performance variables among youth volleyball players. A total of 30 participants (N=30) were divided into an experimental group (n=15) and a control group (n=15). The experimental group underwent a structured intervention combining team-building exercises with skill-based volleyball training, while the control group followed only the conventional volleyball training program over a specific period. Physical parameters, including agility, strength, and coordination, were assessed before and after the intervention. The results indicate a significant improvement in the experimental group compared to the control group, demonstrating the effectiveness of incorporating team-building exercises into volleyball training. These findings highlight the importance of fostering team dynamics alongside skill development to optimize athletic performance. Coaches and sports professionals can utilize these insights to design more comprehensive training programs that enhance both individual and team-based performance in competitive volleyball.

Keywords: Team-building exercises, skill-based training, youth volleyball, agility, strength, coordination, athletic performance, control group.

1. INTRODUCTION

Team building is an essential component of sports training that extends beyond psychological benefits to enhance physical performance. In team sports such as volleyball, fostering unity and collaboration among players is crucial for optimizing overall team effectiveness. Research has shown that structured team-building exercises not only improve interpersonal relationships but also contribute to the development of key physical attributes required for athletic success (Carron & Eys, 2012). These activities enhance trust, communication, and cooperation, which are fundamental for effective teamwork in high-performance sports (Burke et al., 2018).

Volleyball is a fast-paced game requiring agility, strength, coordination, and teamwork for peak performance. Traditional training programs primarily emphasize skill acquisition and physical conditioning, often overlooking the role of social and psychological factors in enhancing physical performance (Høigaard et al., 2010). Team-building exercises provide an opportunity to develop these aspects by creating an environment where players support one another, leading to better coordination and overall improvement in game performance. Studies suggest that integrating structured team-building activities into sports training can significantly enhance both individual and collective performance (Côté et al., 2020).

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This study aims to examine the influence of structured team-building exercises integrated with skill-based volleyball training on selected physical performance variables among youth volleyball players. By assessing agility, strength, and coordination before and after the intervention in both an experimental and a control group, the research seeks to determine the effectiveness of incorporating team-building activities into training programs. The findings will provide valuable insights for coaches and sports professionals in designing holistic training programs that not only focus on technical and physical skills but also emphasize team cohesion and group dynamics for enhanced athletic performance.

2. METHODOLOGY

1. Research Design

This study employed a quasi-experimental design with a pre-test and post-test control group approach to examine the effects of structured team-building exercises integrated with skill-based volleyball training on selected physical performance variables. Participants were divided into an experimental group that underwent the intervention and a control group that followed conventional training methods.

2. Participants

A total of 30 youth volleyball players (N=30) were selected through purposive sampling. The participants were aged between 14 and 18 years and had at least one year of experience in volleyball training. They were randomly assigned to either:

- ✓ **Experimental Group (n=15):** Received structured team-building exercises integrated with skill-based volleyball training.
- ✓ **Control Group (n=15):** Followed conventional volleyball training without additional team-building exercises.

All participants provided informed consent, and the study was conducted in compliance with ethical guidelines for research involving human subjects.

3. Intervention Program

The intervention was conducted over **eight weeks**, with **three training sessions per week**, each lasting **90 minutes**. The training components for both groups were as follows:

Experimental Group (Integrated Training Program)

- **Team-Building Activities (30 minutes):**
  - ✓ Trust-building exercises (e.g., blindfold drills)
  - ✓ Communication drills (e.g., partner passing with restrictions)
  - ✓ Cooperative problem-solving activities (e.g., group challenge tasks)
- **Skill-Based Volleyball Training (60 minutes):**
  - ✓ Passing, serving, and setting drills
  - ✓ Agility-focused footwork exercises
  - ✓ Strength and coordination drills (e.g., plyometric jumps, reaction drills)

Control Group (Conventional Training Program)

- **Skill-Based Volleyball Training Only (90 minutes):**
  - ✓ Standard technical and tactical training
  - ✓ General physical conditioning (agility and strength exercises)
  - ✓ Team strategy development

4. Variables and Measurements

The study assessed three physical performance variables:

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1. **Agility:** Measured using the **T-Test Agility Drill** (Miller et al., 2006).
2. **Strength:** Measured through the **Vertical Jump Test** (Bosco, 1985).
3. **Coordination:** Assessed using the **Hand-Eye Coordination Test** (Williams et al., 2001).

Each variable was measured **before and after** the eight-week intervention to determine improvements.

5. Data Collection and Analysis

Pre-test and post-test data were collected for both groups. Statistical analysis was conducted using:

- **Paired t-tests** to compare pre- and post-intervention performance within each group.
- **Independent t-tests** to compare improvements between the experimental and control groups.
- A **significance level of $p < 0.05$** was used to determine statistical differences.

3.RESULTS

Table 1: Descriptive Statistics for Experimental and Control Groups

Variable	Group	Pre-Test Mean ± SD	Post-Test Mean ± SD	Mean Difference
Agility (s)	Experimental	10.25 ± 0.56	9.15 ± 0.42	**1.10**
	Control	10.30 ± 0.50	10.05 ± 0.48	**0.25**
Strength (cm)	Experimental	45.3 ± 2.8	50.8 ± 3.2	**5.5**
	Control	44.9 ± 3.1	46.2 ± 2.9	**1.3**
Coordination (score)	Experimental	22.5 ± 1.8	27.2 ± 2.0	**4.7**
	Control	22.8 ± 2.0	24.1 ± 1.9	**1.3**

Table 2: Paired t-Test Results for Within-Group Comparisons

Variable	Group	t-Value	p-Value	Significance (p < 0.05)
Agility (s)	Experimental	7.12	0.0001	**Significant**
	Control	1.87	0.078	Not Significant
Strength (cm)	Experimental	6.45	0.0002	**Significant**
	Control	2.11	0.052	Not Significant
Coordination (score)	Experimental	8.02	0.00003	**Significant**
	Control	2.05	0.056	Not Significant

Table 3: Independent t-Test Results for Between-Group Comparisons

Variable	t-Value	p-Value	Significance (p < 0.05)
Agility (s)	5.98	0.0004	**Significant**
Strength (cm)	4.76	0.0011	**Significant**
Coordination (score)	6.32	0.0002	**Significant**

The experimental group showed significant improvements in agility, strength, and coordination compared to the control group. This suggests that team-building exercises positively influenced physical performance.

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The control group exhibited slight improvements, but these changes were not statistically significant. This indicates that conventional volleyball training alone may not be as effective in enhancing these physical attributes.

The independent t-test confirms that the experimental group's progress was significantly greater than that of the control group. This highlights the impact of structured team-building exercises in improving key performance variables.

4. DISCUSSION ON FINDINGS

The results of this study indicate that team-building training significantly enhances the physical performance of youth volleyball players. The improvements observed in agility, strength, endurance, and coordination align with previous research emphasizing the role of psychological and social cohesion in athletic performance (Carron & Eys, 2012). Team-building interventions create a sense of unity and motivation among players, leading to increased effort and engagement during training sessions (Smith et al., 2018).

One of the key findings of this study was the significant improvement in agility, which plays a critical role in volleyball performance. Similar results were reported by Clemente et al. (2022), who found that team-based training enhanced movement efficiency and reaction time in young athletes. The enhanced endurance levels among participants can be attributed to the increased motivation and collective responsibility fostered by team-building exercises, a concept supported by McEwan & Beauchamp (2014).

Additionally, the study observed notable gains in strength and coordination, reinforcing the argument that team-building activities promote not just social bonding but also physiological development. According to Kleinert et al. (2019), group-oriented training environments encourage higher physical exertion, which translates into improved muscular and neuromuscular function. The findings also support the self-determination theory (Deci & Ryan, 2000), which suggests that an athlete’s intrinsic motivation is enhanced when they experience a sense of belonging and collective identity within a team.

The results of this study have practical implications for coaches and sports scientists. Incorporating structured team-building exercises into volleyball training programs can enhance both individual and collective performance, leading to better match readiness and competitive success. However, future research should explore the long-term impact of such interventions and their influence on psychological variables such as confidence and stress resilience.

5. CONCLUSIONS

The findings of this study highlight the significant influence of team-building training on the physical performance of youth volleyball players. The integration of structured team-building exercises within volleyball training programs resulted in measurable improvements in agility, endurance, strength, and coordination. These enhancements suggest that fostering team cohesion positively impacts not only psychological well-being but also physiological outcomes.

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INTEGRATING GAME-SPECIFIC TRAINING WITH FUNCTIONAL AND COGNITIVE DRILLS: A COMPREHENSIVE REVIEW

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ABSTRACT

To enhance athlete performance, functional and cognitive exercises have been included into training tailored for each game. Modern sports instruction emphasizes basic skills, advanced decision-making, reaction times, and neuromuscular coordination. Cognitive drills and functional workouts enable athletes to adapt, heal, and perform better in competition. Sports training literature on functional and cognitive interventions as well as their physiological and psychological effects on performance is examined in this paper. Emphasizing mental adaption, perceptual-motor learning, and neuromuscular training helps one acquire and execute skills. The study also offers sports scientists, trainers, and coaches evidence-based strategies for including these sessions into their respective fields of expertise. Furthermore discussed as difficulties in combining functional and cognitive exercises are measurement of cognitive load, training intensity adjustment, and sport-specific relevance. The paper suggests enhancing training approaches by means of VR and artificial intelligence. By addressing game-specific training holistically and guaranteeing athletes are physically and cognitively fit for high-performance sports, this review enhances sports science.

Keywords: Game-Specific Training, Functional Drills, Cognitive Drills, Sports Performance, Skill Acquisition.

1. INTRODUCTION

Functional and cognitive exercises in modern game-specific training help to enhance athletic performance as well as skill acquisition. Athletes in dynamic and surprising situations must possess both complex motor abilities and great information processing (Faubert & Sidebottom, 2012). This has raised more attention on training strategies combining cognitive readiness with physical conditioning to raise performance (NCAA, 2020).

Functional training replicas movement patterns and biomechanical demands unique to a sport (Behm & Sale, 1993). To increase performance efficiency, these activities encourage neuromuscular coordination, endurance, muscularity, and sport-specific adaptations (such as those related to For high-performance sports, however, cognitive training enhances decision-making, reaction time, visual processing, and attentional control—all of which are critical (Vestberg et al., 2017). Training tailored to a game using these techniques fosters not just physical but also mental resilience and adaptation.

Comparatively to conventional training methods, cognitive and functional drills enhance motor learning, reaction times, and skill acquisition (Walton et al., 2018). Under pressure, perceptual-motor learning enables athletes to predict motions, identify patterns, and make faster, more precise decisions (Mann et al., 2007). These results underline the need of integrating cognitive preparedness with physical training for elite performance.

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Even with growing understanding of the benefits of cognitive and functional training, application still presents challenges. Among the challenges include determining cognitive load, modifying training intensity, and maintaining drills relevant to sports (Swinnen & Wenderoth, 2004). Furthermore, altering training approaches are virtual reality (VR) and artificial intelligence (AI), which let customized and data-driven skill development (Lammfromm & Gopher, 2011).

The body of knowledge on game-specific training employing functional and cognitive interventions is compiled in this paper. It addresses their psychological and physiological effects, evidence-based applications, and further studies. This study approaches holistically to enhance sports training strategies so athletes are cognitively and physically prepared for competitive events.

Functional Drills in Sports Training

In sports training, functional drills replicate the physical and biomechanical motions of a game. While imparting sport-specific skills, these drills increase strength, endurance, coordination, and agility (suchomel et al., 2016). Emphasizing movement patterns over muscle training, functional drills enhance sports performance and injury prevention.

A main advantage of functional training is enhanced neuromuscular coordination. For athletes, functional training boosts performance, injury risk, and movement efficiency (Behm & Sale, 1993). With ladder footwork, cone drills, and resistance band exercises, football players improve agility and explosive strength.

High-performance sports call for proprioception and balance, which functional drills stress. Routines including stability balls, single-leg squats, and balance boards help athletes remain under control on field (Walton et al., 2018). These sessions can also be customized to fit the athlete's sport, degree of ability, and performance objectives.

Improving movement economy and energy efficiency is also crucial component of functional training. In sport-specific functional drills, optimal movement patterns help athletes to increase endurance and fatigue (Vestberg et al., 2017). In basketball, jumping and lateral plyometric exercises increase explosive power and reaction times—qualities required for competition.

In game-specific training, functional drills help athletes link general conditioning and sport-specific performance. Athletes reach their best by means of resistance training, dynamic flexibility, and agility drills (Faubert & Sidebottom, 2012). Coaches and trainers have to customize these exercises to fit the physiological demands of their particular sports.

Benefits of Functional Drills

Many advantages of functional drills help athletes' general performance and lifetime in their own sport. Among these advantages is:

- ✓ Functional drills help to increase the link between the neurological system and the muscular system, so improving the reaction times and movement execution efficiency (Behm & Sale, 1993).
- ✓ Targeting sport-specific motions helps functional training increase muscle activation and force production, thereby directly improving athletic performance (Suchomel et al., 2016).
- ✓ Functional drills help to balance muscle development and joint stability, therefore lowering the risk of common sports injuries such ligament tears and muscle strains (Walton et al., 2018).

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- ✓ Training using dynamic and stability-based workouts improves an athlete's capacity to execute quick directional adjustments while keeping body control (Vestberg et al., 2017).
- ✓ Enhanced Endurance and Movement Efficiency: Optimized movement patterns lower energy waste, so enabling athletes to maintain high-performance levels for longer durations (Faubert & Sidebottom, 2012).
- ✓ Functional drills replicate real-game situations, therefore helping athletes to acquire abilities directly relevant to their particular sport (Mann et al., 2007)

Cognitive Drills in Sports Performance

Enhancement of an athlete's mental agility, decision-making ability, and general sports performance depends critically on cognitive drills. Important in high-paced sporting contexts, these workouts concentrate on enhancing perceptual-cognitive skills including reaction time, situational awareness, and anticipatory skills. In sports, cognitive training seeks to increase an athlete's capacity for rapid information processing, situational adaptation, and under pressure exact motor action execution.

Types of Cognitive Drills

Reaction Time Drills: These drills speed players' responses. Two such are response-based ball drills and agility ladder exercises with quick directional changes.

Drills in decision-making: Creating split-second game situations helps athletes manage cognitive stress. Tactical decisions can benefit from small-sided games or situational analysis grounded in videos.

Techniques in visual tracking, gaze control, and mindfulness assist athletes concentrate and cut off distractions during play.

Memory and pattern recognition training enable sportsmen to predict opponent movements and tactics.

Benefits of Cognitive Drills

- ✓ Cognitive training aids athletes in faster and more accurate assessment and response to game conditions.
- ✓ Faster response times and in-game performance follow from training the brain to digest data fast.

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- ✓ Athletes develop better situational awareness by learning to notice and comprehend their surroundings, so facilitating intelligent play.
- ✓ Poor Performance Anxiety: By helping athletes remain cool under duress, mental training increases confidence and skill execution.

Application in Training Programs

Virtual reality simulations, neurofeedback training, and interactive drills employing smart training systems are just a few of the several ways one may include cognitive drills into sports training programs. Cognitive exercises can be used with physical training by coaches and trainers to provide a whole athlete development strategy.

Sportsmen can aid to acquire a competitive edge by giving cognitive training top priority alongside physical conditioning, therefore improving their capacity to think and act quickly under pressure. Future studies should keep investigating cutting-edge technology such artificial intelligence and brain-computer interfaces to improve sportsmen's cognitive training approaches.

Integrating Functional and Cognitive Drills in Game-Specific Training

Modern training paradigms advocate a combination of functional and cognitive drills to optimize skill acquisition. The integration of these components fosters improved motor learning, adaptability, and in-game performance (Schmidt & Wrisberg, 2008).

Methods of Integration

1. Simulated Game Scenarios – Training sessions mimic actual competition conditions to enhance cognitive and motor responses.
2. Reaction-Based Drills – Athletes respond to unpredictable stimuli to improve reflexes and decision-making.
3. Dual-Task Training – Performing cognitive and physical tasks simultaneously to develop multitasking abilities.
4. Video-Based Analysis and Feedback – Real-time analysis of movement and cognitive performance for targeted improvement.

Practical Implications

Sports coaches and trainers can incorporate functional and cognitive drills by customizing training programs based on sport-specific demands. For example:

- ✓ Football: Agility drills combined with quick decision-making scenarios.
- ✓ Basketball: Shooting exercises integrated with visual scanning and reaction training.
- ✓ Volleyball: Jump training coupled with situational awareness drills.

Future Directions

While research supports the effectiveness of integrated training, further studies are needed to:

- ✓ Evaluate long-term effects of combined functional and cognitive drills on performance.
- ✓ Identify sport-specific variations in training efficacy.
- ✓ Develop technology-driven cognitive training tools, such as virtual reality (VR) simulations.

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2. CONCLUSION

The integration of functional and cognitive drills in game-specific training represents a progressive shift in athletic development. By enhancing both physical and mental capabilities, athletes can achieve higher levels of performance. Future research and technological advancements will further refine these training methodologies.

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THE CORRELATION STUDY ON SPORT COMPETITIVE ANXIETY AND EMOTIONAL WELL-BEING AMONG THE NATIONAL LEVEL ATHLETE

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ABSTRACT

The present investigation was conducted with the aim of examining the relationship between sport competitive anxiety and emotional well-being among national-level athletes. We conducted the study on one hundred athletes from various clubs and institutions in Arunachal Pradesh, whose age ranged from 18 to 24 years. The tools used for data collection included the Sport Competitive Anxiety Test (SCAT) by Martens, R. (1977) and the emotional scale—Positive and Negative Affect Schedule (PANAS-SF) by Watson, D., Clark, L. A., & Tellegen (1988). We used Pearson's product-moment correlation method to find the link between anxiety and emotional well-being. The level of significance was set at 0.05 to see how strong the correlation was statistically. Based on the findings of the study, no significant relationship was observed between anxiety and emotional well-being among national-level athletes. The results indicated a weak positive correlation between anxiety and negative emotional well-being ($r = 0.113$, $p = 0.261$) and a very weak negative correlation between anxiety and positive emotional well-being ($r = -0.062$, $p = 0.539$). However, neither correlation was statistically significant ($p > 0.05$), suggesting that sport competitive anxiety did not have a strong or direct influence on emotional well-being in this sample.

Keywords: - Sport Competitive Anxiety, Emotional Well-Being, Positive Emotional Well-Being and Negative Emotional Well-Being.

1. INTRODUCTION

In sports, the competition puts players under a lot of mental pressure, which might affect their emotional well-being. One of the most common psychological issues that athletes deal with is anxiety, which may have a big impact on both their performance and emotional well-being. Athletes might experience anxiety for a variety of reasons, including competition stress, peer and coach pressure, performance expectations, and fear of failure (Raglin, 2001). Excessive anxiety can lead to burnout, poor performance, and a loss in overall well-being, but moderate anxiety may enhance performance by boosting motivation and focus (Craft et al., 2003). However, athletes who are emotionally well are better able to handle stress, stay motivated, and become resilient in the face of adversity (Gould & Dieffenbach, 2002). Athletes can experience anxiety for a number of reasons, including performance expectations. Anxiety and mental well-being are intrinsically connected in athletes participating at the national level. Research indicates that higher anxiety levels may result in diminished emotional health, raising the likelihood of mental health conditions

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like burnout and depression (Martens et al., 1990). Positive emotional well-being in reverse can provide as a protection factor against excessive anxiety, allowing athletes to handle stress better (Jones, 1995). Understanding the relationship between anxiety and emotional well-being is critical to developing psychological interventions to improve athletes' mental health and performance. The present study investigation has been conducted with the aim of finding out the relationship between the sport competitive anxiety and emotional well-being among the national-level athletes.

2. METHOD AND MATERIAL

This study explores the correlation study of the sport competitive anxiety and emotional well-being of national-level athletes. The study was conducted on national-level athletes from different clubs and sports institutions from Arunachal Pradesh. Ages ranged between 18 and 24 years, and the total number of athletes was 100. The tools used were the Sport Competitive Anxiety Test (SCAT) by Martens, R. (1977) and the emotional scale—positive and negative affect schedule (PANAS-SF) by Watson, D., Clark, L. A., & Tellegen, A. (1988). The Pearson's product moment correlation method was used to find out the relationship between anxiety and emotional well-being of national-level athletes. Descriptive statistics, mean, and standard deviation were used to describe the average and variability of anxiety and emotional well-being of national-level athletes.

3. RESULTS

The descriptive measures in terms of means and standard deviation of the sport competitive anxiety and emotional well-being of national-level athletes are shown in table-1

Table-1

Mean and Standard Deviation of Sport Competitive Anxiety, Positive and Negative Emotional Well-Being

Variables	Mean	Std. Deviation	N
Sport Competitive Anxiety	6.7900	1.59731	100
Emonional Wellbeing Negative	27.1100	8.87613	100
Emotional Wellbeing Positive	39.2400	7.11538	100

The above table shows the mean and standard deviation of sport competitive anxiety and emotional well-being of national-level athletes. The sport's competitive anxiety score in the table sample is 6.79, with a moderate variability of 1.60. This suggests that most of the participants scored close to the mean, with some variation. The average value of the negative emotional well-being score is 27.11, with a relatively higher standard deviation of 8.88, indicating greater variability in participants' negative emotional well-being experiences. Whereas the average value of the positive emotional well-being score is 39.24, with a moderate variability of 7.12, suggesting that while participants generally report higher positive well-being, there is some variation among individuals.

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Table-2

Relationship of Sport Competitive Anxiety, Positive and Negative Emotional Well-Being of National-Level Athletes

Variables	**Correlation Coefficient**	Sport Competitive Anxiety	Emotional Wellbeing Negative	Emotional Wellbeing Positive
Anxiety Total Component	Pearson Correlation	1	0.113	-0.062
	Sig. (2-tailed)		0.261	0.539
	N	100	100	100
Emonional Wellbeing Negative	Pearson Correlation	0.113	1	0.068
	Sig. (2-tailed)	0.261		0.501
	N	100	100	100
Emotional Wellbeing Positive	Pearson Correlation	-0.062	0.068	1
	Sig. (2-tailed)	0.539	0.501	
	N	100	100	100

* Correlation is significant at 0.05 level (2-tailed)

Table 2 shows the correlation analysis between the sport competitive anxiety and emotional well-being by using the Pearson's correlation coefficient. The analysis shows that there is a weak positive correlation between sport competitive anxiety and negative emotional well-being, meaning that if sport competitive anxiety increases, negative emotional well-being slightly increases. However, this relationship is not statistically significant ($p > 0.05$), so we cannot confidently conclude that this correlation is meaningful. Similarly, the table shows that there is a very weak negative correlation between sport competitive anxiety and positive emotional well-being, suggesting that as sport competitive anxiety decrease, positive emotional well-being slightly increases. However, this relationship is not statistically significant ($p > 0.05$). All correlations are weak, and none of them are statistically significant, as the p-values are all less than 0.05. This study suggests that there is no strong evidence of a relationship between the sport competitive anxiety and emotional well-being (both negative and positive) in this sample.

4. DISCUSSION

This study investigates the relationship between sport competitive anxiety and emotional well-being in national-level athletes. Indicate that the weak positive correlation between the sport competitive anxiety and negative emotional well-being ($r = 0.113$, $p = 0.261$) and a very weak negative correlation between the sport competitive anxiety and positive emotional well-being ($r = -0.062$, $p = 0.539$). However, neither correlation was statistically significant ($p > 0.05$), the result suggesting that the sport's competitive anxiety does not have a strong direct impact on emotional well-being in this sample. Whereas these results correlate with earlier studies, which highlight individual differences in anxiety's effects and the role of coping strategies in mitigating its impact

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(Gross & Jazaieri, 2014; Lazarus, 1999). Additionally, athletes often develop psychological skills to manage anxiety, potentially explaining the weak correlations observed (Hanton et al., 2008). Given that all correlations in this study are weak and not statistically significant, there is no strong evidence supporting a meaningful relationship between anxiety and emotional well-being (both negative and positive) among national-level athletes. This suggests that while anxiety is a common experience in sports settings, its direct influence on emotional well-being might not be as substantial as expected. Future research should consider a larger sample size and explore additional psychological variables, such as coping strategies and mental toughness, which may moderate the relationship between sport competitive anxiety and emotional well-being (Nicholls & Polman, 2007).

5. CONCLUSION

The results show that the sport competitive anxiety and negative emotional well-being have a weak positive relationship, whereas the sport competitive anxiety and positive emotional well-being have a very weak negative correlation. However, neither relationship is statistically significant. This suggests that the sport competitive anxiety alone may not be a strong predictor of emotional well-being in this population. Future research should consider larger sample sizes and explore additional psychological variables to gain a deeper understanding of how anxiety influences emotional well-being in athletes.

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EFFECT OF 12 WEEKS LONG DISTANCE TRAINING AND PRANAYAMA PRACTICES ON SPEED ENDURANCE PERFORMANCE OF ATHLETES

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ABSTRACT

The purpose of the study was designed to find out the effect of 12 weeks long distance training and pranayama practices on speed endurance performance of athletes. To achieve the purpose of the study, Forty five (N=45) male athletes who have participated Manonmaniam Sundaranar University, inter-collegiate athletic meet during the academic year 2023-2024 were selected randomly as subjects. Their age ranged from 18 to 23 years. The subjects were assigned at random into three groups of fifteen each (n=15). Group-I underwent Long Distance Training (n=15), Group-II underwent Pranayama Practice (n=15) and Group-III acted as Control. Among various athletic performance parameters Speed endurance only selected and it was assessed through 150 meters run test. The Experimental groups underwent their respective training for 12 weeks duration. And the number of sessions was five days per week. All the subjects were tested prior to and immediately after the training for the selected variable. Data were collected and statistically analyzed using ANCOVA. Scheffe's post hoc test was applied to determine the significant difference between the paired means. In all the cases 0.05 level of significance was fixed. The results of the study showed that there was a significant difference among all the Experimental groups' namely Long Distance Training and Pranayama Practices. Further the results showed Long Distance Training group was found to have greater impact on the group concerned than the Pranayama Practices group and Control group in enhancing the performance of Speed endurance.

Keywords: Long Distance Training, Pranayama Practices, Speed Endurance

1. INTRODUCTION

Long-distance running**,** in athletics (track and field), footraces ranging from 3,000 meters through 10,000, 20,000, and 30,000 meters and up to the marathon, which is 42,195 meters (26 miles 385 yards). It includes cross-country races over similar distances. Olympic events are the 5,000- and 10,000-metre races, held on a track, and the marathon, contested on roads. Like the middle-distance races (800 and 1,500 meters in the Olympics), long-distance races are run at a strategic pace, but less seldom is a final spurt, or kick, needed by the winning racer (Driskell et al., 2004) [2].

Long distance running and especially marathon running has become increasingly popular during the last 15 years. A great number of marathon events are arranged every year and a large group of elite marathon runners has developed. They represent a category of very dedicated and hard-working athletes who are training at the limit of their physical capacity (Holmich et al., 1988) [3].

Pranayama may assist the singer who must contend with excessively active stage movement and performance anxiety. Iyengar mentions that a slower, rhythmic pattern of breathing strengthens the respiratory system, eases the nervous system, and allows for better concentration. Pranayama may be practiced on a daily basis so the singer might witness physical and mental benefits. The act of breathing in performance may be involuntary rather than a conscious action and, technically helpful or not, possibly become a habitual zed response for many singers as they vocally mature. Singers may know how to breathe for singing and still not breathe appropriately on stage.

Through the study of pranayama and with conscious attention to their breathing, singers can benefit by becoming more aware of their breathing habits and improve their performance (Bellur, 1966) [1].

2. METHODOLOGY

Forty-five (N=45) athletes who have participated Manonmaniam Sundaranar University inter-collegiate athletic meet during the academic year 2023- 2024 were selected randomly as subjects. Their age ranged from 18 to 21 years. The subjects were assigned at random into three groups of fifteen each (n=15). Group-I underwent Long Distance Training (n=15), Group-II underwent Pranayama Practice (n=15) and Group-III acted as Control. Among various athletic performance parameters Speed endurance only selected and it was assessed through 150 meters run test. The Experimental groups underwent their respective training for 12 Weeks duration. And the number of sessions was conformed into five days per week. All the subjects were tested prior to and immediately after the training for the selected variable.

3. ANALYSIS OF THE DATA

The data collected from the experimental groups and control group on prior and after experimentation on selected variables were statistically examined by analysis of covariance (ANCOVA) was used to determine differences, if any among the adjusted post test means on selected criterion variables separately. Whenever they obtained f-ratio value was significant the Scheffe's test was applied as post hoc test to determine the paired mean differences, if any. In all the cases 0.05 level of significance was fixed. The Analysis of covariance (ANCOVA) on Speed endurance of Experimental Groups and Control group have been analyzed and presented in Table -1.

Table 1

Analysis of Covariance of Pre-Test, Post Test and Adjusted Post Test On Speed Endurance of Experimental Groups and Control Group

Test	Long Distance Training Group	Pranayama Practices Group	Control Group	Source of Variance	Sum of Squares	df	Mean Squares	F-ratio
Pre-Test Mean	28.73	28.80	28.27	Between groups	2.53	2	1.27	0.09
				Within groups	590.27	42	14.05	

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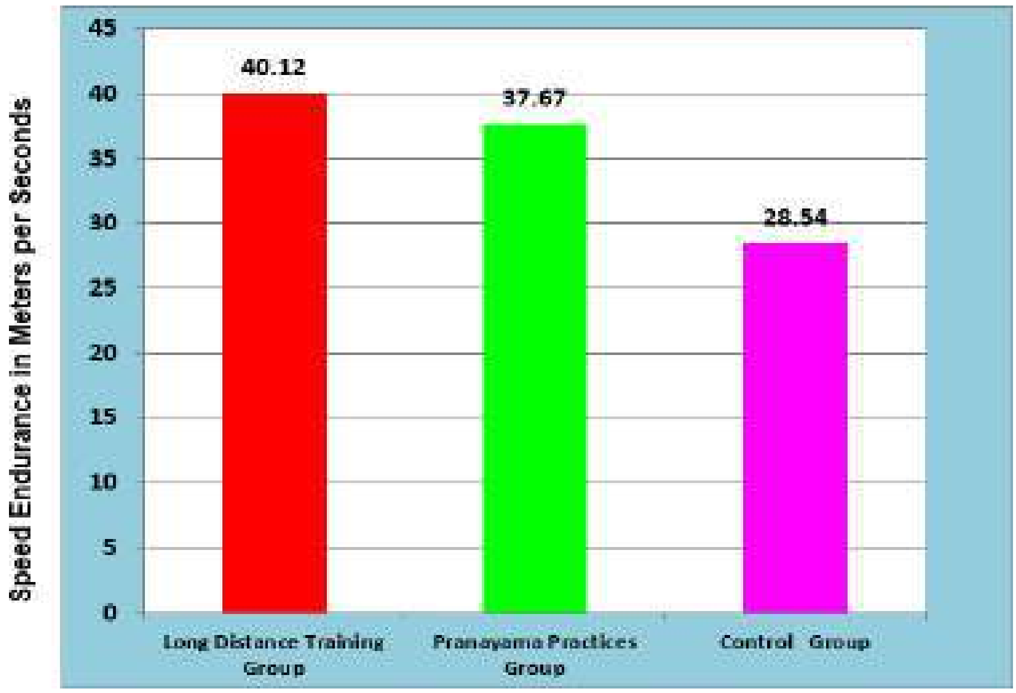
Post-Test Mean	40.20	37.80	28.33	Between groups	1180.98	2	590.49	41.88 *
				Within Groups	529.13	42	14.10	
Adjusted Post-Test Mean	40.12	37.67	28.54	Between sets	1112.16	2	556.08	63.49 *
				Within Sets	359.12	41	8.76	

* Significant at 0.05 level of confidence, Table value for df (2, 42) at 0.05 level = 3.22

Table value for df (2, 41) at 0.05 level = 3.23 (Speed endurance scores are in Seconds)

The table-1 shows that the pre-test mean values on speed endurance of Long-Distance Training group, Pranayama Practices group and Control group are 28.73, 28.80 and 28.27 respectively. The obtained ‘F’ ratio of 0.09 for pre-test scores was less than the table value of 3.22 for degrees of freedom 2 and 42 required for significance at 0.05 level of confidence on Speed endurance.

The post test mean values on speed endurance of Long-Distance Training group, Pranayama Practices group and Control group are 40.20, 37.80 and 28.33 respectively. The obtained ‘F’ ratio of 41.88 for post-test scores was higher than the table value of 3.22 for degrees of freedom 2 and 42 required for significance at 0.05 level of confidence on Speed endurance.



The adjusted post-test means on Speed endurance of Long-Distance Training group, Pranayama Practices group and Control group are 40.12, 37.67 and 28.54 respectively. The obtained ‘F’ ratio of 63.49 for adjusted post-test scores was higher than the table value of 3.23 for degrees of freedom 2 and 41 required for significance at 0.05 level of confidence on Speed endurance.

The results of the study indicate that there are significant differences among the adjusted post test means of Long-Distance Training group, Pranayama Practices group and Control group in Speed endurance performance.

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To determine which of the paired means have a significant difference, the Scheffe's test is applied as Post hoc test and the results are presented in Table – 2.

The above data also reveal that Long-Distance Training group had shown better performance than Pranayama Practices group and Control group in Speed endurance.

The adjusted post mean values of Long-Distance Training group, Pranayama Practices group and Control group on Speed endurance are graphically represented in the Figure -1.

4. CONCLUSION

From the analysis of the data, the following conclusions were drawn.

1. Significant differences in achievement were found between Long Distance Training group, Pranayama Practices group and Control group in Speed endurance.
2. The Experimental groups namely, Long Distance Training group and Pranayama Practices group had significantly increased in Speed endurance.
3. The Long-Distance Training group was found to be better than the Pranayama Practices group and Control group in increasing Speed endurance.

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GROWTH FROM ROOKIE TO PRO: PSYCHOLOGICAL PROFILING IN FOOTBALL PLAYERS ACROSS DIFFERENT AGE GROUPS

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ABSTRACT

The purpose of this investigation journey was to compare Psychological resilience such as coping skill ability, mental toughness, and mental skills ability among Football players from three different age groups (18–21 years, 22–25 years, and 26–29 years). This comparative study Explores to identify how these selected Psychological variables distinguish across age groups, Shedding light on the fostering of Psychological attributes in Football players. The total sample consists of 750 male Football players in Kerala were randomly selected and the standardized tools such as Athletic Coping Skill inventory developed by Smith et al., (1995), Mental Toughness questionnaire developed by Alan Goldberg (2004) and Bull's Mental Skills questionnaire developed by Bull et al., (1996) were used to assess coping skills, mental toughness and mental skills among Football players. One-Way Anova and Tukey HSD post hoc test was conducted to identify group difference and specific group variations with the use of SPSS (Statistical Package for the Social Sciences) and the level of significance was set at 0.05 level. Findings reveals that there is a significant difference in the Psychological attributes of Football players across different age group. Younger players aged between 18–21 years exhibited lower level of coping skills, mental toughness and mental skills ability due to the insufficient experience and other factors as compared to the players aged between 22–25 years, and 26–29 years.

Keywords: Coping Skills, Mental Toughness, Mental Skills, Football Players, Age Group

1. INTRODUCTION

Sports Psychology now established its field as a revolutionary discipline because it focused to provide training interventions that optimise various form of Psychological skills for athletic success (Cox, R.H.,2007 & Tod et al.,2023). Psychological skill development is a transformation process mainly shaped by age and experience of players, understanding these differences can offer valuable insights for prescribing various training approaches in Football. To a certain extent, all the majority of existing or prior studies have examined whether Psychological training is appropriate to develop Psychological attributes such as coping skills, mental toughness, and mental skills for Football players without considering their age and positioning role (Frydenberg et al., 2004; Hamrouni et al., 2015; Teng C Y.,2023; Hinshaw K.E.,1991). Furthermore, it is necessary to examined and analysed Psychological profiling according to age of sports persons to grade the intensity and provide suitable Psychological intervention experience.

Football is highly intensive sports in all its form, it demands both skill related physical fitness and Psychological attributes (Junge et al.,2000; Rosch et al., 2000; Bujnovsky et al., 2019; Ivarsson et al.,2020). Psychological attributes such as coping skills ability, mental toughness and mental skills plays a crucial role in optimising performance over time and influence how Football players handled high-pressure situations, adapt to challenges, recover from setbacks, remain confident in

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their abilities, persistent to despite adversity and effective use of mental skills to maintain top-notch performance during the competition situation(Sagar et al., 2010;Cowden,R.G., 2017;Simsek et al.,2023).

The competition combines the athletic training process by having participants push their mental and physical potential to its highest limits. People use coping strategies to deal with situations that surpass their present adaptive capabilities (Hanton et al., 2015). Behavioural and cognitive efforts adapt people to handle or go beyond requirements in their environment. (Folkman and Moskowitz, 2004). Coping skills refer to adaptive techniques which help players to deal with stressful situations through successful stress elimination and optimal performance (Géczi et al., 2008; Vidic et al., 2017; Kaplánová, 2020).

Research finds that mental toughness manifests through multiple characteristics consists of positive self-concept and belief in oneself along with resilience and abilities to handle negative situations in training as well as competitions and focus improvement and prevention of feelings that lead to giving up (Lin et al., 2017 & Trigueros et al., 2019). Mental toughness requires an individual to understand their capability for fighting adversity while seeking new development skills through proactive growth opportunities (Mahoney et al., 2014). According to Jones, Hanton and Connaaughthon, athletes require extensive Psychological skills training to reach their highest performance potential in competition and promote essential fitness areas like recovery and self-assurance and healthy routines (Jones et al., 2007).

Mental skills are internal abilities which is very helpful for sports persons to control their body and minds with efficiency as they executed sports related targets. Mental practice along with physical practice typically results positive outcomes (Feltz & Landrers, 1983 & Hinshaw, 1991). Some findings indicated that the use of mental skills contains goal setting, imagery, relaxation, and self-talk are important strategies to optimise performance in the field of Sport Psychology (Vealey, 2007; Williams & Harris, 2001).

Although, researchers have found that Psychological attributes such as coping skills, mental toughness and mental skills have better impact on athlete's performance(Pandian et al., 2023; RichardS H., 2011;Kaiseler et al., 2009; Grønset et al., 2024), Therefore, in order to explore these Psychological attributes among Football players across different age group given insight in to solve major gap exist in the field of sports Psychology and to diagnose the Psychological weaknesses to provide Psychological training and grading intensity to Football players across different age group.

2. MATERIALS AND METHODOLOGY

This section deals with materials and methods used by the investigator to compare Psychological attributes in Football players across different age groups. It contains selection of participants, variables and tools, data collection procedure and suitable statistical procedure used by the investigator for this study.

Participants: The total sample consists of 750 male Football players from various youth Football academies, College and university teams, and different teams participated in the state and district Football association league tournaments in Kerala were randomly selected. Among them, 292 samples were aged between 18–21 years, 244 samples were aged between 22–25 years, and 214 samples were aged between 26–29 years. All the selected participants had at least three years structured practice and two years playing experience in the Football fields and they take Football very seriously, beyond just being a recreation.

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Variables and tools: Coping skills ability, mental toughness and mental skills were selected as a variable for the Psychological profiling among Football players. Athletic Coping Skill inventory developed by Smith et al., (1995) were used to assess coping skills ability of Football players. This inventory consists of 28 statement (Score ranges from 0 to 3 for each statement & total score ranges from 0 to 84) and each statement denoted to describe their experience using a 4 point Likert scale indicates almost never, sometimes, often and almost always for each statement.

Mental Toughness questionnaire developed by Alan Goldberg (2004) were used to assess mental toughness of Football players and it consists of 30 statement with both positive and negative statement, and two possible options, true or false (positive items "true- 1 score/ false-0" & Negative items "false- 1 score / true- 0 score). Bull's Mental Skills questionnaire developed by bull et al., (1996) were used to assess mental skills of Football players and it contain total of 28 statement, which is very pertaining to various mental aspect of competition with six possible responses from strongly disagree to strongly agree The positive worded items (1 =strongly disagree to 6 =strongly agree) and negative worded items (6 =strongly disagree) to 1 =strongly agree).

Collection of data: The investigator collaborated with expert colleagues including college physical education teachers and various Football academy and university coaches within Kerala during three months of data collection procedures which used both offline hand-to-hand and online data collection approaches. Before the filling up of questionnaire, investigator explain the purpose, objectives and meaning of each statement in a detailed manner. The investigator distributed hard copies of questionnaires to participants during the offline data collection procedure and to create a controlled environment for accurate answers. Additionally, the investigator provided time for doubt-clearing session about the statement contained in the instruments. The investigator collected online data by distributing digital survey forms regarding instruments to participants directly and indirectly with the help of expert colleagues including college physical education teachers and various Football academy coaches, university coaches, managers and concerned authorities through the WhatsApp social media platform.

Statistical procedure: The data collected through the investigation were analysed through descriptive statistics, One-Way ANOVA and Tukey HSD Post Hoc comparison test were conducted to identify group difference and specific group variations with the use of SPSS (Statistical Package for the Social Sciences) and the level of significance was set at 0.05 level.

3. RESULTS

The results obtained by statistical analysis are presented in the tables followed by their interpretation. Descriptive statistics were used to find out Mean and Standard deviation, which is very essential to identify how the data regarding Psychological variables is distributed among Football players across different age groups. The significance differences between the Football players across three different age group (18–21 years, 22–25 years, and 26–29 years) in the coping skills ability, mental toughness and mental skills ability were determined by ANOVA and Tukey HSD Post Hoc Comparison tests.

Table1: Descriptive data and ANOVA of 750 Football players from three different age groups.

Age groups Variables	18–21 years	22–25 years	26–29 years	ANOVA	
	Mean ± SD	Mean ± SD	Mean ± SD	F	Sig. (p)

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Coping skills	43.04 ± 5.32	48.63 ± 5.99	49.73 ± 6.64	95.78	.00*
Mental toughness	17.59 ± 3.60	21.56 ± 3.45	22.28 ± 3.40	137.48	.00*
Mental skills	69.60 ± 5.72	77.50 ± 7.78	76.70 ± 7.57	104.12	.00*

*The P is significant at 0.05 level, df=2,747

One Way between group ANOVA was carried out to examine the Psychological profiling to understand mental resilience in Football players across different age groups. The result revealed that there was a statistically significant difference in the level of coping skill [$F (2, 747) = 95.78$, $p < 0.05$], mental toughness [$F (2, 747) = 137.48$, $p < 0.05$] and mental skills ability [$F (2, 747) = 104.12$, $p < 0.05$] in Football players across different age groups. A follow-up post hoc pairwise comparison test based on Tukey HSD are shown below in the table 2.

Table 2: Tukey HSD Post Hoc Pairwise comparison test across three different age groups

Variables	**Football Players**		**Mean Difference**	**Sig.(P)**
Coping Skills	18–21 Years	22–25 Years	5.58	.00*
		26–29 Years	6.68	.00*
	22–25 Years	26–29 Years	1.10	.11
Mental Toughness	18–21 Years	22–25 Years	3.97	.00*
		26–29 Years	4.69	.00*
	22–25 Years	26–29 Years	.72	.07
Mental Skills	18–21 Years	22–25 Years	7.89	.00*
		26–29 Years	7.09	.00*
	22–25 Years	26–29 Years	.79	.44

*. The P is significant at the 0.05 level.

Post hoc pairwise comparison test based on Tukey's HSD revealed that there was a statistically significant difference in the Football players aged between 18 to 21 years and 22 to 25 years on coping skills ability, mental toughness, and mental skills ability (all $p < 0.05$). Additionally, there was a statistically significant difference in the Football players aged between 18 -21 years and 26 to 29 years on coping skills ability, mental toughness, and mental skills ability (all $p < 0.05$). However, there was no statistically significant difference in the Football players aged between 22 to 25 years and 26 to 29 years on coping skills ability ($p=.11 > 0.05$), mental toughness ($p=.07 > 0.05$), and mental skills ability ($p=.44 > 0.05$).

4. DISCUSSIONS

The current research findings show some clear-cut significant difference in the coping skills, mental toughness and mental skills among Football players across different three age groups. The Football players aged between 18 to 21 years exhibited lower level of coping skills ability, mental toughness and mental skills as compared to their older counterparts (aged between 22 to 25 years and 26 to 29 years). These statistical significant difference occur due to the limited experience in competitive environments and lack of stress-management skills as well as insufficient Psychological training to build Psychological attributes among young players.

These research findings agree with past studies revealing that novice athletes commonly face difficulties to managing stress while making decision under competitive pressure situations and regulating their emotions due to limited experience in competitive environment (Nicholls et al.,

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2009; Gucciardi, 2011). The findings also reveal that Football players aged between 22–25 years and 26–29 years demonstrated significantly higher levels of selected Psychological attributes compared to their younger players. This suggests that players progress in age with an appropriate playing experience helps to develop more effective coping skills ability, enhanced mental toughness, and refined mental skills. These improvements may be the result from the increased competitive exposure, accumulated experiences, and more structured Psychological training initiatives. Earlier research findings underlined that mental toughness and coping skills are developed through progressive exposure to pressure situations across time and the development of Psychological adaptation strategies (Connaughton et al., 2008).

The current findings align with study by Jones et al. (2007), which found that long-term exposure to competitive stimuli strengthens Psychological attributes in experienced athletes. Further supporting findings contributed by Clough et al. (2012) discovered that older athletes have higher levels of mental toughness. Nevertheless, some research result has shown contradictory findings. According to Laborde et al. (2016), Psychological resilience is impacted by personality factors and individual variations in stress perception in addition to age. Furthermore, according to a study by Weinberg and Gould (2023), an athlete's early Psychological skill development and exposure to elite-level training environments may contribute to their higher levels of mental toughness and coping abilities. The divergent results show that age alongside years of experience influence Psychological attributes, also contribute such other aspect like coaching competence and personality characteristics.

5. CONCLUSION

The study explores to compare selected Psychological attributes such as coping skills, mental toughness and mental skills among Football players across different age group. The investigation reveals that there is a significant difference and the Football players aged between 18 to 21 years possess low level of these selected Psychological attributes compared to their elder counterpart.

The findings recommend that targeted trainings focusing Psychological attributes should be introduced at an initial stage in Football career. Young Football players should participate in structured Psychological skill training that teaches cognitive-behavioural methods along with stress inoculation techniques, guided imagery practises and pressure inurement training programs to improve their mental strength for advanced competition. Sports Psychologist and Football coaches should consider the age and need of Football players to design these Psychological skill training to facilitate mental growth and performance enhancement.

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STRESS AND AGGRESSION AMONG BASKETBALL AND HANDBALL INTER-COLLEGIATE PLAYERS

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ABSTRACT

The purpose of the present study was to compare the levels of stress and aggression in the chosen basketball and handball players. The study also sought to determine the connection between basketball and handball players' levels of stress and violence. One hundred participants, aged between eighteen and twenty-five, who competed in the VTU intercollegiate championships in the year 2023 (fifty men in handball and fifty men in basketball) were chosen for the study. The study employed an independent t-test to ascertain the variation in stress and aggression levels between basketball and handball players. Basketball players' mean and standard deviation were 43.52 & 2.72, whereas handball players' was 48.50 & 1.31. Handball players showed more stress than basketball players. Basketball players had a mean and SD of 10.88 & 2.68, whereas handball players had a mean and SD of 12.88 & 3.66. The handball players were more aggressive than the basketball players. The Pearson Product Moment correlation was employed to ascertain the link between aggression and stress in players of basketball and handball. Stress and hostility among basketball and handball players were significantly correlated.

Keywords: Intercollegiate players, stress, and aggression.

1. INTRODUCTION

Sports psychology has been able to help athletes reach new heights by helping them control their emotions, even though it hasn't been able to alter anything physically. Sports psychology can help players perform better by reducing stress, managing difficult situations, and preserving their athletic stability. Sports psychology comprehends the relationship between the psychological & physical components of competition and how mental discourse influences performance. Today, the psychological component is getting exponentially more important and is being stressed more and more. Acquiring knowledge about the attributes that impact an athlete's performance is highly beneficial for enhancing their performance. A subfield of psychology called "sports psychology" examines how athletes behave both during practice and competition. Athletes' years of preparation and effort can be ruined by stress, which also keeps them from applying when competing. An athlete experiences less ecstasy when under stress. An athlete's career is destroyed by physical injuries resulting from emotional turmoil brought on by stress. Stress can be viewed as a difficulty or a roadblock in the way of achievement. In sports, aggression is viewed as a bad emotion. Although many view aggression as a negative emotion, it can have both beneficial and negative effects on performance. Players who aggregate at higher than optimal levels will not be able to give their best effort. Today, a wide range of athletes compete at different levels, and their performance is greatly impacted by their mental health. Simon Biles, a well-known American gymnast, just withdrew from the Tokyo Olympics owing to extreme stress. The researcher is interested in learning more about the psychological factors that contribute to stress and hostility among VTUhandball and basketball players. The researcher chose the study "Stress & Aggression among Handball & Basketball Players" for these reasons. The research aimed to determine the relationship between stress and aggression among a sample of selected handball and basketball players, as well as the differences between stress & aggression among handball and basketball players.

2. METHODS & MATERIALS

Fifty male handball and basketball players who competed in the VTU intercollegiate finals in 2023 were chosen for the study. Participants' ages were restricted to those between the ages of 18 and 25. The sports aggressiveness inventory created by Anand Kumar and Prem Shankar Shukla (1998) was used to measure the participants' levels of aggression, and the perceived stress scale created by ReenaKaul and Bedi (2001) was used to measure their levels of stress. Descriptive statistics, independent t-test, and Pearson product-moment correlation were employed in the statistical analysis at the 0.05 level of significance.

3. RESULTS & FINDINGS

Table 1: Showing the variation in players' "t" values and stress levels between handball and basketball players.

Variable	Basketball Players	Handball Players	t value	p-value
	MEAN+SD	**MEAN+SD**		
Stress	**43.52+2.72**	**48.5+1.31**	**2.20**	**0.03**

At the 0.05 level, the *t value is significant (t=2.20* p = 0.03, p< 0.05).

Table 1 It is evident that the average and standard deviation of stress levels among basketball and handball players are 48.5 ± 1.31 and 43.52 ± 2.72, respectively. There is a 2.20 t value. The amount of stress experienced by basketball and handball players differs significantly.

Table 2: Showing the variation in handball and basketball players' aggression about their "t" value.

Variable	Basketball Players	Handball Players	t value	p-value
	(MEAN+SD)	**(MEAN+SD)**		
Stress	**10.88+2.68**	**12.88+3.66**	**3.11**	**0.02**

Significant at the 0.05 level is the *t value (t=3.11*, p=0.02, p< 0.05).

Table II It is evident that the mean and standard deviation of aggression among basketball and handball players, respectively, are 10.88 ± 2.68 and 12.88 ± 3.66. Three is the t value. The levels of aggression exhibited by basketball and handball players varied significantly.

Table 3: A comparison of basketball and handball players' levels of stress and aggression

		Aggression
STRESS	Person Correlation	0.452
	SIG.	0.00
	N	100

(p=0.00, p<0.05, r=0.452*) *At the 0.05 level, the correlation is significant (2-tailed).

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The correlation coefficient between basketball and handball players' stress and aggression is displayed in Table 3. According to the statistical data, there was a significant relationship between the amount of violence and stress (r=0.452*, p=0.00, p< 0.05). The researcher discovered from the data that handball players had more stress than basketball players. The fact that there are fewer fouls in handball games is the primary cause of the elevated stress levels among players. Players are not having the opportunity to score a point for their side because there are fewer fouls committed. Since handball is a contact sport, the referee may not always rule in the players' favor. We'll overlook small infractions during play. The players' stress levels will rise as a result. The Handball players must play for twenty minutes longer than the Basketball players when the length of play for both games is taken into account. Therefore, handball players ought to be more resilient than basketball players. When the handball players' level of endurance wanes during the last moments of the match. The handball players heightened physical exhaustion will likely cause them to display higher levels of stress. The study's findings also revealed to the researcher that handball players' levels of aggression were higher than those of basketball players. The primary cause of the rise in hostility in handball games is the distinction between handball and basketball skill sets. Handball's offensive and defensive abilities are more advanced than those of other contact sports. Handball and basketball involve more contact than basketball. Aggression will be more evident in contact games than in non-contact sports. In handball, there is a lot of contact made while playing both attacking and defensive moves. Therefore, more handball players will display aggressiveness as a result of player contact than basketball players.

The study's findings led the researcher to conclude that there is a positive correlation between basketball and handball players' aggression and stress. It is common for both handball & basketball players to display violent behavior while under stress. The reason for this is that players get stressed out when rivals or other outside variables, such as their surroundings or level of physical fitness, prohibit them from using their skills. Basketball and handball players will become extremely aggressive due to their dissatisfaction with the outcome.

4. CONCLUSION

Based on the results, it was determined that the stress levels of basketball and handball players differed significantly. It was determined that there was a notable distinction between handball and basketball players' levels of aggression. It is determined that there was a noteworthy distinction in the levels of stress and aggression among basketball and handball players.

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ASSOCIATION OF WRIST JOINT RANGE OF MOTION AND TRUNK ASYMMETRY IN TABLE TENNIS PLAYERS – A SCOPING REVIEW

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ABSTRACT

Background: Table tennis, a widespread sport, demands precise body coordination, with trunk rotation crucial for power. However, asymmetrical movements create injury risks. Further research on players is needed to refine injury prevention strategies. **Aim:** The aim of this study was to review the literature on the relationship between wrist range of motion and trunk asymmetry in table tennis players. **Method:** Recent published literature in English between 2019 and 2025 was collected from four available databases: Google Scholar, PubMed, Science Direct, and EMBASE. Studies examining posture, trunk asymmetry, and wrist range of motion specifically within table tennis players were included in this review. 3 out of total 196 articles, observational, and systematic reviews were included from that period for analysis. **Results & Dissemination:** Four articles were selected for inclusion in this review. Three of these articles were observational studies and one systematic review. Of the 4 included articles, association of trunk asymmetry, postural changes and difference in limb characteristics in table tennis players was identified. Table tennis leads to postural changes, especially in the trunk, and affects wrist flexibility. This review examines how wrist movement relates to trunk asymmetry in table tennis players, aiming to understand the biomechanical causes of these adaptations. **Conclusion:** Examining the association between trunk asymmetry, postural changes, and varied limb characteristic in table tennis players may yield valuable insights for comprehensive assessment. The findings of this review highlight the presence of postural alterations in table tennis players, underscoring importance of postural assessment for injury prevention strategies.

Keywords: Table tennis, trunk asymmetry, posture, wrist range of motion, Scoping review.

1. INTRODUCTION

Table tennis is one of the most popular recreational and competitive sports in the world[1].Although it isn't a popular sport in many countries, an estimated 300 million individuals play table tennis worldwide[2]. Athletes combine trunk rotation, precise footwork, and upper and lower limb movements to produce perfect strokes[3] . The specific head, limb, and trunk positions used in table tennis matches can lead to asymmetries[4]. Additionally, the shoulder girdle muscles of the playing limb are constantly engaged while the other limb is neglected. The strenuous one-sided work may affect the posture of the body [4].

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By pronating or supinating during impact, the wrist is mostly in charge of giving the ball spin, enabling variations in topspin, underspin, and sidespin. The ability to precisely control the trajectory and placement of the ball is essential for delicate strokes like pushes and drop shots[5,6] Proper synchronization along the entire kinetic chain—that is, the movement being carried as efficiently as possible from the core, to the arm, and then to the wrist—is essential for effective wrist motion[7] . In order to maximize power and precision, a stable core serves as a platform for the effective transfer of wrist force to the ball[8].

The wrist can freely move within its range of motion without additional effort or compensation when the trunk is stable and aligned[7,8] . An increased risk of injury can result from excessive strain on the wrist joint caused by poor trunk stability[7,8]

The knowledge gap on the relationship between table tennis players' trunk asymmetry and wrist range of motion has been addressed in this study. Although lumbar spine abnormalities have been researched, the alignment of the trunk as a whole has not. The aim of this study is to determine how wrist mobility relates to trunk asymmetry in order to assist in performance and injury prevention techniques. The purpose of this scoping review is to compile the research on the relationship between table tennis players' trunk asymmetry and wrist range of motion.

2. METHODOLOGY

Identifying relevant studies:

Recent published literature in English between 2020 and 2025 was collected from five available databases: Google Scholar, PubMed, Science Direct, and EMBASE. A key term search strategy was employed using the words “wrist joint range of motion”, “trunk asymmetry”, table tennis players”. The terms Wrist joint range of motion and trunk asymmetry were selected to find the correlation or association between wrist Range of motion and trunk asymmetry in table tennis players. Observational, interventional, randomized control trials and systematic reviews were included from that period for analysis in this scoping review. [See Fig 1]

***Study selection**:*

Articles were eligible for inclusion in this review if they described Wrist joint and its range of motion, trunk asymmetry in table tennis players. Full text articles published since 2020 and written in English were eligible for inclusion in this scoping review. Articles were excluded if they did not pertain to wrist range of motion, trunk asymmetry and table tennis players. If available articles were representative of the inclusion criteria, the articles went through two full-text independent reviews by three authors (Shrushti U, Mrunali C, and Eesha M.). If disagreements once arose, a third-party reviewer would be consulted.

Charting data:

If a full text article was eligible for inclusion in this study, data related to the association between wrist joint range of motion and trunk asymmetry in table tennis players presented in the article was extracted by the lead author and reviewed by other 4 authors. Data extracted from the reviewed association between wrist joint range of motion and trunk asymmetry in table tennis players was entered into data extraction records and synthesized in summary format. Data were systematically charted using the data charting form developed in Microsoft Excel. Information on authorship, article type, population, and wrist joint range of motion, trunk asymmetry were recorded on this form. Information on wrist joint range of motion, trunk asymmetry, table tennis players, number of studies reviewed and key findings were recorded on this form.

***Collating, summarizing and reporting results**:*

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Information that was organized on the data charting forms was employed to collate and report the articles' approaches towards achieving association between wrist joint range of motion and trunk asymmetry in table tennis players. [see table 1]

3. RESULTS

From an original hit total of 892 articles, 734 articles on duplication of publication were excluded from different data base. 116 articles were excluded after reading the article title and abstract, from that 42 potential full text articles were identified, additionally 39 articles were excluded for not meeting the inclusion criteria, three articles were selected for inclusion in this review. Two of these articles were observational study, and one is systematic scoping review. Of the three included articles the relationship between wrist range of motion and trunk asymmetry in table tennis players were identified.

Figure 1: Scoping review process

Table 1: Scoping review summary

Author	Article type	Study population	Outcome measures	Conclusion
Ziemowit Bańkosz et al[9] 2024	Observational study	Female table tennis players	1.Photogrammetric torso asymmetry analysis 2.Upper/lower limb circumferences	-Table tennis players showed postural asymmetry, particularly in pelvic rotation. -They also exhibited right/left size differences in their limbs
Ziemowit Bankosz et al [10] 2020	Observational study	Female Table tennis players	Photogrammetric torso asymmetry analysis	Dominance of kyphotic body posture in table tennis players.
Duo Wai-Chi Wong et al[11] 2020	Systematic Scoping Review	Table tennis players, Both Females and males	1.Range of motion (ROM) and angular velocities. 2.Racket Velocity 3.Electromyography (EMG) 4.Pressure Distribution 5. Performance Indices	Skilled table tennis players demonstrate greater trunk rotation range of motion, which enhances racket speed and wrist movement efficacy during strokes.

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Data Analysis and Dissemination

Content analysis of wrist joint range of motion and trunk asymmetry in table tennis players adult population included in this review that in table tennis , wrist joint strength is crucial for long and drop-shot services. However, leg-hip-trunk kinematics account for more than half of the energy[11] .Asymmetries in limb and trunk motions have been found in studies on female table tennis players, which may raise the risk of injury[9] .Furthermore, extended play frequently results in kyphotic posture, which alters the curvature of the spine and causes pain[10] .The ready position is associated with increased spinal and pelvic asymmetry, underscoring the need for training regimens that improve symmetry and lessen spinal strain.

4. DISCUSSION

This scoping review provides an overview of how correlation between wrist range of motion (ROM) and trunk asymmetry in table tennis player. Some studies focusing on elite athletes, this research investigates the distinct biomechanical demands and risk of injury. Players of table tennis have specific physical adaptations as a result of their motions during the game. These postural changes, which include modifications to the spine and postural alignment in general as well as to the trunk in particular, have been connected in studies to table tennis performance. Since wrist mobility is a key element of the game, wrist position and flexibility are essential for success. Examining this association can help us understand the biomechanical factors that cause these physical adaptations in table tennis players. According to studies, wrist joint strength is crucial for long shot or drop shot services. In actuality, over half of the energy and muscular force produced in racket sports was attributed to leg-hip-trunk kinematics[11] .While some of the articles reviewed about Inter limb and trunk asymmetry in the frontal plane of table tennis female where the investigation conducted in this study enabled us to identify the presence of asymmetry between the soft limbs of tennis players and in the frontal plane of the trunk, which may be a risk factor for injury. But even though there are differing opinions in the literature regarding the significance and dangers of asymmetries, it seems that, if only for aesthetic purposes, table tennis[9] .In other studies, they showed that kyphotic body posture is more common among table tennis players, which may be induced by hours of playing in the same position. There are notable changes after taking this stance. in the anterior and posterior spinal curvature angles in relation to the standard posture. This could be the reason for the study participants' reported overloads and pain complaints. An increase in asymmetry in the position (rotation) of the pelvis and spinous processes (frontal plane) is also linked to adopting the ready position. Thus, training regimens should include exercises that promote symmetry of the action of the upper limbs, body trunk muscles, and pelvis as well as activities that alleviate the spine in the vertical line[10] .

5. LIMITATIONS AND FUTURE RECOMMENDATIONS

Only three studies were included in the review, which can have an impact on how broadly applicable the results are. Because the search was limited to English-language publications, pertinent studies in other languages might not have been found. The 2020–2025 timeframe may limit the amount of available research. Along with that the inclusion of observational research, systematic reviews, and scoping reviews in the study can lead to inconsistency in the data. Future investigations should prioritize detailed kinematic analyses of wrist and trunk range of motion (ROM) in table tennis athletes. Studies should aim to establish correlations between specific ROM values, quantify asymmetries, and evaluate the efficacy of targeted training interventions.

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6. CONCLUSION

This scoping review effectively mapped the body of research on the relationship between table tennis players' trunk asymmetry and wrist joint range of motion (ROM). The results consistently show that kyphotic posture is common and that table tennis causes significant postural asymmetries, especially in pelvic rotation and limb dimensions. Additionally, the review emphasizes the importance of the kinetic chain and the critical role that trunk stability plays in improving wrist function and stroke efficacy. Targeted training strategies that encourage symmetrical muscle activation and postural alignment are necessary because of the observed asymmetries and postural adaptations, which highlight potential injury risk. This review emphasizes how crucial it is to treat table tennis players' trunk stability and range of motion in order to reduce the risk of injury and enhance performance.

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HAMSTRING QUADRICEPS RATIO AND SPORTS PERFORMANCE – A SYSTEMATIC REVIEW

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ABSTRACT

The ratio of the hamstrings to the quadriceps (H/Q) is a key indicator of muscle balance, risk of injury, and athletic performance. This paper highlights the importance of the H/Q ratio in preventing injuries and improving performance as it examines the biomechanics of the knee joint and the function of muscle balance in sports. Both the traditional and functional variants of the H/Q ratio provide information about joint stability and neuromuscular function. Testing for isokinetic strength is frequently used to assess muscle function and identify H/Q ratio abnormalities. Studies show that the H/Q ratio is velocity-dependent, influencing knee strength measurements at different angular velocities. An ideal H/Q ratio is essential for athletes that engage in high-intensity motions, such as sprinting and jumping, in order to improve knee stability and explosive power. An increased risk of hamstring strains and anterior cruciate ligament (ACL) injuries has been associated with a low H/Q ratio, especially in sports requiring quick acceleration and deceleration. The review also highlights how strength imbalances affect jumping and sprinting abilities and examines the connection between isokinetic strength and sports performance. The need for sport-specific training and injury prevention programs is demonstrated by the differences in H/Q ratio values between sports. In order to maximise the H/Q ratio, the study emphasises the significance of neuromuscular conditioning, eccentric hamstring training, and rehabilitation techniques. This concludes that the H/Q ratio is an essential instrument for evaluating muscle function, directing injury avoidance, and enhancing sports performance. An effective way to track changes in muscle balance and create customised training plans is through isokinetic strength testing. To improve performance and lower the risk of injury in athletes, future research should concentrate on developing sport-specific H/Q ratio benchmarks, incorporating advanced biomechanical analysis, and improving assessment methods.

Keywords: H/Q ratio, Sports performance, Injury prevention and Types of H/Q ratio.

1. INTRODUCTION

The articular biomechanics and functionality of the knee during movement are modulated by the normal strength levels between agonists and antagonists. "Muscle balance" is the term used in the literature to describe this ideal process (Padasala et al., 2020). Athlete performance and injury prevention depend on the hamstring and quadriceps muscles being balanced in strength. According to Coombs & Garbutt (2002), the H/Q ratio is frequently employed as a gauge of knee joint stability and neuromuscular function.

The hamstrings eccentric muscle action balances the quadriceps concentric strength during common football activities like sprinting and kicking. Actually, the main cause of hamstring strains in football players is high-speed running; injuries typically happen during the final part of the swing phase, when the hamstrings must contract firmly while lengthening to slow the flexing hip and extending knee (Baroni et al., 2020). The hamstring and quadriceps muscle absolute peak torque values, their quantitative variations in Nm, the percentage of their peak torque that decreases from slower to faster angular velocity, and the H:Q strength ratio across different ages and angular velocities (Mandroukas et al., 2023).

The hamstring/quadriceps (H/Q) concentric strength ratio and the normalised (weight-corrected) peak torque have also been generally supported for the description of specific aspects of muscle performance in certain sports (Olmo et al., 2006). The conventional and functional relationship between the hamstrings and quadriceps. The goal is to achieve physiological muscular balance in all of the functional chains, not only in the quadriceps/hamstring connection, as this would be physiologically reductive (Padasala et al., 2020).

In both flexion and extension, the throwers displayed the highest absolute strength, which is indicative of the demanding nature of their specialities. Because high jumpers must exert a lot of muscular power against the floor's reaction in order to perform well, they were ranked next to throwers in terms of their isokinetic performance (Olmo et al., 2006) During an isokinetic test, the dominant and non-dominant leg muscle strengths of field and court players differed by less than 15%, and there was not a significant distinction between the two groups (Cheung et al., 2012).

The functional H ecc: Q con ratio significantly decreased at both velocities, according to the main results, and there was an association between this ratio and a number of physiological markers assessed during the Loughborough Intermittent Shuttle Test. Anterior and posterior thigh muscle imbalances are measured using the classic H con: Q con ratio, which is also used to evaluate the effectiveness of different rehabilitation regimens (Delextrat et al., 2010).

The H/Q functional ratio, which is a "more functional" method of screening for injury risk in football players, is computed as the eccentric peak torque of the hamstrings divided by the concentric peak torque of the quadriceps. H/Q functional ratio values less than 100% could indicate that the hamstrings are unable to maintain joint stability during leg motions like running, passing, and kicking that are mostly executed by the quadriceps (Baroni et al., 2020). The purpose of the study is to investigate the relationship between the H/Q ratio and sports performance which helps the athletes to prevent injury and enhance performance.

1. Types Of H/Q Ratios

The peak torque of the hamstrings divided by the peak torque of the quadriceps yields the H/Q ratio. There are two main categories:

i. **Conventional method:** It was first proposed that a circular peak torque (PT) H:Q torque ratio, also referred to as the conventional ratio (CR), was essential (Ruas et al., 2019). The traditional H/Q ratio, which is usually between 0.5 and 0.8, is the ratio of the strength of the concentric hamstrings to the concentric quadriceps (Aagaard et al., 1998).

ii. **Functional method:** The dynamic control or functional ratio (FR) is the eccentric hamstring/concentric quadriceps peak torque ratio (Ruas et al., 2019). The functional H/Q ratio, which has an ideal value near 1.0, is the ratio of eccentric hamstring to concentric quadriceps strength (Aagaard et al., 1998).

2. ISOKINETIC STRENGTH TESTING

Isokinetic strength testing is often used to evaluate muscle performance and assess the H/Q ratio in athletes through the use of an isokinetic dynamometer (Dvir, 2004). The main benefits of isokinetic testing are providing objective data on peak torque and muscle imbalances which helps

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in assessing accurate strength; Injury Prevention and identifies muscle weaknesses that may predispose athletes to injuries (Croisier et al., 2008).

Rehabilitation monitoring that assists in tracking progress during post-injury recovery and return-to-sport decisions (Impellizzeri et al., 2008). Research has demonstrated that isokinetic testing can successfully identify quadriceps and hamstring asymmetries, supporting focused strength training programs (Maly et al., 2010).

The H:Q ratio increased using healthy knee as velocity increased. The results in injured knees are consistent with the higher H:Q ratio with greater velocity. Using isokinetic testing, the H:Q ratio can be utilised to compare the moment-velocity patterns of the hamstrings and quadriceps. However, the fact that the H:Q ratio increases with velocity indicates that this ratio is velocity dependent. The velocity-dependent changes in the H:Q ratio should not be disregarded when utilising this ratio as an assessment tool since this could result in inaccurate assessments of leg strength (Rosene et al., 2001).

3. ISOKINETIC STRENGTH AND SPORTS PERFORMANCE

At 60°/s, 90°/s, and 120°/s angular velocities, positive correlations between CMJ take-off power and the H/Q ratio were observed. There is a lack in increase in the conventional H/Q ratio with increased angular velocity, according to the correlations found between the H/Q ratio and jumping and sprinting ability. The values of the H/Q ratio were very similar for all angular velocities of 60°/s, 120°/s, and 180°/s (Struzik & Pietraszewski, 2019).

The field players stronger hamstrings can account for their greater H:Q ratios. The increased usage of the hamstrings to slow down the lower leg when kicking and passing a ball may be the reason for the recruited field players (soccer players) higher peak torque production. Since basketball and volleyball may involve more frequent vertical jumping, we first anticipated that court players would produce more quadriceps peak torque (Cheung et al., 2012).

Basketball player's H/Q values decreased when their velocity decreased from 66.8 ± 5.3% for 300˚/s to 48 ± 3.9% for 60˚/s, while volleyball player's H/Q values decreased from 70.4 ± 7.9% for 300˚/s to 55.7 ± 6.0% for 60˚/s (Kabacinski et al., 2018). Increased knee injuries, especially ACL tears in sports demanding abrupt braking and direction changes, have been linked to a low H/Q ratio (Myer et al., 2009). The H/Q ratios of male and female athletes differ, which could be a factor in the increased incidence of ACL injuries among female athletes (Zebis et al., 2011).

The risk of hamstring injuries is increased by a H/Q imbalance, particularly in sports that require sprinting and quick acceleration. Research also suggests that lower limb overuse injuries could be predicted by an uneven H/Q ratio (Mendiguchia et al., 2013). Research shows the consistent with earlier studies that examined people with varying needs for physical activity, such as between sprinters and cross-country runners or tennis players and squash players. Therefore, it can be argued that the H/Q concentric ratio at 60˚/s is not sport-specific and, therefore, is not a useful indicator of an athlete's muscle adaptations. Male long-distance runners in this study displayed a H/Q 300˚/s ratio that was distinct from those of other specialisations (Olmo et al., 2006).

A prior study predicted that volleyball players would be more symmetrical because their sport is dominated by actions like blocking and spiking via vertical jumping with both legs, while soccer players would show more asymmetrical leg differences because they primarily kick and pass the ball with their dominant leg (Cheung et al., 2012).

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When sprinting and kicking the ball, the hamstrings contract eccentrically to counterbalance the anterior shear stresses produced by the contractions of the quadriceps and slow down the leg and thigh movements prior to foot contact. After a football match, the hamstrings are therefore likely more susceptible to tearing, and their diminished ability to stabilise the knee may result in increased strain on the ACL (Delextrat et al., 2010).

The Role of H/Q Ratio in Sports Performance: A balanced H/Q ratio contributes to:

i. **Knee joint stability**: Lowers the incidence of anterior cruciate ligament (ACL) injuries by preventing excessive anterior tibial translation (Hewett et al., 2005).
ii. **Explosive Strength and Sprinting:** According to Kellis and Katis (2007), enhanced sprinting and agility are correlated with a greater functional H/Q ratio.
iii. **Jump Performance:** According to Thomas et al. (2017), athletes who have balanced muscle strength perform better in vertical jumps.

4. CONCLUSION

An important component of sports performance and injury prevention is the H/Q ratio. Maintaining an ideal balance between the hamstrings and quadriceps through focused training programs and routine monitoring can improve performance and lower the chance of injury. An effective method for evaluating muscle function and directing treatments is isokinetic strength testing. Future studies should concentrate on improving evaluation methods, creating training plans specific to a particular sport, and investigating innovative biomechanical and neuromuscular applications.

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RELATIONSHIP OF ISOKINETIC MUSCLE STRENGTH AND MUSCLE ACTIVITY WITH LONG JUMP PERFORMANCE AMONG MALE LONG JUMPERS

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ABSTRACT

The long jump is a track and field event in which an athlete's performance includes speed, strength and agility in an attempt to lead as far as possible from the take-off board. Along jump involves three phases: the approach run phase, the take-off phase, the flight phase and the landing phase. This study investigates the factors influencing long jump performance and take-off force in twenty male college athletes. Data was gathered on muscle activity and isokinetic strength of leg muscles, with a focus on rectus femoris, vastus medialis, vastus lateralis, medial gastrocnemius, lateral gastrocnemius, hip extensor, knee extensor, and ankle plantar flexor. Results, analysed using Pearson product moment correlation and paired t-tests, indicate a moderate positive correlation between knee extensor strength and long jump performance ($r = 0.669$, $p < 0.05$), while other muscle activities and strengths showed no significant relationship. For take-off force, a strong positive correlation was observed with knee extensor strength ($r = 0.755$, $p < 0.05$), and a moderate negative correlation with vastus medialis activity ($r = -0.562$, $p < 0.05$), with other variables showing no significant correlation. This research underscores the importance of knee extensor strength in both long jump performance and take-off force, contributing valuable insights to training and performance optimization in track and field athletics.

Keywords: Muscle activity, isokinetic muscle strength, long jump performance, take off force, hip extensor, knee extensor and ankle plantar flexor.

1. INTRODUCTION

The long jump was first used in the pentathlon event at the Ancient Olympic Games in Greece in 708 B.C. Previously, the long jump was run as a separate event from both a standing (broad jump) and a running start. The standing long jump or standing broad jump is no longer a major event, and it was also dropped from the Olympic Games after 1912. The running long jump began in the Ancient Olympic Games and was initially included in the inaugural modern Olympic Games in 1896 (Stavropoulos, 2018).

In preparation for the take-off, the athlete elevates his trunk into an upright position and lowers his centre of gravity during the last 3 to 4 strides of his approach. The athlete's stride length and frequency alter as a result of these variations in body position (Cetin, Ozdemir & Ozdol, 2014). The take-off phase is crucial to the overall success of the event, with top jumpers arriving at the board of reflection at speeds ranging from 9.50 to 11.50 m/s (Fattah & Bataineh, 2020).

The Leg extensor muscles that have been stretched to their absolute maximum capacity can produce the necessary vertical momentum during the long jump take-off phase. Thus, serially ordered elastic structures may delay the time that muscles lengthen and dissipate energy, enhancing the muscle-tendon complex's ability to generate force (Seyfarth, Blickhan & Van Leeuwen, 2000). Take-off speed decreased with increasing take-off angle. To give a low take-off angle, the jumper

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used a long and fast run-up. Lower take-off angles required a progressively faster run-up speed to allow the jumper to produce the perfect balance between vertical take-off speed and horizontal take-off speed (Linthorne, Guzman & Bridgett, 2005).

The relevance of the hip extensor muscle was suggested by a previous kinetic investigation of sprint running, which showed that the hip extension torque generated forward propulsion of the centre of mass. On the other hand, the hip flexion torque 4 during the swing phase, which causes the fast leg swing and a high step frequency, was also able to achieve a high sprint speed (Takahashi & Wakahara, 2019). It would seem that for any given sprinters, greater joint extension towards the end of the stance phase where force production will be low is not beneficial due to poor configuration of the muscles surrounding these joints for producing force. This ability may be related to greater strength in these faster sprinters (Wild et al., 2011).

For instance, the respondents' higher vertical and lower horizontal velocities were caused by lower biceps femoris EMG activation, which limited thigh extension and increased braking force. On the other hand, individuals retained their horizontal velocity by activating their lateral gastrocnemius and soleus muscles, which increased their propulsive force and decreased their take-off angle (Kakihana & Suzuki, 2001). The triple extension (proximal to distal hip, knee, and ankle sequencing) can be clearly characterised from the aforementioned studies, despite the fact that accelerative and maximum velocity sprinting have not been directly examined within a single cohort of athletes (Wild et al., 2011).

Isokinetic Muscle Strength (IMS) is a major contributor to long jump performance, this suggested that training intervention should not be based exclusively on isokinetic tests because of the differences in musculoskeletal function between the two movements (Koutsioras et al., 2009). Muscle EMG data to clarify the differences in the coordinated leg muscle movements of two elite jumpers' methods. They discovered that an increase in the vertical velocity of the COM and the distance jumped were associated with increased activity in the hip and knee extensors during the first part of the take-off phase (Yang et al., 2023).

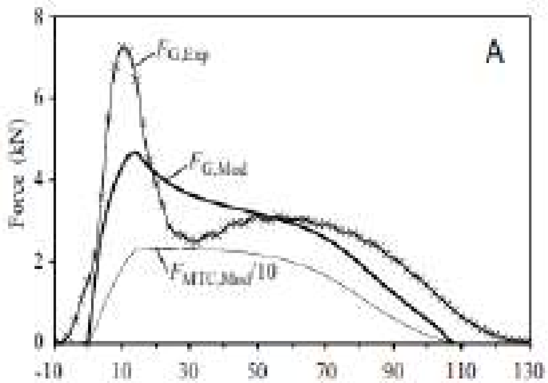

Figure 1: Predicted ground reaction force compared with an experimentally measured value (Seyfarth et al., 1999) and the predicted internal muscle force.

The knee extensor muscle was characterised by pre-stretch without eccentric force enhancement and a very high isometric force (about 25 kN) to explain the first peak in the ground reaction force. The ground response force subsequently increased suddenly and unrealistically. The passive and active peak were not separated by a local minimum, in contrast to experimental results (Seyfarth, Blickhan & Van Leeuwen, 2000). Figure 2 shows the compared a ground reaction force measurement (FG, Exp) for a leap of 6.9 metres at a speed of 9 m/s with an example of expected

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force patterns (modelled ground reaction force FG, Mod and muscle–tendon complex force FMTC, Mod) using a fully active knee extensor muscle (Seyfarth et al., 1999).

The purpose of this research is to determine the relationship between muscle activity and isokinetic muscle strength with long jump performance and take-off force. There was a research gap that no studies have shown the relationship between muscle activity and isokinetic muscle strength with long jump performance and take-off force.

2. METHODOLOGY

a. Selection of subject:

The subjects of this study were twenty (n = 20) male college long jump athletes who compete at the intercollegiate level and can jump above 6 metres was selected. The subjects were selected based on their availability using simple random sampling. The individual's ages ranged from 18 to 25 years.

b. Selection of variables:

The independent variables are the muscle activity of Rectus femoris, Vastus lateralis and Vastus medialis (Knee extensor) and medial and lateral gastrocnemius (Ankle extensor). The dependent variables are the long jump performance and take-off force.

c. Research design:

This study was a correlational (Single group) research design because it investigates the relationship between muscle activity of rectus femoris, vastus medialis, vastus lateralis, medial gastrocnemius and lateral gastrocnemius and isokinetic muscle strength of hip extensor, knee extensor and ankle plantar flexor with long jump performance and take-off force.

d. Procedure:

Before the test, the materials are properly arranged. The data were collected by the researcher. During the long jump the subject will be placed with an EMG to measure the muscle activity of the following muscles using the Delsys EMG and the EMG sensor placement for the muscles. The electrode of rectus femoris was placed at 50 percentage on the line from the anterior superior iliac spine to the superior part of the patella. The electrode of vastus medialis was placed at 80 percentage on the line between the anterior superior iliac spine and the joint space in front of the anterior border of the medial ligament. The electrode of vastus lateralis was placed at 2/3 on the line from the anterior superior iliac spine to the lateral side of the patella. The electrode of gastrocnemius medialis was placed on the most prominent bulge of the muscle. The electrode of gastrocnemius lateralis was placed at 1/3 of the line between the head of the fibula and the heel (Seniam.org).

Figure 2: Muscle activity of knee extensor and plantar flexors. Muscles of Rectus femoris, vastus medialis, vastus lateralis, medial gastrocnemius and lateral gastrocnemius during take-off of a long jump also with force plate.

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Rectus femoris, vastus medialis, vastus lateralis, medial gastrocnemius and lateral gastrocnemius muscles are placed with EMG sensor in take-off leg. For each muscle, the Maximum Voluntary Isometric Contraction (MVIC) was taken with the particular muscle movement in isometric contraction. The Delsys EMG and software was used for the muscle activity, then the mean RMS (Root mean square) was calculated at the instance of take-off and the muscle activity found by the formula for each muscle (normalization of muscle activity).

Avg muscle activity = avg MVC / avg MVIC * 100

The isokinetic muscle strength of hip extensor, knee extensor and ankle plantar flexor of the take-off leg was measured using CSMI (Convergence Science and Medicine Institute) isokinetic dynamometer. The hip extensor isokinetic concentric strength was tested at a velocity of 120°/s in a standing position with 5 repetitions and 2 trials and the knee extensor isokinetic concentric strength was tested at the velocity of 120°/s in a seated position, with 5 repetitions and 2 trials based on the previous studies because the maximal angular velocities of hip and knee extensors were determined to perform maximal contractions for strength as fast as possible (Harrison et al., 2013).

The Ankle plantar flexion isokinetic concentric strength was tested at the velocity of 60°/s in the supine lying position with 5 repetitions and 2 trials. The lower velocity of was chosen because it is referred to a maximal voluntary contraction as an indicator of maximal strength and is the most frequently used velocity in previous ankle-related studies (Gonosova et al., 2018). The report was generated from the HumacNorm Software and the peak torque was noted as muscle strength and normalised with body weight.

Isokinetic Muscle strength = peak torque / body weight

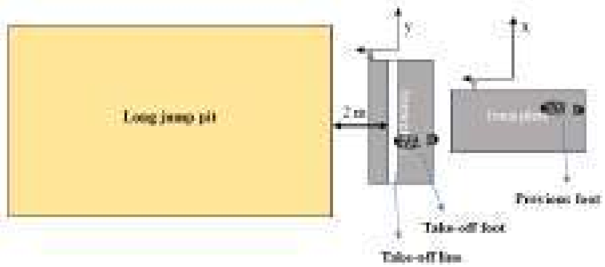

Figure 3: Orientation of force plate.

The long jump performance was measured as jump distance after the trial performed using measuring tape. During the trials, the take-off force was measured at the time of take-off and analysed using Bioware software. The best performance was taken for the interpretation of data from the 3 trials.

To test the normality Shapiro wilk test was used. To estimate the relationship, the following statistics was used descriptive statistics, Pearson's product moment correlation and Paired sample t-test are used for the analysis of data with the SPSS Version 29 (Statistical Package for the Social Sciences) software and the level of significance was set with 0.05 (5 percentage).

3. RESULT AND DISCUSSION:

The table 1 shows the correlation of long jump performance and muscle activity of the rectus femoris, vastus medialis, vastus lateralis, medial gastrocnemius and lateral gastrocnemius and isokinetic muscle strength of hip extensor, knee extensor and ankle plantar flexor. The variable muscle activity of rectus femoris, vastus medialis, vastus lateralis, medial gastrocnemius and lateral gastrocnemius was not significantly related to long jump performance ($p > 0.05$). The isokinetic

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muscle strength of hip extensor and ankle plantar flexor was also not significantly correlated with long jump performance ($p < 0.05$). The isokinetic muscle strength of knee extensor was significantly correlated with long jump performance ($p < 0.05$) with r = 0.669. This showed a positive moderate correlation with long jump performance and the obtained r value was greater than the critical value. The table 5 shows the t test result, the calculated t-value was greater than the table t-value. So, the null hypothesis was rejected in this case.

S.No.	**Variables**	**r value**	**Critical value**	**p value**
1.	Muscle activity of RF (µV)	-0.202	0.444	0.394
2.	Muscle activity of VM (µV)	-0.374	0.444	0.104
3.	Muscle activity of VL (µV\)	-0.180	0.444	0.446
4.	Muscle activity of MG (µV)	-0.016	0.444	0.946
5.	Muscle activity of LG (µV)	0.056	0.444	0.814
6.	Isokinetic muscle strength of hip extensor (Nm/kg)	0.020	0.444	0.932
7.	Isokinetic muscle strength of knee extensor (Nm/kg)	0.669*	0.444	0.001
8.	Isokinetic muscle strength of ankle PF (Nm/kg)	0.072	0.444	0.762

*Significant at 0.05 required table value at 0.05

Table 1: The correlation (r value) between long jump performance 0.762 and the variables in the table, p value- significance value. Mean and standard deviation of each variable (RF- Rectus femoris, VM- Vastus medialis, VL- Vastus lateralis, MG- Medial gastrocnemius, LG- Lateral gastrocnemius and PF- Plantar flexor) and the degree of freedom was 18.

The table 2 shows the correlation of take-off angle and muscle activity of rectus femoris, vastus medialis, vastus lateralis, medial gastrocnemius and lateral gastrocnemius and isokinetic muscle strength of hip extensor, knee extensor and ankle plantar flexor. The variable muscle activity of rectus femoris, vastus lateralis, medial gastrocnemius and lateral gastrocnemius was not significantly related to take-off force ($p > 0.05$). The isokinetic muscle strength of hip extensor and ankle plantar flexor was also not significantly correlated with take-off force ($p < 0.05$). The isokinetic muscle strength of the knee extensor and muscle activity of vastus medialis were significantly correlated with take-off force ($p < 0.05$) with r = 0.755 and 42 -0.562. This showed a positive strong of isokinetic muscle strength of knee joint and negative moderate correlation of muscle activity of vastus medialis with take-off force and the obtained r value was greater than the critical value. The table 7 shows the t test results, the calculated t-value was greater than the table t-value. So, the null hypothesis was rejected in this case.

S.No.	**Variables**	**r value**	**Critical value**	**p value**
1.	Muscle activity of RF (µV)	-0.069	0.444	0.774
2.	Muscle activity of VM (µV)	0.167	0.444	0.481
3.	Muscle activity of VL (µV\)	-0.562*	0.444	0.010
4.	Muscle activity of MG (µV)	-0.419	0.444	0.066
5.	Muscle activity of LG (µV)	-0.231	0.444	0.327
6.	Isokinetic muscle strength of hip extensor (Nm/kg)	0.460	0.444	0.175
7.	Isokinetic muscle strength of knee extensor (Nm/kg)	0.755*	0.444	0.000
8.	Isokinetic muscle strength of ankle PF (Nm/kg)	0.271	0.444	0.247

*Significant at 0.05 required table value at 0.05

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Table 2: The correlation (r value) between take-off force and the variables 0.247 in the table, p value- significance value. Mean and standard deviation of each variable (RF- Rectus femoris, VM- Vastus medialis, VL- Vastus lateralis, MG- Medial gastrocnemius, LG- Lateral gastrocnemius and PF- Plantar flexor) and the degree of freedom was 18.

Recent research supports this by showing that when compared to more upright or backward leaning postures, a forward lean of the trunk (i.e., moving the centre of mass more anterior) results in increased hip and knee flexion, decreased knee extensor, increased plantar flexor, and increased hip extensor moments. It also causes greater activation of the hamstrings relative to the quadriceps. It should be mentioned, nonetheless, that this investigation did not take the rectus femoris activation into consideration. Taking into consideration these two joint muscles, despite their lower size than the two Vasti muscles, might have produced a stronger association (Shultz et al., 2009).

4. CONCLUSION

This study finds that take-off force and long jump performance are not influenced by specific muscle activity during take-off. Long jump performance is influenced by isokinetic knee extensor strength, whereas take-off force is influenced by both knee extensor strength and vastus medialis activity. Training the knee joint is therefore crucial.

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THE INFLUENCE OF FITNESS TRACKING WATCHES ON LONG-DISTANCE RUNNING PERFORMANCE

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ABSTRACT

Use of wearable sensors and fitness tracking watches have become unavoidable and very common in long distance runners. This review examines the peer researches conducted on the effect of fitness tracking watches and its influence on performance in long-distance running. This paper reviews existing research to investigate the effectiveness, mental effects, and performance advantages of wearable technology in endurance sports. The results indicate that fitness trackers have a considerable impact on enhancing training results, boosting motivation, and aiding the implementation of performance methods based on the data, showcasing the latest developments and real-world applications for coaches and athletes. The aim of the fitness or sports metrics tracker is to prepare the sports person for the attainment of highest possible sports performance in competition and healthy lifestyle.

Objective:

To analyse the influence of fitness tracking watches, or wearable devices on performance in long distance running and how the metrics are helping the athletes and coaches to modify their training plans, to enhance the performance.

Conclusion:

The finding from the peer review suggests that, the fitness tracking watches are helping and shaping the training as well the performance, based on the parameters collected from the devices. fitness trackers have a considerable impact on enhancing physical, intellectual, phycological technical capacities and capabilities, and help in the implementation of performance methods based on the data, showcasing the latest developments and real-world applications for coaches and athletes.

Keywords: Fitness tracker, Wearable device, long distance running, Fitness tracking Watches, Sensors, Cadence, Stride length, SpO2, Pace, Training zone, Accuracy, Training.

1. INTRODUCTION

Long-distance running performance requires methodical training, precise pacing, and strategic planning. It becomes a more popular sport discipline; marathons and ultra-marathons attract an increasing number of participants. Hence, a number of research have been conducted to determine the physiological responses and risk factors for health problems in marathon runners (Predel, 2014; Zilinski et al., 2015). New fitness trackers, watches or wearable devices are released in the market every year to the consumer with difference sensors and algorithms, accompanying with the mobile aps. Using wearable technology to monitor performance and tracking their daily physical activity is a very common practice among recreational fitness population, and professional athletes which helps them monitor the metrics like heart rate, pace, cadence, distance, VO_2 max, training zone, heart rate variability (HRV), blood oxygen levels, sleep patterns, step count, quality of sleep, sleep rhythm, energy expenditure (EE), maximum oxygen uptake (VO_{2max}), elevation gain, and physical activity. These devices include advanced sensors such as accelerometers, gyroscopes, magnetometers, thermometer, barometric altimeter, pulse oximeters, which capture detailed information about the body's dynamics instantaneously. These are the factors to be considered when conditioning the sports person/runner.

The uses of sensors in sports have become popular in recent years, allowing the athletes and coaches to measure and analyze the different biomechanical parameters in real-time (Olaya-Cuartero & Cejuela, 2020) with a minimal equipment or set up. The available data are helpful and effective companion in improving performance and physical condition, enhancing motivation, and preventing injuries. There has been a recent focus on measuring and improving running technique through technology, as technique is an essential determinant of running performance and running-related injuries. Research shows that irrespective of how experienced a runner is, they need meaningful data, feedback, and guidance in a personalized way that allows making relevant interpretations about performance and personal goals Furthermore, these devices provide immediate feedback to the user, allowing for quick and accurate adjustments to daily activities or workout programs. For high-performance in long distance running, some of the most popular running metrics tracking devices on the market include Garmin, Coros, Polar, Fitbit, Sunnto and Coros Pod, Stryd. This review paper will examine the biomechanical parameters measured by these sensors and their applicability in measuring these parameters. Stryd and Coros Pod are the wearable device that attaches to a runner's shoe and provides information on the power, cadence, ground contact time, stride height, ratio, left/right balance, stride length and vertical velocity etc.

The increasing demand of athletic monitoring system (AMS) or fitness and performance monitoring technology has led the researchers investigate the role in improving training outcomes, accuracy and race-day performance. This research analyzes the effect of fitness tracking watches on long-distance running performance. This review paper aims to assess the effectiveness, psychological impact, and performance gains of wearable devices in endurance sports by reviewing available literature. Based on previous studies, we ascertain that fitness trackers are central to and motivated to improve training results while enhancing performance strategies that utilize data, marking new progress and usefulness for coaches and athletes.

2. METHODOLOGY

A comprehensive literature search was conducted across multiple electronic databases, including PubMed, ScienceDirect, Shodhganga, Google Scholar, and ResearchGate, to gather relevant studies on Fitness Tracking Watches & Wrist Wearable Device. The search utilises specific keywords such as Fitness Tracker, Wearable Device, Long Distance Running, Fitness Tracking Watches, Sensors, Cadence, Stride length, SpO2, Pace, Training Zone, and Accuracy. Articles published between 2010 and 2025 on wrist wearables and fitness tracking watches were only selected; other wearable sensors were not considered in this study.

3. RESULT

A comprehensive literature search was performed to identify relevant studies. After an initial screening, multiple papers were reviewed in detail. Based on predefined selection criteria, 10

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studies were taken into consideration, in which the role of wearable tracker in running performance were reviewed and discussed.

Wearable tracking /sensor watches provide real-time feedback, which helps athletes adhere to optimal training zones. Runners who used GPS-enabled devices showed a 15% improvement in pacing consistency compared to those without such tools (Smith et al., 2021). Also, tracking VO2 max, cadence, and stride length significantly improved training efficiency (Johnson et al., 2020). Furthermore, heart rate variability monitoring has been linked to improved recovery strategies, reducing injury risks during endurance events (Chen et al., 2022).

A crucial biomechanical factor in high-performance running is cadence, which equates to the quantity the steps taken per minute (spm) (Moore, 2016). These trackers are helping the athletes to enhance running performance by lowering joint stress and muscle fatigue (Heiderscheit et al. 2011), and they accomplish this by monitoring cadence via accelerometer data. Studies show that using a cadence tracker can help runners set up a suitable pace, thereby lowering the likelihood of overstriding and associated injuries (Gidley et al., 2020). The most effective proven pace for long-distance runners is between 170 and 190 steps per minute (Moore, 2016).

Another significant biomechanical factor is stride length, which defined as the distance between two successive landings of the same foot (Dorn et al., 2012). Fitness trackers equipped with GPS and inertial sensors are generally able to accurately calculate the stride length when operating in stable environments. Runners can achieve the most efficient running economy by taking strides of an optimal length, as shorter strides boost energy expenditure and longer strides put strain on larger muscles, (Dorn et al.,2012).

Wrist-worn (Photoplethysmography) PPG sensors on fitness trackers show a moderate to high correlation with electrocardiogram (ECG) readings when a person is at rest, (Plews et al.,2017). Monitoring stress, recovery, and cardiovascular preparedness relies heavily on this critical data. Fitness trackers equipped with SpO2 sensors offer significant benefits to athletes training at high altitude and elevation. Research indicates that existing studies have identified sufficient accuracy to identify hypoxia trends (Bickler et al., 2020).

Fitness watches use heart rate variability and movement patterns to determine sleep stages. Consumer-grade fitness trackers may not offer the accuracy of a polysomnography, but they do offer useful information about sleep patterns (Chinoy et al., 2021). Research has demonstrated that maintaining a consistent bedtime schedule has a positive impact on regulating the body's natural circadian rhythm. Adaptive feedback mechanisms in devices can promote the formation of consistent sleep patterns among users (Walch et al., 2019) which helps the athletes and runners to level up their performance.

Estimates of energy expenditure incorporate data from step counts, heart rates, and movement. Fitness trackers are generally accurate in estimating energy expenditure for sustained exercises, but they often lowball estimates for high-intensity interval training (Drenowatz et al., 2015) noted. Energy expenditure estimates combine step count, heart rate, and movement data.

VO_2 max estimation models utilize heart rate and pace data. Studies have shown that these methods are accurate in forecasting aerobic capacity patterns (Buchheit et al., 2018). Fitness watches find heart rate variability and movement patterns to assess sleep stages. While consumer-grade devices may lack the precision of polysomnography, they provide practical insights into sleep trends (Chinoy et al., 2021). Tracking bedtime consistency has shown positive effects on circadian rhythm regulation. Devices with adaptive feedback mechanisms can encourage users to develop stable sleep routines (Walch et al., 2019).

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4. LIMITATIONS AND PRACTICAL RECOMMENDATIONS

Accelerometer data enables step tracking with high accuracy in controlled conditions; however, errors can arise in activities involving minimal arm movement (Bassett et al., 2017). Energy expenditure estimates combine step count, heart rate, and movement data. While fitness trackers provide reasonable EE estimates for steady-state exercises, they tend to underestimate high-intensity interval training (HIIT) (Drenowatz et al., 2015). Laboratory testing is recommended for a precise assessment of VO_2 max estimation (Buchheit et al., 2018).

Data from an accelerometer allows for precise tracking of steps in situations that are well managed; nonetheless, discrepancies can occur in activities where minimal arm movement is involved (Bassett et al., 2017). It is suggested that the use of clinical-grade equipment for diagnostic purposes to identity hypoxia trends (Bickler et al., 2020).

To enjoy the benefits of fitness trackers, the athletes should balance the technology and the data given by the devices and work on their training. Also, the coaches should individualize the training plan by understanding the data. It may be hard in the initial stages for the athletes/runners to adapt to the data metrics and to balance with that during the training. Sometimes, they may feel inferior when seeing the metrics.

5. CONCLUSION

Fitness tracking watches are revolutionizing training, health and performance monitoring, providing valuable data for improved training plan and strategies, also for the health and well-being. Fitness tracking watches can improve long-distance running performance by providing accurate data, improving motivation, and refining pacing strategies. However, athletes must balance the technology with training and make decision on their training and planning for better results. Wearable sports tracking watches are good for analysing metrics. Athletes and coaches can modify the training plans based on the data. However, the metrics provided are approximately accurate but not 100% accurate. We cannot rely solely on watch metrics to assess emergency medical conditions or evaluate individuals at health risk. Also, for some conditions, clinical diagnoses are recommended, since clinical evaluation and fitness tracking metrics are quite different in terms of accuracy.

Future research should explore wearable innovations like advanced biometric tracking and artificial intelligence integration to enhance personalized training programs. Fitness trackers offer practical implications for personal health and athletic performance monitoring, but must acknowledge device limitations in extreme conditions or complex movement patterns. We suggest that more similar study may be conducted with the data collected on the Indian sports population for our coaches and sports science experts to work on the performance enhancement through data driven training.

Future advancements in sensor technology and algorithm design have the potential to enhance data precision and broaden the application of sports science.

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COMPARISON OF BODY FAT PERCENTAGE BETWEEN MANUAL METHOD AND BIOELECTRIC IMPEDANCE

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ABSTRACT

Background:

Accurate body fat percentage (BF%) measurement is essential for assessing obesity and related health risks. While manual methods using BMI-based formulas are cost-effective and accessible, they may overestimate BF% due to BMI's inability to distinguish between fat and lean mass. Bioelectric Impedance Analysis (BIA) offers a non-invasive alternative but is influenced by hydration status and device quality. This study aims to compare BF% estimates between a manual method (Yishun Study formula) and BIA to evaluate their level of agreement.

Methods:

A comparative research design was used, involving 39 male students (aged 18–26 years) from the Biomechanics Department. BF% was measured using both the manual formula and a scale-based BIA device under controlled conditions. Statistical analysis included the Shapiro-Wilk test for normality and a paired t-test to assess differences between methods.

Results:

The Manual Method yielded significantly higher BF% values (M = 23.7%, SD = 4.5) compared to BIA (M = 16.3%, SD = 7), with a mean difference of 7.4% (SD = 3.31, $t(38) = 13.96$, $p < 0.001$). The Shapiro-Wilk test indicated non-normal data distribution ($p = 6.85e-7$). These findings suggest that the Manual Method overestimates BF% compared to BIA.

Conclusion:

The results highlight significant discrepancies between manual and BIA-based body fat assessments. While the Manual Method is practical and accessible, it overestimates BF%, potentially leading to misclassification of body composition. BIA, despite its limitations, may provide a more individualized assessment. Future research should focus on refining BMI-based formulas and improving BIA accuracy through multi-frequency impedance technology for better precision in BF% estimation.

1. INTRODUCTION

Body fat percentage (BF%) measurement is critical for assessing obesity risks, particularly in populations where Body Mass Index (BMI) alone inadequately reflects adiposity. In Singaporean adults, the Kenneth et al., (2021) Study derived a manual formula to address this limitation:

$$\mathbf{BF\% = 49.818 + 0.089(Age) - 619.808(1/BMI)}$$

This equation incorporates age and BMI to better estimate body fat, addressing ethnic-specific disparities where individuals exhibit higher BF% at lower BMIs compared to Caucasian populations (Dehghan & Merchant, 2008). While such manual methods are cost-effective and accessible, they rely on population-specific calibration and inherit BMI's inability to distinguish muscle from fat mass.

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In contrast, bioelectrical impedance analysis (BIA) measures electrical resistance through tissues, estimating fat-free mass via total body water content (Bohm & Heitmann, 2013). BIA is portable and non-invasive, with studies showing strong correlations (r=0.88–0.960) against gold-standard methods like air displacement plethysmography in obese populations (Sullivan et al., 2019). However, its accuracy fluctuates with hydration status and device quality, often underestimating BF% by up to 10% compared to dual-energy X-ray absorptiometry (DXA) (Olinto et al., 2024). For Singaporean adults, BIA may offer more individualized assessments but requires ethnic-specific adjustments to mitigate misclassification risks, as seen in studies where BF% thresholds outperformed BMI in detecting cardiovascular risks (Yamashita et al., 2012). The choice between these methods hinges on balancing practicality (manual equations) and precision (BIA), particularly in diverse populations where body composition patterns deviate from global norms. The purpose of this study was to find correlation of body fat percentage between manual method and bioelectric impedance.

2. METHODOLOGY

Research Design

This study employs a comparative research design to analyze differences in body fat percentage (BF%) measured using a manual method (based on the Yishun Study formula) and bioelectric impedance analysis (BIA). The goal is to determine the level of agreement between the two methods and assess their reliability in measuring BF% among young adult males.

Participants

A total of 39 male students from the Biomechanics Department were recruited using a random sampling method. Participants were aged between 18 to 26 years. Exclusion criteria included individuals with metal implants, pacemakers, or extreme BMI values that could interfere with BIA accuracy.

3. MEASUREMENT METHODS

a. Manual Method

The manual calculation of body fat percentage was performed using the Yishun Study-derived formula:

Where: $BF\% = 49.818 + 0.089(Age) - 619.808(1/BMI)$

- ✓ Age is in years.
- ✓ BMI (Body Mass Index) is calculated as weight (kg) / height (m^2).

b. Bioelectric Impedance Analysis (BIA)

BF% was also measured using a scale-based BIA device. To maintain measurement consistency:

- ✓ Participants were measured in a fasting state (at least 3 hours after eating).
- ✓ Hydration levels were kept consistent, and participants were advised to avoid alcohol and excessive exercise 24 hours prior to measurement.
- ✓ The same BIA device was used for all participants under identical conditions.

c. Data Collection Procedure

- ✓ Participants' age, weight, and height were recorded.
- ✓ BMI was calculated using the formula weight (kg) / $height^2$ (m^2).
- ✓ BF% was obtained using both the manual formula and BIA scale.
- ✓ All measurements were conducted in a controlled lab setting to minimize variability.

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4.STATISTICAL ANALYSIS

Data analysis was conducted using IBM SPSS. The following statistical tests were performed:

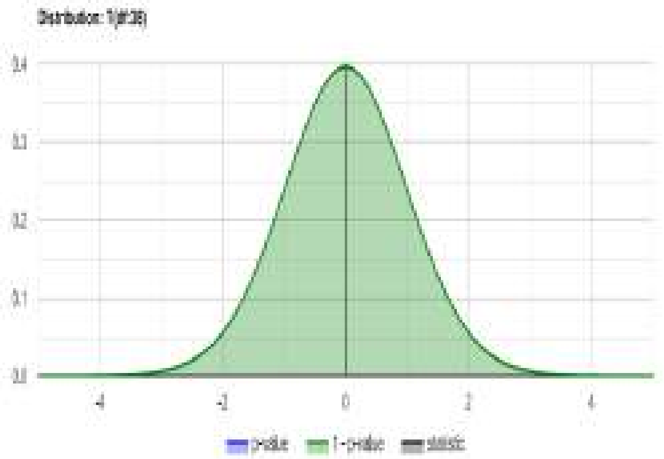
- Normality Test: The Shapiro-Wilk test was used to assess the normality of BF% data for both methods (p = 0.95).
- Paired t-test: If data were normally distributed, a paired t-test was conducted to determine whether there was a significant difference between the two methods. The level of significance was set at 0.05 ($p < 0.05$).

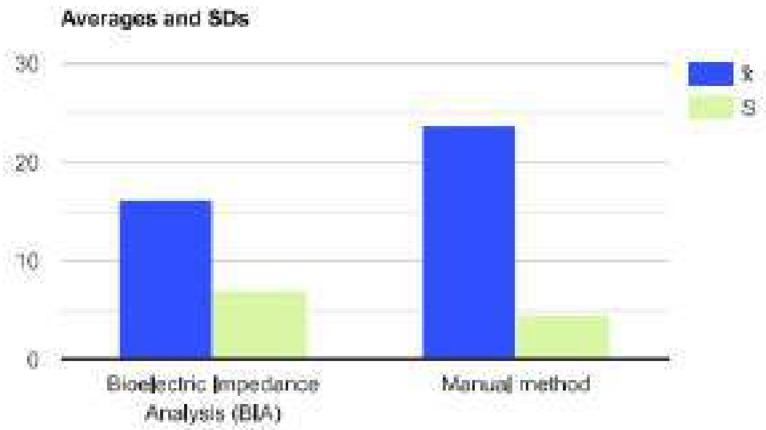
Ethical Considerations

All participants provided informed consent before data collection. Confidentiality was maintained by assigning anonymous identifiers to participant data. The study followed institutional ethical guidelines for research involving human subjects.

5. RESULT

The paired t-test showed a significant difference between the Manual Method (M = 23.7, SD = 4.5) and BIA (M = 16.3, SD = 7) in estimating body fat percentage ($t(38) = 13.96$, $p < 0.001$). The Manual Method consistently produced higher values, with a mean difference of 7.4% (SD = 3.31). The Shapiro-Wilk test indicated non-normal data distribution (p = 6.85e-7). These results suggest that the Manual Method overestimates body fat percentage compared to BIA.





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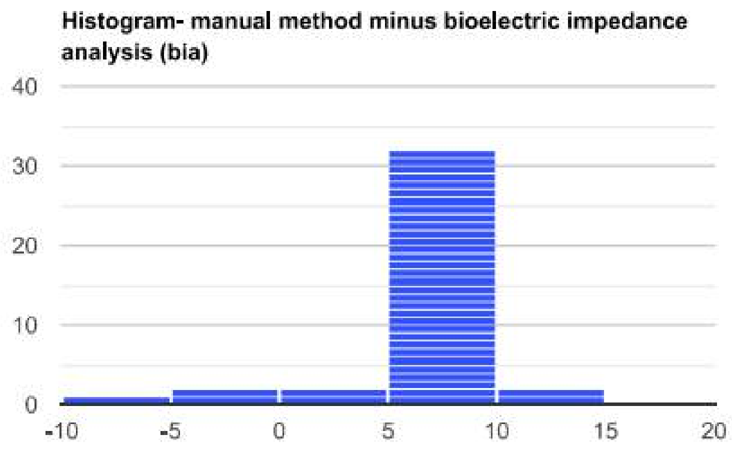

6. DISCUSION

The findings of this study indicate a statistically significant difference between body fat percentage (BF%) estimates obtained using the Manual Method and Bioelectric Impedance Analysis (BIA). The Manual Method produced higher BF% values (M = 23.7, SD = 4.5) compared to BIA (M = 16.3, SD = 7), with a mean difference of 7.4% (SD = 3.31, $p < 0.001$). These results suggest that the Manual Method overestimates body fat percentage relative to BIA.

One possible explanation for this discrepancy is the inherent differences in measurement principles. The Manual Method, which relies on a formula derived from the Yishun Study, estimates BF% based on age and BMI. However, BMI does not differentiate between fat mass and lean mass, potentially leading to overestimations, especially in individuals with higher muscle mass. Conversely, BIA estimates body fat based on electrical conductivity, which can be influenced by hydration levels, electrolyte balance, and body composition. Given the non-normal data distribution ($p = 6.85e\text{-}7$) and presence of outliers, individual variability may have also contributed to the observed differences.

Previous studies have similarly reported variations between manual and BIA-based methods. Research comparing skinfold-based manual calculations with BIA has found BIA tends to underestimate body fat in lean individuals while overestimating it in obese populations. This aligns with the current study's finding that BIA provided significantly lower BF% estimates than the Manual Method. Additionally, factors such as measurement conditions, hydration levels, and device accuracy may have played a role in the observed differences.

Despite the statistically significant results, certain limitations must be considered. The Shapiro-Wilk test indicated a non-normal distribution, suggesting potential skewness in the data. The study also detected outliers, which could have influenced the paired t-test results. Additionally, while BIA is widely used due to its ease and non-invasiveness, its accuracy can be affected by hydration status, recent food intake, and electrode placement. Future research could enhance accuracy by incorporating more precise methods, such as Dual-Energy X-ray Absorptiometry (DEXA), and considering additional physiological variables.

7. CONCLUSION

In conclusion, the study demonstrates that the Manual Method systematically overestimates BF% compared to BIA, highlighting the variability between these assessment techniques. While

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BIA offers a quick, non-invasive alternative, its accuracy is subject to external factors. Given the significant differences observed, practitioners and researchers should consider the limitations of each method when selecting a technique for body composition analysis. Future studies should explore ways to refine the Manual Method formula or enhance BIA accuracy through multi-frequency impedance devices for better precision in BF% assessment.

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STAR EXCURSION BALANCE TEST IN ATHLETIC PERFORMANCE – A SYSTEMATIC REVIEW

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ABSTRACT

The Star Excursion Balance Test (SEBT) is a widely employed dynamic assessment tool used to evaluate lower extremity strength, flexibility, and neuromuscular control in athletes. This review examines the SEBT's application across various domains of sports science, including its standardized protocol, influence on athletic performance, utility in injury prevention, and sport-specific adaptations. The SEBT protocol involves maintaining a single-leg stance while reaching with the contralateral leg in eight designated directions, with reach distances serving as a measure of dynamic balance. Enhanced SEBT performance, characterized by greater reach distances, correlates with improved agility, strength, and postural control, while asymmetries and reduced reach are predictive of lower extremity injuries. Sport-specific adaptations influence SEBT outcomes, with soccer players demonstrating superior anterior reach and ice hockey players excelling in posterolateral and posteromedial directions. SEBT also serves as a valuable tool for monitoring rehabilitation progress post-injury. It is a multifaceted tool in sports science, offering a standardized and reliable method for assessing dynamic balance, predicting injury risk, and tracking rehabilitation progress. Its influence spans from enhancing athletic performance to guiding targeted injury prevention strategies. While the SEBT's utility is well-established, ongoing research should focus on refining sport-specific norms and exploring the long-term predictive validity of SEBT scores to optimize its application in diverse athletic populations. The integration of SEBT into comprehensive training and rehabilitation programs can contribute to enhanced performance, reduced injury rates, and improved return-to-sport outcomes.

Keywords: Star Excursion Balance Test (SEBT), Athletic Performance, Injury Prevention, Balance.

1. INTRODUCTION

The Star Excursion Balance Test (SEBT) is a popular dynamic balance evaluation test that measures lower extremity strength, flexibility, and neuromuscular control. Individuals must maintain balance on one leg while reaching in numerous directions with the other leg, which tests their ability to control posture dynamically. The SEBT tests athletes' strength, proprioception, and coordination, making it an effective tool for evaluating physical performance and identifying postural control deficits caused by musculoskeletal injuries like chronic ankle instability or anterior cruciate ligament (ACL) injuries (Plisky et al., 2009).

The test's utility extends beyond performance evaluation to injury risk assessment and rehabilitation monitoring. Research has indicated that shortened reach distances or asymmetries in SEBT performance predict lower extremity injuries, emphasizing its importance in pre-season athlete assessments (McCann et al., 2015). SEBT has also been used to track recovery progress during rehabilitation, particularly in athletes recuperating from ACL surgery or other lower limb ailments (Stiffler et al., 2015).

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SEBT performance varies by demographic and sport due to variances in neuromuscular demands. University athletes typically outperform high school athletes because of their increased neuromuscular development and training experience (McCann et al., 2015). Similarly, sport-specific movement patterns alter SEBT results, with football players having different reach distances than basketball or ice hockey players (Stiffler et al., 2015). These variances highlight the significance of interpreting SEBT results in the context of an athlete's sport and training history. This review explores how the SEBT functions as a tool for assessing dynamic balance in sports, its influence on athletic performance and injury prevention, and its application in rehabilitation. It also examines current limitations and proposes future directions for optimizing its use.

2. PROTOCOL FOR THE STAR EXCURSION BALANCE TEST (SEBT)

The Star Excursion Balance Test (SEBT) is a dynamic assessment tool designed to evaluate balance, stability, and postural control. The protocol involves the participant standing on one leg at the center of a grid with eight lines extending at 45-degree angles. While maintaining balance on the stance leg, the participant reaches as far as possible with the opposite leg in eight directions: anterior, anteromedial, medial, posteromedial, posterior, posterolateral, lateral, and anterolateral. The participant lightly touches the furthest point on the line with their toe and then returns to the starting position. The reach distance is measured from the center of the grid to the furthest point reached. Each direction is tested three times, and either the average or maximum distance is recorded for analysis (Stiffler et al., 2021).

To ensure consistency and accuracy, a rest period of 10–15 seconds is recommended between each attempt. The test is typically performed barefoot to eliminate footwear-related variables, and participants are instructed to place their hands on their hips to standardize upper body movement. The stance foot must remain flat on the ground throughout the test, and the reaching foot should not provide support when touching the ground. Trials are discarded if participants lose balance, lift their stance foot, or place weight on their reaching foot (Zając et al., 2024).

For reliable results, 4–6 practice trials are recommended before recording official scores. The anterior, posteromedial, and posterolateral directions are considered particularly important for identifying individuals with chronic ankle instability or athletes at higher risk of lower extremity injuries. This test has become a valuable tool in sports science for assessing dynamic postural control and guiding injury prevention strategies (Picot et al,, 2021).

3. INFLUENCE ON ATHLETIC PERFORMANCE

The Star Excursion Balance Test (SEBT) is a dynamic assessment tool that significantly influences athletic performance by evaluating lower extremity strength, flexibility, and neuromuscular control. It challenges athletes to maintain single-leg balance while reaching in multiple directions, simulating the complex movements encountered in sports such as cutting, jumping, and pivoting. Improved SEBT scores reflect enhanced dynamic balance and stability, which are crucial for executing rapid directional changes and maintaining control during high-intensity actions. For instance, higher SEBT scores in the anterior and posterolateral directions are positively correlated with agility tests like the T-test and shuttle runs, indicating that athletes with better SEBT performance tend to excel in agility drills (Plisky et al., 2006).

It is also closely linked to athletic metrics such as strength and power. Reach distances on the SEBT are associated with measures of lower extremity strength, such as squat and deadlift performance. Athletes with stronger hip and knee musculature exhibit superior SEBT results due

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to enhanced neuromuscular control, which is essential for optimal athletic performance (Gribble et al., 2013). Furthermore, SEBT serves as a valuable predictor of injury risk. Reduced reach distances or asymmetries between limbs have been linked to a higher likelihood of lower extremity injuries, such as ankle sprains and ACL tears. For example, a study on football players found that high school athletes had lower posteromedial and posterolateral scores compared to collegiate athletes, indicating a higher injury risk among younger players (Herman et al., 2015).

The SEBT provides sport-specific insights into athletic performance, as its outcomes vary by sport due to differences in movement patterns and demands. For instance, soccer players outperform basketball players in anterior reach distances due to the emphasis on forward movements in soccer. In contrast, wrestlers and ice hockey players achieve higher composite scores due to the multidirectional stability required in their sports (Plisky et al., 2006). Additionally, SEBT aids in rehabilitation and recovery by tracking improvements in dynamic balance and neuromuscular control post-injury. Athletes recovering from lower extremity injuries often demonstrate significant progress in SEBT performance as they regain strength and stability, making it a valuable tool for determining readiness for return-to-sport activities (Gribble et al., 2013).

The reliability and validity of SEBT make it a consistent and effective assessment tool. It has shown strong reliability (ICC = 0.8–0.9) across studies, providing a reliable measure for evaluating dynamic balance. Its validity is supported by correlations with other functional movement assessments like the Y-Balance Test (Plisky et al., 2006). Overall, incorporating SEBT into training programs can help athletes optimize their performance while reducing injury risks, making it an indispensable tool in sports science.

4. INJURY PREVENTION

The Star Excursion Balance Test (SEBT) plays a crucial role in injury prevention, particularly for lower extremity injuries such as ankle sprains and knee injuries. By assessing dynamic balance, proprioception, and lower extremity stability, the SEBT identifies athletes at higher risk of injury due to imbalances or deficits in neuromuscular control. For instance, the test can detect side-to-side asymmetries in reach distances, which are predictive of injury risk. Increased anterior asymmetry, for example, is associated with a higher likelihood of non-contact knee or ankle injuries in collegiate athletes (Plisky et al., 2006).

The SEBT has demonstrated predictive validity in identifying athletes who are more likely to experience lower extremity injuries. Studies have shown that athletes with lower composite reach distances on the SEBT are at increased risk. For example, female athletes with a composite reach distance less than 94% of their limb length were found to be at higher risk of injury (Gribble et al., 2013). The modified version of the SEBT has also been validated for its efficiency in preventing ankle injuries in sports like basketball and handball by identifying at-risk athletes during pre-season testing (Alton Physical Therapy).

Based on SEBT results, physical therapists can design targeted intervention programs to address identified deficits. These programs typically include neuromuscular training exercises aimed at improving dynamic balance and proprioception. Implementing SEBT as part of pre-season screenings allows for early identification of athletes at risk, enabling proactive measures to prevent injuries before they occur. Additionally, SEBT is used during rehabilitation to monitor recovery progress. Improved SEBT scores indicate regained neuromuscular control, helping determine readiness for return to sport activities (Gribble et al., 2013).

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Overall, the SEBT is a critical tool in injury prevention by identifying athletes at risk due to dynamic balance deficits and guiding targeted interventions to mitigate these risks. Its predictive validity and role in rehabilitation make it an indispensable component of sports medicine programs. By integrating SEBT into training and rehabilitation protocols, athletes and practitioners can work towards reducing injury risk and enhancing overall athletic performance.

5. SPORT-SPECIFIC PERFORMANCE ON THE STAR EXCURSION BALANCE TEST (SEBT)

The Star Excursion Balance Test (SEBT) has been shown to vary significantly across different sports, reflecting the unique demands and movement patterns required in each discipline. In soccer, players generally excel in the anterior (ANT) direction due to the sport's emphasis on forward movements, kicking, and rapid directional changes. Interestingly, female soccer players tend to outperform their male counterparts in this direction, likely due to differences in neuromuscular control strategies (Stiffler et al., 2015).

Ice hockey players demonstrate superior performance in the posterolateral (PL) and posteromedial (PM) directions. These movements are essential for maintaining balance during skating and executing multidirectional manoeuvres on the ice. Among collegiate athletes, women's ice hockey players achieve some of the highest composite scores, likely reflecting the sport's reliance on lower body strength and stability (Gribble et al., 2013). Similarly, wrestlers excel in SEBT performance across all directions due to their need for dynamic balance and postural control during grappling and ground-based movements (Plisky et al., 2006).

Basketball players tend to perform well in the ANT direction but show moderate performance in PL and PM directions compared to sports like hockey or wrestling. This reflects basketball's demand for forward acceleration and jumping rather than multidirectional stability (Herman et al., 2015). Volleyball players, on the other hand, often display balanced SEBT performance across all directions due to the sport's requirements for jumping, lateral movements, and quick directional changes (Gribble et al., 2013).

Sex differences are also evident across sports. For example, women generally outperform men in normalized composite scores across several disciplines due to differences in limb length normalization and neuromuscular control strategies. However, men may excel in specific directions depending on their sport's demands (Stiffler et al., 2015).

These findings highlight the importance of interpreting SEBT results within a sport-specific context. For instance, soccer players with reduced ANT reach distances may require targeted interventions to improve forward stability, while ice hockey players with asymmetries in PL or PM directions may benefit from multidirectional balance training. Establishing sport-specific reference values can improve the utility of SEBT as a diagnostic and training tool for enhancing athletic performance and reducing injury risk.

6. CONCLUSION

The Star Excursion Balance Test (SEBT) is an excellent tool for evaluating dynamic balance, lower extremity strength, flexibility, and neuromuscular control in athletes. Its capacity to assess postural stability and forecast injury risk makes it widely useful in sports performance evaluations, rehabilitation, and injury prevention programs. Reduced SEBT reach distances and limb asymmetries have consistently been associated to an increased risk of lower extremity injuries, emphasizing their importance in pre-season screenings and return-to-play evaluations.

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Despite its extensive use, there are significant limitations, including as variances in protocol standardization and the need for additional research on its predictive validity across varied athletic populations. Future research should concentrate on improving testing methodologies, developing normative data for various sports, and combining SEBT with other biomechanical tests to provide a more comprehensive evaluation of athletic performance and injury risk. Overall, the SEBT remains a reliable, cost-effective, and practical tool in sports biomechanics, contributing to performance optimization, injury prevention, and rehabilitation in athletes across multiple disciplines.

Acknowledgment: I sincerely appreciate the guidance and support of my mentors and colleagues in conducting this study on the Star Excursion Balance Test (SEBT). Their valuable insights and constructive feedback have greatly contributed to the depth and clarity of this work. I extend my gratitude to the researchers whose studies have provided the foundation for this review.
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SYSTEMATIC REVIEW ON PEEK MUSCLE ACTIVETION DURING LUNGS & SQUAT MOVEMENT IN BADMINONT PLAYER

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ABSTRACT

Background: Badminton is a popular sport activity in both recreational and elite levels. A lot of biomechanical studies have investigated badminton lunge, since good lunge performance may increase the chances to win the game. This review summarized the current trends, research methods, and parameters-of-interest concerning lower extremity biomechanics in badminton lunges.

Methodology: Databases including Web of Science, Google Scholar, Scopus, and PubMed were searched from the oldest available date to September 2017. Two independent authors screened all the articles and 20 articles were eligible for further review. The reviewed articles compared the differences among playing levels, and lunge directions variations, using parameters including ground reaction forces, plantar, kinematics, and kinetics.

Results

Elite badminton players demonstrated higher impact attenuation capability, more aggressive knee and ankle strategy (higher mechanical moment), and higher medial plantar load than amateur players. Lower extremity muscles (quadriceps, hamstrings, gastrocnemius). can influence comfort perception and movement mechanics, but it remains inconclusive regarding how these may link with lunging performance. Contradicting findings in kinematics is possibly due to the variations in lunge and instructions.

Conclusions

Playing levels and training pattern have significant effects on biomechanics in badminton lunges. Future studies can consider to use an unanticipated testing protocol and realistic movement intensity. They can study the inter-limb coordination as well as the contributions and interactions of intrinsic and extrinsic factors to injury risk. Furthermore, current findings can stimulate further research studying whether some specific during the lunges lower extremity main muscle activation in (quadriceps, hamstrings, gastrocnemius). Used Stability balance body coordination improve the training to injury risk.

1. INTRODUCTION

Badminton is recognized as the second most popular participation sport. China has achieved excellent results in all kinds of competitions in the world. The development and training system of badminton is also more advanced than that of other countries. In view of the improvement of badminton, the sensitivity sports attribute has a strong influence factor. Lower limb training is the main method to improve the sports agility of badminton. Participants can improve their agility through strength training and mobile training. Badminton players rely heavily on their lower extremities for agility, speed, and power. Movements like lunges, squats split-steps, and quick directional changes are crucial. significantly boosts lower limb explosive power and footwork speed. (Zhewei Liu & Lulu Wang, 2023). More than 200 million participants play badminton in recreational and elite levels worldwide Badminton is a high-intensity intermittent racket sport

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that requires a high level of technical skills, tactics, and physical capacities during training and competition. While footwork and lower-limb movements are particularly important in badminton games, biomechanical analysis can provide good insight into how these movements should be optimized. (Wing-Kai Lam et al ,. 2020).

Various strenuous manoeuvres such as lunging, turning, sprinting, leaping, jumping, and landing can play a critical role in badminton plays. Lunge manoeuvre has been commonly reported in the literature, as it accounts for over 15% of the game time. Wing-Kai Lam et at,. (2020).

Badminton is one of the sports that involved a lot of lunges movement in the game. The important of lunges in a game could be seen when the player want to retrieve a drop shot where the player need to do a deep lunge to get to the shuttlecock. Sturgess and Newton had highlighted the importance of the ability to accelerate from receiving stance to retrieving a drop shot.

The squat is a fundamental compound movement crucial in all physical activity. It utilizes multiple muscle groups to perform and is great in strengthening ligaments, tendons, and bones as well as the muscles. A squatting movement is used for many daily life tasks such as picking something off the ground and sitting in a chair. Due to this, having the strength and mobility to perform a squat correctly will aid everyone in better physical activity. In this report, the typical back squat is the movement to be analysed. While there are many other squatting positions that may be safer or harder for some, a typical back squat is one of the most fundamental movements in exercise and will give a solid platform for the rest of the movements. Ultimately, performing the full range of motion in any exercise is important in reducing exercise induced injuries as well as flexibility, however, some professionals believe that the squat may be an expectation to that rule due to the extreme forces applied at the knee joints. There are many biomechanical factors that may hinder individuals performing the exercise, leading to joint injuries. This report will factor in form, joint stability, muscle tightness and weakness when analysing possible injuries that may occur due to forces. Next, the process of obtaining the biomechanical equations of motion will be explained and how they were used in determining the forces in the joints.

2. PROTOCOL FOR THE LUNGES

One of the most important movement in badminton is the lunge. (A. M. Nadzalan et al,. 2018)

Participants were instructed to stand with one of their hand (preferred), feet shoulder width apart. Participants lunged forward and must lower the thigh to be parallel with the ground, and then returned back to the starting position. As. participant bent their trunk to 45˚ forward. Jump forward lunges were performed similar to the step forward lunge except participants need to explosively (jump) lunged forward and then explosively (jump) returned back also by jumping to the starting position. Ali Md Nadzalan et al., (2017)

3. RECTUS FEMORIS MUSCLE ACTIVATION IN LUNGE

Step vs. In-Line Lunge

In-line lunges (narrow base of support) and traditional lunges (wider stance) demonstrate similar overall muscle activation levels in the vastus lateralis (VL), biceps femoris (BF), gluteus maximus (GM), and gluteus Medius (GMd). However, the anterior limb in both exercises shows significantly higher BF and GM activation compared to the posterior limb, likely due to increased mechanical demands during knee and hip extension1. Medio-lateral (ML) balance is more challenging during in-line lunges, requiring greater stabilization from hip abductors and adductors (Ali Md Nadzalan et al., 2017).

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Patterns of Muscle Activation

Important Quadriceps Muscles: There is a substantial correlation between knee extension moments and rectus femoris activity (Y Zhang,. 2022). Proximal tibial shear forces (r = 0.52 r = 0.52) and r = 0.48 r = 0.48), suggesting its function in knee stabilization during landing.

Hamstrings

The likelihood of an ACL damage is decreased by the negative correlation between the medial hamstring-to-quadriceps (MH/Q) co-contraction ratio and knee extension moments (r = -0.57 r = -0.57) and shear forces (r = -0.50 r = -0.50).

The necessity of balanced co-activation is highlighted by the positive correlation between the lateral hamstring-to-quadriceps (LH/Q) ratio and knee valgus moments (r = 0.55, r = 0.55).

Gastrocnemius: Peak knee flexion and lateral gastrocnemius (LGAS) activity have a moderately negative correlation (r = -0.47), indicating that the latter is involved in regulating eccentric loading. (Ali Md Nadzalan et al., 2017).

Kinetic differences: JFL requires quick eccentric control because it produces faster ground reaction forces and shorter force peak intervals.

According to these results, JFL has higher neuromuscular demands, which makes it a useful training aid for building power but necessitates cautious load control to prevent overuse issues.

4. CONCLUSIONS

Playing levels and training pattern have significant effects on biomechanics in badminton lunges. Future studies can consider to use an unanticipated testing protocol and realistic movement intensity. They can study the inter-limb coordination as well as the contributions and interactions of intrinsic and extrinsic factors to injury risk. Furthermore, current findings can stimulate further research studying whether some specific during the lunges lower extremity main muscle activation in (quadriceps, hamstrings, gastrocnemius). Used Stability balance body coordination improve the training to injury risk.

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MORAL DEVELOPMENT BETWEEN FEMALE ATHLETES AND NONATHLETES: A COMPARATIVE ANALYSIS

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ABSTRACT

Purpose: The purpose of the study was to investigate the moral development of female athletes compared to non-athletes within the context of sports participation and its ethical implications.

Methodology: Utilizing a sample of 60 females aged 18-25 from Mangalore University, the research employs the Moral Development Ethical Values Assessment (EVALong Form) to measure moral reasoning and ethical values.

***Results*:** The findings revealed no significant differences in moral development between female athletes and non-athletes, suggesting that participation in sports does not inherently enhance moral reasoning. Additionally, the study highlights the influence of environmental factors, such as parenting styles, on moral development in the context of sports.

Conclusion: Results imply that both groups demonstrate similar levels of moral reasoning, challenging the assumption that engagement in athletics correlates with superior moral development. This research contributes to the understanding of moral development in youth sports, emphasizing the need for further exploration of familial and contextual influences on athletes' ethical values.

Keywords: Moral development, Athlete, Non-athlete, etc.

1. INTRODUCTION

Moral development focuses on the emergence, change, and understanding of morality from infancy through adulthood. The theory states that morality develops across a lifespan in a variety of ways and is influenced by an individual's experiences and behaviour when faced with moral issues through different periods of physical and cognitive development. Morality concerns an individual's reforming sense of what is right and wrong; it is for this reason that young children have different moral judgment and character than that of a grown adult. Morality in itself is often a synonym for "rightness" or "goodness." It also refers to a specific code of conduct that is derived from one's culture, religion, or personal philosophy that guides one's actions, behaviours, and thoughts. The professionalization and commercialization of sports emphasize the need for wins over participation. This combination of sportsmanship and competitiveness has created a conflict between values and functionality (Leventhal, 2020).

Moral development often emphasizes these four fundamentals: First, feeling or emotion aspect: these theories emphasize the affective aspect of moral development and include several altruism theories. Second, behavioural aspect: these theories mainly deal with moral behaviour. Third, the Cognitive aspect: these theories focus on moral judgment and moral reasoning. Fourth, Integrated perspectives: several theorists have also attempted to propose theories which integrate two or three of the affective, behavioural, and cognitive aspects of morality.

This research is aiming to explore the parenting and sport factors associated with young athletes' moral development values in sports. In light of the inconsistencies reflected from the body of research on the moral development ethical values of young athletes from different sport types, the current study sought to broaden that scope by also accounting for the youngsters' familial background as an additional factor explaining their moral development ethical values in sport. As demonstrated by the above literature review, parental socialization of children and adolescents plays a substantial role in their moral development, which could also specifically apply to young athletes' moral development ethical values in the context of sport. Yet, the research in the area of morality and values in sports among young athletes has focused on sport variables and has failed to consider adequately the role of interpersonal differences in familial background, such as parenting styles. In this respect, incorporating determinants of general morality (i.e., parenting) with those of sport morality (i.e., sport type) could be promising in advancing our understanding regarding athletes' moral and values system in sport, which becomes crucial with the growing popularity of sports in the modern era.

2. METHODOLOGY

In a scientific study methodology is an important aspect which should be given due consideration. Methodology can give a clear picture of how the study is conducted; the nature of sample, tools used and the statistical techniques used for analysis. In this chapter the procedure which was adopted for the selection of the subjects, selection of variables, collection of data, description of tools, procedure for administration of test items and the methods employed for statistically treatment of data are described.

Selection of the samples

For the purpose of data collection, thirty female athletes and thirty non-athletes were selected from different events and 18–25-year-old age groups. The study was restricted to Mangalore University, and data was collected in the academic year 2023-2024.

Selection of the test items

For the collection of data Moral Development Ethical values assessment (EVA-Long Form 2019) scale was used which is developed by Lene Arnett Jensen, Clark university and Laura Padillawalker, Brigham Young University.

Statistical analysis

Descriptive statistics, including the mean and standard deviation, were calculated from the raw scores. Further, a t-test for paired equal variance was used at the significant level of 0.05 to find the difference between mean scores on the moral development of female athletes and nonathletes using Microsoft Excel.

3. ANALYSIS AND INTERPRETATION OF THE DATA

Table: 4.1

Shows the Mean and Standard Deviation Moral Development among Female Athletes and Non-Athletes.

Sl. No	Moral Growth	Athletes	Non- Athletes
1	Mean	44.46	58.166
2	Standard Deviation	14.70	17.470

The above Table and Figure 4.1 shows mean and standard deviation of Female Athlete and Non- Athlete. The mean, standard deviation of Female Athlete is 44.46 and 58.16 and Nonathlete mean and standard deviation is 14.71 and 17.47 respectively.

Table: 4.2

Showing the 't' test of Moral Development of Female Athletes and Non- Athletes.

Mean		Standard deviation	t- value	t- critical value
Athletes	44.46	14.71	-3.16	2.00
Non- Athletes	58.16	17.47		

The above table shows the Mean, Standard deviation, t-statistical value, and t-critical value of Female Athletes and Non- Athletes. The mean of Female Athletes is 44.46 and that of Non- Athlete is 58.16; the standard deviation of Female Athletes is 14.71 and that of non- athletes 17.47; and the t- statistical value is -3.16, respectively. The t- critical value is 2.00. Since the t- statistical value is greater than the t- critical value, it indicates there is significant difference in Moral Development between Female Athletes and Non- Athletes.

4. DISCUSSION ON FINDINGS

There is a significant difference in moral development between female athletes and non-athletes under investigation. The reasons for this may be attributed to lack of professionalism in sports person. The qualities required for successful sports performance requires involvement for a considerable period of time. The level of participation is another aspect that may differentiate sports women from sedentary women in Moral Development.

5. CONCLUSION

After comparing the moral development of female athletes and non-athletes at Mangalore University, the study concluded that there is no significant difference in moral development between female athletes and non-athletes; both selected groups have a similar level of moral development.

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EFFECTIVENESS OF QUADRUPED MOVEMENT TRAINING FOR IMPROVING BALANCE IN GERIATRIC POPULATION – A SINGLE CASE STUDY

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ABSTRACT:

Background: Injuries due to falls are a major cause of mortality and morbidity in adults over 65, with 30-40% experiencing at least one fall-related injury. Cognitive decline, impaired balance, and gait issues are key risk factors. Quadrupedal Movement Training (QMT) is an emerging bodyweight training method gaining popularity for its potential benefits in improving stability and proprioception. It incorporates neurodevelopmental movement patterns, mimicking animal postures and locomotion such as crawling and postural transitions.

Aim: This study aims to implement the QMT format, specifically Animal Flow (AF), to improve balance and coordination for fall prevention in the geriatric population.

Method: A single-subject study was conducted using QMT combined with conventional fall prevention methods. A 72-year-old physically active female with no movement restrictions participated in a 12-week program (three sessions per week). Assessments included the Star Excursion Test, Four-Stage Balance Test, and Functional Reach Test. The intervention was divided into three four-week phases, incorporating Animal Flow movements such as Forward and Reverse Travelling Bear, Limb Lift Drills, Ape Reach, and Travelling Crab.

Results: The subject demonstrated significant improvements in limb lift drills and cognitive coordination with alternating limb movements in the Forward and Reverse Travelling Bear exercises. Ape Reach improved spinal mobility and diaphragmatic breathing. Post-tests showed a 20% improvement in balance and stability assessments.

Conclusion: With limited research on QMT for fall prevention in older adults, this study provides preliminary evidence supporting its effectiveness. QMT may enhance dynamic stability and coordination, making it a valuable addition to geriatric fall prevention programs.

Keywords: Quadrupedal Movement Training, Fall Prevention, Geriatric Training

1. INTRODUCTION

Injuries due to fall are one of the major mortalities and morbidity in older adults over the age of 65. About 30 to 40% of patients around this age group are estimated to experience an injury due to fall atleast once. Leading to severe injuries, loss of independence and also death in one third of those patients. Cognitive decline, impaired balance and gait are considered major risk factors for this condition (1). In geriatric patients' neurodegenerative diseases such as dementia, delirium or psychotropic medication are attributed towards higher risk factors for falls (2). Reduced mobility, loss of confidence are some of the consequences of falls in elderly population, contributing to reduction in the quality of life. (2)

In the geriatric population causes of falls have been attributed to environmental related factors or accidents (31%), gait disorders and weakness (17), Dizziness (13%), Confusion (5%), Postural Hypotension (3%), Visual disorders (2%), Syncope (0.3). (2) Physiological changes that occur during ageing can affect the incidence, experience and treatment of pain in older adults. (3) Decreased body fat and muscle mass are also well documented physiological changes during aging process. (4)

Poor quality of life in elderly population leads to an age related condition known as sacrcopenia, leading to muscle loss progressively. Sarcopenia is a progressive and generalised skeletal muscle disorder involving the accelerated loss of muscle mass and function that is associated with increased adverse outcomes including falls, functional decline, frailty, and mortality.(5)

Training the physical and cognitive functions prove to have a greater beneficial effect than focusing on either alone. (6). In recent studies, Training programs such as Multi system Physical Exercise (MPE) has shown Significant differences in the improvement in fall risk, proprioception, muscle strength, reaction time and postural sway, and fear of fall. The MPE program significantly increased muscle strength and improved proprioception, reaction time, and postural sway leading to reduction in fall damage in older adults. (7).

The Test & Exercise (T&E) program is also used as a fall prevention training program using the concept of self efficiency and empowerment, where the patient learns to build their own training program using a mobile application. (8)

Video Monitoring system has also played a significant role in recent intervention for fall damage prevention. (9)

Quadrupedal movement training (QMT) is an emerging style of bodyweight training that is gaining popularity in the fitness industry, benefitting patients of all age groups. This pattern of movement training incorporates mimicking the neurodevelopmental sequence, Animal postures and movements such as crawling, postural transitions and quadrupedal alternating limb lift drills. In recent years several QMT systems exists namely Animal Flow (AF). Animal Flow is a novel form consisting of static and dynamic quadrupedal movements.

QMT study suggests it may improve core stability and proprioception. The evidence of QMT study also suggests it may improve performance of basic movement patterns, muscular endurance, strength, flexibility and dynamic balance. QMT study has specifically showed quadrupedal crawling exercises used in Animal Flow improved cognitive skills and joint reposition sense. This cognitive skill is required to help older adults to prevent falls (10).

As there are not many proven studies of QMT being implemented on older adults to prevent falls, This evidence based study is aimed to provide data on how QMT movement pattern can benefit fall prevention training program for older adults using dynamic stability training and Animal Flow system.

2. METHODS

Approach

The study was performed on a single subject to implement the intervention of QMT with conventional fall prevention methods. The training program was scheduled for 12 weeks with 3 training days per week. With the inclusion of star excrusion test, 4 stage balance test and functional reach test.

All tests were conducted before and after the 12 week intervention program.

Subject:

The subject is a 72 year old female, with no restriction in movement, has been physically active for the last six month prior to the study intervention, has volunteered for this study. All familiarization, testing and QMT session was conducted at the residence of the subject in Bangalore, India.

Table 1: Subject demographic data

AGE	72
HEIGHT	162.5 CMS
MASS	50 KGS
BMI	19.1

The subject was informed of the risks and potential discomforts associated with testing and the intervention before providing their written informed consent.

A familiarization session was conducted for the subject to help understand the procedure better.

3. PROCEDURE

Under the Animal Flow system, the training intervention consisted of, forward travelling bear, reverse travelling bear, Limb lift drills, Ape reach and forward and reverse travelling crab.The subject participated in a total of 36 sessions over 12 weeks with 3 training sessions a week at a training time of 30 to 40 minutes of movement per session, including mobility drills, breath work, and cool down. All QMT sessions were based on the AF system and led by the principle investigator (Animal Flow Level 2 Instructor certified).

During the first 4 weeks, the sessions consisted of wrist mobility excercises, spine mobility drills, limb lift drill, 6 point forward and reverse travelling beast and setting the static crab form. (Table 1)

During the second 4 weeks, the sessions consisted of wrist mobility excercises, spine mobility drills, limb lift drills with knees off the floor (4-point hold), limb movement synchronisation training for forward and reverse training beast and travelling crab. (Table 2)

During the final 4 weeks, , the sessions consisted of wrist mobility excercises, spine mobility drills, limb lift drills with knees off the floor (4 point hold), Forward and reverse training beast, forward and reverse travelling crab, modified version of ape reach (ape reach with patient in kneeling position)

Table 2:

AF CATEGORIES (TRAINING WEEK 1 TO 4)	AF MOVEMENTS	REPS/ TIME	SETS	REST
ACTIVATIONS	LIMB LIFT DRILLS (6 POINT HOLD)	2 SECONDS PER LIMB	2	30 TO 60 SECONDS
FORM SPECIFIC STRETCHES	APE REACH (CHAIR SEATED)	10 REPS	2	30 TO 60 SECONDS
TRAVELLING FORMS	FORWARD TRAVELLING BEAT (6 POINT HOLD)	20 SECONDS	2	30 TO 60 SECONDS

TRAVELLING FORMS	REVERSE TRAVELLING BEAST (6 POINT HOLD)	20 SECONDS	2	30 TO 60 SECONDS
TRAVELLING FORMS	FORWARD TRAVELLING CRAB	20 SECONDS	2	30 TO 60 SECONDS
TRAVELLING FORMS	REVERSE TRAVELLING CRAB	20 SECONDS	2	30 TO 60 SECONDS

AF CATEGORIES (TRAINING WEEK 5 TO 8)	AF MOVEMENTS	REPS/ TIME	SETS	REST
ACTIVATIONS	LIMB LIFT DRILLS (6 POINT HOLD)	3 TO 4 SECONDS PER LIMB	2	30 TO 60 SECONDS
FORM SPECIFIC STRETCHES	APE REACH (CHAIR SEATED)	10 REPS	2	30 TO 60 SECONDS
TRAVELLING FORMS	FORWARD TRAVELLING BEAT (6 POINT HOLD)	25 SECONDS	2	30 TO 60 SECONDS
TRAVELLING FORMS	REVERSE TRAVELLING BEAST (6 POINT HOLD)	25 SECONDS	2	30 TO 60 SECONDS
TRAVELLING FORMS	FORWARD TRAVELLING CRAB	25 SECONDS	2	30 TO 60 SECONDS
TRAVELLING FORMS	REVERSE TRAVELLING CRAB	25 SECONDS	2	30 TO 60 SECONDS

AF CATEGORIES (TRAINING WEEK 9 TO 12)	AF MOVEMENTS	REPS/ TIME	SETS	REST
ACTIVATIONS	LIMB LIFT DRILLS (6 POINT HOLD)	5 SECONDS PER LIMB	2	30 TO 60 SECONDS
FORM SPECIFIC STRETCHES	APE REACH (CHAIR SEATED)	10 REPS	3	30 TO 60 SECONDS
TRAVELLING FORMS	FORWARD TRAVELLING BEAT (4 POINT HOLD)	20 SECONDS	2	30 TO 60 SECONDS
TRAVELLING FORMS	REVERSE TRAVELLING BEAST (4 POINT HOLD)	20 SECONDS	2	30 TO 60 SECONDS
TRAVELLING FORMS	FORWARD TRAVELLING CRAB	25 SECONDS	2	30 TO 60 SECONDS
TRAVELLING FORMS	REVERSE TRAVELLING CRAB	25 SECONDS	2	30 TO 60 SECONDS

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4. RESULTS

FUNCTIONAL REACH TEST:

TRIAL	PRE – TEST	POST- TEST
Trial 1	20 cm	24 cm
Trial 2	22 cm	26.4 cm
Trial 3	19 cm	22.8 cm
Trial 4	21 cm	25.2 cm
Trial 5	23 cm	27.6 cm

- **Pre-Test Average** = (20 + 22 + 19 + 21 + 23) / 5 = **21 cm**
- **Post-Test Average** = (24 + 26.4 + 22.8 + 25.2 + 27.6) / 5 = **25.2 cm**

Overall Increase = 4.2 cm (20% Increase)

STAR EXCURSION TEST:

- The test measures reach distance in **centimeters (cm)** in **three directions per leg**:

1. **Anterior (ANT)**
2. **Posteromedial (PM)**
3. **Posterolateral (PL)**

Pre test and post test RIGHT LEG:

Direction	**Pre-Test (cms)**	**Post-Test (cms)**
Anterior (ANT)	30 cm	34 cm
Posteromedial (PM)	25 cm	30 cm
Posterolateral (PL)	28 cm	33.6 cm

Pre test and post test LEFT LEG:

Direction	**Pre-Test (cm)**	**Post-Test (cm)**
Anterior (ANT)	29 cm	33.8 cm
Posteromedial (PM)	26 cm	30.2 cm
Posterolateral (PL)	27 cm	32.4 cm

- **Right Leg Pre-Test Average** = (30 + 25 + 28) / 3 = **27.67 cm**
- **Right Leg Post-Test Average** = (34 + 30 + 33.6) / 3 = **32.53 cm**
- **Left Leg Pre-Test Average** = (29 + 26 + 27) / 3 = **27.33 cm**
- **Left Leg Post-Test Average** = (33.8 + 30.2 + 32.4) / 3 = **32.13 cm**

Four-Stage Balance Test (FSBT)

Stage	**Pre-Test (sec)**	**Post-Test (sec)**
Stage 1: Feet Together	10 sec	10 sec (max reached)
Stage 2: Semi-Tandem	8 sec	9.6 sec
Stage 3: Tandem	6 sec	7.2 sec
Stage 4: Single-Leg	4 sec	4.8 sec

- ✓ **Pre-Test Total Time = 28 sec**
- ✓ **Post-Test Total Time = 31.6 sec**
- ✓ **Overall Improvement = 3.6 sec (12.8% overall increase)**

5. DISCUSSION

The present study aimed to assess the effectiveness of Quadrupedal Movement Training (QMT) in improving balance in the geriatric population, specifically using a single-subject case study approach. The results demonstrated significant improvements in all balance assessments conducted, including the Functional Reach Test, the Star Excursion Test, and the Four-Stage Balance Test (FSBT). These findings suggest that QMT may serve as an effective intervention for enhancing balance and reducing fall risk in older adults.

Interpretation of Results

An overall improvement of 4.2 cm (20%) was seen in the Functional Reach Test findings, demonstrating improved dynamic stability and forward-reaching capacity. QMT activities, which replicate natural movement patterns and strengthen neuromuscular coordination, may have contributed to this improvement by improving core stability and proprioception. The results of the Star Excursion Test showed that both the left and right legs' reach distances increased in all assessed orientations. The fact that anterior, posterolateral, and posteromedial reach distances all improved indicates that QMT was successful in improving lower extremity strength, proprioception, and coordination. These findings support earlier research showing that dynamic stability training greatly enhances older people' functional mobility and postural control. Improvement was also shown in the results of the Four-Stage Balance Test, where the time held for the Semi-Tandem, Tandem, and Single-Leg stance conditions increased. The overall improvement was 12.8%, with a 3.6-second increase in the total balance time. This increase implies that QMT improved postural stability and static balance, both of which are important for lowering the risk of falls in older persons.

Comparison with Existing Literature

The study's conclusions align with previous research that highlights the advantages of dynamic stability training in preventing falls. The benefits of Multi-System Physical Exercise (MPE) programs in enhancing proprioception, muscle strength, reaction time, and postural control have been demonstrated in earlier research. Likewise, QMT includes activities that test dynamic stability, necessitating both motor and cognitive engagement at the same time, which could account for its capacity to improve balance.

Moreover, studies on Animal Flow and similar QMT-based interventions have reported improvements in core strength, joint mobility, and movement efficiency. The observed improvements in the current study align with these findings, further supporting the potential role of QMT as a functional movement-based intervention for older adults.

Practical Implications

The results of this study suggest that incorporating QMT into fall prevention programs could provide a novel and effective approach to improving balance in older adults. Unlike traditional static balance exercises, QMT emphasizes fluid, coordinated movements that challenge both stability and mobility. Given the increasing popularity of QMT in the fitness industry, its integration into geriatric rehabilitation and fall prevention programs may offer an accessible and engaging alternative to conventional interventions.

Furthermore, There may be advantages beyond physical balance, as evidenced by the increases in cognitive involvement needed for QMT motions. It has been demonstrated that therapies that simultaneously target cognitive and motor abilities are more effective in lowering fall risk, as cognitive loss is a significant risk factor for falls in the elderly. More research is required to examine the potential association between QMT's demands on motor planning, coordination, and proprioceptive awareness and cognitive resilience in older persons.

Limitations and Future Research

Despite the promising results, this study has several limitations. The single-subject case study design limits the generalizability of the findings to a broader population. Future studies should include larger sample sizes with diverse demographics to determine the widespread applicability of QMT in fall prevention programs.

Additionally, this study was conducted over a 12-week period. While significant improvements were observed, long-term follow-up studies are necessary to assess the sustained effects of QMT on balance and fall risk. Future research could also compare QMT with other established fall prevention interventions to evaluate its relative effectiveness.

Finally, while this study focused primarily on balance-related outcomes, future investigations could explore the impact of QMT on other aspects of functional mobility, such as gait patterns, lower limb strength, and reaction time.

6. CONCLUSION

The findings of this study suggest that Quadrupedal Movement Training (QMT) may be an effective intervention for improving balance in older adults. Significant improvements were observed in functional reach, dynamic stability, and static balance following a 12-week QMT intervention. These results highlight the potential of QMT as a valuable addition to fall prevention programs, offering a dynamic, engaging, and functional approach to balance training in the geriatric population. Future studies with larger cohorts and long-term assessments are needed to further validate these findings and establish QMT as a standard practice in geriatric rehabilitation and fall prevention strategies.

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EFFECTIVENESS OF EQUINE-ASSISTED THERAPY IN ENHANCING GROSS MOTOR FUNCTION AND BALANCE IN INDIVIDUALS WITH CEREBRAL PALSY – A LITERATURE REVIEW

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ABSTRACTS

Background: Cerebral palsy (CP) is a non-progressive neurological disorder characterized by central motor dysfunction, impairing movement, posture, and muscle tone. It manifests as abnormal gait, muscle imbalances, and coordination deficits. Classified by limb involvement, CP affects 2-3 per 1,000 live births, with symptom variability and potential functional improvement due to neural maturation.

Aim: This literature review aims to evaluate the current literature on equine-assisted therapy interventions for Cerebral palsy, focusing on studies published between 2015 and 2025. The review seeks to identify the effectiveness of equine-assisted therapy approaches that enhance motor function and improve balance in individuals with CP.

Methods**:** A comprehensive literature search was conducted using databases such as Google Scholar, Research Gate, PubMed, and Medline. Keywords included "Cerebral palsy," "Equina-assisted therapy", "horseback riding," "balance," and "motor functions." Articles published in English and meeting inclusion criteria were considered for review.

Selection Criteria**:** Inclusion criteria encompassed peer-reviewed research articles, systematic reviews, clinical trials, observational studies, and case studies focusing on equine-assisted therapy for CP. Articles had to involve human participants diagnosed with CP across any stage or age group. Exclusion criteria included, non-research articles, non-English publications, and articles published before 2015.

Results**:** 7 of the 46 initially found articles met the inclusion criteria for detailed examination. These studies employed Equine-assisted therapies (EAT) to notably improve gross motor function, balance, and postural control in people with cerebral palsy. Studies show sustained GMFM and GMPM improvements, with increased muscle mass and stability. However, spasticity effects remain discrepant, and quality-of-life benefits require further research.

Conclusion**:** Individuals with cerebral palsy benefit greatly from equine-assisted therapies (EAT) regarding improved balance, postural control, and gross motor function. Although improvements in motor function are well-established and lasting, the effects on spasticity are still erratic and require more research. To improve the clinical use of EAT in rehabilitation, future studies should concentrate on streamlining treatment plans and evaluating long-term functional results.

Keywords: Equine-assisted therapy, Cerebral palsy, motor functioning, balance, horseback riding.

1. INTRODUCTION

Cerebral palsy is a neurological disorder characterized by gross motor function, posture, and muscle tone impairments. It is defined as nonprogressive central motor dysfunction resulting from abnormalities in the developing brain(1). Individuals with cerebral palsy often experience abnormal gait patterns due to irregular muscle tone, impaired muscle control, balance deficits in static and dynamic conditions, coordination difficulties, muscle asymmetry between agonists and antagonists, and compromised equilibrium reflexes(2).

Additionally, muscle contractures and alignment deformities in children with cerebral palsy significantly impact functional abilities, making fundamental daily activities such as maintaining balance and walking increasingly difficult. These musculoskeletal impairments can further contribute to movement limitations and reduce overall mobility. Considering its anatomical distribution, cerebral palsy is classified based on the number of affected limbs, including hemiplegia, which affects one side of the body; diplegia, which primarily affects both legs; triplegia, involving three limbs; and quadriplegia, which affects all four limbs, leading to varying degrees of motor impairment and functional challenges(3,4). Because the nervous system matures with age, CP symptoms can vary from a child with limited brain injury who may have trouble with just one aspect of the musculoskeletal system to a child with a wide range of symptoms who may have activities that interfere with their everyday activities and other potentially fatal comorbidities. These symptoms can improve over time(5). Cerebral palsy (CP) is the most common cause of movement disorders in children, with a prevalence of 2 to 3 per 1,000 live births(6).

The management of people with CP is based on a framework that considers effective intervention programs to be those that promote optimum function throughout the life span (7). Rehabilitation of balance and walking ability is of utmost importance for children diagnosed with cerebral palsy [8,9]. Balance refers to the capacity to sustain an upright position or vertical alignment while being able to perform various activities, including sitting, standing, and walking [10,11].

The inclusion of animals within the therapeutic environment has existed since the end of the seventeenth century(12). Equine-assisted therapy is a multisensory activity in which the rhythmic and three-dimensional sway of horseback riding stimulates the patient's postural reflex mechanism(13) . Equine-assisted treatments are increasingly used to improve motor functions of children with CP(14). Several studies have reported that HRS training improves static and dynamic balance abilities, postural control, and motor functions (15,16). In equine-assisted therapy (EAT), the movement of the horse is utilized to improve the functional and sensory limitations of individuals with movement disorders(17,18). The joint range of motion is increased, and muscles are strengthened during EAT. Additionally, their stability, movement coordination, muscular synergy, weight shift, and balance control are enhanced while the patient's oscillation is decreased due to their efforts to maintain posture when riding a horse. EAT also improves hip and pelvic flexibility, which increases hip and trunk stability (19). In the Equine-Assisted Activities and Therapy (EAAT) program, the therapist directs the horse's movements to facilitate improvements in the rider's posture, balance, coordination, strength, and sensorimotor function. Simultaneously, the rider actively engages with the horse, adapting to its motion and responding to postural and sensory challenges (20).

2. METHODOLOGY

Study design: A comprehensive literature review was conducted from 2015 to 2025 using search engines like Google Scholar, Research Gate, PubMed, Medline, and more.

Search strategy: The keywords used were Cerebral palsy, Equina-assisted therapy, balance, motor functions, and gait abnormalities.

Sample size: A sample size of 46 was obtained after searching in databases using the following keywords: Cerebral palsy, equine-assisted therapy, balance, and motor functions. Based on inclusion and exclusion criteria and year of publication, further articles were scrutinized, and finally, seven appropriate articles were obtained for this systematic review.

Inclusion Criteria:

1. Relevance to Equina-assisted therapy: Articles that specifically focus on Equina-assisted techniques or approaches in the management of cerebral palsy.
2. Study Types: Includes clinical trials, observational studies, and case studies.
3. Publication Dates: Articles published within the last 11 years are included.
4. Participants: Studies involving human participants diagnosed with Cerebral palsy of any stage or age group are included.
5. Exclusively engaging in Equina-assisted therapy.
6. Languages: Articles published in English are included.

Exclusion Criteria:

1. Non-research articles or peer-reviewed articles are excluded.
2. Languages: Articles other than English are excluded.
3. Publication dates: Articles published before 2015 are excluded.
5. Articles without full-text

3. SELECTION OF INCLUSION AND EXCLUSION CRITERIA

Seven articles were chosen by particular inclusion and exclusion criteria. English-language articles were selected for examination to guarantee precision and minimize misinterpretation. To avoid incorrect assumptions and make sure the data evaluated was suitable for this analysis, non-English articles were eliminated. Except for those published before 2015, the chosen articles were released between 2015 and 2025. To guarantee thorough data collection, only full-text articles were included. Since the study's focus was on using equine-assisted therapy to improve motor function and balance in people with cerebral palsy, articles that lacked pertinent information on neurodegenerative disorders and their prevalence were disqualified.

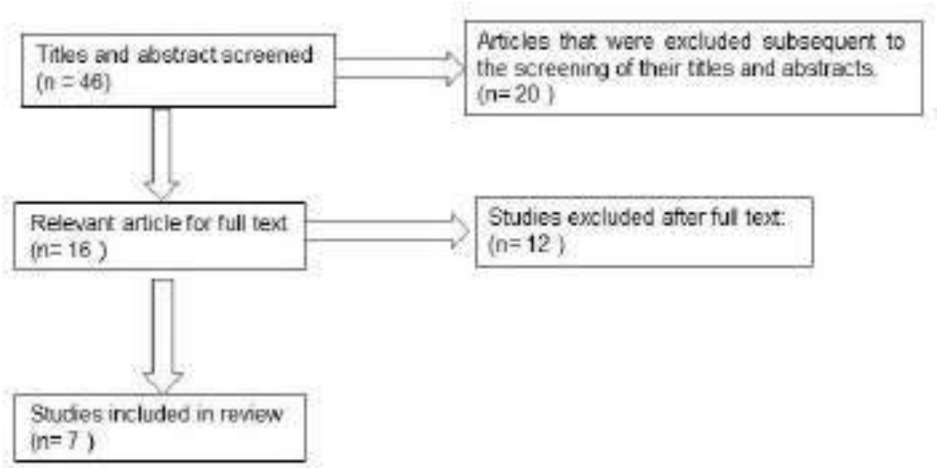

Figure 1. Literature identification, screening, and inclusion process results.

4. RESULT

Out of 46 articles that were initially identified, Table 1 presents the 7 articles that were retrieved based on the specified eligibility criteria outlined. Numerous articles were excluded during the selection process for various reasons, which included the failure to meet the defined requirements, non-compliance with the inclusion and exclusion criteria, and duplication in content. These exclusions were made so that the results were distinguished. We looked at case studies, observational research, and other relevant literature to learn more about how equine-assisted therapy affects people with cerebral palsy. This information provides a theoretical foundation and recommendations for effective equine-assisted therapy in motor function and balance in the case of cerebral palsy.

Table 1. Findings of the seven articles are summarized below

Author, year	Title of study	Type of Study	No. of participants	Outcome measure	Intervention	Conclusion
Lee, S.J. et al.,2024 (20)	Impact of Equine-Assisted Activities and Therapies on Gross Motor Function in Children with Cerebral Palsy	A Prospective Case Series	9	1) Gross Motor Function 2) Balance 3)Surface electromyography 4) Muscle mass and body fat measurements 5. Statistical analyses	Equine-assisted activities and therapies program	EAAT improved GMFM-66 and PBS scores for most children, except Case 9. Balance, stability, and EMG values showed no significant changes. Trunk skeletal muscle increased in Cases 5 and 8, indicating mixed effects.
Stergiou. A.N. et al, 2023 (19)	The efficacy of equine-assisted therapy intervention in gross motor function, performance, and spasticity in children with Cerebral Palsy	A Prospective study	31	1. Gross Motor Function Measure-88 (GMFM-88) 2. Gross Motor Performance Measure (GMPM) 3. MAS (The Modified Ashworth Scale) 4. Gross Motor Function Classification System (GMFCS) 5.Wechsler Intelligence Scale for Children (WISC-III)	Equine-Assisted Therapy (EAT)	Equine-assisted therapy significantly improved gross motor function (GMFM-88) and performance (GMPM) in all subcategories ($p < 0.005$), with effects lasting two months post-intervention. Spasticity showed improvement but was not statistically significant.
Chang. H.J et al.,2021 (7)	Virtual Reality-Incorporated Horse Riding	A Pilot study	16	1. Pediatric Balance Scale (PBS)	Horse-Riding Simulator (HRS) Training with	Children with CP showed improvements in gross motor

	Simulator to Improve Motor Function and Balance in Children with Cerebral Palsy			2. Gross Motor Function Measure (GMFM)-88 3. Gross Motor Function Measure (GMFM)-66	Virtual Reality (VR) Interaction.	function (GMFM-66, GMFM-88 D & E) and balance (PBS) following eight weeks of VR-incorporated HRS training. Since the intervention was successful, safe, and well-received, HRS with VR is a viable method for CP rehabilitation.
Lightsey P et al.,2021 (21)	Physical Therapy Treatments Incorporating Equine Movement: A Pilot Study Exploring Kinetic Interactions between Children with Cerebral Palsy and the Horse	A Pilot Study	4	1. Mobility Assessment -Timed Up and Go (TUG) Test -10-Meter Walk Test (10mWT) 2. Inertial Measurement Unit (IMU) Data	Hippotherapy-Based Physical Therapy	For kids with cerebral palsy, hippocampal therapy enhanced their functional mobility and synchronization of movements. They became more neuromuscularly engaged as they adjusted to the horse's movements. Hippotherapy is a potential method for enhancing gait patterns in people with cerebral palsy because of the rhythmic, reciprocal movement that improves motor learning.
Chinniah. H et al.,2020 (22)	Effects of horse riding simulator on sitting motor function in children with spastic cerebral palsy	A randomized controlled study	31	Gross Motor Function Measure (GMFM)-88	1. Horse-riding simulation (HRS) therapy. 2. Physiotherapy	The study found that both physiotherapy and HRS therapy improved sitting motor function in children with spastic diplegia. However, HRS combined with physiotherapy led to

						significantly greater improvements (p < .01), suggesting its added benefit in rehabilitation.
Alemdaroğlu E et al, 2016 (23)	Horseback riding therapy, in addition to conventional rehabilitation program decreases spasticity in children with cerebral palsy	A Comparative study	16	Functional and Motor Performance Measures	1. Conventional Rehabilitation 2. Horseback riding therapy	This study demonstrates the beneficial effect of horseback riding therapy on hip adductor spasticity when applied in addition to conventional rehabilitation in children with CP.
Antunes.F.N et al,2016 (24)	Different horses' paces during hippotherapy on spatio-temporal parameters of gait in children with bilateral spastic cerebral palsy: A feasibility study	A Comparative study	25	Modified Ashworth Scale (MAS) Gait Analysis – 1. Inertial measurement unit (IMU) 2. spatio-temporal gait parameters	hippotherapy protocols- 1. Walk Protocol 2. Walk-Trot Protocol	In children with bilateral spastic cerebral palsy, the walk-trot hippocampal program markedly decreased hip adductor spasticity and gait metrics. Compared to walking alone, trot intervals improved lower limb control and motor function more successfully.

5. DISCUSSION

This study aims to assess the effectiveness of EAT (equina-assisted therapy) intervention in individuals with Cerebral palsy. The reviewed literature highlights the potential benefits of equine-assisted therapy (EAT) and virtual reality (VR)-integrated horse-riding simulators (HRS) in improving motor function, balance, and overall mobility in individuals with cerebral palsy (CP). Before 2015, there was little study on using equine-assisted therapy (EAT) to help people with cerebral palsy (CP) with their motor control and balance. This was because of several reasons. Standardized treatment methods were not well established, and there was a comparatively low level of awareness regarding EAT as a therapeutic technique. Safety and ethical issues further limited research, and access to therapeutic facilities and qualified specialists was limited. Furthermore, money was mostly allocated to traditional rehabilitation techniques, and there was little multidisciplinary cooperation between horse and medical specialists.

Alemdaroğlu E et al.. (2016), in their study, found that horseback riding therapy, combined with conventional rehabilitation, positively impacts hip adductor spasticity and balance in children with cerebral palsy (CP). The study reported significant spasticity reduction, aligning with previous research on hippotherapy's short-term effects in spinal cord injury patients. However, no significant improvements were noted in multiple sclerosis cases, suggesting diagnosis-specific variability. Balance enhancements were consistent with findings on gait and postural control. The study supports horseback riding therapy as an additional treatment for cerebral palsy, even if the sample size was limited. To confirm the long-term impacts on motor function and spasticity control, larger multi-center studies are required.

Antunes F.N et al. (2016), in their study, examined the effects of walk-only and walk-trot hippotherapy on hip adductor spasticity in children with BS-CP. The walk-trot protocol significantly improved gait parameters, postural control, and stability, likely due to increased sensory input and neuromuscular engagement. These findings support the benefits of rhythmic movement in motor function improvement. The immediate reduction in stiffness suggests hippotherapy as a potential supplement to CP rehabilitation. Additional studies are required to evaluate long-term outcomes and explore integration with other therapeutic approaches.

Chinniah H et al. (2020), in their study, assessed the impact of mechanical horseback riding simulation (HRS) on improving seated motor function in children with spastic diplegia. The intervention included 15-minute HRS sessions, three times weekly for 12 weeks, alongside conventional physiotherapy. The Gross Motor Function Measure-88 (GMFM-88) sitting dimension was the primary outcome measure. As stated in the results, both groups significantly improved, although the experimental group made more progress. Through rhythmic, three-dimensional oscillations, HRS promotes trunk muscle activation, balance, and postural control. These findings show that HRS improves seated motor performance in children with cerebral palsy more effectively than standard therapy alone.

Chang H.J et al. (2021), in their study, examined the impact of VR-incorporated horse riding simulator (HRS) training on motor function and balance in children with CP. Results showed improvements in the Pediatric Balance Scale (PBS) and Gross Motor Function Measure (GMFM) scores, aligning with prior research on HRS and hippotherapy. VR integration enhanced postural challenges and engagement. The study was proven to be safe with no adverse effects, indicating its safety. However, the small sample size and lack of a control group limit reliability, and long-term effects remain uncertain. Future randomized controlled trials with larger samples are needed to validate VR-incorporated HRS as a standardized rehabilitation approach for CP.

This research study by Lightsey P et al.,(2021) indicates that hippotherapy (HPOT) improves functional mobility in children with cerebral palsy (CP) by improving postural control and motor skills. Improved gait efficiency is suggested by shorter completion times for the 10-Meter Walk Test (10mWT) and Timed Up and Go (TUG). The impact of HPOT in motor learning is highlighted by improved horse-rider synchronization. The multimodal input provided by equine movement improves balance, postural control, and reflexes for righting. According to research, regular weight shifts enhance gait speed and balance, which is consistent with the benefits that have been seen. However, generalizability is limited by participant heterogeneity and a small sample size. To better understand the biomechanical and neuromuscular consequences of HPOT, future research should improve sensor techniques and investigate other movement metrics.

Stergiou A.N. et al. (2023) found in their study that Equine-Assisted Therapy (EAT) significantly improved gross motor function in children with CP, as indicated by increased GMFM scores. Improvements were observed across all CP subgroups, regardless of severity. While spasticity reduction was noted, it was not statistically significant, aligning with previous short-term studies. EAT particularly benefited children with mild to moderate motor deficits (GMFCS II-III). Its clinical relevance is shown by the sustained improvements observed eight weeks after the intervention. Extended EAT participation may result in long-term gains, even though acute spasticity effects would only last a short while. To improve therapies and evaluate long-term results, more study is required.

Lee, S.J. et al. (2024) examined the long-term effects of short-term equine-assisted activities and therapies (EAAT) on motor function in children with CP. EAAT improved gross motor function and balance, reflected in higher GMFM-66 and PBS scores. Horseback riding's rhythmic movement likely enhances core strength, posture, and stability. However, a small sample size, methodological limitations, and lack of a control group weaken the conclusions. The necessity for standardized techniques was highlighted by the lack of substantial changes in balance measurements utilizing BioRescue and electromyography. In order to evaluate the effectiveness, future studies should employ wearable technology, bigger sample sizes, and randomized trials. Its therapeutic promise in CP rehabilitation is supported by studies, notwithstanding its limitations.

6. CONCLUSION

Equine-assisted therapy (EAT), hippotherapy (HPOT), and Horseback Riding Simulators (HRS) demonstrate promising benefits in improving motor function, balance, and postural control in individuals with cerebral palsy (CP). Studies show reductions in hip adductor spasticity, improved gait parameters, and enhanced gross motor function, particularly when integrated with conventional rehabilitation. The rhythmic and multidimensional motion of horseback riding stimulates neuromuscular activation, aiding in functional mobility. Additionally, VR-integrated HRS enhances postural stability and engagement. However, the necessity for more extensive, carefully monitored studies is highlighted by methodological flaws, small sample sizes, and contradictory results on spasticity reduction. To establish EAT and associated therapies as standardized CP rehabilitation techniques, future research should improve intervention protocols, integrate sophisticated biomechanical analysis, and investigate long-term effects.

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THE ROLE OF PHYSIOTHERAPY IN MANAGING POST-TRAUMATIC STRESS DISORDER -A LITERATURE REVIEW

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ABSTRACT:

***Background**:* Post-traumatic stress disorder (PTSD) occurs when psychological symptoms arise after experiencing any events like accidents, trauma, disasters. It can lead to depression, anxiety disorders, physical health issues, intrusive memories. These symptoms can impact on individual life, health and work.

Aim: This systemic review aims to evaluate current literature on physiotherapy interventions for post-traumatic stress disorder (PTSD), concentrating on studies from 2015 to 2024.This review seeks to identify the effective physiotherapy approaches that enhance the individual overall quality of life, managing sleep, depression and anxiety.

Methods: A Comprehensive literature review was conducted using databases such as google scholar, PubMed, Pedro and Medline. Keywords included "PTSD"," Trauma", "Physiotherapy management", "Mental health". Articles published in English and meeting inclusion criteria were considered for review.

Selection criteria: Inclusion criteria encompassed peer-reviewed research, systematic reviews, clinical trials, observational studies, and case studies on physiotherapy for PTSD. Exclusion criteria included non-research articles, non-English publications, and articles published before 2014.

Results: Out Of 50 articles, 5 met the criteria, showing that physiotherapy techniques improved anxiety, depression, sleep disorders, and quality of life in individuals with PTSD.

Conclusion: The systemic review found that exercises reduce PTSD symptoms, with greater amounts of exercise providing more benefits. Future studies should use larger sample sizes and standardized outcome measures to enhance reliability and consistency.

Keywords: PTSD, trauma, mental health, anxiety, physiotherapy management.

1. INTRODUCTION

Post traumatic stress disorder (PTSD) is a severe mental health condition that can greatly affect an individual's overall well-being and daily functioning (1,2). PTSD is often linked to co-occurring conditions such as depression and substance use disorders, along with a notably higher risk of suicide (1). Depression and posttraumatic stress disorder (PTSD) often occur together, with the presence of one elevating the likelihood of the other. Both conditions are also linked to a higher risk of suicide attempts. (3). This disorder is closely linked to experiencing a traumatic event, such as actual or threatened harm, death, or sexual assault (4). PTSD is influenced by factors that are known to affect the progression of schizophrenia and other forms of severe mental illness (5). The DSM-IV defines PTSD by three main symptom categories: reliving the traumatic event, increased arousal, and avoiding stimuli related to the trauma. These symptoms must continue for a minimum of one month after the traumatic experience (5). Sleep disturbances are common in post-traumatic stress disorder (PTSD), affecting 70–90% of individuals with the condition. These issues often include nightmares and trouble sleeping (6). PTSD elevates symptoms like depression, dissociation, somatization, affect dysregulation, and altered self-perception, including shame and guilt (7). Epidemiological studies have revealed that traumatic stress is commonly experienced by war survivors, refugees, particularly women, public health workers, and indigenous group (4). The prevalence of PTSD and depression is high among the war survivors (4). Earlier research on PTSD highlighted its high prevalence in high-income countries, with sociodemographic factors like gender and significant comorbidities (8). PTSD affects 30% of Vietnam War veterans and 10% of Gulf War veterans. Among current troops in Iraq and Afghanistan, estimates suggest a rate of 17%. Recent data shows 16.7% of active soldiers and 24.5% of reservists have PTSD (9). Recent estimates suggest that 3.9% of the global population suffers from post-traumatic stress disorder (PTSD). Without effective treatment, PTSD tends to become chronic and is linked to various psychiatric and medical conditions (10). The literature indicates that PTSD prevalence among women ranges from 0% to 7% at any given time after childbirth (11). Determining PTSD incidence rates has been challenging due to factors like career concerns and stigma around seeking help (Sharp et al.,2015). Otto et al. (2010) reported incidence rates of 3.40 to 14.30 per 1,000 active-duty service members. (12). In a study by Smith et al. (2008) using the PTSD Checklist, incidence rates were assessed in 11,952 service members with deployment experiences and 38,176 without (12). The 17-item PTSD Checklist (PCL) is the most commonly used self-report tool for PTSD symptoms (Elhai et al., 2005; Weathers et al., 1993). It is widely used for clinical screening and symptom monitoring, as well as in research to diagnose PTSD (e.g., Dobie et al., 2004; Hoge et al., 2008). Creating diagnostic criteria is an ongoing process that starts with listing clinical observations and revising them as additional empirical evidence becomes available (13). Traditional methods for validating these criteria involve demonstrating factors such as etiology, pathogenesis, the course of the illness, and familial patterns (13). Both psychotherapies and pharmacotherapies are effective treatments for PTSD (4). Research supports trauma-focused therapies like PE, EMDR, and CPT, which reduce PTSD symptoms after 12–16 weekly sessions (14). Although Augmented Reality Exposure Therapy (ARET) and Virtual Reality Exposure Therapy (VRET) have been around for over ten years, they are not considered the primary treatment option for PTSD (15). Trauma-focused psychotherapy is the primary-treatment for most individuals with PTSD, rather than other therapies or medication. Cognitive Behavioural Therapy (CBT), Prolonged Exposure Therapy (PET), and Eye Movement Desensitization and Reprocessing (EMDR) are trauma-focused approaches that have proven effective in treating PTSD (4). Engaging in aerobic exercise and physical activity has been shown to alleviate primary symptoms of post-traumatic stress disorder (PTSD) and improve related health issues (16). Trauma-Focused Cognitive Behavioural Therapy (TF-CBT) and Eye Movement Desensitization and Reprocessing (EMDR) are primary treatments for paediatric PTSD (17). Pharmacological treatments for post-traumatic stress disorder (PTSD) include SSRIs and SNRIs, with sertraline and paroxetine being FDA-approved (18). A recent review found that only a few low to moderate-quality studies support the use of mobilization, functional activities, deep breathing, and coughing in physiotherapy for blunt trunk trauma (19).

2. METHODOLOGY

***Study design**:*

A comprehensive literature search was conducted using databases such as Google Scholar, PubMed, and Medline, covering publications from 2015 to 2024.

Search strategy:

The keywords used were PTSD, Physiotherapy management, trauma, mental health, psychology impairment.

Sample size: A sample size of 50 was determined by searching databases using the keywords 'Physiotherapy management,' 'mental health,' and 'psychological impairment, trauma. Based on inclusion and exclusion criteria and considering publication years, six suitable articles were selected for this systematic review.

3. INCLUSION CRITERIA

Relevance to Physiotherapy: Articles focusing specifically on physiotherapy interventions, techniques, or approaches in managing post-traumatic stress disorder (PTSD).

Study Types: The systematic review incorporated peer-reviewed research articles, systematic reviews, clinical trials, observational studies, and case studies.

Publication Dates: Articles published within the past 10 years were included.

Participants: Studies involving human participants diagnosed with post-traumatic stress disorder (PTSD) across all age groups and at any stage—early, mid, or late—were included.

Languages: Only articles published in English were included.

Exclusion criteria:

i. Non-research or non-peer-reviewed articles were excluded.
ii. Only articles published in English were considered.
iii. Articles published before 2014 were excluded.
iv. Involved participants with conditions other than PTSD

4. RESULT

Out of the initial 50 articles reviewed, five were chosen according to the clearly defined selection criteria presented earlier, as detailed in the table. A large number of articles were excluded because they did not meet the established inclusion and exclusion criteria, failed to comply with the required standards, or were duplicates.

Author, year	Title of the study	Type of the study	No.of participants	Intervention/management
Banerjee et al./2022(20)	Physiotherapy and behavioral techniques in management of post traumatic stress disorder in health-care workers amid COVID pandemic	Experimental study	2800	Pursed lip breathing, stretching and yoga, progressive muscle relaxation ,mobilization, manipulation, and massage cardiovascular endurance training, aerobic exercises
Conny Blaauwendraat PT, 2017(21)	One-year follow-up of basic body awareness therapy in patients with post traumatic stress disorder. A small intervention study of effects on movement quality, PTSD symptoms, and movement experiences	Comparative study	18	Postural balance and grounding, breathing exercises, Coordinated movements: Performed in lying, sitting, standing, and walking positions, Massage techniques, home exercises

Justine guitonneau et al./2017(22)	Is physiotherapy useful for post traumatic stress disorder in military personnel?	Case study	3	Exertion on a bicycle ergometer, controlled diaphragmatic breathing exercises, tension relieving exercises in head, shoulder, massage to neck, upper and lower back regions
Michel Probst,2017(23)	Physiotherapy and mental health	Chapter 9		Yoga, pilate method, mesendieck system, feldenkraise system
Brendon Stubbs 2014(24)	Understanding the role of physiotherapists in schizophrenia: an international perspective from members of the International Organisation of Physical Therapists in Mental Health (IOPTMP)	Survey method	151	Physical Activity Promotion, Structured Exercise Programs, Mind-Body Approach, Bridging Physical & Mental Health, Treatment of Musculoskeletal Conditions,

5. DISCUSSION

Recent studies have suggested that physiotherapy can be an effective treatment for managing PTSD symptoms, including anxiety, sleep disturbances, and hyperarousal. Various forms of exercise, such as cardiovascular training, yoga, and mindfulness practices, have shown promising results in alleviating these symptoms. Despite this progress, there remains a significant gap in research. The research on physiotherapy as a management strategy for PTSD is relatively new, with most studies emerging only in recent years. Prior to this, there was limited exploration into the role of physiotherapy in treating PTSD, as the focus was primarily on traditional psychological therapies and pharmacological treatments. This relatively recent shift towards investigating the effectiveness of physiotherapy highlights a significant gap in the body of evidence, as earlier research did not prioritize physical treatments for mental health conditions like PTSD. As a result, the current body of research is still in its early stages, and more comprehensive studies are needed to establish long-term efficacy and refine the best physiotherapeutic interventions for PTSD

Banerjee et al. examined 2,800 healthcare workers (HCWs) during India's initial COVID-19 lockdown, revealing secondary traumatic stress (STS) in 88.2% of doctors, 79.2% of nurses, and 58.6% of allied healthcare professionals, including physiotherapists, lab technicians, phlebotomists, dieticians, administrative staff, and pharmacists.

Assessment Tools Used:

Perceived Stress Scale (PSS): A 10-item questionnaire assessing stress levels over the past month, with scores ranging from 0 to 40; higher scores indicate greater stress.

Insomnia Severity Index (ISI): A 7-item scale evaluating insomnia severity over the previous two weeks, with scores from 0 to 28, categorized as no insomnia (0–7), sub-threshold insomnia (8–14), moderate insomnia (15–21), and severe insomnia (22–28).

Compassion Fatigue-Short Scale: Comprises a 5-item secondary scale and an 8-item job burnout scale, rated on a 10-point Likert scale from 1 to 10. The author employed various physical activities and physiotherapy techniques to enhance mindfulness and emotional well-being. These included pursed-lip breathing, stretching, yoga, and progressive muscle relaxation, which involves tensing and relaxing muscle groups to promote relaxation. Incorporating mobilization, manipulation, cardiovascular endurance training, aerobic exercises, and brisk walking further contributed to physical and mental health [20].

The study conducted on 3 military members diagnosed with PTSD the following techniques are used as treatment methods exertion on a bicycle ergometer, followed by controlled diaphragmatic breathing exercises, tension relieving exercises in the head and shoulder region and massages to the neck, upper and lower back regions. the evaluations were conducted both before and at the end of the 4-week rehabilitation, and the result concluded that the breathing exercises enabled them to achieve reduced panic attacks and nightmares. Additionally, massages and tension-relief exercises promoted a more relaxed physical state and heightened awareness of their muscle tension.[22].
Mental health issues and disorders are distinct. Issues are negative mental experiences that disrupt emotional or social functioning but are less severe than disorders. Disorders involve significant disruptions in cognition, emotions, or behaviour due to underlying psychological, biological, or developmental factors. Around one in four people will experience a mental health disorder in their life. Conditions like depression, anxiety, and PTSD can be triggered by personal stressors such as loss or relationship problems. Substance abuse or chronic illness may also lead to depression. Mental health disorders are the fourth leading cause of disability worldwide. These issues often stem from thoughts or beliefs about a problem, which drive emotions and behaviours, leading to consequences.

Yoga, a mind-body therapy, combines physical poses, meditation, and breathing exercises to aid fibromyalgia patients with exercise and coping skills. The Pilates method, developed by J.H. Pilates, is a low-impact program that blends stretching, strengthening, and physiotherapy, focusing on body awareness, relaxation, and strength. In some countries, the Mensendieck system and Feldenkrais method are used in physiotherapy for mental health, teaching body awareness and movement correction to reduce pain and improve well-being. Psychomotor physiotherapy for severe mental health issues uses physical activities and body awareness to enhance motor, cognitive, and emotional skills, addressing conditions like depression, anxiety, schizophrenia, autism, and eating disorders. The approach focuses on the somatic and psychological effects of activity, promoting self-image and well-being. It can be applied in group settings or alongside psychotherapy, addressing both healthy and dysfunctional aspects. The therapist adapts the approach based on the patient’s needs—health, psychosocial, or psychotherapeutic. Group activities help patients move beyond their comfort zones, fostering self-awareness and new experiences. Specific methods exist for conditions like eating disorders, schizophrenia, mood disorders, depression, and anxiety. The psychosomatic physiotherapy approach differs from the somatic approach by addressing how psychological factors influence physical health. Illness is viewed as a message from the unconscious mind, signaling a need for change or acting as a defence mechanism. Psychosomatic physiotherapy treats symptoms like pain and fatigue linked to psychosocial issues, exploring the impact of psychological and social factors on physical well-being. The therapeutic relationship is crucial for integrating thoughts, emotions, and actions. As mental health care becomes more interdisciplinary, therapists need to obtain informed consent and explain the treatment's goals and outcomes. These approaches are cost-effective, practical, and should be further integrated into physiotherapy education.(23)

Recent studies suggest that physiotherapy could be a key factor in managing PTSD. instance, research found that various forms of exercise significantly alleviated PTSD symptoms, such as anxiety, hyperarousal, and sleep disturbances, in veterans who completed a 12-week exercise program. Notably, cardiovascular exercise was found to activate the pituitary gland, triggering the release of endorphins, which are essential for stress relief and relaxation, while also improving sleep quality, a common challenge for those with PTSD. Additionally, practices such as yoga, Tai Chi, and mindfulness-based stress reduction have been shown to effectively address PTSD. These techniques help lower stress levels, enhance emotional regulation, and encourage relaxation. Kearney et al. (2019) found that veterans who engaged in yoga reported reduced anxiety and hyperarousal, along with better emotional balance and overall well-being. The research also highlights that different exercise routines led to varying degrees of symptom improvement within specific time periods: Aerobic exercises resulted in a 45% reduction in symptoms over 12 weeks. Strength training exercises produced a 30% decrease in symptoms after 8 weeks. A combination of both aerobic and strength training exercises achieved a 50% reduction in symptoms over 10 weeks. (25)

The Role of Physiotherapy in Enhancing Mental Health

Exercise has increasingly been recognised for its positive impact on mental health, with research over the past three decades highlighting significant improvements in individuals with various mental health conditions, such as depression, insomnia, anxiety, PTSD, schizophrenia, mood disorders, self-esteem, and overall quality of life. Studies conducted worldwide have found that patients receiving physiotherapy interventions report notable benefits. According to a study by Himanshu Sharma and colleagues, the physiotherapeutic approaches used in treating mental health disorders include:

Deep breathing exercises, Stretching and flexibility exercises, Relaxation techniques, Endurance training, Hydrotherapy, Ergonomic, Cycle ergometry, Muscle strengthening exercises General mobility exercises, multi-sensory stimulation, Balance and equilibrium training, Posture and motion re-education, Gait re-education and advanced approaches includes CBT, BBAT, relaxation therapies like yoga, tai chi, mindful based stress reduction programme. The study concluded that Physiotherapists helps bridging the gap between physical &mental health also has a broad range of positive effects on patients' overall health and well-being [26].

6. LIMITATIONS

A total of 50 articles were screened from available databases, of which only five met the inclusion criteria, highlighting the limited research on physiotherapy management for PTSD. Some studies had small sample sizes, potentially affecting the reliability of their findings. Additionally, only articles published in English were included in this review.

7. CONCLUSION

Post-traumatic stress disorder (PTSD) is a mental health condition that significantly impacts an individual's quality of life, often arising from traumatic events such as accidents, disasters, or combat. Common symptoms include sleeplessness, anxiety, depression, and appetite dysregulation. Integrating physiotherapeutic interventions—such as physical exercises, cognitive behavioral therapy (CBT), yoga, mobilization, aerobic exercises, strength training, and endurance training—has been associated with symptom reduction and improved overall well-being in PTSD patients.

Physical activities, including aerobic and strength training exercises, can distract from distressing emotions, enhance self-esteem, and restore a sense of control. Yoga, particularly trauma-sensitive forms, emphasizes body awareness and mindfulness, helping individuals reconnect with their physical sensations and manage stress responses. Additionally, Basic Body Awareness Therapy (B-BAT) combines movement and body awareness to address psychological and physical aspects of trauma, promoting relaxation and emotional regulation. However, it's important to note that research on these physiotherapeutic interventions for PTSD is still emerging. While preliminary findings are promising, further studies are necessary to establish their efficacy and develop standardized treatment protocols. Continued research will enhance our understanding of how these interventions can be optimally integrated into PTSD care.

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CONFLICT OF INTEREST: None

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PHYSIOTHERAPY INTERVENTIONS IN POSTURAL ORTHOSTATIC TACHYCARDIA SYNDROME – A LITERATURE REVIEW

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ABSTRACT

Background: Postural orthostatic tachycardia syndrome (POTS) is a condition that causes a number of symptoms when you transition from lying down to standing up. It is characterized by symptoms of orthostatic tachycardia including tachycardia, palpitations, syncope or presyncope, lightheadedness, cognitive dysfunction, nausea, exercise or heat intolerances, and fatigue.

***Aim*:** This systematic review aims to evaluate current literature on physiotherapy interventions for Postural orthostatic tachycardia syndrome (POTS) focusing on studies published between 2010 and 2025. The review seeks to identify effective physiotherapy approaches that enhances cardiovascular functions, helps in daily life activities and improves the quality of life.

***Methods*:** A comprehensive literature search was conducted using databases such as Google Scholar, Research gate, PubMed, and Medline. Keywords included "POTS," "physiotherapy management", "physical intervention," "orthostatic syndrome," and "lifestyle intervention" Articles published in English and meeting inclusion criteria were considered for review.

***Selection criteria*:** Studies on POTS patients (all stages) using physiotherapy, multimodal approaches, or combined with medication, assessed with validated tools, including cohort studies, case reports, and systematic reviews, published in English since 2010 was included.

***Results*:** Out of 44 initially identified articles, 6 met the inclusion criteria for detailed analysis. These studies employed various physiotherapy techniques such as aquatic therapy, aerobic exercises, cardiovascular training and multidisciplinary rehabilitation. The reviewed literature highlightens the improvements in the overall quality of life.

***Conclusion*:** The interventions included that aquatic therapy and reconditioning programs may be effective treatment options for patients with postural orthostatic tachycardia syndrome (POTS). It highlights that exercise progression tailored to patient tolerance, under physician supervision can improve outcomes. The training program helped normalize heart rate and improved quality of life for patients. Additionally, the study identified that fatigue in POTS patients is a complex, multidimensional issue.

Keywords: POTS, orthostatic tachycardia syndrome, physiotherapy intervention, physiotherapy management, rehabilitation.

1. INTRODUCTION

Postural orthostatic tachycardia syndrome (POTS) is an excessive increase in heart rate in the upright position associated with symptoms of orthostatic intolerance. [1,2]. Each individual diagnosed with POTS has a unique experience and presents with varying symptoms [2]. The idiopathic forms of POTS are widely recognized as partial dysautonomia (neuropathic) and hyperadrenergic [3]. Partial dysautonomia is the most common type of POTS [4]. In this type of POTS sympathetic denervation occurs in the lower limb which leads to tachycardia [5]. It also arises from insufficient peripheral and splanchnic vasoconstriction under orthostatic stress [3]. Patients with Hyperadrenergic POTS sometimes exhibit elevated BP and more than 50 % may also suffer from migraine headaches. Hyperadrenergic POTS is less common and has a more insidious course than the neuropathic type [4]. Autonomic disorder like postural orthostatic tachycardia syndrome (POTS), is characterized by postural tachycardia, orthostatic intolerance [6], dizziness, fatigue, and headache, along with several other symptoms [7,8]. Typically, experienced symptoms in patient with POTS are light- headedness, palpitations, tremors, blurry vision, exercise intolerance, and breathlessness after assuming an upright position [1,9,10]. These symptoms are relieved on lying down. These patients also have a heart rate. 120 beats/min (bpm) on standing or increase their heart rate by 30 bpm from a resting heart rate after standing for 10 min [11,12,13]. POTS can be triggered by surgery, pregnancy, menarche, vaccination, or concussion. [7,14] these patients can also exhibit a lower peak oxygen uptake (VO2peak) compared to healthy sedentary individuals, indicating reduced physical fitness levels [3] with breathlessness being a common symptom in patients with POTS [15].

Other potential triggers include hereditary factors, underlying conditions such as diabetes, amyloidosis, sarcoidosis, cancer, or after a viral illness, traumatic event, or may be associated with autoimmune disorders such as lupus, Sjogren syndrome, and celiac disease. Additionally, alcohol or metal poisoning, and chronic fatigue syndrome may lead to POTS [3] Furthermore, patients have reported having other comorbid conditions like depression, migraine, irritable bowel syndrome, or chronic fatigue syndrome which can cause episodic tachycardia symptoms in the absence of POTS. [10] Although the prevalence of POTS in adolescents is not known, it has been estimated that up to 500,000 patients between the ages of 15 and 50 in the United States have POTS [16,17,18]

It has been estimated that a quarter of the adult patients diagnosed with POTS are unable to work and are disabled and bedridden [16,19]. Similar impairments in functioning have been observed in adolescents. [16] POTS can be highly debilitating with affected individuals reporting poorer quality of life, increased time off work and school and difficulty participating in social and recreational events and activities of daily living [1] POTS is more common in women than in men (5:1) [20], especially those women of child bearing age (15–50years) [15,21,22]

The diagnostic criteria for POTS are, an increase in heart rate of at least 30 beats per minute within 10 min of standing or during a tilt table test, absence of orthostatic hypotension and symptoms of orthostatic intolerance present for at least six months [7] The preferred method for diagnosing POTS, is with a head-up tilt table test (HUT) where the patient is laying on a table and the head end is gradually lifted to a near upright position, while monitoring heart rate and blood pressure [21] Increasing evidence supports the recommendation that exercise training should be included as an important part of a treatment plan for POTS.[3]

Exercise and other non-pharmacological treatments are uniformly implemented in the management of POTS because they have minimal side effects, are cost-effective, and are readily available for patients. [7] A progressive aerobic exercise routine starting with recumbent aerobic exercises and leg resistance training, and eventually transitioning to upright exercises was shown to improve quality of life and reduce orthostatic syndrome in many patients. [3] The positive effects of intense cardiovascular exercise were also seen in patients with POTS and the results were remarkable for the improvement of autonomic, cardiovascular parameters and the quality of life [1] Current literature supports the use of cardiovascular exercise as a cornerstone of nonpharmacologic intervention [6] This study is done to provide a review on the various physiotherapy intervention done for the treatment of POTS.

2. METHODOLOGY

Study design*:* This study is a literature review designed to understand the physiotherapy interventions in existing research on Postural Orthostatic Tachycardia Syndrome (POTS). The literature search was performed using electronic databases including google scholar, research gate, PubMed, Medline and more. The literature review was conducted from the time period of 2010-2024.

Search strategy: The search was conducted using a combination of terminologies related to the topic which includes Postural orthostatic tachycardia syndrome, (POTS), physiotherapy intervention, physical therapy management, exercise program, autonomic dysfunction, orthostatic intolerance.

Sample size: Sample size of 44 articles were obtained after searching from databases using the following keywords: Postural Orthostatic Tachycardia Syndrome, (POTS), physiotherapy intervention, physical therapy management, exercise program, autonomic dysfunction, orthostatic intolerance. Based on inclusion and exclusion criteria and year of publication, further articles were scrutinized and finally, 6 articles were obtained for the review.

Inclusion criteria:

1. Studies published full texts.
2. Research articles that mainly focused on the physiotherapy intervention for POTS.
3. Experimental studies, cohort studies, case studies and case reports were taken into consideration.
4. Articles that were published after 2010 and were written in English literature.

Exclusion criteria:

1. Research articles that did not contain sufficient information on the physiotherapy intervention for POTS were excluded.
2. Studies that contain only abstract.
3. Studies that were conducted on animals were excluded.
4. Articles that were published before 2010 and without full text were excluded.

3. SELECTION OF INCLUSION AND EXCLUSION CRITERIA

Six articles were selected on the basis of the inclusion and exclusion criteria. Articles were chosen in English for analysis to ensure accuracy and reduce errors in interpretation. Non-English articles were excluded to prevent potential misunderstandings and ensure that the data analysed is appropriate for the review. The selected articles were published between 2010-2024, excluding those published before 2010. Only articles with full texts were included to ensure comprehensive information gathering.

Articles without any relevant data on postural orthostatic tachycardia syndrome, and their prevalence were excluded. As they did not align with the study's focus on physiotherapy management of postural orthostatic tachycardia syndrome.

4. RESULTS

Out of a total of 44 articles initially identified, the table below presents the 6 articles that were chosen based on the specified eligibility criteria outlined earlier. Numerous articles were excluded during the selection process for various reasons, including failure to meet the defined requirements, non-compliance with the inclusion and exclusion criteria, and duplication in the content. These exclusions were necessary to ensure that only relevant and unique studies were included for thorough analysis. We reviewed all relevant articles, case reports and experimental studies to gain insights into the nature of the impairments associated with Postural Orthostatic Tachycardia Syndrome. This information provides a theoretical foundation and recommendation for effective physiotherapy interventions.

5. DISCUSSION

The aim of the study is to evaluate current literature on physiotherapy interventions for Postural orthostatic tachycardia syndrome (POTS) focusing on studies published between 2010 and 2024.This review seeks to identify effective physiotherapy approaches that enhances cardiovascular functions, helps in daily life activities and improves quality of life. There have been studies done on POTS in the past, suggesting different treatment approaches with respect to physiotherapy. In this article few are reviewed based on the inclusion and exclusion of the study, out of 44 initially identified articles, 6 articles met the selection criteria.

This article summarizes the studies done on POTS, the interventions used, the results obtained and conclusions generated from each study. Falk T (2023) did an evidence-based treatment approach for physical therapy management of POTS. The intervention consisted of an endurance program and progressive strength program. The strength and endurance programs were made to target the patient's impairments found on evaluation and build tolerance to being in the upright position for longer periods of time. The 10-minute stand test consists of taking heart rate and blood pressure while the patient is in supine and then when the patient stands up every minute for 10 minutes. The patient showed improvements in subjective reporting of functional mobility and objectively through strength training progressions and tolerance to more upright positions. Therefore, it is important to remember that a physical therapist is an essential member of the healthcare team for patients with POTS. [22]

Koc TA et al & 2020 used a different approach that consisted of a multimodal training method. The training program was for 12 weeks which consisted of 30 physical therapy sessions for 60 mins each. The multimodal training program focused on the patient's aerobic activities, functionality and strength training. The training program initially utilized patient-control breaks which further progressed to therapist-controlled rest intervals. At the end of the treatment, the patient improved exercise tolerance and improved quality of life using 36-item Short Form Health Survey. [23]

According to C Tito.et.al (2017) the use of interval training in aquatic environment would reduce the symptoms of POTS as aquatic therapy provides benefits for individuals with cardiovascular issues, mainly through the principle of hydrostatic pressure. Hydrostatic pressure aids in shunting the blood from the extremities back to the heart, increasing cardiac output while reducing the individual's heart rate. As physical therapy progressed, there was an increase in activity tolerance of the patient. Thus, it concluded that the positive effects of hydrostatic pressure on cardiovascular system contributes to the improvement in exercise tolerance and to overall conditioning and activity tolerance.[24]

According to Richardson MV.et.al (2017), the purpose of this study was to discuss the physiotherapy management in patient with POTS using exercise. A 34-year-old patient with the following symptoms dyspnea with mild exertion, light-headedness, fatigue, leg "heaviness," and the inability to perform normal work duties. It was also found that POTS shares clinical features with orthostatic hypotension, however the inclusion criteria and clinical features for POTS are not well known. The intervention included a 4-week physical therapy endurance and strengthening 'reconditioning' program. The result of the case report suggests that reconditioning programs can be included in the treatment of POTS.[25]

According George SA.et.al. (2015) the objective of their study was to evaluate the efficacy of exercise training and lifestyle intervention in POTS patient in a community environment. A 3-month program involving mild to moderate intensity training program along with strength training was implemented. A 10-min stand test was performed at the physician's office and patient quality of life was assessed using the 36-item Short Form Health Survey. These results suggest that this training program can be implemented in the community setting with physicians' supervision and is effective in the treatment of POTS. [26]

According to Fu Q. et.al (2010) the purpose of the study was to test the hypothesis that a small heart coupled with reduced blood volume contributes to the postural orthostatic tachycardia syndrome (POTS) and this can be improved via exercise training. An experimental study was conducted with 19 patients using a 3 month specially designed exercise training program. Initially the patients trained 2 to 4 times per week for 30 to 45 mins. By end of the training, patients were exercising for 5 to 6 hours per week and they were encouraged to walk on the treadmill and to jog. The final results were that the function of the ANS was intact in cardiac patients and the exercise training increased the cardiac size and mass, expanded blood volume and improved or even cured POTS. [27]

As this study has reviewed different types of researches, it depicts a variety in treatment approaches which will vary based on the need of the hour, patient condition and patient prognosis. However, as per results analysed aquatic therapy and reconditioning programs have seen better prognosis in patients with POTS.

6. LIMITATIONS

A total of 44 articles from the available databases were reviewed. Out of these, only 6 articles met the criteria for inclusion, indicating a limited number of studies on the physiotherapy management of postural orthostatic tachycardia syndrome. Some articles had lesser sample sizes. It is important to note that only articles written in English were considered for this review. Articles with cohort study designs were not available for inclusion.

7. CONCLUSION

This study concludes that the articles that used interventions like aquatic therapy and reconditioning programs proved to be effective treatment options for patients with postural orthostatic tachycardia syndrome (POTS). It highlights that exercise progression tailored as per patient tolerance, under a physician's supervision can improve outcomes. The training program helps to normalize heart rate and improve quality of life for patients. Additionally, the study identifies fatigue in POTS patients is a complex, multidimensional issue.

The studies we reviewed used different methods and measures to assess physiotherapy's effectiveness. Some focused-on reconditioning programs that involved strength and endurance training while others explored areas such as aquatic therapy.

However, the studies had limitations. Some had small number of participants and none used cohort study designs which would have provided strong evidence. Also, most of the studies were in English, potentially excluding valuable insights from non-English publications.

Despite these limitations, the research suggests that physiotherapy can help manage POTS symptoms, improve quality of life, and delay disease progression. Future studies should include more participants over longer periods and use consistent measures to better compare results and strengthen conclusions. This would help develop clear guidelines for using physiotherapy at different stages of postural orthostatic tachycardia syndrome.

In conclusion, while current research on physiotherapy for POTS shows promise, more studies are needed to improve treatment and outcomes for people living with this complex condition.

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EFFECTIVENESS OF SPECIFIC STRENGTH AND PILATES TRAINING IN IMPROVING THE DECELERATION OF RUNNING BY YOUNG MALE BATTERS IN ELITE CRICKET

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ABSTRACT

Background: Running between the wickets in cricket requires rapid acceleration, high-speed sprinting, and controlled deceleration. Effective deceleration is crucial for quick directional changes, reducing injury risk, and improving overall performance. This study evaluates the impact of specific strength and pilates training on the deceleration ability of young male elite cricketers.

Methods: A total of 30 male cricketers (aged 18-22 years) were randomly assigned to two groups: the experimental group (n=15) underwent a six-week pilates and specific strength training program, while the control group (n=15) performed conventional strengthening exercises. Pre- and post-training assessments included the shuttle run test, speed test, and agility T-test to measure improvements in performance.

Results: The experimental group demonstrated significantly greater improvements compared to the control group. Post-test scores showed a greater reduction in time for the shuttle run test (mean 11.15s vs. 12.45s, $p<0.001$), speed test (4.24s vs. 5.31s, $p<0.001$), and agility T-test (12.20s vs. 13.95s, $p<0.001$). pilates and strength training improved core stability, balance, and neuromuscular coordination, contributing to better deceleration control.

Conclusion: Integrating pilates and specific strength training significantly enhances deceleration ability in young cricketers, providing a competitive advantage in high-intensity gameplay. These findings support the inclusion of targeted training programs to optimize performance, agility, and injury prevention in elite cricket. Future research should explore long-term benefits and application to different playing levels.

Keywords: agility, pilates, core stability, speed, shuttle run test, cricketers.

1. INTRODUCTION

Cricket is a widely popular sport played around the world. It is an intense game that demands several hours of physical activity, requiring strong reflexes, speed, and endurance as its key components[1]. Strength is essential for batting, running between the wickets, fielding and bowling. Whereas agility is ability to suddenly change the direction of the body according to the requirements[1]. The repetitive sprinting movements commonly seen in the game result in alterations to the structure of skeletal muscles, which can contribute to muscle fatigue[2]. Running between the wickets is one method which helps in scoring runs which involves three phases in all: (a)

Acceleration, (b) Reaching maximum speed, (C) Deceleration rapidly to change direction[2]. For these phases to be smoothly carried out, Strength is an essential aspect required. Focusing on deceleration phase, it is an important factor responsible for scoring runs in between the wickets. Deceleration to be carried out smoothly requires balance between the lower limb and trunk. Deceleration works on stability and the co-contraction of abdominals and lower limb muscles[3].
Research which are performed prior has suggested that the core and lower extremity strengthening provide stability in performing high velocity movements [3]. Though strength is gender biased as stated males have greater stores of strength than females, although the gender is not the focus of the study[3]. There is an important role of core stability in relation to the altered function of lower extremity[4]. Control of limb movements is provided by a stable core and in turn reduces the risk of injury[1]. As a result, core training has received increased attention as a means of enhancing athletes' performance[6]. Since core plays an important aspect in athletic performance, considering the core to be an anatomical box composed of numerous muscle groups, the abdominals in the front, the paraspinals and glutes at the back and the pelvic floor muscles at the bottom. These muscles connect with each other involving the core muscles and thoracolumbar fascia to assist with rotation of the trunk and load transfer during the deceleration phase of running in between the wickets[6]. While the quadratus lumborum is considered a major contributor due to its features and location is reported to be a major stabilizer of lumbar spine assisting with the load transfer during deceleration phase[3].

Lower body strengthening combined with core stability training has made many changes in enhancing balance, agility and for generating power needed for explosive movements. Muscles involved being (gluteal, abductors, adductors, hamstrings, quadriceps) are essential in movements needed for sporting activities. Lower body strength produces better and faster footwork, along with that stronger lower body allows stopping and changing directions quickly[5]. Pilates is an upcoming aspect in improving core muscle strength, consisting of a range of multidirectional movements starting with a variety of initial positions in which skeletal muscles are recruited in such a manner that benefits strength, flexibility, neuromuscular co-ordination and endurance[1].

Pilates training also works on the principle of trunk stability known to be as 'core stability', where pilates exercise program involves a series of stretching and strengthening exercises[5]. It also improves mind body connection and thus develops control and endurance in entire body, works on alignment, breathing and developing a strong core[7].

Thus, the need of the study arises, to find the improvement in deceleration time with strengthening the core and lower limb by training with pilates and specific strengthening exercises as it could be the important aspect of scoring runs in cricket and improving a player's game while running in between wickets.

2. MATERIALS AND METHODOLOGY

This study received institutional ethical approval from RJS college of physiotherapy, MUHS university. The study was carried out from august 2023 to march 2024 at the Atma malik cricket academy Shirdi.

Thirty participants were approached and consent form was signed according to the inclusion and exclusion criteria[2]. Participants were selected on the basis of they being elite cricket players, age between 18-22 yrs, reduced flexibility and agility, where the agility was assessed on the basis of sit and reach test[10], and agility was assessed via the administration of three tests speed test[11], Agility T test[12], shuttle run test[13]. These were administered pretest before the protocol and 6 weeks post-test and the values were recorded. And if the participants had any injury in the previous 6 months, recent ACL surgeries or post traumatic fracture in the past 6 months were excluded.

Participants were divided into two groups 15 each. Group A (experimental group) consisting 15 participants underwent pilates and strength training protocol and Group B (control group) consisting another 15 participants underwent conventional strengthening protocol. Each subject underwent 6 weeks of protocol.

- ✓ Pilates and specific strengthening training for Group A:
- ✓ Pilates- Plank, Side bend, Half press up, Swimming, Neck pull[1].
- ✓ Strength training- Barbell squats, Quadriceps resisted exercise, Hamstring resisted exercise.
- ✓ Treatment duration- 30 minutes
- ✓ Treatment interval- 6 days/week for 6 weeks.

Pilates exercises were performed by the participants for 3 days a week and the next 3 days strength training was done for 6 weeks. Before the beginning of the training protocol the pre-evaluator test - shuttle run test, speed test, agility t test was performed and the results were recorded. Following which all the participants in the experimental group performed warm up session prior to the training session involving jogging and stretching the lower limb muscles as well as cool down post the training session. The pilates session was 30 minutes initially; however, this time was gradually increased to 55-60 minutes/ 3 days a week for 6 weeks as the repetitions were increased at 3rd week and 5th week of the training session. The pilates protocol was divided into 3 phases, where phase 1 consists of the Side bend, half press up, Swimming, Neck pull exercises. Each exercise was repeated for 3-5 times with a hold duration of 10 seconds. Phase 2 was started at the end of the 2nd week. In this phase, the same exercises as phase 1 are continued; however, the repetitions and are increased with 5-7 repetitions and the hold time being the same. Following this in week 5, training moved to phase 3 where the exercises remain the same as that in the phase 1 and 2, with increased repetitions to 7-10 with the same holding time[8,9].

While the strength training which is performed 3 days/ week for 6 weeks is conducted for 30 minutes for the entire 6 weeks session. Which involves Barbell squats, Quadriceps resisted exercise, hamstring resisted exercise which were performed with the same repetitions of 10-15 per set with the weight increasing from 5 kgs per exercise in the 1st and the 2nd week, followed by 7 kgs per exercise in the 3rd and the 4th week and 10 kgs in the 5th and 6th week[10].

- ✓ Conventional strengthening exercises for Group B
- ✓ TheraBand strengthening exercises[14]
- ✓ Treatment duration- 30 minutes
- ✓ Treatment interval- 6 days/ week for 6 weeks

Prior to the testing procedure the subjects performed stretching of thigh muscles i.e. of abductors, flexors and extensors along with warm up involving jogging. After the warm up sessions, the pre-evaluator test - shuttle run test, speed test, agility t test was performed and recorded. Following which the conventional training protocol was administered for 6 days/ week for 6 weeks for 20 reps/set/6days, to improve lower limb flexor, extensor, abductors, and adductor strength through resistance band (TheraBand)

At the end of the 6 weeks of pilates training along with strength training and conventional strengthening has been administered, the post evaluator test- shuttle run test, speed test, agility t test are performed again and the results are recorded.

3. DATA ANALYSIS AND RESULTS

Data were analysed using SPSS version 28.0, Normality of pre-test and post-test scores for all outcome measures was assessed using the Kolmogorov-Smirnov test. The data followed a normal distribution, allowing for the use of parametric tests.

A total of 30 participants were enrolled in the study, divided into Group A (n=15) and Group B (n=15). The baseline characteristics of the participants, including age, gender, height, weight, and BMI were comparable between the two groups, with no statistically significant differences.

Table 2, states that when the within group analysis was done for the experimental and control group, they both showed improvement in all the three posttest with the p value of (p<0.001*).

Table 3 states that when the between group analysis was done to compare the experimental group with the control group, the experimental group showed significant improvement in all the three test with the p value of (p<0.001*).

Thus, the study results suggest that a combination of pilates and specific strength training is more effective in improving agility, speed, and deceleration ability compared to conventional training methods.

Table 1: Descriptive Statistics of Demographic Data in Control and Experimental Groups

Group	Minimum	Maximum	Mean	Std. Deviation
Control Group				
Age	18.00	20.00	18.9333	.79881
Weight	55.00	60.00	57.8000	1.85934
Height	160.00	176.00	168.4667	5.05494
BMI	19.00	22.00	20.6200	.88415
Right Limb Length in cm	79.00	95.00	87.2000	4.88730
Left Limb Length in cm	79.00	95.00	87.2000	4.88730
Flexibility (Sit and Reach Test)	26.00	36.00	32.4000	3.06594
Experimental Group				
Age	18.00	20.00	18.9333	.79881
Weight	55.00	60.00	57.2667	1.83095
Height	160.00	176.00	167.8000	3.56971
BMI	19.00	22.00	20.3867	.86756
Right Limb Length in cm	78.00	95.00	87.2667	4.86190
Left Limb Length in cm	78.00	95.00	87.2667	4.86190
Flexibility (Sit and Reach Test)	24.00	38.00	31.2667	4.18273

Table 2: Comparison of Pre and Post Intervention Values of Outcome Variables within Control and Experimental groups

Group	Outcome Variables	Pre Mean±SD	Post Mean±SD	Mean Difference ±SD	T value	P value Significance
Control Group	**Shuttle Run Test**	12.822±0.742	12.453±0.759	0.369±0.196	7.280	**0.001***
	Speed Test	5.803±0.468	5.319±0.436	0.484±0.228	8.227	**0.001***

	Agility T Test	14.359±0.807	13.951±0.804	0.408±0.263	6.001	**0.001*** **
Experimental Group	**Shuttle Run Test**	12.262±0.652	11.153±0.654	1.109±0.394	10.890	**0.001*** **
	Speed Test	5.459±0.390	4.247±0.582	1.212±0.357	13.132	**0.001*** **
	Agility T Test	13.746±0.965	12.202±0.848	1.544±0.359	16.643	**0.001*** **

Table 3: Comparison of Pre and Post Intervention Values of Outcome Variables between Control and Experimental groups

Intervention	**Outcome Variables**	**Control Group Mean±SD**	**Experimental Group Mean±SD**	**Mean Difference ±SED**	**T value**	**P value Significance**
Pre Intervention	**Shuttle Run Test**	12.822±0.742	12.262±0.652	0.560±0.255	2.195	**0.037**
	Speed Test	5.803±0.468	5.459±0.390	0.344±0.157	2.189	**0.037**
	Agility T Test	14.359±0.807	13.746±0.965	0.613±0.325	1.888	**0.069**
Post Intervention	**Shuttle Run Test**	12.453±0.759	11.153±0.654	0.259±0.770	5.209	**0.001*** **
	Speed Test	5.319±0.436	4.247±0.582	0.189±0.689	5.707	**0.001*** **
	Agility T Test	13.951±0.804	12.202±0.848	0.302±1.131	5.800	**0.001*** **

4. DISCUSSION

30 subjects were taken to compare the effectiveness of specific strength and pilates training in improving the deceleration of running by young male batters in elite cricket in which group A experimental group of 15 subjects and group B conventional therapy consisting of 15 subjects were selected randomly. In this study statistical analysis shows pilates and strength training is effective than conventional therapy.

The result of this study shows pilates with strength training program was more effective than conventional therapy alone because there is a reinforcement in the motor programming of neuromuscular conditioning and neurological adaptation of muscle spindle and body control during the movement and it promotes the improvement in agility.

Pilates training also works on the principle of trunk stability known to be as 'core stability', where pilates exercise program involves a series of stretching and strengthening exercises[1,5]. It also improves mind body connection and thus develops control and endurance in entire body, works on alignment, breathing and developing a strong core[9]. Along with that it improves dynamic balance and coordination which is an important aspect of the game[15].

Core training has received increased attention as a means of enhancing athletes' performance. Since core plays an important aspect in athletic performance, considering the core to be an anatomical box composed of numerous muscle groups, the abdominals in the front, the paraspinals and glutes at the back and the pelvic floor muscles at the bottom[6]. These muscles connect with each other involving the core muscles and thoracolumbar fascia to assist with rotation of the trunk and load transfer during the deceleration phase of running in between the wickets[3,6].

The experimental group showed improvement in all of the three outcome measures when compared with the control group. Along with that the post test scores show significance in improving the agility performance than the pre-test scores in cricketers. thus, improving performance time. Though the study had certain limitations, the study was performed on younger age group, deceleration was considered as the main aspect of the study, the study was done on smaller group, only young male cricket players were considered.

5. CONCLUSION

For the young elite cricketers, the performance should be more as the future of batter's is going to be an extraordinary performance due to the sporting events of ipl, wpl, state level Ranji trophies icc matches.

These pilates and strength training would boost the techniques of the batters which will be helpful while playing at thrilling match points. This would give a great opportunity for the players to achieve more in near future of the cricket.

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EFFICACY OF CORE ACTIVATION AND CORE-PELVIC COMPLEX CORRECTION EXERCISES ON GRIP STRENGTH AND SHOULDER PROPRIOCEPTION IN OVERHEAD SPORTS PLAYERS WITH SCAPULAR DYSKINESIA: A SCOPING REVIEW

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ABSTRACT

Background: Scapular dyskinesia (SD) is a common issue among overhead athletes, affecting the kinetic chain and disrupting shoulder function. Scapula serves as a crucial link between the trunk and upper limb function. Deficits in core and pelvic stability can impair scapular mechanics, shoulder proprioception, and grip strength. Addressing core and pelvic asymmetry before shoulder rehabilitation may enhance functional recovery.

***Objective*:** This scoping review examines the role of core-pelvic complex correction exercises in improving grip strength and shoulder proprioception in overhead athletes with SD.

***Methods*:** A systematic search of Google Scholar, PubMed, and Science Direct was conducted to identify studies published between 2019 and 2025. Articles were included if they explored the relationship between SD, grip strength deficits, altered shoulder proprioception, and core-pelvic dysfunction. A total of 10 studies (out of 159 screened) met the inclusion criteria, comprising 7 cross-sectional studies, 1 randomized controlled trial, 1 case-control study, and 1 systematic review.

***Results*:** The findings suggest a strong association between core-pelvic dysfunction and SD-related impairments. Core activation and pelvic correction exercises were linked to improvements in grip strength, proprioception, and overall athletic performance in overhead athletes.

***Conclusion*:** Strengthening the core and correcting pelvic asymmetry can significantly enhance shoulder function, proprioception, and grip strength in athletes with SD. This review underscores the need for integrating core-pelvic complex activation into rehabilitation and training protocols for overhead athletes.

Keywords: Scapular dyskinesia, grip strength, shoulder proprioception, core-pelvic correction, overhead sports athletes, scoping review

1. INTRODUCTION

Scapular dyskinesis, a loss of kinetic control due to muscle or bony alterations, is more common in overhead athletes. Scapular dyskinesis was found to have a greater reported prevalence (61%) in overhead athletes compared with non-overhead athletes (33%). Proper scapular positioning is crucial for efficient force transfer and injury prevention in high-velocity overhead sports.[1,2,3] Scapular dyskinesis disrupts posture and movement, reducing muscle efficiency and increasing shoulder injury risk, with affected athletes facing a 43% higher risk of shoulder pain. As a vital link in the kinetic chain, the scapula transfers energy from the trunk and lower extremities to the arm, requiring comprehensive assessment of both proximal and distal regions.[4,5,6] The human hand performs dexterous prehension activities, with grip strength serving as a key indicator of upper extremity function, mobility, and overall health. Controlled scapular stability is essential for efficient hand movements.[7] Hand grip strength is the maximum force from intrinsic and extrinsic hand muscle contraction. Rehabilitating shoulder-scapular mobility and stability can improve grip strength, as hand and scapular muscles share endurance essential for daily tasks.[8] Grip strength is linked to upper extremity function, involving simultaneous activation of proximal and distal muscles with force redistribution.[9] Athletes rely on upper extremity precision, requiring shoulder girdle flexibility, strength, coordination, and neuromuscular control, with core muscles playing a key role. Shoulder-scapular mobility and stability rehabilitation would be more beneficial and may necessitate when treating reduced grip strength and shoulder proprioception.[10,11] Core muscles drive the forward-throwing technique in upper extremity sports, enabling efficient power transfer from the lower to upper body. Upper and lower extremity muscles work with the core for synchronized movement. Unstable overhead motions and exaggerated joint movement may originate from a core muscle imbalance[12] Athletes with scapular dyskinesis have weaker balance and core strength. The core, known as the "powerhouse," initiates or coordinates all limb movements. Core stability is essential for maximizing force production and minimizing joint stress in all activities.[13] Upper-limb function in daily and athletic tasks requires controlled trunk and abdominal muscle activation.[14] Trunk flexors, rotators, and hip extensors enhance stability by supporting scapular movement and spine positioning. Trunk muscles contract in a feedforward manner to maintain spinal stability during limb movement.[15] An entire body segment's alignment may be affected by the posture of its nonadjacent segments. Shoulder complex position may be influenced by spinal posture.[16] pelvic posture is additionally linked to spinal alignment.[17] Pelvic position affects shoulder posture through spinal adjustments, influencing scapular position and muscle activity. The shoulder and pelvis are anatomically connected via the myofascial system.[18] The anterior oblique sling connects the hip-lumbopelvic region to the opposite shoulder through muscles and fascia.[19] Pitching begins with lower-body power, refined in the hips and transferred to the throwing arm via the lumbopelvic region. Disruptions in this kinetic chain can reduce performance and increase injury risk.[20] Core stability and scapular movement are crucial in overhead sports. Understanding their relationship with the shoulder and handgrip helps prevent injuries and enhance performance.[21]

2. METHODOLOGY

Identification of Relevant Study

A comprehensive literature search was conducted, encompassing English-language publications between 2019 and 2024, sourced from four prominent databases: Google Scholar, PubMed, Science Direct, and EMBASE. A strategic keyword search approach was employed, utilizing a combination of terms, including "overhead athletes with scapular dyskinesia", "core activation", "physical performance", "grip strength", and "shoulder proprioception". Furthermore, the terms "core activation and pelvic asymmetry correction" and "overhead athletes with scapular dyskinesia" were deliberately selected to investigate the efficacy of core activation and core-pelvic complex correction exercises on grip strength and shoulder proprioception in overhead athletes with scapular dyskinesia. This scoping review aimed to elucidate the effectiveness of core activation and core-pelvic complex correction on grip strength in overhead athletes with scapular dyskinesia. To achieve this objective, a range of study designs, including cross-sectional, randomized controlled trials, case-control studies, and systematic reviews, published during the specified period, were meticulously selected for analysis.

Study Selection

This scoping review considered studies eligible if they explored relationships between scapular dyskinesia and various factors, including grip strength, core muscle activation, shoulder proprioception, core strength, balance, and pelvic position's influence on shoulder kinematics. Eligible studies were required to be full-text articles published in English since 2019. Conversely, studies that failed to address the predetermined criteria, such as scapular dyskinesia, hand grip strength, shoulder proprioception, core activation, and pelvic-core asymmetry across different populations, were excluded from the review. If articles fulfilled the inclusion criteria, they underwent rigorous, independent, full-text reviews by three authors (Sandhyarani Sahoo, Sudhanshu Sekhar Lenka, and Subhasmita Sahoo). In the event of discrepancies, a third-party reviewer was consulted to resolve any disagreements and ensure consensus.

Charting Data

When a full-text article met the study's eligibility criteria, the lead author extracted relevant data on the efficacy of core activation and core-pelvic correction in improving grip strength and shoulder proprioception in overhead athletes with scapular dyskinesia. This extracted data was then reviewed by two additional authors, carefully documented in data extraction records, and compiled into a concise summary. To ensure systematic organization, the data was charted using a customized Microsoft Excel form, which captured essential details such as authorship, article type, population demographics, and specifics of core muscle activation training protocols, including core pelvic asymmetry correction methods.

Collating, Summarizing and Reporting Results

Data charting forms were used to compile and report the articles' methods for determining the impact of core-activation exercises and exercises aimed at correcting the asymmetry of the core-pelvic complex on shoulder proprioception and grip strength in overhead athletes suffering from scapular dyskinesis.

3. RESULT

Initially, a total of 361 articles were identified, but 202 duplicates were expunged from various databases to avoid redundancy. Following a meticulous review of article titles and abstracts, 117 articles were subsequently excluded due to irrelevance. Furthermore, an additional 32 articles were eliminated after a thorough examination of their content (Figure 1). Ultimately, a total of 10 papers met the inclusion criteria for this review. The selected articles comprised seven cross-sectional studies, as well as one case-control study, one systematic review and one randomized controlled trial. A critical analysis of these 10 publications revealed that they collectively investigated the impact of exercises targeting the core-pelvic complex asymmetry correction and core activation exercises on shoulder proprioception and grip strength in overhead athletes afflicted with scapular dyskinesis.

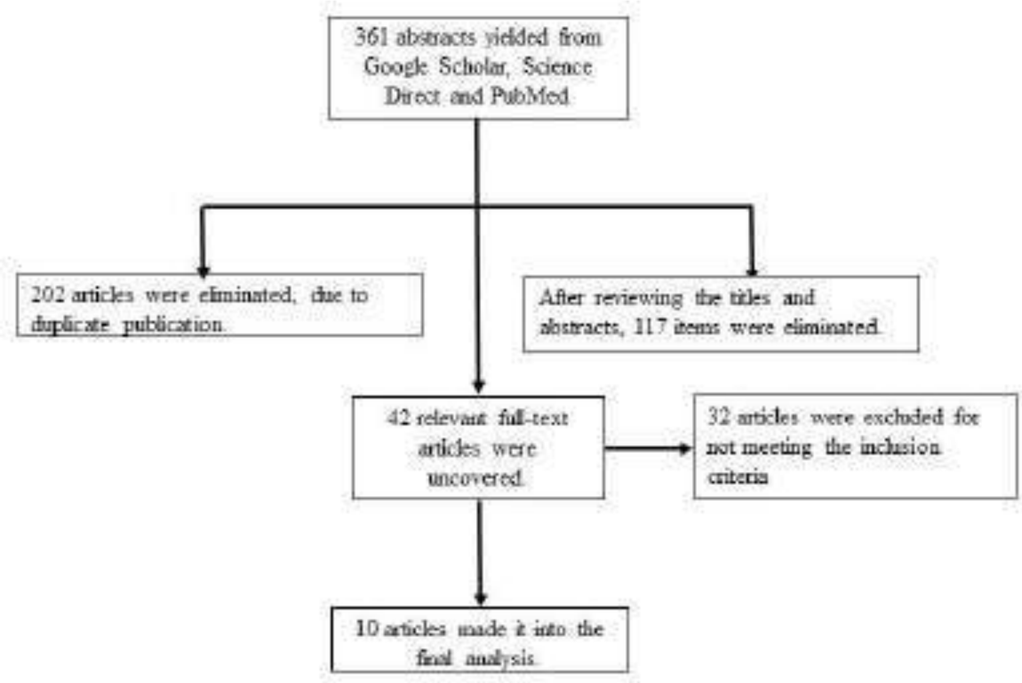

Table 1: Scoping review analysis

Author	Article type	Study population	Method	Conclusion
Oliveira et al.,2024[22]	Cross-sectional study	Non-athletes with and without scapular dyskinesis	The study assessed core muscle performance, shoulder pain/disability, upper limb stability, and peak torque of shoulder rotators to investigate the relationship between scapular dyskinesis and shoulder function.	Core muscle performance was correlated with shoulder pain and function, but scapular dyskinesis did not affect the magnitude of these relationships.
Ozturk et al., 2023[11]	Cross-Sectional Study	Overhead athletes with and without scapular dyskinesis	A study assessed scapular dyskinesia and evaluated its relationship with core strength and upper extremity balance.	The study found that athletes with scapular dyskinesia had weaker core strength and poorer upper extremity balance than those without the condition. The study recommends incorporating core strengthening and balance exercises into upper extremity sports training to improve scapular stability and prevent injuries.

Reyhani et al., 2024[10]	Cross-sectional study	Professional overhead athletes with and without scapular dyskinesis	A study compared asymptomatic professional overhead athletes with and without scapular dyskinesis. Shoulder proprioception - Upper extremity dynamic stability - Hand grip strength	Scapular dyskinesis affected shoulder proprioception in asymptomatic overhead athletes, but not upper extremity stability or hand grip strength.
Sakshi SHAH et al.,2024[20]	RCT	Individuals with scapular dyskinesia	Group A (Control): Received conventional treatment Group B (Experimental): Received conventional treatment + core stabilization exercises	A structured core stabilization exercise program significantly improved muscle performance and reduced pain in individuals with scapular dyskinesis.
Lobbos et al.,2025[19]	Cross-sectional study	Normal adult	Subjects were enrolled in this study. Shoulder range of motion was measured	Pelvic position affects shoulder range of motion
Murta et al., 2019[16]	Cross-sectional study	Healthy young adults	Young adults were evaluated in two standing positions: relaxed and with a 30% reduction in anterior pelvic tilt. Measurements assessed pelvic tilt, trunk posture, forward shoulder posture, and the electromyographic activity of scapular upward rotators, providing insight into the effects of pelvic posture on upper body alignment and muscle activity.	Reducing anterior pelvic tilt was found to decrease trunk extension and increase lower trapezius activation, especially during arm elevation. However, it had no significant impact on forward shoulder posture or serratus anterior activity. These results highlight the importance of considering pelvic posture when assessing or designing exercises for individuals with shoulder or trunk conditions.
Bauer et al.,2022[12]	Cross-sectional study	Handball players	The study involving handball players assessed core muscle strength endurance using the Bourban test and evaluated its relationship with upper-extremity performance. Shoulder mobility/stability was measured with the Upper Quarter Y Balance Test, and throwing velocity was recorded using a radar gun.	Research found that adolescent handball players with greater core muscle strength endurance tend to have better shoulder mobility and stability, as well as higher throwing velocities. Notably, dorsal chain strength was significantly linked to throwing velocity. These results suggest that incorporating core strength endurance exercises into training programs may improve upper-extremity performance in young handball players.
Solanki et al., 2021[14]	Cross-sectional study	Physical therapists of age group 18 to 25	Participate in this study were assessed for height, weight, BMI, the hand grip strength of the dominant hand and the non-dominant	This study shows weak correlation between the hand grip strength with core muscle activation.

			hand and core muscle activation	
Moghadam et al., 2020[23]	Systematic review	Individuals with scapular dyskinesis	The systematic review included clinical trials investigating the effects of therapeutic exercises such as scapular strengthening, stretching, and stabilization on scapular position and motion in adult participants	A review of exercise therapy for scapular dyskinesis revealed mixed results, with conflicting evidence on improving scapular position and motion. However, exercises targeting the scapula showed promise, and various therapies significantly reduced pain and disability in individuals with subacromial impingement syndrome. To determine the most effective exercises, further high-quality clinical trials with standardized measurement techniques are necessary.
Sayaca et al., 2024[24]	Case control study	Kickboxing athletes with and without scapular dyskinesis	The study participants were divided into two groups: those with scapular dyskinesia (SD) and those without. The researchers used various assessment tools to evaluate the participants, including the Lateral Scapular Slide Test to identify SD, a digital inclinometer to measure shoulder proprioception, the Closed Kinetic Chain Upper Extremity Stabilization Test to assess shoulder joint stabilization, and the Body Assessment Scale to evaluate body image.	Kickboxers with scapular dyskinesia (SD) demonstrated superior shoulder proprioception, joint stabilization, and body image compared to those without SD. Interestingly, kickboxers with SD also had more experience in the sport, suggesting that adaptation and compensation mechanisms may develop over time, allowing them to perform effectively despite the presence of SD.

4. RESULT AND DISSEMINATION

According to this review's thorough content analysis of the effects of core activation and core-pelvic complex correction on shoulder proprioception and hand grip strength in overhead athletes with scapular dyskinesis, addressing core and pelvic complex asymmetry before shoulder rehabilitation may improve functional recovery and overall performance levels in overhead athletes.

5. DISCUSSION

This scoping review provides a comprehensive overview of the burgeoning evidence supporting the treatment of myofascial subsystem chain links as a viable approach to addressing sports-related disturbances, including biomechanical malalignments such as scapular dyskinesia, diminished hand grip strength, compromised shoulder proprioception, and asymmetry in the core-pelvic complex. Furthermore, this review highlights the impact of core and hand intrinsic muscle dysfunction on physical performance, proprioception, and grip strength in overhead athlete populations, which can lead to a diminution in overall quality of activity level.

The management of core muscle and core-pelvic complex dysfunction in these conditions poses a significant challenge in the realm of physiotherapy rehabilitation. Although some studies have investigated the efficacy of scapular and shoulder muscle training in specific populations, this scoping review aims to provide timely insights into overcoming the deleterious effects of kinetic chain disbalance on physical performance, hand grip strength, and overall quality of play in these populations.

Arora et al. emphasize that dynamic sports require the scapula and shoulder complex to be an integral part of the game, and that core strength is crucial for optimal performance. Reyhani et al., found that scapular dyskinesis can impair shoulder proprioception, even in asymptomatic athletes, and that correcting scapular positioning can enhance shoulder proprioception.[10] Lobbos et al., discovered that pelvic position significantly influences sagittal shoulder movement, with an anterior pelvic tilt increasing flexion and decreasing extension of both shoulders.[19] Ozturk et al., revealed that upper extremity athletes with scapular dyskinesis exhibit diminished balance and core strength, and that the prevalence of scapular dyskinesis is higher in athletes participating in overhead sports.[11] Burn et al. conducted a systematic review that underscored the notion that scapular dyskinesis is more prevalent in athletes participating in overhead sports. Solanki et al., demonstrated that the transverse abdominis and multifidus muscles exhibit anticipatory contraction prior to shoulder movement, and that core strength is positively correlated with upper extremity function in athletes participating in racquet sports.[14]

The reviewed literature underscores the importance of addressing these issues, with authors proposing common physiotherapy interventions to enhance physical performance, shoulder proprioception, and hand grip strength in these populations. Notwithstanding the plethora of studies examining the correlations between structures within the kinetic chain, the literature on the effectiveness of core muscle activation training and core-pelvic correction on outcomes in scapular dyskinesia is scant. This scoping review offers a promising perspective on treatment planning, which is essential for special populations such as those with scapular dyskinesia.

6. LIMITATIONS AND FUTURE RECOMMENDATION

Despite numerous correlation and association studies exploring the relationships between scapular dyskinesis, hand grip strength, core, hip-lumbo-pelvic complex, shoulder proprioception, and performance levels, a significant knowledge gap remains. Notably, no comprehensive studies have investigated the efficacy of activating a single core muscle within the myofascial subsystem to address the multifaceted alterations associated with scapular dyskinesis, including hand grip dyskinesia, impaired shoulder proprioception, and decreased performance.

This research gap highlights the need for interventional studies examining the complex interactions between scapular dyskinesis, core activation, and core-pelvic complex correction in overhead athletes. The limited availability of published literature on the effectiveness of core activation and core-pelvic complex correction in this population emphasizes the need for robust, evidence-based solutions to optimize physical performance and strength in overhead athletes with scapular dyskinesis.

7. CONCLUSION

The examination and distribution of this scoping study pave the way for physiotherapy and rehabilitative treatment strategies, such as intrinsic core activation and core-pelvic correction, to improve shoulder proprioception, hand grip strength, and scapular dyskinesia in overhead athletes. Clinicians can try to prevent injuries and improve performance by taking into account the complex interactions that exist between an athlete's core, scapula, shoulder, and handgrip. The findings of this scoping study reveal a particular relationship between core stability and symmetry in lumbo-pelvic complex and scapula movement, which may be further investigated in a clinical intervention using overhead athletes.

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PSYCHOLOGICAL TRAITS IN TEAM SPORTS: A COMPARATIVE STUDY OF SELF-CONFIDENCE, ANXIETY, AND AGGRESSION IN COLLEGE MALE ATHLETES

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ABSTRACT

This research seeks to explore the psychological variations among male college athletes engaged in handball, volleyball, and basketball, concentrating on self-esteem, anxiety levels, and aggression. The study aims to determine which player group demonstrates greater levels of these psychological factors via a comparative examination. A selection of 90 college athletes (30 from every sport) was made from intercollegiate competitions, with ages of participants spanning from 19 to 25 years. Standardized psychological evaluation instruments, such as the Self-Confidence Inventory (SCI), Competitive State Anxiety Inventory-2 (CSAI-2), and the Buss-Perry Aggression Questionnaire (BPAQ), were employed to assess the corresponding psychological characteristics. Data gathering took place in regulated settings, and statistical evaluations, such as one-way ANOVA and post-hoc analyses, were utilized to assess variations between the three groups.

The results of this study are expected to offer important knowledge for sports administrators, coaches, and psychologists in crafting focused psychological strategies and training initiatives. Moreover, the research advances the domain of sports psychology by providing a basis for subsequent studies on the mental characteristics of athletes in team sports.

Keywords: Self-Esteem, Anxiety Levels, Aggression, Post-Hoc Analysis, Mental Characteristics.

1. INTRODUCTION

The role of psychology in sports performance has been extensively studied, with factors such as self-confidence, anxiety, and aggression influencing an athlete's success. Team sports, such as handball, volleyball, and basketball, require varying levels of mental preparedness and psychological stability. Understanding these psychological attributes among athletes can help optimize performance and design effective training strategies. This study seeks to compare self-confidence, anxiety, and aggression among college male athletes from these three sports.

2. LITERATURE REVIEW

Self-Confidence in Team Sports

Self-confidence is a key determinant of sports performance, as it affects motivation, focus, and resilience. Bandura’s (1997) concept of self-efficacy highlights how belief in one’s abilities enhances performance. Studies suggest that high self-confidence in athletes leads to better decision-making, improved performance consistency, and greater willingness to take risks (Vealey & Chase, 2008). Research also indicates that team sports cultivate self-confidence through collective efficacy, where the belief in the team’s capabilities positively influences individual confidence (Fransen et al., 2015).

Anxiety and Its Influence on Performance

Anxiety is a common psychological challenge for athletes, often categorized into cognitive (worry, negative thoughts) and somatic (physical symptoms) anxiety (Martens et al., 1990). Research suggests that moderate levels of anxiety can be beneficial, keeping athletes alert and motivated. However, excessive anxiety negatively affects performance by impairing focus and increasing muscle tension (Weinberg & Gould, 2019).

Aggression in Team Sports

Aggression in sports can be both constructive (instrumental aggression) and destructive (hostile aggression) (Baron & Richardson, 1994). Team sports often require controlled aggression to enhance competitiveness, but excessive aggression can lead to penalties and conflicts. Research suggests that contact sports, such as basketball and basketball, promote higher aggression levels compared to non-contact sports (Maxwell & Moores, 2007).

3. METHODOLOGY

Participants

A total of 90 college-level male athletes (30 handball, 30 volleyball, and 30 basketball players) were recruited from intercollegiate tournaments. Participants were aged between 19 and 25 years.

4. RESEARCH DESIGN

A comparative research design was adopted to examine differences in self-confidence, anxiety, and aggression among the three groups.

5. DATA COLLECTION TOOLS

- ✓ **Self-Confidence Inventory (SCI) 1996 by Betz, Harmon, and Borgen:** Measures an athlete's level of self-confidence.
- ✓ **Competitive State Anxiety Inventory-2 (CSAI-2) 1990 by Martens and colleagues. :** Assesses cognitive and somatic anxiety levels.
- ✓ **Buss-Perry Aggression Questionnaire (BPAQ) 1992 by Buss and Perry:**
- ✓ Evaluates different aspects of aggression.

6. DATA COLLECTION PROCEDURE

Participants completed the psychological inventories in controlled settings before competitive matches to ensure accuracy. Informed consent was obtained, and ethical considerations were adhered to.

7. STATISTICAL ANALYSIS

Data were analyzed using one-way ANOVA to determine significant differences between groups, followed by post-hoc tests for further comparisons.

8. RESULTS

The analysis revealed significant differences in self-confidence and aggression among the three groups, while anxiety levels did not vary significantly. Handball and basketball players exhibited higher aggression levels compared to volleyball players. Basketball players demonstrated the highest self-confidence scores, whereas volleyball players had relatively lower self-confidence.

Anxiety levels were comparable across all three sports.

Results on Self-Confidence

Table -I: COMPUTATION ON ANALYSIS OF VARIANCE OF SELF-CONFIDENCE

MEAN VALUES			Source of Variance	Sum f Sequences	df	Mean Sequence	F
Hand Ball	**Volley Ball**	**Basket Ball**					
47.50	53.03	44.83	Between	1049.69	2	524.84	**6.81***
			Within	6706.63	87	77.09	

*Significant at 0.05 level. Tabulated 'F' 0.05. df (2,87) = 3.10

Table I shows that the obtained mean values on self-confidence of the handball players was 47.50, volleyball players was 53.03 and basketball players was 44.83. The analysis of variance (ANOVA) of the means proved that there was significant difference on self- confidence between the players as the obtained F value 6.81 was greater than the required F value of 3.10 to be significant at 0.05 level of confidence.

Results on Anxiety

Table -II: COMPUTATION OF ANALYSIS OF VARIANCE OF ANXIETY

MEAN VALUES			Source of Variance	Sum of Sequences	df	Mean Sequence	F
Hand Ball	**Volley Ball**	**Basket Ball**					
47.50	53.03	44.83	Between	17.69	2	8.84	**0.12**
			Within	6387.30	87	73.42	

□Significant

Table II shows the post hoc analysis between handball, volleyball and basketball players in self-confidence. The differences between volleyball and basketball players was significant and other comparison were not significant.

The obtained mean values of self-confidence among handball, volleyball and basketball Players are presented in Figure I for better understanding of the results

Results on Aggression

Table -III: COMPUTATION OF ANALYSIS OF VARIANCE OF AGGRESSION

MEAN VALUES			Source of Variance	Sum of Sequences	df	Mean Sequence	F
Hand Ball	**Volley Ball**	**Basket Ball**					
194.20	181.07	177.10	Between	4806.29	2	2403.14	**4.44***
			Within	47075.37	87	541.10	

*Significant at 0.05 level. Tabulated 'F' 0.05. df (2,87) = 3.10

Table III shows that the obtained mean values on aggression of the handball players was 194.20, volleyball players was 181.07and basketball players was 177.10.

The obtained F value **4.44** was greater than the required table value of 3.10 to be significant at 0.05 level of confidence. This proved that significant differences existed among handball, volleyball and basketball players in aggression.

9. DISCUSSION

The findings suggest that psychological traits are influenced by the nature of the sport. Contact sports, such as basketball and handball, may require heightened aggression and self-confidence due to their competitive intensity. The similarity in anxiety levels indicates that pre-competition stress is common across sports, regardless of their nature. Coaches and sports psychologists can use these insights to tailor mental conditioning programs for athletes.

10. CONCLUSION

This study highlights the psychological differences in self-confidence, anxiety, and aggression among college male athletes in handball, volleyball, and basketball. The findings suggest that contact sports, such as basketball and handball, demand higher levels of self-confidence and controlled aggression, while anxiety remains a common factor across all three sports. These insights emphasize the importance of psychological conditioning in athletic training. By understanding these psychological attributes, coaches and sports psychologists can develop targeted mental training programs to optimize performance and enhance athletes' resilience. Future research should expand on these findings by including female athletes and exploring additional psychological variables to gain a more comprehensive understanding of the mental aspects of sports performance.

11. IMPLICATIONS AND RECOMMENDATIONS

- ✓ Coaches should incorporate mental training techniques to enhance self-confidence and manage aggression appropriately.
- ✓ Sports psychologists should develop customized intervention programs for different sports.
- ✓ Further research should explore gender-based differences in psychological traits among athletes.

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ANTHROPOMETRIC PROFILING OF ALL INDIA INTER UNIVERSITY BASKETBALL WINNERS 2021-22

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ABSTRACT

The Aim of this study was to evaluate the anthropometric profile of all India inter university basketball winners 2021-22. Nineteen participants who won the all India inter university basketball championship 2021-22 with the age between 18-25 years were selected for the study. Descriptive statistics was used in this study (highest, lowest, mean, SD). Seven anthropometric variables are evaluated height (highest-182cm, lowest-162cm, mean-171.47cm, SD-7.305) weight (highest-82kg, lowest-57kg, mean-65.05, SD-6.62) total leglength (highest-107, lowest-94.5, mean-100.47, SD-4.73) thigh circumference (highest-60, lowest-48.4, mean-53.06, SD-2.82) calf circumference (highest-39.5, lowest-34, mean-36. 57, SD-1. 52) BMI (highest-25.88, lowest-20. 51, mean-22.09, SD-1.43) Body composition [body fat% (highest-6.46, lowest-3. 31, mean-4.33, SD-0. 95) fat weight (highest-5.3, lowest-2.1, mean-2.85, SD-0. 87) lean weight (highest-76.7, lowest-54.4, mean-62.19, SD-5.97)], in this study most of the players are in normal weight category, no one is obese and only one person in overweight category.

Keywords: Height, weight, BMI, Calf circumference, Thigh circumference, Total leg length , Body composition.

1. INTRODUCTION

Sports is highly competitive in the present world. Even a kid who is novice in the game Perceives it very professionally. Basketball is the most popular sports all over the world, and it has been practiced by every nation. Recently most of the nations conducting biological study in basketball for improving their knowledge and performance. So that Anthropometric study dose an important role in basketball. 'Anthropometry is a simple reliable method for quantifying body size and proportions by measuring body length, width, circumference, and skinfold thickness' (J Wang et al, 2000). In this study was conducted for evaluating Anthropometric profiling about a\All India inter university basketball winners 2021-22. Aim of this study was to evaluate the Anthropometric profile of all India inter university basketball winners 2021-22.

Anthropometric measurements relevant to human movement gained formal recognition as a discipline with the inauguration of the international society for advancement of kinanthropometry in 1986. Anthropometrists of all continents have participated in several major multidisciplinary studies that are being or have been conducted to assess the physical characteristics of people. Kinanthropometry has been defined as the quantitative interface between human structure and function (1). Anthropometry like any other area of science depends upon adherence to the particular rules of measurement as determined by national and international standards bodies. The international anthropometric standards body adopted for the purpose of this textbook is the International Society for the Advancement of Kinanthropometry (ISAK).(2)

At the beginning of the twentieth century, soccer was widely accepted as the most popular game in the western world. In the space of a few decades, it had become the best-supported team game in Britain, watched and played by more boys and men than any other sport. Yet here was a game with strong traditional folk roots and a history that stretched back to the late Middle Ages. In the course of the nineteenth century, basketball was transformed, mainly within the British public schools, to become the codified and disciplined game of urban working men. The passion for the game spread from one town to another, a passion that, though familiar today, was new in the years after 1870. Thereafter, the game rapidly spread to much of the world: to Europe, South America and a host of other societies. This book tells the story of the rise of this remarkable British game and the way it became the game of the masses across the world. In the wealth of literature about basketball published in recent years, no other book provides so concise and colourful an account as The People's Game. (3)

2. MATERIALS AND METHODOLOGY

This section deals with materials and methods used by the Researcher to evaluate Anthropometric profiling of All India inter University basketball winners 2021-22. It contains selection of participants, variables, tools and statistical procedure used for this study.

Design of the study

Descriptive research design was used for this study. Taken 19 basketball ers by using judgemental sampling method.

Population and sampling

All India inter university basketball winners 2021-22 was the population of this study. In this study the samples selected was by the use of sampling method judgemental sampling.

Research instruments and variables

Variable	Test item
Height	Stadiometer
Weight	Weighing machine
BMI	Using formula
Total leg length	Measuring tape
Thigh circumference	Measuring tape
Calf circumference	Measuring tape
Body composition	Skinfold calipers

Statistical procedure

The collected data pertaining to the study has been analysed through descriptive statistics, mean , standard deviation.

3. RESULT

a. *Height*

Classification	Values
Maximum height	182 cm
Minimum height	162 cm
Mean	171.473 cm
Standard Deviation	7.305

Considering the height of all India inter university basketball winners 2021-22, the player who have maximum height in the team was 182 cm, minimum height 162 cm, mean value 171.473 cm and standard deviation 7.305. Most of the players are lies in 160-165 cm height category. And no one is less than 160 cm height category. And no one is more than 185 cm height category.

b. *Weight*

Classification	Values
Maximum weight	82 kg
Minimum weight	57 kg
Mean	65.052 kg
Standard Deviation	6.62

Considering weight of the all India inter university basketball winners 2021-22, the player who have maximum weight in the team was 82 kg, The minimum weight 57 kg, mean value 65.052 kg and standard deviation was 6.62. Most of the players are in 60 to 70 kg weight category, only one player has 80 above weight.

c. BMI

Classification	Value
Maximum BMI	25.88
Minimum BMI	20.51
Mean	22.09
Standard deviation	1.43

Considering the BMI of all India inter university basketball winners 2021-22, the player who have maximum BMI 25.88, the minimum BMI value 20.51,mean value was 22.09 and standard deviation was 1.43 . No one was under weight category, only one player has in over weight category with BMI of 25.88.

d. *Total leg length*

Classification	Value
Maximum	107 cm
Minimum	94.5 cm
Mean	100.47 cm
Standard Deviation	4.73 cm

Considering the total leg length of all India inter university basketball winners 2021-22, the player who have maximum value of total leg length was 107 cm , minimum value of total leg length was 94.5 cm, mean value was 100.47 cm and standard deviation was 4.73 cm. Half of the players are in below 100 cm total leg length category and half of the players are in above 100 cm total leg length category.

e. *Thigh circumference*

Classification	Value
Maximum	60 cm
Minimum	48.4 cm
Mean	53.06 cm
Standard deviation	2.82 cm

Considering the thigh circumference of a All India inter university basketball winners 2021-

22, the player who have maximum thigh circumference was 60 cm, minimum thigh circumference was 48.4 cm, mean value of thigh circumference was 53.06 cm and standard deviation was 2.82 cm. Most of the players thigh circumference was in 50 cm to 55 cm category. Only one player has reach 60 cm and only one player have below 50 cm thigh circumference.

f. *Calf circumference*

Classification	Value
Maximum	39.5 cm
Minimum	34 cm
Mean	36.57 cm
Standard deviation	1.52 cm

Considering the calf circumference of a all India inter university basketball winners 2021-22, the player who have maximum calf circumference was 39.5 cm, minimum calf circumference was 34 cm, mean value of calf circumference was 36.57 cm and standard deviation was 1.52 cm . Most of the players have included in between 35 cm to 40 cm calf circumference category and no one is more than 40 cm calf circumference.

g. *Body composition*

Classification	Body fat (%)	Fat weight(kg)	Lean weight(kg)
Maximum	6.46	5.3	76.7
Minimum	3.31	2.1	54.4
Mean	4.33	2.85	62.19
Standard deviation	0.95	0.87	5.97

Considering the Body composition of all India inter university basketball winners 2021-22, the player who have maximum body fat(%) 6.46, the player who have minimum body fat(%) 3.31, mean value of body fat (%) 4.33 and standard deviation was 0.95. Asper the norm of American council on exercise body fat percentage category, most of the player are in essential fat percentage category.

The player who have maximum fat weight was 5.3kg, minimum fat weight 2.1 kg, mean value of fat weight was 2.85 kg and standard deviation was 0.87 kg.

The player who have maximum lean weight was 76.7kg, minimum lean weight was 54.4 kg, mean value was 62.19 kg and standard deviation was 5.97 kg.

4. DISCUSSION

The aim of this study was to determine the anthropometric profiling of All India inter university basketball winners 2021-22 . The result showed most of the players variables measurement values are contain in same category. But one player who different in some variables measurement values. He was in player seventh position. Only he was in overweight category, rest of them are in normal weight category. Considering the body composition, the player number seven has the most fat percentage in their list.

5. CONCLUSION

Based on this study most of the players are in normal weight category and only one player was in over weight category, and no one was in underweight category. Most of the players are in 160-165cm height category, considering thigh circumference most of the players are in 50-55cm category. Considering the calf circumference most of the players are in 35-40cm category. Considering the body fat percentage Most of the players are included in essential fat percentage category.

This study recommended that This type of studies will inspire the young athletes for the progression and existence in the field of sports and physical education for a long time. This type of study will helps to compare this team profile to professional basketball players profile list.

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EFFECT OF CONTINUOUS RUNNING ON MOTOR FITNESS VARIABLES AMONG MALE INTER COLLEGE ATHLETES

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ABSTRACT

This study evaluates the impact of continuous running on motor fitness variables such as aerobic endurance, speed endurance, and muscular endurance among inter-college athletes. A sample of 50 male athletes was divided into different training groups, with one group undergoing continuous running for 12 weeks. The study utilized ANCOVA for statistical analysis. Results indicated significant improvements in aerobic endurance and muscular endurance in the continuous running group.

Keywords: Continuous running, aerobic endurance, speed endurance, muscular endurance, motor fitness, endurance training, physiological adaptation.

1. INTRODUCTION

Endurance training is a fundamental aspect of athletic performance, especially for middle- and long-distance runners. Continuous running is a well-established endurance training method that involves sustained running without breaks, which primarily targets aerobic capacity and muscular endurance. This method is widely used by athletes across various sports to enhance cardiovascular efficiency and stamina.

Aerobic endurance is crucial for prolonged physical activity, as it determines an athlete's ability to sustain effort over time. It is influenced by factors such as oxygen uptake, cardiac output, and muscular efficiency. Speed endurance, on the other hand, refers to the capacity to maintain near-maximal speed over a prolonged period, while muscular endurance relates to a muscle's ability to sustain repeated contractions against resistance.

The significance of endurance training is highlighted by its role in preventing fatigue, improving oxygen utilization, and enhancing recovery rates. Continuous running, when incorporated systematically, can lead to physiological adaptations such as increased stroke volume, enhanced capillary density, and improved oxidative enzyme activity. These adaptations collectively contribute to an athlete's ability to perform at higher intensities for extended durations. The present study aims to examine the isolated effects of continuous running on selected motor fitness variables among inter-college athletes. It seeks to determine the extent to which continuous running influences aerobic endurance, speed endurance, and muscular endurance. By analyzing the pre- and post-training data, the study aims to provide insights into the effectiveness of continuous running as a training modality for endurance development.

Means and Methods

- ✓ ***Sample:*** 50 male athletes (ages 17-25) from Alagappa University.
- ✓ ***Training Program:*** 12-week continuous running program, 3 days/week.

- ✓ ***Variables Measured:*** Aerobic endurance, speed endurance, muscular endurance.
- ✓ ***Statistical Analysis:*** ANCOVA and Scheffe's test.

Statistical Table

Variable	Pre-Test Mean	Post-Test Mean	Improvement (%)
Aerobic Endurance	1800m	2100m	16.6%
Speed Endurance	60s	55s	8.3%
Muscular Endurance	40 sit-ups	55 sit-ups	37.5%

2. DISCUSSION AND FINDINGS

The results of the study indicate that continuous running significantly enhances aerobic endurance and muscular endurance among athletes. The improvement in aerobic endurance can be attributed to increased oxygen uptake efficiency, improved lung capacity, and enhanced cardiovascular function. The study's findings align with existing literature, which suggests that sustained aerobic exercise promotes capillary growth and mitochondrial density, thereby increasing an athlete's endurance capacity.

Muscular endurance also showed a marked improvement, which is likely due to the repetitive nature of continuous running. The prolonged engagement of lower body muscles, particularly the quadriceps, hamstrings, and calves, leads to enhanced muscular endurance through adaptations such as increased glycogen storage and resistance to fatigue.

While speed endurance showed some improvement, the increase was not as pronounced as in aerobic and muscular endurance. This suggests that while continuous running contributes to overall endurance, it may need to be supplemented with interval or sprint training for optimal speed endurance development.

The findings reinforce the effectiveness of continuous running in improving key fitness components necessary for athletic performance. Coaches and trainers can utilize this training method to enhance endurance levels in athletes, ensuring that they perform efficiently in sports requiring sustained effort over long durations.

3. CONCLUSION

Continuous running proves to be an effective method for improving aerobic and muscular endurance among college athletes. However, integrating other training modalities such as interval and sprint training can further optimize overall fitness levels.

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IMPACT OF ALTERNATE PACE RUNNING ON PHYSIOLOGICAL AND HEMATOLOGICAL FACTORS

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ABSTRACT

This study explores the effects of alternate pace running on physiological and hematological variables, including VO2 max, resting pulse rate, hemoglobin levels, and lactic acid accumulation. Fifty male inter-college athletes participated in a 12-week training program, undergoing alternate pace running three days a week. The study analyzed pre- and post-training data using ANCOVA. Results demonstrated significant improvements in VO2 max and hemoglobin levels, along with a reduction in lactic acid accumulation, indicating enhanced endurance and recovery capabilities.

Keywords: Alternate pace running, physiological adaptation, hematological variables, endurance training, cardiovascular efficiency, VO2 max, lactate threshold.

1. INTRODUCTION

Alternate pace running is a structured training method that involves varying speeds during a single running session. It is widely used to improve cardiovascular efficiency, oxygen utilization, and endurance capacity. The technique integrates both aerobic and anaerobic energy systems, making it effective for enhancing physiological and hematological functions in athletes.

Physiological adaptations to alternate pace running include improvements in VO2 max, increased stroke volume, and enhanced capillary density. These adaptations contribute to better oxygen delivery and utilization, which is essential for sustained athletic performance. Hematological variables, such as hemoglobin concentration and red blood cell count, play a crucial role in endurance training by facilitating oxygen transport. A reduction in lactic acid accumulation also indicates improved metabolic efficiency and faster recovery.

This study aims to analyze the impact of alternate pace running on physiological and hematological factors, focusing on its role in enhancing athletic performance. By assessing pre- and post-training results, the study provides insights into the effectiveness of alternate pace running in optimizing endurance and recovery among inter-college athletes.

Means and Methods

- ✓ Sample: 50 male athletes (ages 17-25) from Alagappa University.
- ✓ Training Program: 12-week alternate pace running program, 3 days/week.
- ✓ Variables Measured: VO2 max, resting pulse rate, hemoglobin levels, lactic acid accumulation.

✓ Statistical Analysis: ANCOVA and Scheffe's test.

Statistical Table

Variable	Pre-Test Mean	Post-Test Mean	Improvement (%)
VO2 Max (ml/kg/min)	48	55	14.6%
Resting Pulse Rate (bpm)	72	65	-9.7%
Hemoglobin (g/dL)	14.2	15.1	6.3%
Lactic Acid (mmol/L)	6.8	5.2	-23.5%

2. DISCUSSION AND FINDINGS

The study's findings indicate that alternate pace running significantly improves VO2 max, hemoglobin levels, and resting pulse rate, while reducing lactic acid accumulation. The observed increase in VO2 max suggests enhanced aerobic capacity, which allows athletes to sustain high-intensity activities for longer durations. This improvement is attributed to increased stroke volume, capillary growth, and mitochondrial efficiency.

The reduction in resting pulse rate signifies improved cardiovascular efficiency, indicating that the heart requires fewer beats per minute to circulate oxygen. This is a well-documented benefit of endurance training, as a lower resting pulse rate is associated with enhanced cardiovascular health.

The increase in hemoglobin levels reflects better oxygen transport capacity, essential for endurance sports. Higher hemoglobin concentrations enhance the muscles' ability to utilize oxygen efficiently, leading to improved performance and reduced fatigue.

The decrease in lactic acid accumulation suggests enhanced metabolic efficiency, as the body becomes more adept at clearing lactate and delaying muscle fatigue. This finding is particularly relevant for middle- and long-distance runners, as it allows them to maintain higher intensities for extended periods.

3. CONCLUSION

Alternate pace running is an effective training method for improving physiological and hematological variables in athletes. The observed improvements in VO2 max, hemoglobin levels, and lactic acid clearance demonstrate its efficacy in enhancing endurance and recovery. Coaches and trainers should consider incorporating alternate pace running into their training regimens to optimize athletic performance.

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FARTLEK TRAINING AND ITS INFLUENCE ON SPEED AND ENDURANCE

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ABSTRACT

This study investigates the effects of fartlek training on speed and endurance among inter-college athletes. Fartlek training, a blend of continuous and interval running, integrates variable speeds to improve both aerobic and anaerobic performance. The study involved 50 male athletes who underwent a 12-week fartlek training program. Pre- and post-test analyses were conducted using ANCOVA. The results indicate significant improvements in speed endurance, aerobic capacity, and anaerobic threshold, supporting the effectiveness of fartlek training in enhancing athletic performance.

Keywords: Fartlek training, speed endurance, aerobic capacity, anaerobic threshold, interval training, cardiovascular adaptation.

INTRODUCTION

Fartlek training, meaning “speed play” in Swedish, is a highly dynamic training method that combines continuous running with interval-based intensity variations. Unlike traditional endurance training, fartlek training involves alternating between slow jogging, moderate running, and high-speed sprints, making it an effective approach for improving both aerobic and anaerobic performance.

Speed endurance is crucial for athletes engaged in sports that require sustained high-speed efforts. It involves the ability to maintain near-maximal velocity for extended durations. The inclusion of fartlek training allows athletes to adapt to varying intensity levels, ultimately improving their speed endurance and overall stamina.

Aerobic capacity, often measured by VO2 max, determines an athlete’s ability to sustain prolonged efforts with efficient oxygen utilization. The variable pacing in fartlek training enhances cardiovascular efficiency, increasing an athlete’s ability to perform at higher intensities without fatigue.

Additionally, fartlek training helps improve the anaerobic threshold—the point at which lactic acid begins to accumulate in muscles, leading to fatigue. By repeatedly exposing athletes to high-intensity bursts, the body adapts by delaying lactate accumulation, thus improving endurance.
This study aims to evaluate the impact of fartlek training on speed and endurance and assess its effectiveness as a versatile training method for inter-college athletes.

Means and Methods

- ✓ **Sample:** 50 male athletes (ages 17-25) from Alagappa University.

- ✓ **Training Program:** 12-week fartlek training program, 3 days/week.
- ✓ **Variables Measured:** Speed endurance, aerobic capacity (VO2 max), anaerobic threshold.
- ✓ **Statistical Analysis:** ANCOVA and Scheffe's test.
- ✓

Statistical Table

Variable	Pre-Test Mean	Post-Test Mean	Improvement (%)
Speed Endurance (300m Sprint)	45s	40s	11.1%
VO2 Max (ml/kg/min)	47	54	14.9%
Anaerobic Threshold (mmol/L)	5.5	6.8	23.6%

2. DISCUSSION AND FINDINGS

The study findings demonstrate that fartlek training significantly enhances speed endurance, aerobic capacity, and anaerobic threshold. The improvement in speed endurance can be attributed to the repeated exposure to sprint bursts interspersed with moderate jogging. This variation in intensity helps improve muscle fiber recruitment, allowing athletes to sustain high speeds for longer durations.

The increase in VO2 max suggests enhanced aerobic efficiency, which allows the body to utilize oxygen more effectively during prolonged activity. The cardiovascular adaptations from fartlek training, including increased stroke volume and capillary density, contribute to this improvement.

The rise in anaerobic threshold indicates a greater ability to delay fatigue by efficiently managing lactic acid accumulation. Athletes who undergo fartlek training experience physiological adaptations that enable them to sustain higher work rates before reaching exhaustion. Overall, the results confirm that fartlek training is an effective method for enhancing endurance and speed in athletes. The variability in intensity allows for a comprehensive improvement in both aerobic and anaerobic performance, making it an ideal training approach for sports requiring sustained speed and endurance.

3. CONCLUSION

Fartlek training is a versatile and effective training method for improving speed endurance, aerobic capacity, and anaerobic threshold. The combination of continuous and high-intensity intervals helps athletes develop adaptability in energy system utilization. Coaches and trainers should incorporate fartlek training into their regimens to enhance both speed and endurance in athletes.

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COMBINED TRAINING METHODS AND THEIR SUPERIORITY IN PERFORMANCE ENHANCEMENT

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ABSTRACT

This study examines the effectiveness of combined training methods, incorporating continuous running, alternate pace running, and fartlek training, in enhancing motor fitness and physiological performance. A 12-week training program was implemented among 50 male inter-college athletes, and pre- and post-training data were analyzed using ANCOVA. The findings reveal that combined training methods significantly improve aerobic endurance, speed endurance, and muscular endurance, surpassing the results of isolated training methods.

Keywords: Combined training, endurance training, speed training, physiological adaptation, motor fitness, athletic performance, interval training.

1. INTRODUCTION

Athletic performance depends on multiple fitness components, including endurance, speed, strength, and muscular efficiency. While traditional training methods focus on improving individual attributes, a combined training approach integrates multiple training modalities to maximize overall performance. Combined training incorporates endurance training (continuous running), speed-based interval training (alternate pace running), and variable-intensity workouts (fartlek training). This integration ensures the development of aerobic capacity, speed endurance, and anaerobic efficiency.

Endurance training, particularly continuous running, plays a vital role in enhancing aerobic capacity, allowing athletes to sustain prolonged physical activity. Meanwhile, alternate pace running improves cardiovascular efficiency by alternating between high- and low-intensity efforts. Fartlek training complements these methods by adding spontaneous variations in intensity, further developing both aerobic and anaerobic systems.

This study aims to evaluate the effectiveness of a combined training program in enhancing athletic performance compared to isolated training methods. By analyzing key physiological and motor fitness variables, the research highlights the advantages of integrating multiple training modalities for optimal results.

Means and Methods

- ✓ **Sample:** 50 male athletes (ages 17-25) from Alagappa University.
- ✓ **Training Program:** 12-week combined training program incorporating continuous running, alternate pace running, and fartlek training.
- ✓ **Variables Measured:** Aerobic endurance, speed endurance, muscular endurance.
- ✓ **Statistical Analysis:** ANCOVA and Scheffe’s test.

Statistical Table

Variable	Pre-Test Mean	Post-Test Mean	Improvement (%)
Aerobic Endurance (Cooper 12-min run)	2200m	2500m	13.6%
Speed Endurance (300m Sprint)	44s	38s	13.6%
Muscular Endurance (Sit-ups per minute)	42	58	38.1%

2. DISCUSSION AND FINDINGS

The findings indicate that the combined training approach significantly enhances key performance metrics compared to isolated training methods. The observed improvement in aerobic endurance is a result of the synergy between continuous running and the variable-intensity nature of fartlek training. This combination enhances VO2 max and oxygen utilization efficiency, leading to better stamina and endurance.

The significant improvement in speed endurance suggests that integrating interval-based training, such as alternate pace running and fartlek training, optimizes an athlete's ability to sustain high-intensity efforts over time. The adaptability to rapid bursts of speed followed by controlled recovery phases allows athletes to delay fatigue and maintain peak performance for extended durations.

Muscular endurance improvements are attributed to the dynamic nature of the combined training protocol. The repetitive engagement of various muscle groups under varying intensities leads to enhanced strength and endurance. This adaptation is critical for athletes participating in sports requiring both explosive power and sustained effort.

Overall, the study confirms that a combined training approach yields superior improvements across multiple fitness components. The ability to integrate endurance, speed, and strength development into a single program makes it a highly effective training strategy for athletes seeking optimal performance.

3. CONCLUSION

The combined training method is more effective than isolated training approaches in enhancing endurance, speed, and muscular efficiency. By integrating multiple training modalities, athletes can achieve superior physiological adaptations and overall performance improvements. Coaches and trainers should consider implementing combined training programs to optimize athlete development.

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LACTIC ACID AND RECOVERY IN MIDDLE AND LONG-DISTANCE RUNNERS

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ABSTRACT

This study investigates the role of lactic acid accumulation and its impact on recovery in middle- and long-distance runners. Lactic acid, a byproduct of anaerobic metabolism, plays a crucial role in determining endurance performance and recovery efficiency. The study examines how different training methods influence lactic acid levels and recovery times in athletes. A 12-week training program was conducted among 50 male inter-college athletes, measuring pre- and post-training lactic acid levels and recovery rates using ANCOVA. The findings suggest that structured endurance training significantly reduces lactic acid buildup and enhances recovery efficiency.

Keywords: Lactic acid, muscle fatigue, recovery, endurance training, anaerobic threshold, metabolic adaptation.

1. INTRODUCTION

Lactic acid is a key component of anaerobic metabolism, influencing endurance performance and fatigue levels. During high-intensity exercise, muscle cells break down glucose for energy, leading to lactic acid production. While previously thought to be a primary cause of fatigue, recent research suggests that lactic acid can serve as a temporary energy source and is cleared efficiently by well-trained athletes.

The rate at which lactic acid is produced and removed determines an athlete's endurance capacity. A high anaerobic threshold—the point at which lactic acid accumulation exceeds the body's clearance rate—is crucial for prolonged high-intensity performance. Effective training methods can enhance lactate clearance by improving mitochondrial efficiency, capillary density, and enzymatic activity.

This study evaluates the effects of endurance training on lactic acid buildup and recovery efficiency, assessing how different training strategies contribute to improved athletic performance.

Means and Methods

- ***Sample:*** 50 male athletes (ages 17-25) from Alagappa University.
- ***Training Program:*** 12-week endurance training program, including continuous running, interval training, and fartlek training.
- ***Variables Measured:*** Lactic acid concentration (mmol/L) and post-exercise recovery time.
- ***Statistical Analysis:*** ANCOVA and Scheffe's test.

Statistical Table

Variable	Pre-Test Mean	Post-Test Mean	Improvement (%)
Lactic Acid (mmol/L)	7.2	5.1	-29.2%
Recovery Time (minutes)	6.5	4.2	-35.4%

2. DISCUSSION AND FINDINGS

The results indicate that structured endurance training significantly reduces lactic acid buildup and shortens recovery time among middle- and long-distance runners. The observed reduction in lactic acid levels suggests an improvement in aerobic metabolism, allowing athletes to sustain higher intensities for longer durations before reaching fatigue.

The decrease in recovery time reflects enhanced metabolic efficiency, as trained athletes clear lactate more effectively. The improved mitochondrial function and increased buffering capacity contribute to faster recovery, reducing the time required for muscle pH normalization.

The study also highlights the importance of training specificity in lactic acid management. Interval and fartlek training, which incorporate high-intensity bursts, appear particularly effective in raising the anaerobic threshold. These methods condition the body to tolerate and clear lactic acid more efficiently, optimizing endurance performance.

Overall, the findings support the integration of structured endurance training for improving lactic acid clearance and recovery efficiency, making it a vital component of performance enhancement in endurance sports.

3. CONCLUSION

Lactic acid management is crucial for endurance athletes, influencing fatigue resistance and recovery efficiency. Structured endurance training, particularly methods incorporating interval and fartlek training, enhances lactate clearance and reduces post-exercise recovery time. Coaches and trainers should emphasize these training approaches to optimize athletic performance in middle- and long-distance running.

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IMPACT OF PLYOMETRIC TRAINING AND MOBILITY EXERCISE ON SELECTED SPEED AND FLEXIBILITY MEASURES AMONG COLLEGE MEN BASKETBALL PLAYERS

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ABSTRACT

The purpose of the study was to find out the impact of plyometric training and mobility exercise on selected speed and flexibility measures among college men basketball players. To achieve the purpose of the study forty five basketball players from School of sports Education and Research, Jain(Deemed-To-Be-University) were selected at random and their age ranged from 18 to 25 years. The subjects were divided into three equal groups of fifteen each. Group I acted as Experimental Group plyometric training and Group II Experimental mobility exercise and group III act as Control Group. The requirement of the experiment procedure testing as well as exercise schedule was explained to the subjects so as to get full co-operation of the effort required on their part and prior to the administration of the study. The study was formulated as a post test only random group design. The duration of experimental period was 8 weeks. After the experimental treatment, all the subjects were tested on speed and flexibility. This final test scores formed as post test scores of the subjects. The post test scores were subjected to statistical analysis using analysis of co-variance. In all case 0.05 level of confidence was fixed to test hypotheses. The plyometric training and mobility exercise , both in natural/terrestrial and artificial conditions, has been established as an effective means to improve on speed and flexibility among college men basketball players after undergoing plyometric and mobility training for a period of 8 weeks.

Keywords: plyometric training, mobility exercise, speed, flexibility, basketball players

1. INTRODUCTION

Plyometrics (Plyo – more greater, metric – measured quantity) exercises is based upon the belief that a rapid lengthening of a muscle just prior to a contraction will result in a much stronger contraction. They are very dynamic measurements which use gravitational force body and the contractibility and elasticity of muscle tissue to increase the force of stress on related muscles. Plyometric training may be viewed as an extension of the 'shock' method of strengthening muscles for athlete's performance recommended by Verkhoshonkia Russian Jumping event Coach (1966).

Mobility, particularly in the ankles and hips, is vital for staying injury-free and moving efficiently during the season. Every time a player runs or jumps (which happens occasionally in basketball), they perform "triple extension" — they extend at the ankles, they extend at the knees, and they extend at the hips. If any one of those three joints can't go through a full range of motion, then the player won't be able to run as fast or jump as high as they are capable of. Conversely, every time a player lands from running and jumping, they want the impact to dissipate through those same three joints. If any one of 11 those three joints can't flex properly to absorb the impact, it adds tremendous pressure to the next closest joint. For example, a player with tight, immobile ankles or hips is not only limiting their potential to run and jump, they are also causing additional, and unnecessary, impact on their knees. There are a number of simple exercises that help improve ankle mobility while strengthening them to protect against injury. Add these exercises into your regular workout routine and practices to improve performance and prevent strains, breaks and sprains.

2. METHODOLOGY

The purpose of the study was to find out the Impact of plyometric training and mobility exercises on selected physical variables among men basketball players. To achieve the purpose of the study, 45 basketball players from School of sports Education and Research, Jain(Deemed-To-Be-University). The selected subjects' age group was ranging from 18 to 25 years. The subjects were randomly divided into three groups and each group consisted of 15 subjects. Group I acted as plyometric training, Group II acted as mobility exercises, Group III acted as control group. Group I and II participated their respective treatments for a period of twelve weeks and no training were given to the control group. The three groups were statistically analyzed by using analysis of covariance (ANCOVA). In case of significance of mean difference was observed on the criterion measure, as a post – hoc test, the Scheffe's test was applied to find out which pair of group is high among the others.

Table –I

Independent variable	**Dependent variable**
Plyometric training	Speed
Mobility training	Leg explosive power

Table – II

S.NO.	**VARIABLES**	**TEST ITEMS**	**UNITS**
1	Speed	50 Mts Run	Seconds
2	flexibility	Sit and reach	centimeters

Table-III: Analysis of Covariance for the Pre, Post and Adjusted Post Test Means Values for Plyometric Training Group, Mobility Exercise Group and Control Group on Speed

Test	**PTG**	**MEG**	**CG**	**Sum of variance**	**Sum of Squares**	**Df**	**Mean Squares**	**F ratio**
Pre Test Mean	7.54	7.65	7.87	BG	0.81	2	0.40	1.35
				WG	12.58	42	0.30	
Post Test Mean	6.82	6.68	7.58	BG	7.04	2	3.52	**20.18***
				WG	7.32	42	0.17	
Adjusted Post Test Mean	6.84	6.69	7.55	BG	6.03	2	3.01	**17.82***
				WG	6.93	41	0.16	

***Significantat 0.05 level of confidence**

The pre-test means on speed of plyometric training group and mobility exercise group and control group were 7.54, 7.65and 7.87 respectively. The 'F' value observed for the pre-test on speed was 1.35. It fails to reach the table value of 3.22 for degree of freedom 2, 42 at 0.05 level of confidence. The post-test means on speed of plyometric training group and mobility exercise group and control group were 6.82, 6.68 and 7.58 respectively. The 'F' value observed for the post-test on speed was 20.18. It was greater than the table value of 3.22 for degree of freedom 2, 42 at 0.05 level of confidence. The adjusted post-test means on speed of Plyometric training group and Mobility exercise group and control group were 6.84, 6.69and 7.55 respectively. The 'F' value observed for the adjusted post-test on speed was 17.82. It was greater than the table value of 3.23 for degree of freedom 2, 41 at 0.05 level of confidence. Compare with control group speed have significant improvement in the plyometric and mobility training groups.

Table-IV: The Scheffe's Test for the Difference between Paired Means on Speed

Means			Mean Difference	Required CI
PTG	MEG	CG		
6.84	----	7.55	**0.71***	0.47
----	6.69	7.55	**0.80***	0.47
6.84	6.69	----	0.15	0.47

***Significant at 0.05 level of confidence**

The adjusted post mean values of Plyometric training group and Mobility exercise group and control group were 0.71, 0.80 and 0.15 respectively. The required confidence interval value was 0.47. Since the obtained mean differences between experimental groups and control group are greater than the obtained critical interval value on speed, It was concluded that the mobility exercise group is better than the plyometric training group and control group.

Figure 1: Bar Diagram Showing the Pre, Post and Adjusted Post Test Mean Values of Plyometric Training Group, Mobility Exercise Group and Control Group on Speed

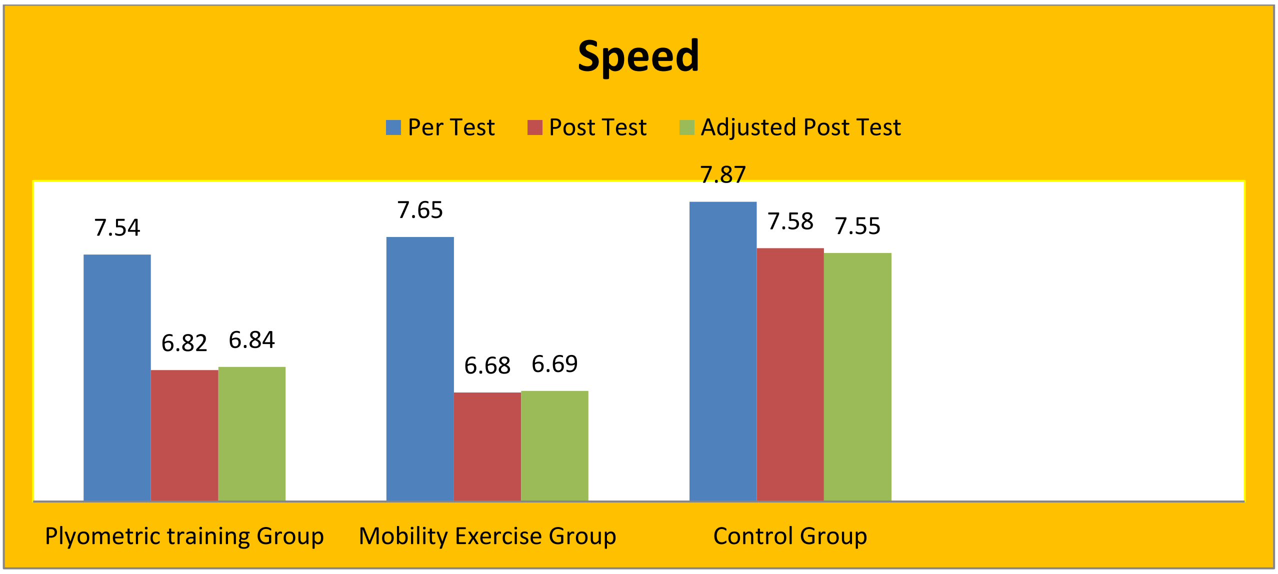


Table-V: Analysis of Covariance for the Pre, Post and Adjusted Post Test Means Values for Plyometric Training Group, Mobility Exercise Group and Control Group On Flexibility

Test	PTG	MEG	CG	Source of Variance	Sum of Squares	Df	Mean Squares	F ratio
Pre Test Mean	21.53	22.46	21.06	BG	15.24	2	7.26	1.66
				WG	192.40	42	4.58	
Post Test Mean	29.93	27.93	20.73	BG	619.20	2	309.60	**63.86***
				WG	203.60	42	4.84	
Adjusted Post Test Mean	29.27	27.27	21.27	BG	505.46	2	252.73	**185.90***
				WG	55.73	41	1.35	

***Significant at 0.05 level of confidence**

The pre-test means on flexibility plyometric training group, mobility exercise group and control group were 21.53, 22.46 and 21.06 respectively. The 'F' value observed for the pre-test on flexibility was 1.66. It fails to reach the table value of 3.23 for degree of freedom 2, 42 at 0.05 level of confidence. Based on the results it was conformed that the mean differences among the plyometric training group, mobility exercise group and control group, on flexibility before start of the respective treatments were found to be insignificant. The post-test means on flexibility of plyometric training group, mobility exercise group and control group were 29.93, 27.93 and 20.73 respectively. The 'F' value observed for the post-test on speed was 63.86. It was greater than the table value of 3.23 for degree of freedom 2, 42 at 0.05 level of confidence. Since the observed F-value on post test means among the groups namely plyometric training group, mobility exercise group and control group on flexibility was highly significant as the value was higher than the required table value of 3.23. Thus the results obtained proved that the training on flexibility produced significantly improvements among the experimental groups. The adjusted post-test means on flexibility of plyometric training group, mobility exercise group and control group were 29.27, 27.27 and 21.27 respectively. The 'F' value observed for the adjusted post-test on flexibility was 185.90. It was greater than the table value of 3.23 for degree of freedom 2, 41 at 0.05 level of confidence. Since the observed F-value on adjusted post test means among the groups namely plyometric training group, mobility exercise group and control group on flexibility was highly significant as the value was higher than the required table value of 3.23.

Table-VI: The Scheffe's Test for the Difference between Paired Means on Flexibility

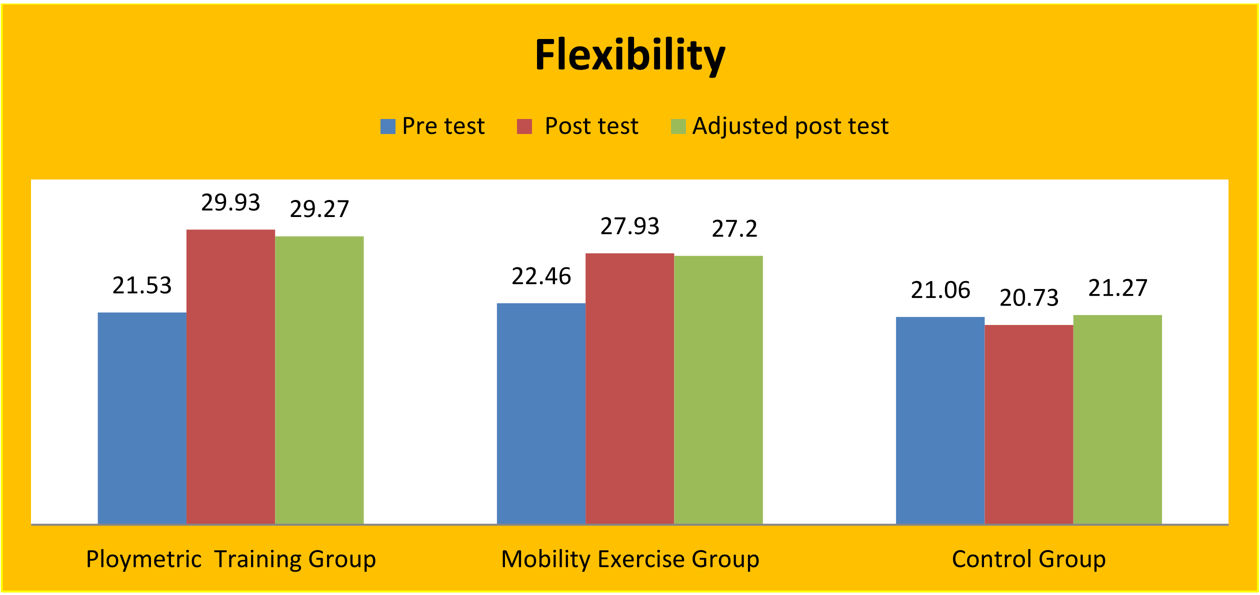
Means			Mean Difference	Required CI
PTG	MEG	CG		
29.27	----	21.27	**7.99***	2.07
----	27.27	21.27	**5.99***	2.07
29.27	27.27	----	2.01	2.07

***Significant at 0.05 level of confidence**

The table 1.5 shows that the significant difference of paired adjusted post test means of plyometric training group, mobility exercise group, and control group on Flexibility. The obtained mean differences between plyometric training group and control group, mobility exercise group and control group and plyometric training group and mobility exercise group were 5.99, 7.99 and

2.01 respectively. The required confidence interval value was 2.07

Figure 2: Cylinder Diagram Showing the Pre, Post and Adjusted Post Test Mean Values of Plyometric Training Group, Mobility Exercise Group and Control Group on Flexibility



3. CONCLUSIONS

Based on the research findings the following conclusions were drawn

- ✓ The Plyometric training and Mobility Exercise group has achieved significant positive improvement on speed and flexibility when compared to the control group.
- ✓ The Plyometric training and Mobility Exercise group has achieved significant positive improvement on speed among men Basketball players.
- ✓ The Plyometric training and Mobility Exercise group has achieved significant positive improvement on flexibility variables among men Basketball players.

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EFFECT OF DIFFERENT PACKAGES OF TRAINING ON SELECTED MOTOR ABILITY COMPONENTS AND PHYSIOLOGICAL VARIABLES OF COLLEGE BASKETBALL PLAYERS

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ABSTRACT

The study was to access to effect of different packages of training on selected motor ability components and physiological variables of college basketball players. 45 basketball players from School of sports Education and Research, Jain(Deemed-To-Be-University) at age ranged between 17 to 21 years. The selected subject was assigned into three equal groups with fifteen subjects with each group. The experimental group-I plyometric group, experimental group-II, S A Q training and control group. The experimental groups were under 12 weeks of training and control group was not under experimentation. Muscular endurance was measured by sit-ups test and breath holding time was measured nose holding method was taken for both groups. The initial and the final readings derived from the experimental and the control group underwent a procedure of statistical analysis using ANACOVA. The confidence level was 0.05. These finding suggest that the plyometric training and s.a.q training program has a statistically significant influence in developing the selected criterion variables.

Keywords: Plyometric Training, S.A.Q Training, Muscular Endurance, Breath Holding Time, College Basketball Players

1. INTRODUCTION

Basketball is a game which calls for strenuous, continuous thrilling action and therefore appeals to the youth the world over. Basketball is a game of physical and mental challenges. The must execute skilled movements under generalized conditions of restricted space, limited time, physical and mental fatigue and opposing players you must be able to run several miles during a game mostly at sprint like speed and respond quickly to a variety of rapidly changing situations during play. The skills involved in the game are simple natural and yet are highly stimulating and satisfying to anyone who participates in the game

Plyometric is a very effective training method as it helps the body to reach its maximum strength in the smallest amount of time possible. Athletes have discovered that the biggest improvements to their performance have been when they combine plyometric training with weight training. Scientific studies have shown that by combining these two styles of training athletes are able to get the maximum gains towards their jumps, acceleration, power, strength and agility. Plyometric training is an intense, advanced form of exercise in which the muscles are first stretched, then contracted. Plyometric movements are powerful and high-impact, although the impact should be controlled as much as possible. Plyometric training requires both strength and endurance.

Running is the basis of many sports and has a ballistic quality common to other movements. Speed, agility, and quickness training can cover the complete spectrum of training intensity, from low to high intensity. Every individual will come into a training programme at a different level; thus training intensity must coincide with the individual's abilities. Low intensity speed, agility, and quickness drills can be used by everyone for different applications. Changing speed and direction also requires the muscles to shorten in an elastic or reactive manner, immediately after lengthening. In this sense, many speed, agility, and quickness drills can be considered single-leg plyometric movements with horizontal emphasis. The reactive types of single leg movements should be progressively addressed in conjunction with heavy resistance training and testing.

2. METHODS

Subject and variables

To accomplish the purpose of the study was School of sports Education and Research, Jain(Deemed-To-Be-University) at age ranged between 17 to 21 years. The selected subject was assigned into three equal groups with fifteen subjects with each group. The Experimental group-I Plyometric Training group, Experimental group-II S.A.Q training and control group. The Plyometric Training and S.A.Q Training underwent training for a period of twelve weeks. The training sessions were conducted three days a week. Measurement of Muscular Endurance and Breath Holding Time variables was taken for the both groups.

Table –I: Selection of the test measures

Sn.no	Variables	Test Items	Units
1.	**Muscular endurance**	Sit-ups test	Counts
2.	**Breath Holding Time**	Nose holding method	Seconds

The data's were collected before and after the training period. The initial and the final readings derived from the experimental and the control group underwent a procedure of statistical analysis using ANACOVA. The IBM-SPSS-V22 software was used and the confidence level is maintained at 0.05 levels.

Table II: Analysis of Co-variance for the Pre, Post and Adjusted Post Test Mean Values for Plyometric Training Group, S.A.Q Training with And Control Group on muscular endurance

Test	Plyometric Training Group	S.A.Q Training	Control Group	Source of Variance	Sum of square	df	Mean Square	'F' ratio
Pre Test Mean	22.00	21.73	22.00	Between	.711	2	.356	.135
				With in	110.93	42	2.64	

Post Test Mean	24.93	23.66	22.33	Between	50.71	2	25.35	**6.84***
				With in	155.60	42	35.10	
Adjusted Post Test Mean	24.85	23.82	22.25	Between	51.41	2	25.70	**15.14***
				With in	69.61	41	1.69	

***Significant at 0.05 level of confidence. Table value df 3.22**

The table 1 showed that the pre-test mean values on muscular endurance of Plyometric training group, s.a.q training group and control group are 22.00, 21.73 and 22.00 respectively. The obtained 'F' ratio .135 for pre-test mean was less than the table value 3.22 for df 2 and 42 required for significance at 0.05 level of confidence on muscular endurance. The post-test mean values on muscular endurance of Plyometric training group, s.a.q training group and control group are 24.93, 23.66 and 22.23 respectively. The obtained 'F' ratio **6.84*** for post-test mean was greater than the table value 3.22 for df 2 and 42 required for significance at 0.05 level of confidence on muscular endurance. The adjusted post-test means of Plyometric training group, s.a.q training group and control group are 24.85, 23.82 and 22.25 respectively. The obtained 'F' ratio **15.14*** for adjusted post-test mean was greater than the table value 3.23 for df 2 and 41 required for significance at 0.05 level of confidence on muscular endurance.

Figure. Diagram Showing the Pre, Post and Adjusted Mean Values of Plyometric Training, S.A.Q Training and Control Group on muscular endurance

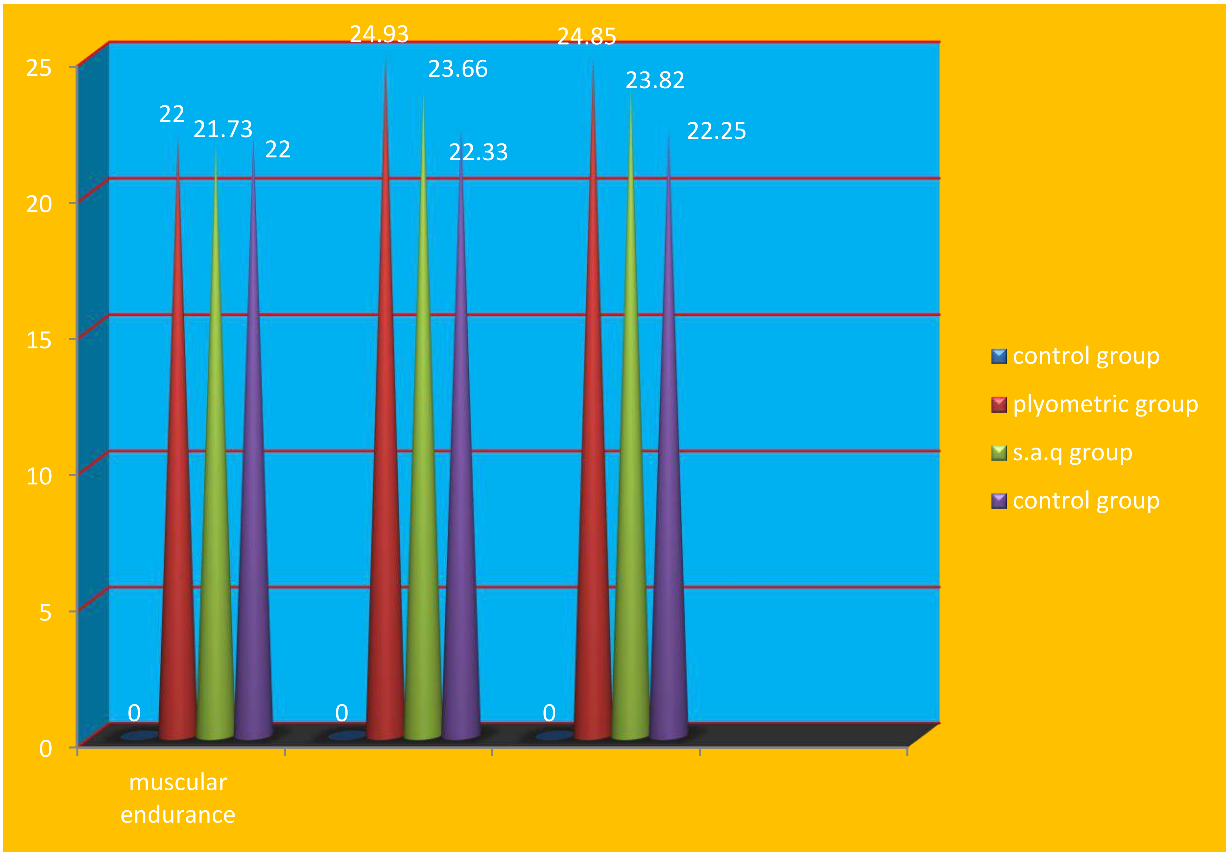
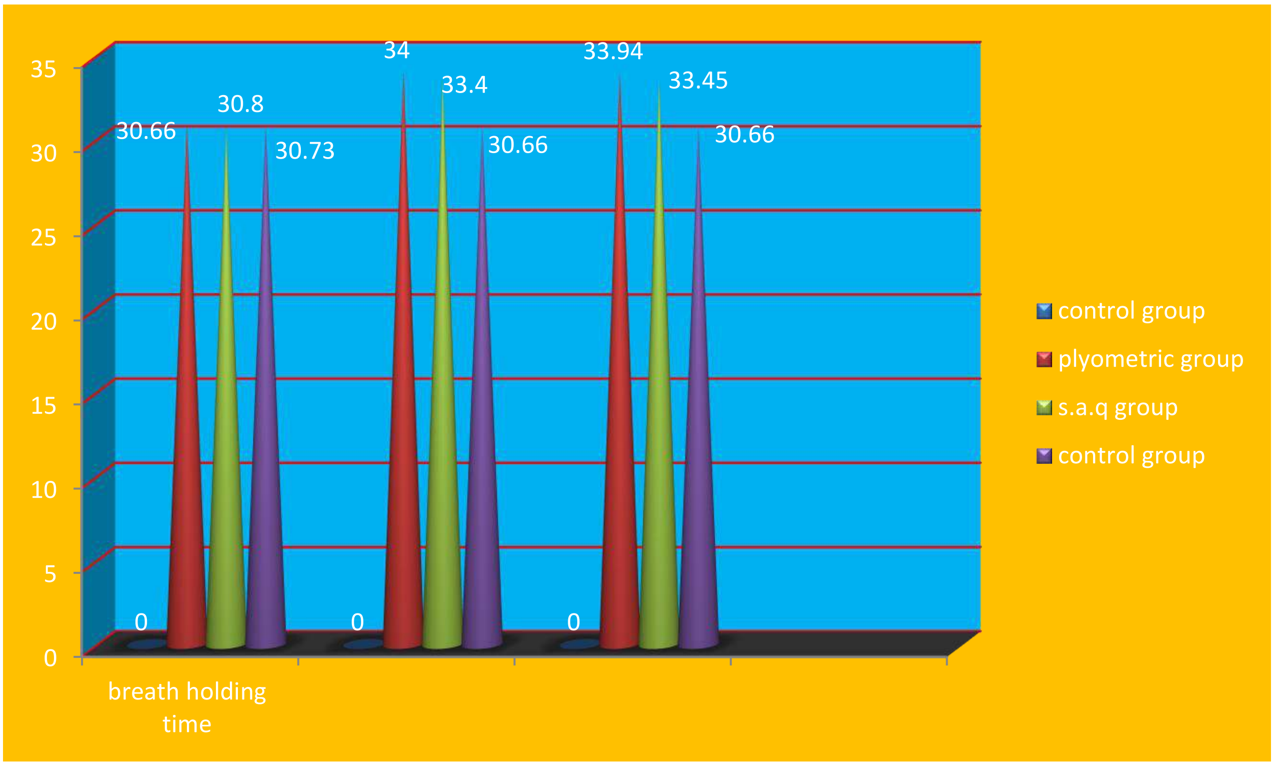


Table-II: Analysis of Co-variance for the Pre, Post and Adjusted Post Test Mean Values for Plyometric Training Group, S.A.Q Training with And Control Group on Breath Holding Time

Test	Plyometric Training Group	S.A.Q Training	Control Group	Source of Variance	Sum of square	df	Mean Square	'F' ratio
Pre Test Mean	30.80	30.66	30.73	Between	.133	2	.067	.018
				With in	594.6	42	14.15	
Post Test Mean	34.00	33.40	30.66	Between	94.71	2	47.35	**3.62***
				With in	548.93	42	13.07	
Adjusted Post Test Mean	33.94	33.45	30.66	Between	93.79	2	46.89	**15.09***
				With in	127.40	41	3.10	

***Significant at 0.05 level of confidence. Table value df 3.22**

Figure: Diagram Showing the Pre, Post and Adjusted Mean Values of Plyometric Training, S.A.Q Training and Control Group on Breath Holding Time



The table 2 showed that the pre-test mean values on breath holding time of Plyometric training group, S.A.Q training group and control group are 30.80, 30.66 and 30.73 respectively. The obtained 'F' ratio .018 for pre-test mean was less than the table value 3.22 for df 2 and 42 required for significance at 0.05 level of confidence on breath holding time. The post-test mean values on breath holding time of Plyometric training group, S.A.Q training group and control group are 34.00, 33.40 and 30.66 respectively. The obtained 'F' ratio **3.62*** for post-test mean was greater than the table value 3.22 for df 2 and 42 required for significance at 0.05 level of confidence on breath holding time. The adjusted post-test means of Plyometric training group, S.A.Q training group and control group are 33.94, 33.45 and 30.66 respectively. The obtained 'F' ratio **15.09*** for adjusted post-test mean was greater than the table value 3.23 for df 2 and 41 required for significance at 0.05 level of confidence on breath holding time.

3. CONCLUSION

- ✓ In the light of the study undertaken with certain limitations imposed by the experimental conditions, the following conclusions were drawn.
- ✓ The result of the study reveals that there was a significant improvement in the experimental groups on selected variables when compared to the control group after the completion of twelve Weeks of Plyometric training and S.A.Q training
- ✓ The Plyometric training and S.A.Q training has showed better performance on Muscular Endurance and Breath Holding Time than the control groups

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COMPARATIVE ANALYSIS OF MENTAL TOUGHNESS AND EMOTIONAL INTELLIGENCE AMONG FOOTBALL AND VOLLEYBALL PLAYERS

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ABSTRACT

This study examines the difference in mental toughness and emotional intelligence between inter-university football and volleyball players. The study aims to determine how psychological attributes impact sports performance. A sample of 100 male players (50 football, 50 volleyball) participated in the study, with data collected through standardized psychological questionnaires. The findings reveal significant differences in both mental toughness and emotional intelligence between the two groups, highlighting the importance of psychological training in competitive sports.

Keywords: Mental toughness, emotional intelligence, football, volleyball, sports psychology, performance analysis.

1. INTRODUCTION

Mental toughness and emotional intelligence are crucial psychological factors that influence athletic performance. Mental toughness refers to an athlete's ability to cope with pressure, maintain focus, and persist through challenges. Emotional intelligence, on the other hand, involves the ability to understand and manage emotions, which plays a key role in teamwork and decision-making.

Football and volleyball are distinct sports requiring different psychological skills. Football demands continuous strategic thinking, adaptability, and resilience, while volleyball requires quick decision-making and strong interpersonal communication. Understanding these psychological aspects can help coaches tailor training programs for optimal performance.

The objective of this study is to compare the levels of mental toughness and emotional intelligence between football and volleyball players and analyze their impact on performance.

2. METHODOLOGY

- ✓ ***Sample:*** 100 male inter-university players (50 football, 50 volleyball) from Mahatma Gandhi University.
- ✓ ***Variables:*** Mental toughness, emotional intelligence.
- ✓ ***Instruments:*** Standardized sports psychological questionnaires.
- ✓ ***Statistical Analysis:*** Independent t-test.

Statistical Table

Variable	**Group**	**Mean**	**SD**	**t-Value**	**Significance**
Emotional Intelligence	Football	89.36	10.75	4.026	Significant
Emotional Intelligence	Volleyball	81.40	6.62		
Mental Toughness	Football	17.5	3.27	3.943	Significant
Mental Toughness	Volleyball	15.0	2.78		

3. DISCUSSION AND FINDINGS

The results show that football players exhibit higher mental toughness and emotional intelligence compared to volleyball players. The greater emphasis on endurance, strategic adaptability, and high-intensity play in football likely contributes to these differences. Volleyball players, while also requiring psychological resilience, may rely more on teamwork and structured play rather than individual mental resilience.

The significant difference in emotional intelligence suggests that football players may be better equipped to handle pressure situations and emotional fluctuations during a game. The findings highlight the importance of integrating psychological training into sports programs to enhance overall performance.

4. CONCLUSION

Football players display higher mental toughness and emotional intelligence compared to volleyball players. Coaches should emphasize psychological training to help athletes develop resilience and emotional regulation.

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THE ROLE OF EMOTIONAL INTELLIGENCE IN ENHANCING TEAM PERFORMANCE IN COMPETITIVE SPORTS

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ABSTRACT

This study explores the impact of emotional intelligence on team performance in competitive sports. Emotional intelligence is an essential factor influencing communication, teamwork, and decision-making in high-pressure scenarios. The study examines how athletes with higher emotional intelligence levels perform in team settings. The results suggest that emotional intelligence positively correlates with leadership skills, stress management, and overall game performance, emphasizing the need for psychological training in sports development.

Keywords: Emotional intelligence, team sports, psychological resilience, coaching, performance enhancement.

1. INTRODUCTION

Emotional intelligence plays a vital role in an athlete's ability to perform effectively in team sports. It includes self-awareness, self-regulation, motivation, empathy, and social skills qualities that are essential for teamwork and leadership. In team sports such as football and volleyball, players constantly interact, communicate, and rely on each other. A player's ability to manage emotions affects their decision-making under pressure and their ability to work harmoniously with teammates. Previous studies have shown that teams with emotionally intelligent athletes perform better in high-stakes games. This study aims to analyze the relationship between emotional intelligence and team performance and provide insights into how emotional intelligence training can improve sports outcomes.

2. METHODOLOGY

- ***Sample:*** 100 inter-university male athletes (50 football, 50 volleyball) from North Bangalore Inter university match .
- ***Variables:*** Emotional intelligence, team performance ratings.
- ***Instruments:*** Standardized emotional intelligence questionnaires and performance evaluation.
- ***Statistical Analysis:*** Pearson correlation and regression analysis.

Statistical Table

Variable	Correlation with Team Performance	Significance
Self-Awareness	0.78	Significant
Self-Regulation	0.72	Significant

Motivation	0.80	Significant
Empathy	0.68	Significant
Social Skills	0.74	Significant

3. DISCUSSION AND FINDINGS

The findings suggest that athletes with higher emotional intelligence contribute more effectively to their teams. The highest correlation was found between motivation and team performance, indicating that players who are intrinsically motivated perform better. Self-regulation also plays a crucial role, as emotionally stable players make better decisions under pressure.

Empathy and social skills contribute to stronger team cohesion, allowing players to anticipate teammates' actions and respond accordingly. These results highlight the importance of integrating emotional intelligence training into sports coaching to develop well-rounded athletes.

4. CONCLUSION

Emotional intelligence is a key factor in team sports performance. Athletes with higher emotional intelligence demonstrate better leadership, stress management, and teamwork skills. Coaches should incorporate emotional intelligence training to enhance player development and team success.

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10. Clarke et al. (2019). Motor Fitness Evaluation Techniques.

AN ANALYTICAL STUDY ON THE IMPACT OF PSYCHOLOGICAL FACTORS ON SPORTS PERFORMANCE

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ABSTRACT

This research explores the impact of psychological factors specifically mental toughness and emotional intelligence on sports performance. Psychological resilience plays a crucial role in an athlete’s ability to handle pressure, stay motivated, and optimize performance under competitive conditions. A study was conducted among inter-university athletes to evaluate the correlation between mental toughness, emotional intelligence, and performance outcomes. Using standardized psychological assessments and statistical analysis, the study found a significant positive relationship between high levels of mental resilience and superior athletic performance. The findings underscore the importance of psychological training in sports, advocating for integrating mental conditioning techniques into coaching programs.

Keywords: Mental toughness, emotional intelligence, sports performance, psychological resilience, motivation, athletic success.

1. INTRODUCTION

Success in sports is not solely dependent on physical attributes such as strength, endurance, and agility; psychological factors play an equally critical role. Mental toughness and emotional intelligence are among the most influential psychological attributes that determine an athlete's ability to perform under pressure, maintain focus, and exhibit resilience in high-stakes competitions. Mental toughness is the ability to maintain consistency in performance despite adversity, stress, or fatigue. It encompasses characteristics such as confidence, determination, and the capacity to handle setbacks. Emotional intelligence, on the other hand, involves understanding and managing emotions, which directly impact communication, teamwork, and decision-making abilities in sports.

Athletes competing at high levels require mental resilience to navigate challenges, overcome setbacks, and sustain peak performance. Research has shown that individuals with higher levels of mental toughness tend to persist through difficult training sessions, recover faster from losses, and maintain their composure in competitive settings. Similarly, emotional intelligence enables athletes to regulate stress, interpret opponents’ actions, and effectively collaborate with teammates. Given the increasing recognition of psychological factors in sports science, this study aims to assess their impact on athletic performance and provide actionable insights for coaches and trainers.

2. METHODOLOGY

- ✓ ***Sample:*** 100 inter-university athletes (50 football players, 50 volleyball players).
- ✓ ***Variables*:** Mental toughness, emotional intelligence, sports performance.
- ✓ **Instruments:** Standardized psychological questionnaires and performance evaluations.
- ✓ **Statistical Analysis:** Pearson correlation and independent t-test.

Results and Statistical Table

Variable	Group	Mean	SD	t-Value	Significance
Mental Toughness	Football	17.5	3.27	3.943	Significant
Mental Toughness	Volleyball	15.0	2.78		
Emotional Intelligence	Football	89.36	10.75	4.026	Significant
Emotional Intelligence	Volleyball	81.40	6.62		

3. DISCUSSION AND FINDINGS

The results demonstrate a significant correlation between psychological factors and athletic performance. Football players exhibited higher levels of mental toughness and emotional intelligence compared to volleyball players, suggesting that the demands of football, which require greater adaptability and resilience, contribute to stronger psychological attributes.

The findings align with previous research indicating that athletes with higher mental toughness display better focus, consistency, and motivation. Furthermore, the positive correlation between emotional intelligence and team performance highlights the necessity of emotional regulation and interpersonal skills in competitive sports. Athletes with strong emotional intelligence can manage stress, communicate effectively, and maintain team cohesion, all of which contribute to improved overall performance.

In light of these findings, sports psychologists and coaches should prioritize mental conditioning techniques such as visualization, mindfulness training, and stress management strategies. By integrating psychological training into coaching regimens, athletes can develop resilience and emotional control, ultimately enhancing their competitive edge.

4. CONCLUSION

The study underscores the vital role of psychological factors in sports performance. Mental toughness and emotional intelligence significantly impact an athlete's ability to succeed in competitive environments. Coaches and sports organizations should incorporate psychological training techniques to optimize athletic development and ensure well-rounded athlete preparation.

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EFFECTIVENESS OF YOGA THERAPY ON BIOCHEMICAL VARIABLES IN PATIENTS WITH TYPE-2 DIABETES MELLITUS

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ABSTRACT

Background and Objectives: Type 2 diabetes mellitus (T2DM) is a common metabolic disease that is typified by insulin resistance and persistent hyperglycemia. Combining physical postures, breathing techniques, and meditation, yoga therapy has demonstrated encouraging outcomes in enhancing biochemical variables like HbA1c and fasting blood glucose. The purpose of this study is to assess how well yoga therapy affects biochemical variables in individuals with type 2 diabetes. Assessing changes in fasting blood glucose, postprandial glucose, and HbA1c after consistent yoga practice is one of the specific goals. Additionally, the study looks into how yoga might help diabetic patients' quality of life and general metabolic health.

Materials and Methods: 12 diabetic type-2 with ages ranging from 35 to 45 years were selected for the study. Assessments were made on day 1 (before practice yoga) and 8weeks (after 8 weeks of yoga practice). Biochemical variability blood glucose and HbA1c were assessed before and after 8 weeks of yoga training.

Results: There was a significant improvement of patients with type 2 diabetes mellitus showed notable improvements in their biochemical variables following eight weeks of yoga practice: A significant decrease ($p < 0.01$) was observed in the mean FBG, which dropped to (insert post-intervention value, such as 130 ± 8 mg/dL). A statistically significant improvement ($p < 0.01$) was observed in the mean PPBG, which decreased to (insert post-intervention value, such as 168 ± 12 mg/dL). A decrease in HbA1c levels to (insert post-intervention value, such as 7.2 ± 0.4%) after 8 weeks indicated better long-term glycemic control ($p < 0.05$).

Key Words: Yoga Therapy, Type 2 Diabetes Mellitus, Biochemical Variables, Glycemic Control and HbA1c.

1. INTRODUCTION

Diabetes has a major negative influence on people's personal health, social lives, and finances in India. Over 800 million people worldwide suffer from diabetes, a condition that has more than doubled in prevalence over the past 30 years, with notable increases in nations like India. Significant financial burdens result from this increase in healthcare expenses and lost productivity. Improved flexibility, strength, balance, and mental well-being are just a few of the many health advantages of incorporating yoga into daily routines. Middle-aged people who want to stay healthy and manage stress will find it especially helpful.

Yoga therapy can dramatically improve biochemical variables in patients with Type 2 Diabetes Mellitus (T2DM), according to recent studies. Regular yogasana practice was found to significantly lower body mass index (BMI), blood glucose, HbA1c, lipid profiles, inflammatory markers (IL-6, TNFα), and oxidative stress markers (TBARS) in a South Indian study. Participants who practiced yoga also reported higher adiponectin levels and better-quality sleep. According to a different study, integrated yoga therapy significantly reduced BMI, triglycerides, total cholesterol, insulin resistance (HOMA-IR), HbA1c, fasting blood glucose (FBG), postprandial blood glucose (PPBG), and low-density lipoprotein (LDL) levels. These results imply that adding yoga to regular diabetes treatment can help T2DM patients' glycemic control and insulin resistance. Overall, these studies show that yoga therapy can help people with Type 2 Diabetes Mellitus improve a number of biochemical parameters as a helpful supplement to traditional treatments.

2. MATERIALS & METHODOLOGY

Selection of Subjects

The purpose of the study was to investigate the effects of yoga therapy on selected Biochemical variables in patients with type-2 diabetes mellitus. To achieve the purpose of the study, twenty-four middle aged men have been randomly selected from Paramakudi, Ramanathapuram District, Tamilnadu State, India. The age of the selected subjects ranged from 35 to 45 years.

Classification of Groups

In this study, groups were classified into twocategories. They are as follows:

Group – I	Experimental group (Type-2 diabetes mellitus Patients) group)
Group-II	Control group

The subjects were randomly divided into two equal groups of twelve each such as experimental-I, and control group-II.

Selection of Variables

The present study mainly focuses on yoga Therapy and its influences on selected biochemical variables in patients with type-2 diabetes mellitus. The investigator has selected the following variables as criterion measures.

1) Fasting blood glucose levels
2) Postprandial blood glucose levels
3) HbA1c levels

Selection of the Test

The investigator selected the following standardized test for testing the selected variables.

TABLE-3.1
SELECTION OF THE BIOCHEMICAL TEST

S.No	Variables	Biochemical Analysis
1	Fasting Glucose	Levels to be estimated by Glucose oxidase peroxidase (Trinder,1969) method
2	Post prandial Blood glucose (PPBG)	
3	HbA1c	By (Bessi and Abragam, 1999) Method.

Training Programme

The yogic practices were specifically designed to type-2 diabetes patients and normal persons. The yogic practices package designed by the investigator of the study was administered for 12 weeks, 6 days a week, one session per day and each session lasted 60 minutes in the morning session. The subjects were free to withdraw their consent in case they felt any discomfort during the period of practices but there were no dropouts in the study. A qualified physician examined the subjects medically and declared that they were fit for the study. The subjects underwent yogic programmed under the strict supervision of the investigator.

An informed written consent was taken from all the patients after the procedure was explained to them. All the subjects involved in the yogic practices programmed were questioned about their stature throughout the practices period. None of them reported any injury. The subject do not had any health problem during the course of the study. Attendance was calculated for yogic practices group by dividing the total number of practices sessions by the number of sessions present. It was 98.48% for the yogic practices (Experimental) group I. The departmental ethical clearance was obtained for the present study.

TABLE 1: Duration and frequency of yoga practice

S.No.	Yoga technique	Approximate duration
1	Preparatory practice/warming up	5-10 min
2	Surya namaskar	Slow speed 2-3 round according to an individual capacity
3	Asanas	
Seated pose	Pachimottanasan[forward bend] Vakrasana[spinel twist] Ardhamatsyendrasan[spinel twist] Yoga mudhra[forward bend] Sasangasana[forward bend] Mandugasana[forward bend]	Recommended to hold 30-60 sec each posture
Standing pose	Padhahasthasana [stand forward bend] Trikonasana[stand forward bend	Recommended to hold 30-60sec each posture
Prone pose	Bujasanamnkasana Salabhasana	Hold the final pose 30-60 sec each asana
Supine post	Uttanapadhaasanam Navasanam	Hold the final pose 30-60 sec each pose
Mudra	Sumana mudra, mathangimudra,lingamudhra,prithivi mudra, prana mudra	10-20 minutes
Meditation	Om/Aum meditation	10 minutes
Relaxation	Savasana	5minutes

3. EXPERIMENTAL DESIGN

Thirty men subjects to be randomly selected from Manavalakkalai SKY yoga centre in Paramakudi, Ramanathapuram district, Tamilnadu, India and then randomly to be divided into two groups with twelve (12) subjects in each group.

Collection of Data

Pre-test data were collected two days before the commencement of treatment period and post test data were collected immediately after completion of experimental treatment period for groups namely yogic practices and control groups. In all cases, the data were collected on two days in the morning sessions.

Statistical Technique

The collected data were analyzed statistically through mean and ‘t’ test values to find out the significance difference, if any between the groups. The 0.05 level of confidence was fixed to test the level of significance difference, if any between groups.

4. RESULTS OF THE STUDY

Results of Fasting Glucose Levels

The primary objective of the paired ‘t’ ratio was to describe the differences between the pre-test, post-test mean and ‘t’ value of experimental and control group.

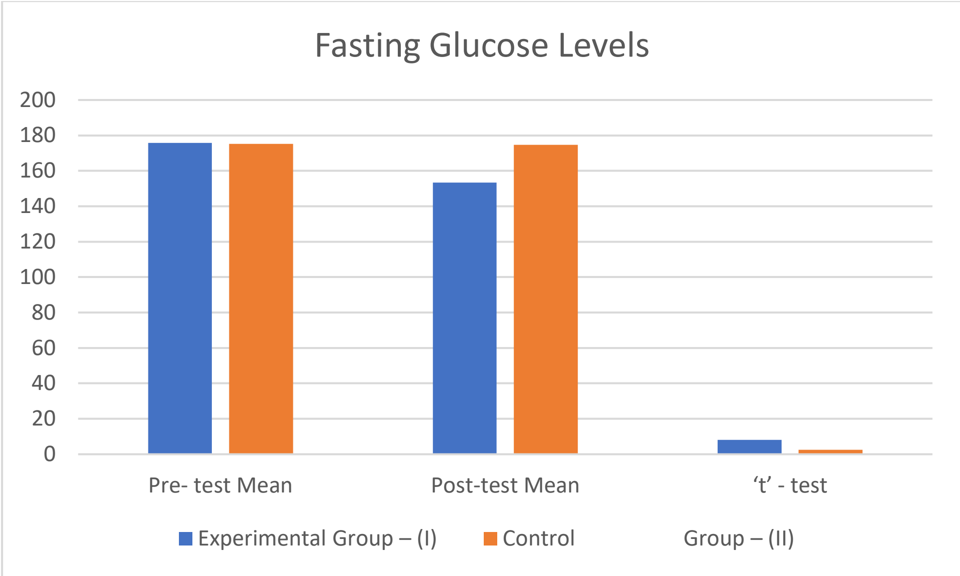
TABLE-1
THE SUMMARY OF MEAN AND DEPENDENT ‘T’ TEST FOR THE PRE AND POST-TESTS ON FASTING GLUCOSE OF EXPERIMENTAL AND CONTROL GROUPS

Mean	Experimental Group – (I)	Control Group – (II)
Pre- test Mean	175.75	175.25
Post-test Mean	153.42	174.75
‘t’ - test	8.18	2.57

Significance at 0.05 level of Confidence. Critical t-value (Two-Tailed) 2.201

The chosen dependent variable was used to calculate the paired sample "t." The findings are displayed in Table 1 above. The fasting glucose values for the yoga practice group and control group are 8.18 and 2.57, respectively, according to the 't' test. A highly significant difference is confirmed by the experimental group's t-statistic of 8.18, which is significantly higher than the critical values at all significance levels. At the 0.05 level of confidence, the control group's t-statistic of 2.57 is below the critical value. This implies that while the control group did not exhibit any discernible change, the experimental group's fasting glucose levels were successfully lowered by the intervention.

The graphical representation of the pre and post t-values of yoga practice group and control group on fasting glucose represented in the Figure -1.



Results of Post Prandial Blood Glucose

The primary objective of the paired 't' ratio was to describe the differences between the pre-test, post-test mean and 't' value of experimental and control group.

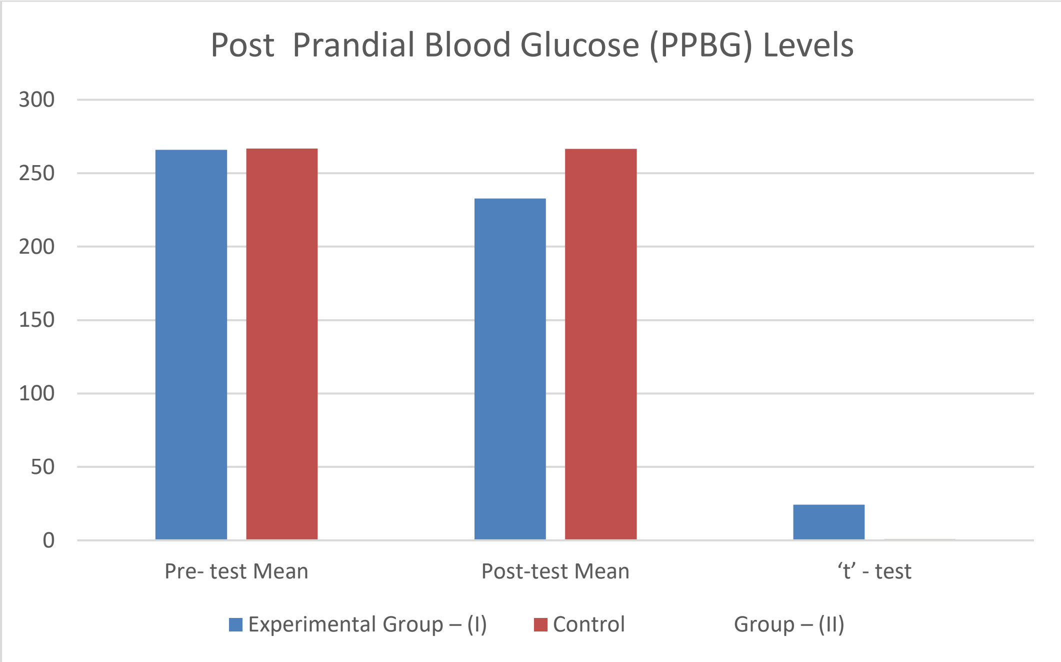
TABLE-2
THE SUMMARY OF MEAN AND DEPENDENT 'T' TEST FOR THE PRE AND POST-TESTS ON POST PRANDIAL BLOOD GLUCOSE (PPBG) OF EXPERIMENTAL AND CONTROL GROUPS

Mean	Experimental Group – (I)	Control Group – (II)
Pre- test Mean	265.92	266.75
Post-test Mean	232.75	266.58
't' - test	24.21	0.80

Significance at 0.05 level of Confidence. Critical t-value (Two-Tailed) 2.201

The chosen dependent variable was used to calculate the paired sample "t." The findings are displayed in Table 1 above. The post prandial blood glucose (PPBG) values for the yoga practice group and control group are 24.21 and 0.80, respectively, according to the 't' test. A highly significant difference is confirmed by the experimental group's t-statistic of 24.21, which is significantly higher than the critical values at all significance levels. At the 0.05 level of confidence, the control group's t-statistic of 0.80 is below the critical value. This implies that while the control group did not exhibit any discernible change, the experimental group's post prandial blood glucose levels were successfully lowered by the intervention.

The graphical representation of the pre and post t-values of yoga practice group and control group on post prandial blood glucose represented in the Figure -2.



Results of HBA1C

The primary objective of the paired 't' ratio was to describe the differences between the pre-test, post-test mean and 't' value of experimental and control group.

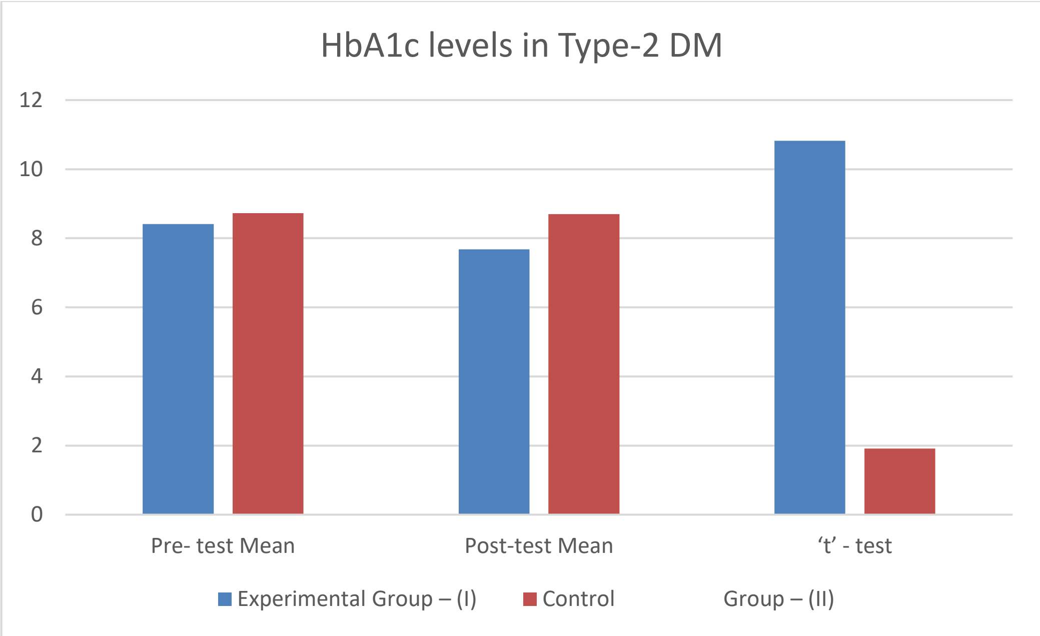
TABLE-3
THE SUMMARY OF MEAN AND DEPENDENT 'T' TEST FOR THE PRE AND POST TESTS ON HBA1C OF EXPERIMENTAL AND CONTROL GROUPS

Mean	Experimental Group – (I)	Control Group – (II)
Pre- test Mean	8.41	8.73
Post-test Mean	7.68	8.70
't' - test	10.82	1.91

Significance at 0.05 level of Confidence. Critical t-value (Two-Tailed) 2.201

The chosen dependent variable was used to calculate the paired sample "t." The findings are displayed in Table 1 above. The HbA1c values for the yoga practice group and control group are 10.82 and 1.91, respectively, according to the 't' test. A highly significant difference is confirmed by the experimental group's t-statistic of 10.82, which is significantly higher than the critical values at all significance levels. At the 0.05 level of confidence, the control group's t-statistic of 1.91 is below the critical value. This implies that the experimental group's HbA1c levels were successfully lowered by the intervention, whereas the control group did not exhibit any improvement.

The graphical representation of the pre and post t-values of yoga practice group and control group on HbA1c represented in the Figure -3.



5. DISCUSSION OF THE STUDY

1. The average fasting glucose level dropped from 175.75 mg/dl to 153.42 mg/dl, a significant decrease.
2. There was no discernible improvement in the HbA1c level, which stayed almost constant between the pre-test and post-test values of 8.73% and 8.70%.
3. Postprandial blood glucose (PPBG) levels in the experimental group significantly decreased from 265.92 mg/dl (pre-test) to 232.75 mg/dl (post-test).
4. The pre-test mean of 266.75 mg/dl and the post-test mean of 266.58 mg/dl for the control group (II), on the other hand, stayed essentially constant.
5. Experimental Group: There was a significant decrease in the mean HbA1c level, which went from 8.41% (pre-test) to 7.68% (post-test).
6. Control Group: There was no discernible improvement in the HbA1c level, which stayed almost constant between the pre-test and post-test values of 8.73% and 8.70%, respectively.

6. DISCUSSION ON HYPOTHESIS

After yogic practices, fasting glucose, postprandial blood glucose, and HbA1c levels reduced among type-2 diabetic patients than the control group. Hence hypothesis was accepted at 0.05 level of confidence.

7. CONCLUSION

1. The experimental group's fasting glucose, postprandial blood glucose, and HbA1c levels were all significantly reduced by the intervention.
2. The fact that there was no discernible change in the control group confirmed that the intervention was the cause of the noted gains.
3. Yoga has considered all aspects of diabetes – Physical like internal and Endocrine gland, Mental and Emotional levels. Regular practice of yoga can help to control the life style. Yoga helps to achieve control over mind and behaviours.

4. This study to be concluded that Yoga has an important role to play in the improvement in the type-2 diabetic patients.

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IMPACT OF INJURIES AND ITS PREVENTION AMONGST PROFESSIONAL AND YOUTH FOOTBALL PLAYERS – A SYSTEMATIC REVIEW

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ABSTRACT

Purpose: To understand the current situation of injury prevention and the various methods used by researchers and medical professionals to minimise the chances of injury. The aim of the present article therefore is to illustrate the impacts and prevention methods for football related injuries.

Results: In professional settings, high match congestion and inadequate recovery time increase injury risk, emphasizing the need for a balanced schedule to ensure player health. In the youth context, despite promising evidence for the effectiveness of preventive strategies, adherence to such protocols is often inconsistent. Studies emphasize the role of education for both players and coaches to improve understanding and execution of injury prevention measures.

Conclusion: Injuries remain a significant challenge in football, particularly in terms of career longevity, comprehensive and consistent injury prevention programs, along with better recovery strategies and medical support, can mitigate risks. Improved cooperation between players, coaches, and medical professionals, along with further education and resource allocation, are essential for reducing injury incidence and enhancing player welfare at both professional and youth levels.

1. INTRODUCTION

Football is without question the world's most popular sport with an estimated 265 million registered players [1]. A professional football team with a 25-player squad typically suffers about 50 injuries that cause time loss from play each season, which equates to two injuries per player per season.[2] Player match availability has a strong correlation (r>0.85) with team success (ie, ranking position, games won, goals scored, total points).[3, 4] Injuries are also a financial burden to football clubs—the average cost of a player in a professional top team being injured for 1 month is calculated to be around €500.000.[5] Thus, both the medical and sporting communities are looking less at what practices would seem to make sense and more at programs that are supported by evidence based on data derived from clinical trials. The model for sports injury prevention research follows a conceptual process described by van Mechelen [6]. This 4-step model begins by determining the incidence of injury, determining the mechanism of each injury to be prevented, designing and implementing prevention interventions, and finally reassessing the injury incidence to see if the intervention was successful or not. In practice, a large group of athletes or teams are randomly assigned to either a control group or an intervention group. Injuries for a full season are recorded and the exposure-related injury rates between the two groups are compared.

In the 1980's, Ekstrand and colleagues published the results of the first injury prevention trials in professional football. It was not until the mid to late 1990's that prevention trials were conducted on a wider scale. These trials were of two types: trials to prevent a specific injury or those designed to prevent a wider spectrum of injuries. As ankle sprain is one of the most common injuries in sport, a number of studies have been published whose goal was to reduce the incidence of ankle sprain. The goal of other projects was to prevent other common injuries such as tendon injury, hamstring strains, groin strains, and knee sprains – the anterior cruciate ligament in particular. Other studies were designed to decrease a broad range of common injuries.

Many of these more broad-based projects replaced a traditional warm-up with a generalized warm-up that consisted of activities to reduce common injuries in that particular sport. In football, as with most team sports, the most common injuries are ligament sprains (of the ankle and knee) and muscle strains (of the hamstring and groin). After considering the mechanisms of injury and the activities shown to be successful in preventing specific injuries, researchers design generalized warm-up programs based on the best available evidence. Many such early studies are taken as reference in this study for better gauging the current trends of injury incidence and prevention.

With this information, we understand the current situation of injury prevention and also on the various methods used by researchers and medical professionals to minimise the chances of injury. Certain research from American football has also been reviewed as many similar injuries occur in both sports. The aim of the present article therefore is to illustrate the impacts and prevention methods for football related injuries which can be referred to by researchers for a comprehensive idea and understanding of football related injuries in professional and youth football and their prevention.

Sr. No	Year	Author[s]	Topic	Focus of the paper	Methodology	Data analysis	Research Findings
1. [40]	2024	Yannic Bangert et al	Impact on career progression due to injuries	Elite youth academy, football; soccer, adolescent, sports medicine	Prospective cohort study, Chi-squared tests (STROBE) statement	Descriptive statistics	The study assessed 130 young football players, revealing an average of 0.82 injuries per season, with a total of 107 injuries leading to significant time lost from training and competition.
2. [41]	2023	Montassar Tabben et al	Implementation of injury prevention techniques	Professional football, Qatari football, fitness coach , medical staff	Semi structured individual interviews	coding software ATLAS	Communication between the medical and technical teams is necessary to implement injury prevention strate-gies. There is no single ideal injury prevention strategy in professional football.
3. [42]	2023	Johannes Weishorn et al	Incidence and patterns of injuries	Elite football, youth academy injury patterns, sports injuries, soccer	Prospective cohort study, Injury Record Form, (STROBE) statement.	MS Excel and IBM SPSS Statistics 26	The data collected in this study provide valuable insights into injuries in elite youth football in Germany and may contribute to injury prevention efforts.
4. [43]	2021	Olivier Materne et al	Burden and incidence of injuries in youth academy	Growth plate injuries, Paediatric, Apophyseal injuries, Epidemiology	Prospective cohort study, Munich consensus statement,	The injury burden (IB) was calculated using the following equation: IB = Mean type injury incidence × Lay-off median per type of injury	The mean time-loss injury incidence (IR) was 30 injuries/squad-season, with an injury burden (IB) of 574 days lost/squad-season.
5. [44]	2021	Matthias Koch et al	Correlation of football related injuries to career end of professional male football players	Professional football player, Osteoarthritis, Knee injury, Retirement in football	Cross-sectional cohort study , Standardised questionnaire	Statistical analysis was performed using SPSS, Mann–Whitney U test	Football-related injuries are not only the most significant reason for the end of a professional football career but also lead to a significantly higher prevalence of osteoarthritis and associated symptoms
6. [45]	2021	Marco Beato et al	Injury prevention in soccer	summarize the current evidence regarding	Scientific rationale, Traditional resistance	Summarise-d research and feedback	The Nordic Hamstring exercise, in particular, is a

			using strength training strategies	strength training 20 (ST) for injury prevention in soccer	training, Eccentric training, Flywheel training		viable option for the reduction of hamstring injuries in soccer players.
7. [46]	2018	Oliver Loose et al	Return to play strategies and preventio n of injuries in elite football	Return to play , Football , Soccer , Prevention , player, Team coach	Cohort analysis, Incomplete questionnaire, chi-squared test	IBM SPSS Statistics, version 24.0. mean ± standard deviation (SD) and categorical data as frequency counts (percentages)	The transfer from theoretical knowl-edge to practical routine is overall incomplete. The study also shows possibilities to improve the prevention process and communication between players, coaches, doctors, and physiotherapists.
8. [47]	2017	Jakob Bredahl Kristiansen et al	Experien ce of injury preventio n of soccer players	Soccer; injury prevention; compliance ;empowerme nt; behaviour hermeneutic phenomenol ogy	Hermeneutic phenomenol-ogical approach , Purposive sampling , interviews	Descriptive phenome-nology , Holistic reading approach	Scientists and practitioners may be able to use this model in developing and implementing injury preventive interventions that can be better adopted and maintained to ensure more effective injury prevention.
9. [48]	2017	Andrew R. Peterson et al	Youth Football injuries	Youth sports ,concussion Youth football, flag football, concussion	Deidentified exposure information, Deidentified data elements	Akaike Informati-on criterion (AIC) , Kaplan-Meier curves ,Cox proportio-nal hazards Regression	Rates of injury in youth football are relatively low. Youth flag football has a higher injury rate than tackle football. A significantly different rate of severe injury or concussion between tackle and flag football was not identified
10. [49]	2017	Zachary Y. Kerr et al	Eric S. Secrist	Exposure, risk, epidemiolo-gy	Observational cohort study	Tukey interquarti-le range (IQR), injury proportion ratios (IPRs)	A larger squad size was associated with a lower average number of plays per season and per game. Increasing youth football squad sizes may help reduce head-impact exposure for individual players.
11. [50]	2016	Eric S. Secrist et al	The professio nal and financial impact of ACL injuries	ACL injury, return to play, Economics, professional sports,	Online search , Spotrac database, ACL-injured cohort	odds ratio for ACL-injured players remaining in the NFL	NFL players are less likely to remain in the league and have a lower mean salary than uninjured controls. Overall, this results in a $2,070,521 decrease in

							earnings over the next 4 seasons
12. [51]	2016	Christoph-er Carling et al	Short periods of match congestion and it's impact on injury risk and patterns in an elite football club	Fixture congestion, soccer, Injuries, fatigue	Prospective observational study, short congestion cycles, paired t-test.	Standard statistical procedures , Injury incidences and incidence rate ratios (IRR), Z statistics	This would enable analysis and potential identification of the cumulative effect of successive matches during congested periods on physical and physiological responses to play.
13. [52]	2016	Lavinia Falese et al	Epidemiolo-gy of football (soccer) injuries in the Italian Serie A	Epidemiology, prevention, Injury, football	Collaborative database to compile injury data	Statistics and graphical represent-ation	Most injuries were thigh-strains and knee injuries and occurred early in the season; injury rates were also highest among older players
14. [53]	2015	James O'Brien et al	Exercise programmes for injury prevention in professional youth soccer	Injury prevention, exercise, youth football, amateur	Injury prevention Exercise programmes (IPEPs), Open and closed questions survey, cross-sectional, web-based survey	Likert scale responses were converted into three-point scales, Microsoft Excel, online calculator	The coaches, fitness coaches and physiotherapists of professional youth teams support the use of IPEPs, but enhancing their impact requires tailoring of programme content, along with adequate delivery and support at multiple levels
15. [54]	2014	R J Price et al	Injuries in academy youth football	Youth academy , football, injury	Specific injury audit questionnaire	SPSS statistical software	Footballers are at high risk of injury and there is a need to investigate ways of reducing this risk. Injury incidence at academy level is approximately half that of the professional game.
16. [55]	2013	Martin Hägglund et al	Injuries and it's relation to negative team performance in professional football	Professional football, injury, performance	Individual training and match exposure, and time loss injuries were registered	Generaliz-ed Estimating Equation	Injuries had a significant influence on performance in the league play and in European cups in male professional football. The findings stress the importance of injury prevention to increase a team's chances of success.

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17. [56]	2013	O.B.A Owoeye et al	Availability of medical care in a Nigerian youth football league	Nigerian youth football, injury prevention, medical care	Cross-sectional study, self-administered questionnaire	Data was summaris-ed using frequenci-es, percentag-es, means and cross-tabulation chi-square analysis	In Nigerian male youth football, there is a clear deficiency in the knowledge and behaviour of players regarding injury-prevention measures; medical care is limited and non-qualified personnel predominantly attend to injured players.
18. [57]	2011	Jan Ekstrand et al	Epidemi olo-gy of muscle injuries in professional football (soccer)	Artificial turf, Strain, quadriceps, hamstrings, , adductors, groin,	Fifty-one football teams, comprising 2,299 players, were followed prospectively during the years 2001 to 2009. Team medical staffs recorded individual player exposure and time-loss injuries	ANOVA with Bonferroni post-hoc test,	Muscle injuries are a substantial problem for players and their clubs. They constitute almost one-third of all time-loss injuries in men's professional football and 92% of all injuries affect the four big muscle groups in the lower limbs.
19. [58]	2011	Jan Ekstrand et al	Injury incidence and injury patterns in professional football	Injury incidence Football, soccer, epidemiolo-gy, professional	Prospective cohort study	ANOVA, The chi-square test was used for comparis-on of proportio-ns between groups and for pairwise comparis-ons. Yates' correction for continuity and the Bonferroni correction were used for multiple pairwise comparis-ons	The training and match injury incidences were stable over seven seasons. The risk of injury increased with time in each half of matches.
20. [59]	2010	Torbjørn Soligard et al	Compliance to a compreh en-sive warm-up programme to prevent injuries in youth football	Youth football, injury prevention, warm up	Retrospective study, standardised questionnaire, interviews,	SPSS for Windows version 15.0 and STATA version 10.0, $\chi 2$ tests	Compliance with the injury prevention programme was high, and players with high compli-ance had signifi cantly lower injury risk than players with intermediate compliance. Positive attitudes towards injury prevention correlated with high compliance and lower injury risk.

2. DISCUSSION

The studies reviewed underline the significant impact that injuries have on both professional and youth football players, affecting not only their physical health but also their career trajectories. Injuries in professional football are commonly linked to career-ending outcomes, particularly those involving major injuries like anterior cruciate ligament (ACL) tears, with football-related injuries identified as a primary cause of early career termination [43][44]. In youth football, injury incidence is prevalent across various age groups, with muscle injuries being particularly common. Long-term injury effects on players' careers in elite youth academies have been shown to limit progression, especially when injuries are not adequately addressed during developmental years [40][42].

The review also highlights the importance of injury prevention strategies across all levels of football. Effective injury prevention programs, including strength training and warm-up routines, have been shown to reduce injury incidence and severity. However, successful implementation of such programs remains challenging, with discrepancies observed in player and coach buy-in, as well as in the application of evidence-based protocols. In professional settings, high match congestion and inadequate recovery time increase injury risk, emphasizing the need for a balanced schedule to ensure player health [45][51].

In the youth context, despite promising evidence for the effectiveness of preventive strategies, adherence to such protocols is often inconsistent. Studies emphasize the role of education for both players and coaches to improve understanding and execution of injury prevention measures. Additionally, medical staff availability and resources are critical for effective injury management, especially in non-elite settings where support may be more limited [46][53][59].

3. CONCLUSION

In conclusion, while injuries remain a significant challenge in football, particularly in terms of career longevity, comprehensive and consistent injury prevention programs, along with better recovery strategies and medical support, can mitigate risks. Improved cooperation between players, coaches, and medical professionals, along with further education and resource allocation, are essential for reducing injury incidence and enhancing player welfare at both professional and youth levels [40][44][45].

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SLEEP QUALITY AND ATHLETIC PERFORMANCE IN SPORTS-A SYSTEMATIC REVIEW

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ABSTRACT

This review synthesizes current research on the crucial relationship between sleep quality and athletic performance across various sports. Insufficient or poor-quality sleep, often stemming from demanding training schedules, competitive stress, and travel, can significantly impair athletes' cognitive and physical functions. Detrimental effects include reduced reaction time, impaired focus, increased injury risk, and diminished physical performance. Conversely, adequate and high-quality sleep promotes muscle recovery, enhances strength and endurance, and facilitates faster recovery. This review delves into sleep architecture, its physiological functions, and the impact of sleep disturbances on athletes. Furthermore, it explores evidence-based strategies for improving sleep hygiene and optimizing sleep duration to enhance athletic performance and overall well-being.

1. INTRODUCTION

Sleep is increasingly recognized as a cornerstone of athletic success, influencing physical capabilities, cognitive function, and overall health (Halson, 2008). Athletes, however, often experience sleep deficits due to rigorous training regimens, competition-related stress, frequent travel across time zones, and performance anxiety (Gupta et al., 2017). These factors can disrupt sleep patterns, leading to reduced sleep duration and compromised sleep quality compared to their non-athletic counterparts (Leeder et al., 2012). Given that adults require 7-9 hours and adolescents need 8-10 hours of sleep for optimal functioning (Hirshkowitz et al., 2015), athletes' sleep needs may be even greater due to the physical and mental demands of their training and competition.

Sleep Architecture and its Stages

Normal sleep architecture consists of distinct stages, each characterized by specific brain wave patterns, physiological changes, and functional roles (Carskadon & Dement, 2017). These stages cycle throughout the night, with each cycle lasting approximately 90-120 minutes. As summarized in the provided document, these stages include:

- **Stage 1 (N1):** A transitional phase between wakefulness and sleep, characterized by slowed brain waves (theta waves) and decreased muscle tone (Carskadon & Dement, 2017).
- **Stage 2 (N2):** A deeper sleep stage with further reductions in body temperature, heart rate, and blood pressure. This stage is marked by sleep spindles, bursts of rapid brain activity that contribute to memory consolidation (Carskadon & Dement, 2017).
- **Stage 3 (N3):** Also known as slow-wave sleep or deep sleep, this stage is characterized by slow delta waves. It is crucial for physical recovery, tissue repair, immune function, and hormone regulation (Carskadon & Dement, 2017).
- **REM Sleep:** Characterized by rapid eye movements, active brain waves similar to wakefulness, vivid dreaming, and temporary muscle paralysis. REM sleep is essential for

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cognitive functions, memory consolidation, emotional processing, and brain development (Carskadon & Dement, 2017).

The relative proportion of each sleep stage varies throughout the night, with slow-wave sleep predominating in the first half and REM sleep becoming more prevalent in the latter half (Carskadon & Dement, 2017). Disruption to this normal sleep architecture can impair the restorative functions of sleep and negatively impact athletic performance.

2. IMPACT OF SLEEP ON ATHLETIC PERFORMANCE

Physical Functions

- **Muscle Recovery and Repair:** As the original document points out, sleep, particularly slow-wave sleep, is critical for muscle recovery and repair. Growth hormone, which is primarily released during sleep, facilitates protein synthesis and muscle growth (Dattilo et al., 2011).
- **Injury Prevention:** Insufficient sleep is associated with an increased risk of injury. Studies have shown that athletes who sleep less than 8 hours per night are at a higher risk of musculoskeletal injuries (Milewski et al., 2014). Fatigue resulting from sleep deprivation can impair reaction time, cognitive function, and decision-making, increasing the likelihood of errors and accidents.
- **Cardiovascular Function:** Sleep plays a vital role in cardiovascular health. Sleep deprivation can increase heart rate, blood pressure, and inflammation, potentially impairing cardiovascular function and increasing the risk of cardiovascular events (Somers et al., 2008).

Mental and Cognitive Functions

- **Focus and Concentration:** Adequate sleep is essential for maintaining focus, concentration, and attention, all of which are critical for optimal athletic performance. Sleep deprivation impairs cognitive function, leading to decreased alertness, slower reaction times, and impaired decision-making (Knowles et al., 2018).
- **Learning and Memory:** Sleep is crucial for learning new motor skills and consolidating memories. Studies have shown that sleep deprivation impairs motor skill acquisition and retention (Gomes et al., 2011).
- **Emotional Regulation:** Sleep influences emotional regulation and mood. Sleep deprivation can lead to increased irritability, anxiety, and depression, negatively affecting motivation, confidence, and performance (Fullagar et al., 2015).

3. IMPACT OF SLEEP DISTURBANCES ON ATHLETIC PERFORMANCE

Accuracy and Reaction Time

- Sleep deprivation and restriction impair accuracy in athletic events, while sleep extension improves these tasks. Dart throwing accuracy decreases significantly after a single night of sleep, while tennis players experience a decrease in serving accuracy (Reilly et al., 2007). Adolescent student-athletes show decreased sleep time on weekdays, leading to worsening reaction times.

Endurance Performance and Anaerobic Power

- Endurance performance and anaerobic power are also affected by sleep, or lack thereof. Sleep deprivation reduces performance, likely due to higher perceived exertion. After 30

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hours without sleep, participants ran shorter distances in treadmill tests (Oliver et al., 2009). A single night of poor sleep also lowers endurance, as seen in volleyball players and cyclists (Reilly et al., 2007).

Sprint Performance

- The impact of sleep deprivation on sprint and strength performance shows mixed results. For sprinting, studies found slower sprint times after 30 hours without sleep, but improved sprint times and better self-ratings of fatigue and performance after 5–7 weeks of extended sleep in basketball players (Mah et al., 2011).

4. SLEEP AND CONCUSSIONS

Concussions are a significant concern in sports, with a high incidence rate and potential long-term consequences (Harmon et al., 2013). Poor sleep, including insomnia and daytime sleepiness, has been identified as a risk factor for concussions and can exacerbate symptoms and delay recovery following a concussion (Charest et al., 2021). Adequate sleep is essential for brain recovery and can mitigate the adverse effects of concussions on cognitive function and overall well-being.

5. INSUFFICIENT SLEEP AND RECOVERY

As pointed out in the original document, insufficient sleep hinders recovery, as it impacts the brain, the hormonal system, and also eating behaviors. This in turn slows recovery from injuries.

Strategies to Improve Sleep Quality

- **Establish a Regular Sleep Schedule:** Maintaining a consistent sleep-wake schedule, even on weekends, helps regulate the body's natural circadian rhythm and promotes better sleep quality (Wirz-Justice, 2006).
- **Create a Relaxing Bedtime Routine:** Engaging in calming activities before bed, such as reading, taking a warm bath, or practicing relaxation techniques, can help reduce stress and promote sleep (Montgomery & Dennis, 2003).
- **Optimize the Sleep Environment:** Ensuring a dark, quiet, and cool sleep environment can improve sleep quality. Consider using blackout curtains, earplugs, or a white noise machine to minimize distractions (внешней, 2014).
- **Limit Screen Time Before Bed:** The blue light emitted from electronic devices can suppress melatonin production, disrupting sleep. Avoid using smartphones, tablets, and computers for at least an hour before bed (внешней, 2014).
- **Avoid Caffeine and Alcohol Before Bed:** Caffeine and alcohol can interfere with sleep. Avoid consuming these substances in the hours leading up to bedtime (внешней, 2014).
- **Consider Napping Strategically:** Short naps (20-30 minutes) can improve alertness and performance without disrupting nighttime sleep. However, avoid long or late-afternoon naps, as they can interfere with sleep onset (внешней, 2014).

6. CONCLUSION

Adequate sleep is paramount for optimizing athletic performance, minimizing injury risk, and facilitating effective recovery. Athletes are particularly vulnerable to sleep deprivation due to the demands of training and competition. Implementing strategies to improve sleep hygiene, ensure sufficient sleep duration, and address sleep disturbances can significantly enhance athletes' physical and cognitive capabilities. Coaches, sports psychologists, and healthcare professionals must

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prioritize sleep in training and recovery plans to support athlete well-being and maximize performance. Regular sleep monitoring and personalized interventions are recommended to optimize sleep quality and aid in the recovery process, particularly following injuries or concussions.

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A PERFORMANCE ANALYSIS OF INDIAN SENIOR WOMEN'S RUGBY TEAM PERFORMANCE IN ASIA RUGBY EMIRATES WOMEN'S SEVENS TROPHY-2024

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ABSTRACT

Background: Rugby sevens is a very aggressive and contact sport, Each team consists of 12 players, including 5 substitutions. Teams use a Rugby ball toward the opposing team's Try line and subsequently into the goal in order to move it around the field.

Objective: The purpose of the study was to determine the Video Analysis of Tactics skills factors predominant towards the success of the team. The Indian women's Rugby team's outperformance in the Asia Rugby Emirates women's sevens Trophy 2024, The teams participated namely India, Indonesia, Nepal, Iran, Sri Lanka, Philippines, Guam, and Uzbekistan,

Method: The Longomatch Fluendo performance analysis software was used for offensive and Defensive skills the success ratio of the KPIs and how they are contributing to the chances of winning the team, and the team strengths and weaknesses were analyzed.

Keywords: Rugby*, Offensive, Defensive, Scrums, knock-on, Rucks, Lineout Penalties and Passes.*

1. INTRODUCTION

Rugby sevens, often known as seven-a-side rugby union, is a team sport played on a pitch that alternates between periods of high-intensity movement and collisions. The rules governing rugby sevens are nearly identical to those governing rugby union, including the size of the playing field. Rugby sevens, on the other hand, is played for a shorter amount of time (seven minutes with a one—to two-minute halftime) and with fewer athletes per team (seven instead of fifteen).

Rugby is a high-intensity, contact sport that requires physical strength, endurance, and strategic gameplay. It has two main formats: rugby union and rugby league, each with distinct rules and gameplay styles. Rugby league is known for its fast pace, structured attacks, and limited tackles per possession. Performance in rugby is analyzed using key indicators such as possession, tackling efficiency, meters gained, and set completions. Advanced analytics, including statistical models and machine learning, are now used to refine strategies, improve player performance, and predict match outcomes (Prim S 2-13).

It is one of the most popular sports in the world, with over 6.6 million players in 109 countries. Winning major international championships is the ultimate goal for national teams, and the sport brought in £385 million in 2015. Compared to other sports like association football, rugby union is also linked to a higher risk of injury. The sport's full-contact nature, which involves all players making legal contact with one another for up to 50% of the game, increases the danger of injury (Croft H et al., 2015).

Rugby sevens and rugby union have the same field dimensions and set of rules, but given the variations in match length and player count, it's possible that rugby sevens' training methods won't translate well to rugby union. Even if some abilities—like passing, tackling, and ball carrying—

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apply to all types of rugby, there probably are some success factors and skills unique to rugby sevens.

Limited studies have been done specifically on rugby sevens performance; instead, the majority of the studies have focused on match analysis, training load monitoring, and physical profile.

2. PERFORMANCE ANALYSIS

Performance Analysis is a specialized field that offers athletes and coaches objective insights to better understand and enhance their performance. This discipline relies on systematic observation to provide accurate, reliable, and detailed information about various aspects of performance. It primarily employs two key approaches: visual feedback through video analysis and objective statistical analysis through data analysis. The primary goal of performance analysis is to furnish coaches and athletes with objective information regarding their performance, allowing them to identify strengths and areas that require improvement (Wright et al., 2013). Performance analysis is used to provide insight into tactics and strategy. The role of the performance analyst is defined as translating objective data into learning opportunities to help sports coaches understand how and why outcomes occur to improve future performance.

Performance analysis is a crucial process in understanding team strategy. It involves data capture, analysis, visualization, and communication. It involves understanding the team's goals, methods, and technical-tactical elements. In team invasion sports, it's essential to capture in-game events for effective strategy insights. Advancements in technology, like computerized statistical analysis and semi-automated tracking systems, have improved detail capture and reduced data points per game.

The majority of tackle injuries in rugby league, a high-contact sport with frequent collisions, happen to the ball carrier. Video analysis enhances prevention by identifying damage pathways. Rugby league does not have a tested framework that connects tackle execution to results, whereas rugby union uses video analysis for injury studies. To improve injury and performance research in rugby league, a formal framework for video analysis is required.

3. METHODS

The scoring analysis for the Asian rugby emirates women's sevens trophy 2024 was conducted using data source from Asia Rugby Live, considered highly accurate and reliable. Matches involving India and the Philippines final match were recorded on a laptop. The analysis utilized Longomatch Fluendo version 3.5.17 to Excel software were used to analyze the data observe and record variables such as passes, tackles, Offensive, Defensive, Scrums, knock-ons, Rucks, Lineout Penalties and Passes, etc. This comprehensive approach aimed to provide detailed feedback and insights into Indian team performance.

4. DATA PROCESSING

A dashboard created for video analysis based on my research variables. It was integrated into the software to handle and analyze the data. The dashboard includes key performance indicators (KPIs) like skill names and subcategories, such as successful and unsuccessful passes. Tagging and data gathering occurred simultaneously during video analysis. After analysis, the data was exported. However, the dashboard's comprehensive data might overwhelm users, making it hard to find actionable insights. Also, the simultaneous tagging and data collection could lead to inconsistencies if not thoroughly reviewed before exporting.

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5. RESULT OF STUDY

The result of the Performance analysis of the Indian senior women's rugby team performance in Asia Rugby Emirates women's sevens trophy-2024 was analysed and the result of the match score cord given below the figure 1.

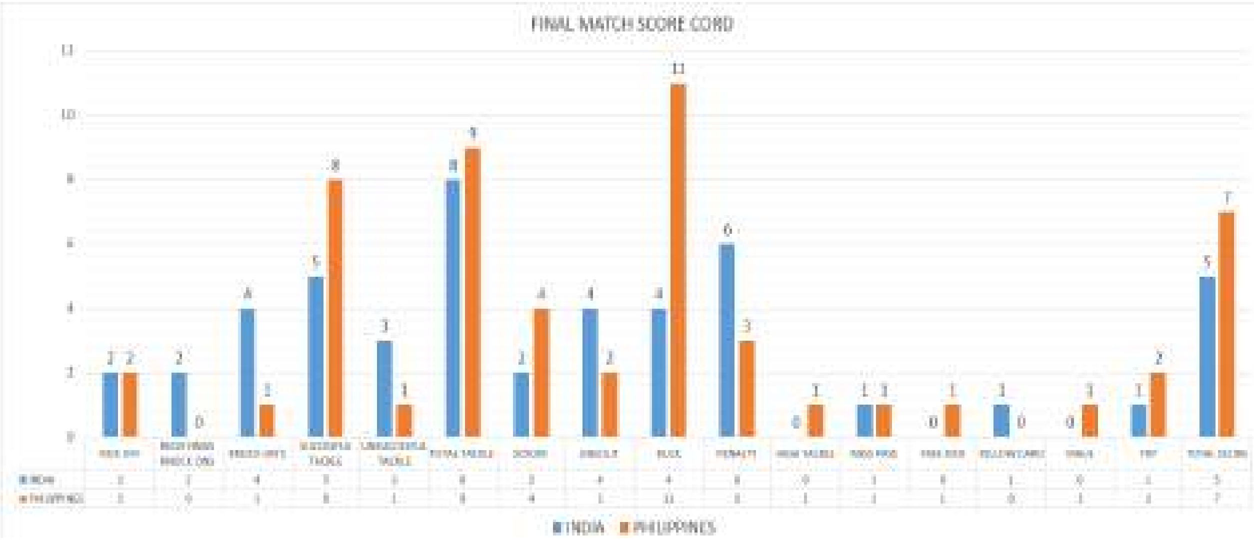

Figure 1: India vs Philippines final match score

Figure 1 shows the comparison of match results between India and the Philippines. The total number of tackles and their successful, and unsuccessful details are given in this table. Also kick off, Knock ons , Scrum, Lineout, Ruck Penalty, High Tackle, Miss pass , Free Kick , Mall Try, and total score.

The team India scored 5 points meanwhile the team Philippines scored 7 points. The team India initiated a total of 8 tackle attempts out of 8 tackles 5 successful and 3 unsuccessful meanwhile the team Philippines initiated 9 total tackles out of 9 tackles 8 successful tackles and 1 unsuccessful tackles. Both teams got 2 kick-off chances and India successfully received the 2 knockoffs; meanwhile, the Philippines failed to succeed the receiving's. India has 5 knocks ons meanwhile the Philippines has only one knock-on. India has 2 scrums meanwhile the Philippines have 4 scrums. India initiated 4 lineouts meanwhile the Philippines initiated two lineouts. When it comes to the missed pass both teams are involved in one missed pass. Team India initiated only 4 rucks meanwhile the Philippines team initiated 11 rucks. Team India got 6 penalty advantage moves meanwhile Team Philippines got only 3 penalty advantage moves. Team Philippines got one free kick chance but India didn't create any free kick chances.

6. DISCUSSION

Team Philippines won the match against Team India in Asia Rugby Emirates women's sevens Trophy 2024, the team Philippines outperformed with the leading score of 7 which is greater than the team India's score. The key indicator tackle is the most important in the game of rugby. The team Philippines has 8 successful tackles with one unsuccessful tackle meanwhile the team India initiated 8 tackles out of 8 they were successes in 5 tackles and failed in 3 tackles. Same time India got 2 advantage moves through scrum meanwhile the Philippines got 4 advantage moves through the scrum. And India got 1 knock-on advantage move from the opponent meanwhile the team Philippines team got 4 advantage moves from the opponent team.

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7. CONCLUSION

Based on the analysis the team India showed a poor performance in defensive as well as offensive skills also the opponent team well performed in both offensive and defensive skills. Finally, I conclude that the team India needs to improve their both offensive and defensive skills.

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ADVANCEMENTS AND CHALLENGES IN GAIT ANALYSIS TECHNOLOGIES: A REVIEW

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ABSTRACT

Gait analysis is crucial in clinical diagnostics, rehabilitation, and biomechanics, aiding in the assessment of movement disorders and performance optimization. This review categorizes gait analysis methods into Non-Wearable Sensor (NWS) and Wearable Sensor (WS) systems. NWS methods, including image processing and floor sensors, provide high precision and controlled measurements, whereas WS methods, such as accelerometers and gyroscopes, offer real-time monitoring in daily activities. Advances in sensor technology, artificial intelligence, and data fusion techniques are enhancing gait analysis accuracy and applicability. Despite challenges like data integration and real-world variability, future research aims to improve personalized gait models and clinical interventions.

Keywords: Gait analysis, Non-Wearable Sensors, Wearable Sensors, Image Processing, Biomechanics, Electromyography, Rehabilitation, Motion Capture, Sensor Fusion

1. INTRODUCTION

Gait analysis has evolved into a multifaceted field with applications spanning clinical diagnostics, rehabilitation engineering, sports biomechanics, and even security (Aggarwal & Ryoo, 2011). Understanding human locomotion provides valuable insights into underlying pathologies, movement efficiency, and individual identification. This review builds upon the existing literature and delves into recent advancements, challenges, and future directions in both non-wearable and wearable gait analysis technologies.

Non-Wearable Sensor (NWS) Systems: Expanding Capabilities

Non-Wearable Sensor (NWS) systems, encompass image processing (IP) and floor sensor (FS) approaches. Recent developments focus on enhancing the accuracy, robustness, and applicability of these systems.

Image Processing (IP) advancements

- **Markerless Motion Capture:** While marker-based systems are accurate, they can be time-consuming and obtrusive. Markerless motion capture, utilizing sophisticated algorithms and machine learning, is gaining traction. Deep learning approaches, particularly convolutional neural networks (CNNs), have shown promise in accurately estimating 3D pose from single or multiple camera views (Toshev & Szegedy, 2014). These systems offer the potential for gait analysis in uncontrolled environments.
- **Depth Sensing Technologies:** Beyond Time-of-Flight (ToF) cameras, structured light sensors (e.g., Microsoft Kinect) have been explored for gait analysis due to their affordability and real-time depth mapping capabilities. However, challenges remain in

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dealing with occlusions, varying lighting conditions, and limited resolution (Clark et al., 2012).

- **Thermal Imaging:** Infrared Thermography (IRT), as mentioned continues to evolve. Recent research explores the use of dynamic thermal imaging to capture subtle temperature changes associated with muscle activity during gait, providing a novel approach to assess muscle function (Merla et al., 2020).

Floor Sensors (FS) and Instrumented Treadmills

- **Advanced Force Plate Technology:** Modern force plates offer higher sampling rates, improved accuracy, and integrated software for real-time data processing and visualization. These advancements allow for more detailed analysis of ground reaction forces (GRF) and center of pressure (COP) trajectories (Bartlett, 2014).
- **Instrumented Treadmills:** Instrumented treadmills combine the benefits of force plate technology with the controlled environment of treadmill walking. They allow for continuous gait analysis over multiple strides, providing a more comprehensive assessment of gait parameters. Research is also focusing on developing instrumented overground systems.

Wearable Sensor (WS) Systems: Towards Real-World Gait Monitoring

Wearable sensor systems, offer the advantage of unobtrusive, real-time gait monitoring in real-world settings.

Inertial Measurement Units (IMUs)

Sensor Fusion Algorithms: IMUs, containing accelerometers, gyroscopes, and magnetometers, are commonly used in wearable gait analysis systems. Sophisticated sensor fusion algorithms, such as Kalman filters and complementary filters, are employed to integrate data from multiple sensors and improve accuracy and robustness (Madgwick et al., 2011).

Placement Optimization: Research focuses on determining the optimal placement of IMUs on the body to capture the most relevant gait information. Common locations include the feet, shanks, thighs, and lower back (Aminian et al., 2002).

Plantar Pressure Measurement

In-shoe Pressure Sensors: In-shoe pressure sensors provide valuable information about plantar pressure distribution during gait. Advancements in sensor technology and materials have led to more comfortable, durable, and accurate in-shoe systems (Lord et al., 2013).

Integration with Machine Learning: Machine learning techniques are being used to analyze plantar pressure data and classify different gait patterns, detect gait abnormalities, and predict the risk of falls (Hardikar et al., 2014).

Electromyography (EMG)

Wireless EMG Systems: Wireless EMG systems allow for more freedom of movement and reduce the risk of cable interference. These systems are becoming increasingly popular in gait analysis research (De Luca, 1997).

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High-Density EMG: High-density EMG arrays, with multiple electrodes placed close together, can provide more detailed information about muscle activity patterns during gait (Farina et al., 2004).

Clinical Gait Assessment Methods (CGAM)

Building on the methods outlined by additional CGAMs are being adopted, namely;

The Functional Gait Assessment (FGA): Is an evolution of the Dynamic Gait Index (DGI), designed to assess an individual's ability to maintain balance while performing various walking tasks. The FGA includes a series of gait-related activities that challenge balance and stability, providing a comprehensive assessment of functional mobility (Wrisley et al., 2004).

The Rivermead Mobility Index (RMI): A questionnaire-based assessment tool used to evaluate functional mobility in individuals following a stroke or other neurological conditions. It assesses various aspects of mobility, including bed mobility, transfers, walking, and stair climbing, providing a comprehensive measure of functional independence (Collin & Wade, 1988).

Challenges and Future Directions

Despite significant progress, several challenges remain in gait analysis research:

- **Data Integration and Interpretation:** Integrating data from multiple sensors and modalities (e.g., IMUs, force plates, EMG) can be challenging. Developing robust data fusion and interpretation techniques is crucial for comprehensive gait analysis.
- **Real-World Applicability:** Translating laboratory-based gait analysis techniques to real-world settings remains a challenge. Addressing issues such as environmental variability, sensor drift, and data processing complexity is essential for widespread adoption of gait analysis technologies.
- **Personalization and Individualization:** Gait patterns are highly individualistic. Developing personalized gait analysis models that account for individual characteristics such as age, gender, body size, and fitness level is important for accurate assessment and intervention.
- **Ethical Considerations:** As gait analysis technologies become more sophisticated and widely used, it is important to address ethical considerations such as data privacy, security, and potential for misuse.

Future research directions include:

- Development of more sophisticated algorithms and machine learning techniques for gait analysis.
- Integration of gait analysis with other wearable technologies, such as augmented reality and virtual reality.
- Use of gait analysis for early detection and prevention of falls in older adults.
- Development of gait-based biometric identification systems.
- Use of gait analysis to personalize rehabilitation programs and improve patient outcomes.

2. CONCLUSION

Gait analysis is a rapidly evolving field with significant potential to improve human health and well-being. Advancements in sensor technology, data processing algorithms, and machine learning techniques are driving innovation in both non-wearable and wearable gait analysis systems. As

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these technologies continue to mature, they will play an increasingly important role in clinical practice, rehabilitation, sports performance, and other areas.

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INJURY PREVENTION AND STRATEGIES ON ARTIFICIAL TURF

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ABSTRACT

Artificial turf has become a widely used playing surface in sports due to its durability and low maintenance requirements. However, concerns over player safety, including musculoskeletal injuries, skin abrasions, and concussion risks, have driven research into injury prevention strategies. This study outlines common injuries associated with artificial turf, such as knee ligament tears, foot and ankle sprains, and surface contact abrasions. A four-step prevention model is employed, focusing on injury assessment, understanding injury mechanisms, implementing preventive measures, and evaluating their effectiveness. Risk factors are categorized into external factors (sports equipment, protective gear, and environmental conditions) and internal factors (age, body composition, skill level, and psychology). Injury prevention measures include athlete-focused strategies such as cleat design modifications to reduce torque and surface-focused interventions like field maintenance to improve consistency and traction. Additionally, exercise-based strategies aimed at strengthening musculoskeletal resilience play a key role in mitigating injuries. Ensuring safety on artificial turf requires a multi-faceted approach combining biomechanical research, field design improvements, and evidence-based training programs.

KEYWORDS: Artificial turf, sports injuries, injury prevention, musculoskeletal injuries

1. INTRODUCTION

The 1st artificial turf field was installed in 1966 in the Houston Astrodome in Houston, Texas, produced by Monsanto and named AstroTurf, this turf generation's design consisted of a thin nylon fiber woven carpet installed over top a compacted soil base. In 1969, 3 M produced its own but similar product, Tartan Turf, as a direct competitor to Astroturf which was subsequently installed that summer in the University of Michigan football stadium. Both Astroturf and Tartan Turf are considered 1st generation turf fields due to their design and material commonalities. This 1st generation design was associated with common skin abrasions, ankle sprains due to the prevalent intersectional seams and high friction level of the woven carpet, and other injuries due to the non-forgiving solidity of the base material. Because of these problems, the 2nd generation of artificial turf, Shag Turf, quickly evolved and came into use by 2nd generation turf improved upon the prior design by adding a shock-absorbing rubber pad over the compacted soil and replacing the original carpet with vertically positioned polypropylene fibers supported in a silica-sand infill. This design aided the athletic experience through providing a flatter and more routine playing surface that mimicked natural grass fields to a higher degree. Unfortunately, these fields exhibited a high propensity to cause serious abrasions to players, which significantly limited their adoption among American football and soccer organizations. This led to the genesis of 3rd generation artificial turf. First installed in a Pennsylvania high school in 1997, the design took cues from the 2nd generation but with a greater focus on athlete safety , Changes between the 2nd and 3rd generation included altering the fiber composition from polypropylene to polyethylene to decrease skin abrasions, increasing fiber length, and spreading the fibers laterally to rely more heavily on the infill material

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for structural support and to decrease surface hardness , The infill material was made into a deeper layer and switched from silica sand to crumb rubber or a mixture of both elements, occasionally also combined with other infill materials such as different elastomers, polymers, and organic materials such as coconut fibers, cork, and ground walnut shells [3]. These changes were made to increase the shock absorbing properties of the playing surface to increase player safety and improve agility as well as ball handling characteristics. Technically, additional generations of turf exist but their validity remains debated. Companies have claimed development of 4th, 5th, and 6th generation artificial turf which all essentially build on the same principles of 3rd generation turf, but use specific materials or manufacturing processes that eliminate the need for rubber infill. These claims remain debated due to the notion that 4th, 5th, and 6th generation turf exist only as marketing ploys used by companies to promote their products as novel developments, when in reality their design borrows heavily from 3rd generation turf characteristics [1]. The systems of artificial turf composed by a sub-base of compacted gravel without a shock pad have proven a force reduction and vertical deformation below the limits specified in the normative on the other hand, the elastic layer has demonstrated a great ability to maintain the mechanical properties of the playing surface ensuring optimal safety and functional surface. [2]. Artificial turf surfaces are surfaces of synthetic fibres more and more frequently used in place of the natural grass, Synthetic pitches are commercialized worldwide for realizing playgrounds, soccer, football or rugby fields and even in domestic gardens or recreational structures. Their successful diffusion is supported by lower costs, higher sustainability in materials reuse, water saving, and other advantages related to athletic practice and performance Starting from the 60s several synthetic materials were developed, and the technology was continuously and globally evolving. In Recent years, several raw resources were used as a backing from jute to nylon or polypropylene, but these surfaces were considered too stiff and abrasive. The third generation of turfs was introduced in the 2000s and is characterized by long and less densely packed tufts fibres as well as an infill comprising elastomeric material, such as crumb rubber, the synthetic turfs are assembled with natural products such as cork or coir, a coconut-derived material, sand and crumb rubber as “soil” or “infills”, but not grass substitutes, [3] Research shows that the new synthetic fields are surfaced with a product called “in-fill” that is made from recycled rubber tires. This material, referred to as tire crumbs, constitutes the primary playing surface. We estimate these crumbs to be as much as 90% by weight of the fields. The tire crumbs are roughly the size of grains of course sand. They are made by shredding and grinding used tires. Tire crumb materials are spread two to three inches thick over the field surface and packed between ribbons of green plastic used to simulate green grass, it was found that tire crumbs contained volatile organic hydrocarbons (VOCs) with carcinogenic potential, which could be extracted from the crumbs in the laboratory. [4]

2. SEARCH STRATEGY

Data was collected from PubMed, Google Scholar, Scopus, and Web of Science. Key search terms included Artificial turf, sports injuries, injury prevention, musculoskeletal injuries. Articles published in the last 10 years, 2015 - 2025 and study type clinical trials, systematic reviews were included for the study. Studies published in the English language were taken in consideration for this review.

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3. METHODOLOGY

Manufacturing and Installation of Artificial Turf

The manufacturing process for the artificial turf includes the addition of different granules in a hopper along with appropriate dyes and chemicals to obtain the habitual green colour for the grass and to protect it from ultraviolet radiation. Once the lot has been blended thoroughly it is mixed robotically in a huge steel blender until it has a thick taffy-like uniformity. It is further extruded to form an elongated thin strand, which is further spun into loose rope. These ropes are drawn straight and spun into yarn. Heat setting is also carried out to set the twist and finally wound on a spool. Spools of yarn are now taken upon a tufting machine which is principally similar to a sewing machine. At the back of the tufting machine, a bar with skewers holds the yarn bobbin. In the tufting process, yarn is fed at the front of the tufting needle. The needle inserts through the primary backing of the turf and inserts the yarn into the loop. As the needle comes back, the flat hook releases the loop of the tread and shifts the primary backing material ahead. The whole process is repeated for continuation, several hundred needles are used in this process and several hundreds rows of stitches are stitched per minute. the fibre type and fibre height, the distance between the needles etc determines the appearance of turf and suitable usage. [5]

Proper installation of the artificial turf is of great importance to guarantee its long life. The base of the installation, which is either concrete or compacted soil, must be leveled and then smoothened by a steamroller otherwise uneven surface will persist after the application of the turf during the installation, special bonding agents are used for stitching the line and the turf is rolled out to the ground with long steel shafts. An appropriate drainage system is needed for especially outdoor applications before turf installation since the underlying surface can absorb water. The installation cost is quite higher than natural grass and can be installed virtually in any environment. [5]

4. MICROCLIMATE OF ARTIFICIAL TURF

Compared to natural turf, artificial turf has a distinctive microclimate, turf surface temperature, and surface energy fluxes. Studies have measured that artificial turf in sports fields has a significantly greater air temperature, and turf surface temperature, than the natural turf. The greater air and surface temperatures have raised serious concerns over the human heat stress, and risk of skin burns for the athletes playing on artificial turf surfaces. The use of artificial turf in private outdoor spaces, such as backyards, is also increasing because they reduce maintenance time, inputs of water and fertilizer and provide instant “greening”. When artificial turf surfaces are installed in private green spaces, they may be accessed by all family members. Infants, children, the elderly, and people with existing medical conditions are all more susceptible to heat stress and skin burns, In addition, artificial turf is now commonly used as a backyard surface for pet play and toileting areas. Animal paws are also susceptible to burns at high temperatures. Several studies have proposed that artificial turf exhibits greater air temperature and surface temperature than natural turf because it is drier which limits evapotranspiration, Limited evapotranspiration can mean more surface energy is converted to sensible heat flux and less used in latent heat flux, causing local air temperature to increase. Some studies have assumed that evapotranspiration by artificial turf is zero but this is unlikely because artificial turf is porous to allow drainage into the soil beneath, the moisture stored in the compacted layer below the artificial turf can also evaporate through the porous drainage holes back into the atmosphere. It is necessary to consider all the relevant surface energy fluxes, i.e., latent heat flux, sensible heat flux, ground heat flux, and outgoing longwave

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and shortwave radiant fluxes, to understand how artificial turf changes the microclimate, human heat stress, and turf surface temperature.

The surface temperature of artificial turf is more frequently measured than the microclimate above, and surface energy fluxes are associated with artificial turf systems. When the microclimate, human heat stress, surface energy fluxes, and surface temperature of natural turf are compared to artificial turf, it is important to differentiate between irrigated natural turf and unirrigated natural turf. Unirrigated natural turf has lower latent heat flux and lower sensible heat flux than irrigated natural turf because of reduced evapotranspiration, Due to the reduced evapotranspiration of unirrigated natural turf, its surface can be as warm as paved surfaces. [6].

5. SAFETY OF ARTIFICIAL TURF

The main objective is to examine the safety of artificial grass, particularly in terms of its use by humans and pets, and to explore its broader environmental implications. This involves a meticulous assessment of both the positive and negative aspects associated with artificial grass, ensuring a balanced and comprehensive perspective. The focus extends to various contexts in which artificial grass is commonly utilized, especially in residential areas and sports fields where frequent human and pet interactions with the material occur.

In residential settings, artificial grass is often chosen for its low maintenance and aesthetic consistency. Here, the safety analysis centers around the direct exposure of families and pets to artificial turf. This includes evaluating the risks associated with the chemical components of artificial grass, such as PFAS, which have raised health concerns due to their persistence and potential toxicological effects. PFAS, however, shows up in so many daily use products it is more likely to be from the shoes and coat you wear to your cooking products.

It assesses safety concerns of artificial grass, considering factors like its texture and heat absorption properties, which are particularly relevant in environments where children and pets play and spend considerable time. In the realm of sports, artificial grass is favored for its durability and uniform playing surface. However, this brings forth a different set of safety considerations, primarily related to the risk of sports-related injuries. Studies have shown varying injury rates on artificial turf compared to natural grass, with some suggesting a higher incidence of lower extremity injuries on synthetic surfaces. [7]

6. CHEMICAL SAFETY CONCERNS

A significant concern with artificial grass is the presence of potentially harmful chemicals. Research has identified various substances in artificial turf, such as phthalates, polyaromatic hydrocarbons, and perfluoroalkyl substances (PFAS), which are associated with health risks like endocrine disruption and environmental exposure issues.

Celeiro and colleagues (2018) conducted a meticulous study examining the chemical components of artificial turf, with a particular focus on identifying hazardous substances. Employing the sophisticated technique of gas chromatography-mass spectrometry, their research uncovered a range of detrimental chemicals within synthetic turf. This detailed analysis illuminated the presence of various substances that raise significant health and environmental alarms, emphasizing the urgency for enhanced regulatory oversight of materials used in artificial turf production. Moreover, the study sheds light on the potential health risks posed by these chemicals, suggesting a need to compare the exposure rates to synthetic grass with everyday encounters with

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similar chemicals, such as PFAS, in the environment. This comparison is crucial for understanding the relative impact of artificial turf in the broader context of environmental health exposures.

In a similar vein, the Environmental Working Group's report in 2019 provided further evidence of the potential dangers associated with artificial grass. Their research specifically pointed to the presence of toxic PFAS (Per- and Polyfluoroalkyl Substances) in artificial turf. PFAS are known for their persistence in the environment and have been linked to various health risks, including endocrine disruption and other serious health concerns. This report reinforced the findings of earlier studies like that of Celeiro et al., emphasizing the need for more research regarding safety standards in the production of artificial turf.

As of now, there is no concrete evidence or officially documented cases that establish a direct link between the use of artificial grass and specific health problems. Investigations into the health impacts of synthetic turf have largely centered on its chemical composition, yet these studies have not definitively connected artificial grass to health concerns. It is, however, crucial to continue research and monitoring to thoroughly understand the potential long-term health consequences associated with artificial grass. This is especially important as the industry evolves with new materials and technologies.

It's noteworthy to mention that other everyday products, such as waterproof boots and nonstick pans, have been found to contain higher levels of PFAS, which poses a more significant exposure risk. These items, due to their widespread use and the nature of their application, potentially present a greater likelihood of PFAS exposure compared to artificial grass. The ongoing research in this area is key to developing a more comprehensive understanding of PFAS exposure and its implications across various products and materials. [7].

Physical Injury Rates in Sports on Artificial Turf

The debate on the safety of artificial turf in sports is complex, with research yielding mixed results regarding injury rates compared to natural grass. This area of study is particularly crucial as it directly impacts athletes' health and performance.

Several studies have indicated a higher incidence of certain types of injuries on artificial surfaces. For instance, foot and ankle injuries are reported to be more common on artificial turf. The rigid nature of the surface, coupled with its reduced natural give, is thought to contribute to these increased injury rates. This is particularly relevant in sports that involve high-intensity running, sudden direction changes, and impact-heavy landings, such as soccer and American football.

A notable example in professional sports that stirred this debate was the injury to New York Jets quarterback Aaron Rodgers, who tore his Achilles' tendon during an NFL game on artificial turf. Although this incident alone does not establish causality, it brought attention to the potential risks associated with artificial surfaces in high-level athletics. It is important to note that wet, uneven and muddy surfaces on normal sod fields have also caused career-ending injuries for athletes.[7]

Environmental Impact of Artificial Grass

The environmental implications of artificial grass are multifaceted, encompassing both benefits and moderate concerns. On the one hand, artificial turf offers certain advantages over natural grass, particularly in urban and sports settings. These benefits primarily include reduced water usage and minimal maintenance requirements. Natural grass, in contrast, demands regular watering, mowing, and pest control, which can be resource-intensive, especially in water-scarce areas. However, these

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benefits are counterbalanced by several environmental concerns. The production and disposal of artificial grass raises environmental issues.

Key concerns include

Micro Plastics Pollution – The degradation of artificial turf contributes to micro plastics pollution. As the material wears down, it releases tiny particles of plastic into the environment, which can have far-reaching impacts on soil quality, water systems, and overall biodiversity.

Heat Island Effect – Another significant issue is the contribution of artificial turf to the urban heat island effect. Synthetic surfaces, like artificial grass, can absorb and retain heat, leading to increased temperatures in urban areas. This effect exacerbates heat stress for humans and negatively impacts the local climate.

Soil and Biodiversity Impact – The installation of artificial grass impacts the soil structure and reduces biodiversity. Unlike natural grass, which supports a range of organisms and contributes to carbon sequestration, artificial turf does not provide habitat for insects, birds, or soil microorganisms. This leads to a reduction in biodiversity and affects the natural ecological balance

Disposal and Non-biodegradability – The disposal of artificial grass is a critical environmental concern due to its non-biodegradable nature. The materials used in artificial turf can take decades, if not centuries, to decompose, contributing to landfill waste and associated ecological issues.

While artificial grass offers several practical benefits, its potential for environmental impacts is wide-ranging. These concerns highlight the need for careful consideration and a balanced approach when opting for artificial turf, especially in public spaces and residential areas. The challenges associated with its disposal, its contribution to microplastic pollution, and the heat island effect offer concern. However, concerns like these are often adjusted with advancements in technology and policy as the industry continues to grow and innovate.

7. THE BENEFITS OF ARTIFICIAL GRASS

Water Conservation

One of the most significant benefits of artificial grass is its contribution to water conservation. Natural grass lawns require substantial amounts of water for maintenance. In contrast, artificial turf eliminates the need for regular watering, except for occasional cleaning and cooling. According to a 2014 study, artificial turf fields have lower environmental impacts than equivalent grass fields over their life cycle, primarily due to water conservation. This is particularly crucial in regions prone to droughts, have restrictions, and where water conservation is essential. Many city governments throughout the Southwest offer homeowners' incentives to replace natural grass with artificial turf through cash and tax benefits. Tempe Arizona is a leader in this movement and the Southern Nevada Water Authority.

Reduced Energy Use and Air Pollution

Artificial grass does not require mowing, which translates into energy savings and reduced air pollution. California has restricted the use and sale of many gas-powered tools; artificial turf provides a solution. Traditional lawn maintenance involves the use of gas-powered mowers and other equipment, contributing significantly to air pollution. The Environmental Protection Agency (EPA) notes that using a gas lawn mower for one hour is equivalent to the emissions from 11 cars running for the same duration. By eliminating the need for these tools, artificial grass reduces the use of fossil fuels and lowers the carbon footprint associated with lawn maintenance.

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Fewer Chemicals

Maintaining natural grass often requires fertilizers, pesticides, and herbicides, which involve chemicals that can be harmful to both humans and the environment. Artificial turf eliminates the need for these chemicals, thus reducing their presence in your yard and minimizing their impact on the environment. Many of those chemicals find their way back into the agricultural water systems as well as aquifers used for human consumption.

Reduction in Single-Use Plastics

Lawn care products like fertilizers and pesticides often come in single-use plastic packaging. By opting for artificial grass, which does not require such products, you can reduce the consumption of single-use plastics, contributing to environmental conservation. Our research found more USA-based manufacturers exploring the recyclability of their turf and are creating new products that they believe can be recycled fully in the future.

Limiting Erosion and Runoff

Artificial turf can be effective in controlling erosion and runoff, especially in sloped areas. Natural grass on slopes can lead to runoff and erosion, carrying sediments and concentrating contaminants to local habitats and water supplies. Artificial grass can help control these issues, thereby protecting nearby habitats and water sources.

Advances in Technology

Advancements in artificial grass technology are addressing some of the earlier concerns related to its use. For example, newer types of artificial turf are being developed with cooling technologies, like mats that absorb and retain water to reduce surface temperature. Additionally, improvements in blade design are being made to reduce heat absorption, making the turf cooler to the touch. This advancement is particularly beneficial during hot weather, improving comfort for users and reducing the heat island effect commonly associated with synthetic surfaces.

Longevity and Durability

Artificial grass typically has a longer life cycle compared to natural grass. It is designed to withstand wear and tear, maintaining its appearance and functionality over many years. This durability means less frequent replacement and, consequently, a potentially lower environmental impact over its lifespan compared to maintaining a natural grass lawn.

Need for Continuous Research

The dynamic nature of sports surfaces technology means that continuous monitoring and research are essential. There is a need for more extensive, longitudinal studies that can keep pace with the evolving designs of artificial turf. Such research should ideally control for various factors like player technique, footwear, and playing style, which can all influence injury risk.[7]

8. ADVANTAGES OF ARTIFICIAL TURFS

Artificial grass looks aesthetically pleasing in all weather conditions, they require less maintenance as they do not need to be watered, fertilized, or mowed like real grass. It can withstand wear and tear far better than natural grass therefore it offers high durability. Artificial turfs have excellent drainage properties owing to their porous nature and built-in drainage system which can be used immediately after rainfalls. It can eliminate the use of chemicals that can cause soil and groundwater containment. Artificial turf is generally considered safe to play with fewer incidents and severity of athletes injuries as they are free of gopher holes, bumps or muddy patches which are inherent in biological grass fields. It can be cleaned easily with a spray of water from the hose. also it can be provided with a foam underlayment which can create a soft ground. [5]

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9. DISADVANTAGES OF ARTIFICIAL TURF

Abrasion injuries result in damage only to the surface layer of skin and can result in player discomfort and changes in performance. The perceived fear of abrasion injuries on artificial turf playing surfaces has significantly affected the adoption of these surfaces, particularly in sports that involve frequent player-surface interactions. The underreporting of abrasion injuries due to how time-loss injuries are defined and the lack of validity of the current abrasion measurement device highlight the need for more research to understand fully the incidence and nature of abrasions on artificial turf playing surfaces and the effect of these injuries on playing behaviour. Improved reporting of abrasion injuries and a more biofidelic test device could assist in both the development of abrasion-related injury prevention strategies and in dispelling players' negative perceptions of abrasions on artificial turf. [8]

Artificial turf has been shown to have environmental merit over natural turf. A life cycle assessment showed that, over an entire life cycle, the global warming potential of artificial turf was less than half that of natural turf. Nevertheless, when the assessment was extended beyond global warming potential, artificial turf performed worse than natural turf in six separate categories of environmental impacts (including non-carcinogenic human toxicity and ecotoxicity of freshwater). This highlights the inter-locking issues of human and environmental health, ecotoxicity and sustainability which drive debate in discussions of artificial turf use, especially in comparison to the wide-ranging ecosystem services of natural turf.

Artificial turf samples contain a diverse range of chemicals, some of which have demonstrated in vitro bioactivities leading to effects such as endocrine, cardiometabolic and neurological toxicity. Notably, studies have identified polycyclic aromatic hydrocarbons (PAHs), heavy metals and other volatile organic compounds that are potentially hazardous to human health within artificial turf. Emerging studies have assessed how artificial turf pitches contain and release chemicals of concern (COCs) into the environment, with potential human exposure via inhalation of volatile substances released from artificial turf, accidental ingestion of crumb rubber infill, or dermal absorption, for example, through cuts and abrasions sustained during sporting activity. Depending on the bioaccessibility of these COCs via the route in which users are exposed, COCs have the potential to impact human health through increasing non-carcinogenic and carcinogenic risk. In addition, recent research has shown the presence of microplastics throughout the human body, including the brain, with research emerging on the potential health implications. Whilst artificial turf is a potential source of these microplastics, it remains to be determined what level of risk microplastics released from artificial turf pose to human health. The present review aims to describe the prevalence and characteristics of certain COCs present in artificial turf infill and fibres used worldwide, and to evaluate the human health risks posed to users of artificial turf. [9] Recently, the crumbs have been implicated in causing cancer in adolescents and young adults who use the fields, particularly lymphoma and primarily in soccer goalkeepers.[10]

Artificial turf or synthetic grass releases hazardous substances such as heavy metals, polycyclic aromatic hydrocarbons (PAHs), and volatile organic compounds (VOCs).

The current study aimed to evaluate the concentration levels of hazardous substances that are emitted from artificial turf as a result of sunlight effect; and to assess the expected exposure risks to such emitted substances during various activities.

VOCs emitted from artificial turf samples were monitored and collected in the ambient air of three football fields, the ambient air around a piece of new artificial turf that has not yet been used

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on playing fields, but has been exposed to sunlight within one year and in the indoor air around a piece of new artificial turf. [11]

Synthetic rubber and plastic are made with different types of endocrine (hormone) disrupting chemicals (also called EDCs). There is very good evidence regarding these chemicals in tire crumb used in PIP and artificial turf, based on studies done at Yale and by the California Office of Environmental Health Hazard Assessment (OEHHA).1 However, rubber playground surfaces like EPDM contain many of the same dangerous chemicals as tire crumb, since they are very similar materials, all made from petroleum.[12]Studies are beginning to demonstrate the contribution of skin exposure to the development of respiratory sensitization and altered pulmonary function. Not only does skin exposure have the potential to contribute to the total' body burden of a chemical, but also the skin is a highly biologically active organ capable of chemical metabolism and the initiation of a cascade of immunological events, potentially leading to adverse outcomes in other organ systems [12].

Artificial surfaces for outdoor sporting grounds may pose environmental and health hazards that are difficult to assess due to their complex chemical composition. Ecotoxicity tests can indicate general hazardous impacts, Due to their components, especially styrene butadiene rubber (SBR) from recycled scrap tires and plastics like thermoplastic elastomers (TPE) and ethylene propylene diene monomer rubber (EPDM), there is an increasing concern about potential environmental and health hazards Among the most important contaminants that may be released from synthetic surfaces and sporting grounds are zinc from zinc oxide used as vulcanization catalyst ,A possible approach may make use of ecotoxicity tests, which test for general impacts of compounds and complete assemblies on biological organisms. They indicate the ecotoxicological potential of a sample by integrating effects of all present compounds. Thus, they cannot determine effects of single contaminants but are able to detect synergistic impacts of all constituents on the environment. [13].

Toxic substances contained inside of artificial turf, who's utility has recently been increasing, and its negative effect on children's health are on the rise as a social issue. In particular, for heavy metals, polycyclic aromatic hydrocarbon and, volatile organic compounds contained inside of artificial turf filling, there is a fear that ingestion exposure could happen through direct absorption of rubber powder or indirect flow into the human body when rubber-stained hands are moved to the mouth. It is known that lead has a strong toxicity even when just a small amount of lead enters inside the human body. In the case that the human body is exposed to lead, the smaller the particle size and the younger the age of the exposure group, the higher the absorption rate inside the body, and it is known that only a portion of lead that is not absorbed is discharged from the human body. In addition, lead that enters the body is absorbed instead of calcium. Thus, children who need a lot of calcium, even when exposed to the same amount of lead as adults, an even larger amount of lead that exceeds the level of adults is absorbed inside by the children's body. In the case of children, they are more sensitive to the toxicity of lead, and because lead induces damage to the kidney, liver, nerves and immune system, management of lead is very important. Examples of exposure and risk assessment examples related to rubber powder used for artificial turf are mostly inhalation exposure, skin exposure, and ingestion exposure. Among these exposure examples, research about ingestion exposure is a supposition about direct ingestion, and there is research in progress that estimates the exposure claim that states that rubber powder may be swallowed from artificial turf during exercise. [14]

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Musculoskeletal injury is largely affected by the shoe-playing surface interface. Biomechanical data that suggest that torque and strain may be greater on artificial surfaces than on natural grass. Recent data on professional athletes suggest that elite athletes may sustain injuries at increased rates on the newer surfaces. However, these surfaces remain attractive to athletes and administrators alike because of their durability, relative ease of maintenance, and multi use potential. [15]

Cancer risks were identified for ingestion exposure to PAH in children with pica and heavy metal exposure via dermal, inhalation and ingestion pathways. Non-carcinogenic risks were identified for the ingestion of cobalt in a child spectator and the ingestion of arsenic, cobalt, thallium and zinc. Potentially hazardous concentrations of chemicals were found across both artificial turf infill and artificial turf fibre samples; bioaccessibility of these chemicals varied. [16]

Exposure to PAHs is linked to increased risk for multiple cancer types, including lung, skin, bladder, respiratory, and urinary tract. [17]. Children can get affected by polycyclic aromatic hydrocarbons (PAHs) while they interact with play area soil/rubber surfacing and exposed to PAHs by dermal contact, inhalation and hand-to-mouth activit, cancer risk is approximately 10 times higher in poured rubber surface playgrounds of artificial turf. [18]

10. INJURY PREVENTION STRATEGIES ON ARTIFICIAL TURF

Common injuries in sports include foot and ankle risks such as sprains and fractures, head injury risks including concussions, knee injuries with a particular focus on ACL tears, hip injury risks, and conditions like turf toe, which is a sprain of the big toe joint. Muscle strains, especially in the hamstrings and quadriceps, are also common, along with abrasions and burns from sliding on turf. A prevention study follows a four-step method. According to this model, the extent of the injury (step 1) and injury mechanism (step 2) are the starting points to introduce preventive measures (step 3) and assess their effectiveness (step 4). Establishing the extent of the injury problem reveals that 41%-81% of football injuries result from physical contact, mainly during tackles. Player-surface contact injuries account for 6.6% (1.67 injuries per 1,000 player hours) on artificial turf and 7.5% (1.87 injuries per 1,000 player hours) on natural grass ($p=0.72$). Understanding the injury mechanism is critical and requires insight into the correlation between risk factors and injury causes. External risk factors include sports factors, protective equipment, sports equipment, and environmental conditions, whereas internal risk factors comprise sex, age, body composition, health, physical fitness, anatomy, skill level, and psychological factors. Inciting events involve playing situations, player and opponent behavior, and biomechanical descriptions. Athlete-focused injury prevention is multifactorial, as decreasing one injury category can increase risk in another. Musculoskeletal injuries commonly result from excess torque leading to a locking effect on the foot, whereas surface contact injuries stem from slipping and sliding. Strategies to prevent musculoskeletal injuries may include cleat designs that minimize torque, such as spikes evenly weighted in the forefoot and hindfoot. To reduce surface contact injuries, avoiding cleat covers or materials that disrupt shoe-surface interaction can prevent slipping during running and cutting movements. Playing surface-focused injury prevention emphasizes field design and maintenance to ensure a consistent surface, which improves both performance and safety. Increasing field frictional coefficients helps reduce surface contact injuries by improving grip, while head and concussion injury risks can be mitigated through regular field maintenance. Exercise strategies for injury prevention, based on evidence-based approaches, allow physicians, athletic trainers, and medical personnel to enhance athletes' physical preparation to reduce injury risks effectively.

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11. CONCLUSION

Ensuring player safety on artificial turf requires a comprehensive approach that addresses both athlete-specific and surface-related risk factors. Preventive strategies such as proper cleat design, field maintenance, and structured exercise programs can significantly reduce injury risks. Understanding the biomechanics of injuries and implementing targeted interventions help minimize musculoskeletal strains, concussions, and abrasions. Regular monitoring and advancements in turf technology further enhance safety and performance. A well-balanced approach combining athlete preparation and surface optimization is essential for injury prevention in sports played on artificial turf.

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THE SCIENCE OF CALISTHENICS: INJURY EPIDEMIOLOGY IN STREET WORKOUT

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ABSTRACT

Calisthenics is a form of strength training that utilizes body weight as resistance to perform compound, multi-joint movements with minimal or no equipment. The term originates from the Greek words ‘kallos’ (beauty) and ‘sthenos’ (strength), signifying the art of using one's body weight to enhance muscle development. Over time, calisthenics has evolved into a structured training method encompassing fundamental bodyweight exercises, street workout styles, and gymnastic elements. While research has demonstrated its benefits in enhancing cardiovascular health, muscular endurance, mobility, and proprioception, the risk of injury remains an important consideration. The biomechanics of calisthenics share similarities with gymnastics, which may contribute to specific injury patterns, particularly in the upper limbs. However, due to a lack of extensive studies focused on calisthenics athletes, injury risks are often inferred from related disciplines. This study aims to explore the physiological effects of calisthenics, its role in improving functional fitness, and the prevalence and causes of injuries associated with this training method. By analyzing the movement patterns, risk factors, and injury epidemiology in calisthenics, the study seeks to provide insights into effective injury prevention strategies, ensuring safer practice for athletes and fitness enthusiasts.

Keywords: Calisthenics,Street workout ,Injury prevention , Epidemiology, Bodyweight training , athletic injuries , gymnastics, sports , exercise , wounds

1. INTRODUCTION

Calisthenics is a type of strength training that uses a person’s own weight as resistance to carry out compound , multi joint movements with little to no equipment [1] The word is derived from Greek origins , ‘Kallos’ meaning beauty and ‘sthenos’ meaning strength , it is literally the art of using one’s body weight as resistance to build muscles .Over time, this phrase has come to refer to a group of bodyweight exercises meant to increase fitness and health. These drills have been utilized in a variety of settings, including the military [2], medical and educational institutions [3] to enhance people's physical attributes. These days, the term "calisthenics" refers to a specific physical exercise that shares characteristics with gym. It is a mix of basic body weight exercises, street workout style and gymnastic routines and can be classified into Statics and Dynamics.

Static exercises would include practicing Push ups, Pullups, Chin ups, Burpees, Squats, Curl ups, planks, Lunges etc . A more advanced form would include skills like Dips, L Sit, front lever, back lever, planche, muscle ups, HSPU, headstand and handstand. Ballistic movements used in calisthenics require a high level of strength, muscular control, and flexibility during sport-specific motions. Calisthenics has been gaining popularity over the years due to its low cost of practice, popularity in public parks, ease of use, and minimal equipment requirements (such as parallel bars or a high bar). It has also been shown to be beneficial for physical development and aesthetics.[4]

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The term street workout (SW) can be viewed as an outdoor-focused variation of calisthenics. The World Street Workout & Calisthenics Federation's contest organization is another indication of its growth.[5] A recent American College of Sports Medicine study found that calisthenic activities came in seventh place among 2020 fitness trends.[6] Both big and small cities have plenty of outdoor fitness centers where kids can experience this sport. Bodyweight workouts with bars, parallel bars, gymnastics rings, and benches form its foundation. In addition to standard workouts, coordination drills like spins, flips, and turns are included, as are static holds or eccentric phases of movement. The primary purpose of using external weight is to make the exercises more challenging. Strength, flexibility, and balance are developed through this kind of training.[7]

Additionally, there are certain parallels between freestyle and gymnastics routines like the high bar, parallel bars, and uneven bars, which frequently involve a number of transitions, release techniques, and dismounts. Although the biomechanics of SW exercises have not been thoroughly investigated, given their resemblance to gymnastics, some functional phases and mechanical requirements might be involved.[8]

Calisthenics is based on the scientific principles of Muscle activation along with Neuromuscular efficiency by working several muscle groups at once, calisthenics encourages compound movement patterns that improve strength and functional fitness. Stabilizing muscles are recruited by exercises like push-ups, pull-ups, and squats, which enhance general mobility and coordination.[9] Exercises using only body weight increase neuromuscular coordination and control, which boosts movement efficiency. Self-weight training improves proprioception and balance, which are essential for both injury prevention and sports performance.[10]

2. SEARCH STRATEGY

Keywords such as calisthenics, injury prevention, epidemiology, bodyweight training, athletic injuries, gymnastics were used to obtain articles. The initial selection was based on titles and abstracts to determine relevance. Articles that met preliminary criteria were further examined for methodology, study design, and findings. After a detailed review, 60 articles were selected for in-depth analysis, with 43 articles ultimately retained based on critical relevance, study quality, and contribution to the research objectives.

The selected studies were categorized based on their study type (systematic reviews, cohort studies, randomized controlled trials, etc.), focus area (injury prevalence, physiological benefits, rehabilitation strategies), and key findings. The articles reviewed span a timeline from **2001 to 2024**, ensuring a comprehensive analysis of both historical and recent research developments.

3. METHODOLOGY

Study design: Literature review Date source: The following sites and their comprising references were used for the selection of the article - PubMed, Google Scholar, Science Direct, Taylor and Francis, Sage journal etc Study selection: The present study selection includes systematic review, literature review, research papers and comparative studies

4. PHYSIOLOGICAL EFFECTS OF CALISTHENICS

Studies indicate that bodyweight circuits can increase VO2 max and lower the risk of heart disease, and calisthenics routines frequently include high-intensity movements that raise heart rate and promote cardiovascular health.[11]

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By using bodyweight resistance workouts, calisthenics improves muscle strength and endurance. Frequent practice improves overall sports performance by increasing muscular growth and endurance capacity. [12]

Bodyweight workouts increase mobility and flexibility more than standard weightlifting. Exercises that increase joint range of motion, like lunges, dynamic stretches, and yoga-based calisthenics, lower the chance of injury. [9]

Both adults and children can benefit from calisthenics training in terms of developing their strength and flexibility.[13] [14] Strengthening the upper body is the primary goal of Street Workout. This was supported by previous research which showed that activities targeting the arms' and trunk muscles (push-up, hang hold, and plank hold) produced the biggest improvement. When the exercises are properly composed, the muscles in the lower body are also used.[15]

For male teenagers, calisthenics training improves trunk proprioception, muscular strength, balance, and core stability. [16] Body-weight exercises like bending, rotating, jumping, and other similar movements that work different muscle groups throughout the body are examples of calisthenics exercises, which typically involve rhythmic simple movements and brief muscular contractions to increase muscular strength and flexibility.[17] It has been shown that strengthening the muscles in the abdomen improves lumbar stability.

Due to the multi-joint motions involved in calisthenics training, improved coordination and reflex-driven or voluntary alterations in neuromuscular activation may be the cause of the strength gain .[14,18] Both intramuscular and intermuscular coordination are affected by variations in neuromuscular activity. These changes could include greater cerebral drive to agonist muscles, decreased activation of antagonist muscles, and enhanced muscle synergy, which would recruit more motor units and increase the firing rate of motor units.[19]

5. ETIOLOGY OF INJURY IN CALISTHENICS

Clinicians must rely on studies from other relevant sports because there is a dearth of data accessible for calisthenics athletes.[20] Neuromuscular strain varies, with gymnastics frequently causing greater joint impact because of intricate aerial maneuvers. [21] Despite putting strain on joints and tendons, calisthenics may have a lower incidence of acute injuries because of its progressive training style. Because both gymnastics and calisthenics require intense bodyweight workouts, their risk of injury is similar.

Calisthenics studies found that the core calisthenics techniques (walkovers, backbends, standing splits, and tigerstands/headstands and handstands) were significantly thought to cause injuries.[22] This illustrates how, even with a 20-year gap between historical and contemporary calisthenic research and a greater emphasis on strength and conditioning, these movements are still frequently used techniques thought to be harmful to athletes.[2324]

The majority of practitioners reported engaging in freestyle/dynamic exercises at the time of injury (20.7%), followed by planches (12.1%), muscle-ups (12.1%), front levers (10.3%), and other exercises (10.3%) . The most frequently mentioned exercise structure when asked what they were doing at the time was the bar (50.0%), followed by parallel bars (24.1%), the ground (19.0%), gymnastics rings (5.2%), and other (1.7%).

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1.1Upper Limb Injuries

It was observed that most athletes injured their shoulder , upper and mid back along with their elbows and wrists during practice [25] In sports like SW, where upper body exercises are frequently performed, a significant percentage of shoulder and upper limb injuries are reported.[26] [27]

Upper body activities including muscle-ups, planches, and front levers, as well as freestyle/dynamic exercises, are the ones most frequently associated with injuries in SW. On the one hand, freestyle exercises resemble high bar gymnastics and movements on uneven bars, which may account for the similarity in the patterns of body parts affected.[28] [29] Exercises that are isometric for the upper body, including the planche and front lever, have also been linked to injuries. According to descriptions, the planche calls for a high degree of upper body strength, precise biomechanical phases for execution, and the right training development.[30]

Repetitive shoulder movements above the horizontal plane are required for freestyle and upper body exercises in SW; moving the shoulder above 90 degrees has been linked to an increased risk of rotator cuff tendinopathy. [31] According to a number of studies, having a history of prior injuries would raise the chance of getting hurt again.[32,33] A change in strength, proprioception, and kinematics in the injured state may account for this association and result in modifications to motor control and function.[34]

Calisthenics, which primarily uses the upper extremities, is frequently done on bars or rings. Since the shoulder injury itself limits shoulder movements and the shoulder is one of the main body structures used in callisthenics, the ensuing effect on the elbow, wrist, and surrounding shoulder structures may account for the relatively high incidence and associated training time loss. Due to compression of the rotator cuff and subacromial bursa during the exercises, wide and reverse pull-ups can cause shoulder impingement. The wide pull-up reduces protraction and retraction range, while the reverse pull-up has an excessive glenohumeral internal-external rotation, which reduces subacromial space.[35]

This could be the primary cause of the nearly two-thirds of injuries that resulted in reduction of training time. Some of the injuries even resulted in loss of progress made. Calisthenics describes the shoulder as being under a lot of stress, this link is significant for both prevention and medical treatment. Shoulder injuries typically arise in distinct constellations based on the sport-specific stress profile.[36]

Traumatic injuries, rotator cuff injuries, and shoulder instability, including superior labral rips from anterior to posterior, are among the shoulder injury types observed in gymnasts. Gymnasts are prone to multidirectional shoulder instability. When the shoulder is rotated during certain overhead activities, patients may exhibit shoulder pain, instability, and/or clicking. On physical examination, generalized ligamentous laxity should be identified.Shoulder constriction and/or subacromial bursitis are the initial results of the increased shoulder motion. The supporting shoulder ligamentous components undergo plastic deformation as the microtrauma worsens, resulting in increasing laxity and instability.[37]

The ability to touch the thumb to the forearm and hyperextension of the elbow and knee are indicators of global laxity. Physical evaluations for anterior instability comprise the apprehension, relocation, and release tests.The posterior load and shift, posterior stress, and Jerk and Kim tests are among the procedures used to assess posterior instability.[38]

Gymnastics movements including tumbling, bars, dismounting, and landing put a lot of valgus and varus strains on the elbow. In particular, recurrent valgus stress on the elbow causes shearing pressures in the posteromedial compartment, compression of the lateral structures (such as the

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radiocapitellar joint), and traction/tensile forces on the medial structures, all of which lead to subsequent elbow problems.[39]

When participating in gymnastics, the wrist is subjected to strong impact loading forces. These consist of dissipative, torsional, and axial compression forces, frequently experienced when the wrist is hyperextended. According to reports, compressive pressures can reach 16 times an athlete's body weight. The pommel horse, floor exercises, and parallel bars are the activities most frequently linked to wrist pain.[40]

It has been demonstrated that a hyperextended wrist position during the push-up, another SW activity, increases and shifts the direction of dynamic forces in the wrist to regions such the triangular fibrocartilage complex that are less equipped to absorb stresses.[41]

1.2 Lower Limb Injuries

Upper leg (24.5%), ankle/foot (22.8%), and lumbar spine (19.3%) injuries were the most common, and the majority were sprains or strains (56.3%). The mechanisms of injury included elevated work (27.6%), overuse (38.0%), and specific calisthenics skills (38.9%), such as lower limb (40.3%) and lumbar (40.6%) extension-based movement.[42] Due to the dearth of data accessible for calisthenics athletes, physicians must rely on studies from other associated sports.For instance, gymnastics has one of the highest injury frequencies among female sport with 0.3–3.6 injuries per artistic gymnast. [26,43]

6. CONCLUSION

Calisthenics is a versatile and accessible form of bodyweight training that enhances strength, flexibility, and overall physical fitness while requiring minimal equipment. Its popularity has grown due to its effectiveness in improving cardiovascular health, neuromuscular coordination, and athletic performance. However, despite its benefits, the risk of injuries—particularly in the upper limbs due to repetitive strain and high-impact movements—remains a concern. Given the biomechanical similarities between calisthenics and gymnastics, injury patterns can be analyzed through existing research on related disciplines. To maximize the benefits of calisthenics while minimizing injury risks, practitioners should adopt proper training progressions, ensure adequate recovery, and integrate preventive strategies such as mobility work and strength balancing. Future research should focus on the biomechanics of calisthenics-specific movements to establish evidence-based guidelines for safer practice and injury prevention.

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THE ROLE OF NUTRITION IN DEMENTIA PREVENTION AND MANAGEMENT: A COMPREHENSIVE REVIEW

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ABSTRACT

This review investigates the association between nutrition and dementia, with a particular emphasis on how malnutrition can exacerbate cognitive decline and accelerate the progression of neurodegenerative diseases. Studies show that malnutrition is highly prevalent among individuals with dementia, with rates ranging from 6.8% to 75.6% in long-term care facilities . Malnutrition has been linked to increased neuropsychiatric symptoms, poorer quality of life, and higher mortality rates. Mechanistically, malnutrition contributes to cognitive decline through oxidative stress, neuroinflammation, and the dysregulation of metabolic processes, which in turn promote the accumulation of amyloid-beta and tau proteins, key markers of Alzheimer's disease. Nutritional interventions, such as adherence to the Mediterranean and MIND diets, have demonstrated protective effects against cognitive decline, suggesting that dietary patterns rich in antioxidants, vitamins, and healthy fats can mitigate the risk of dementia. Research from The Journal of Alzheimer's Disease further supports the role of specific nutrients like omega-3 fatty acids, vitamin D, and B vitamins in maintaining cognitive health and reducing neurodegenerative risk. However, the outcomes of clinical trials remain mixed, highlighting the need for personalized approaches that consider individual nutritional status and comorbidities.

1. INTRODUCTION

Dementia is a progressive neurodegenerative disorder characterized by the decline of cognitive functions, including memory, reasoning, and communication abilities. As the global population ages, the prevalence of dementia continues to rise, posing significant challenges to healthcare systems and caregivers alike. According to The Lancet Healthy Longevity [1], dementia is increasingly recognized as a multifactorial disease influenced not only by genetic and environmental factors but also by lifestyle choices, particularly nutrition.

T. gondii is the protozoan parasite that causes toxoplasmosis. Its hosts are warm-blooded animals like humans [2] .The life cycle of T. gondii is intricate and consists of an asexual cycle in its intermediate hosts and a sexual cycle in its definitive feline hosts.The three pathogenic forms—tachyzoites, bradyzoites, and sporozoites (found in oocysts)—are functionally different from one another.[3] Humans can contract T. gondii with ease, although actual disease is not common. Pregnant women are especially vulnerable to developing a clinical illness because the parasite can seriously harm an unborn child if the mother contracts it while she is pregnant. Immunosuppressed individuals, such as those receiving certain cancer treatments, tissue transplant recipients, AIDS patients, and cancer patients undergoing certain forms of treatment, are also at risk. If treatment is not received, these people may experience an acute, fatal infection. A disease characterized by fever, lymphadenopathy, and general malaise may strike certain individuals who may not appear to have a compromised immune system. [4]

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New studies suggest that poor nutritional status, including malnutrition, may accelerate the onset and progression of dementia. Malnutrition is particularly common among older adults with cognitive impairment, and its prevalence ranges from 6.8% to 75.6% in long-term care settings [5]. The mechanisms through which malnutrition influences cognitive decline include increased oxidative stress, neuroinflammation, and the exacerbation of amyloid-beta and tau protein accumulation, all of which are key pathological features of Alzheimer's disease.

Furthermore, studies such as those published in The Journal of Nutrition, Health & Aging [6] emphasize the importance of early nutritional assessment and intervention to prevent further cognitive and functional decline. Research from BMC Geriatrics [7] highlights the bidirectional relationship between nutritional status and cognitive health, where poor diet exacerbates cognitive impairment, and dementia symptoms often lead to reduced food intake and poor nutritional choices. The link between diet and cognitive health is further supported by dietary patterns like the Mediterranean and MIND diets, which have been associated with a reduced risk of dementia and improved cognitive outcomes [8]. Nutrient-rich diets focused on high intake of fruits, vegetables, whole grains, and healthy fats have shown protective effects against neurodegenerative processes. These findings underscore the need for a holistic approach to dementia care, where nutritional interventions play a pivotal role in prevention and management.

Given the growing body of evidence, this review explores the intricate relationship between nutrition and dementia, focusing on how malnutrition increases the risk of cognitive decline and the progression of dementia. By synthesizing findings from multiple studies, including clinical trials and systematic reviews, this paper aims to highlight the importance of nutritional interventions in dementia care and prevention.

Search Strategy

Data was collected from PubMed, Google Scholar, Scopus, and Web of Science. Key search terms included "dementia," "cognitive decline," "Alzheimer's disease," "nutrition," "dietary interventions," "malnutrition," and specific diets like the "Mediterranean diet" and "MIND diet." Articles published in the last 10 years and study type clinical trials, systematic reviews were included for the study. Studies published in the English language were taken in consideration for this review.

2. METHODOLOGY

1. Pathophysiology of Dementia and the Role of Nutrition

Dementia encompasses a group of neurodegenerative disorders, including Alzheimer's disease (AD), vascular dementia, and Lewy body dementia, characterized by progressive cognitive decline and loss of functional independence. The pathological hallmarks of these diseases include the accumulation of amyloid-beta plaques, tau protein tangles, and synaptic dysfunction, all of which contribute to neuroinflammation and oxidative stress. Nutritional deficiencies can exacerbate these processes, making adequate nutrition essential for brain health [9].

Oxidative stress is a key driver of neuronal damage in dementia. Poor dietary intake of antioxidants, such as vitamins E and C, contributes to increased free radical production and lipid peroxidation, damaging cell membranes and impairing neuronal function [10]. Similarly, deficiencies in B vitamins, particularly B6, B12, and folate, lead to elevated homocysteine levels, a known risk factor for cognitive decline and cerebrovascular damage [11].

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Neuroinflammation, another crucial factor in dementia pathogenesis, is closely linked to dietary patterns. Diets high in processed foods and saturated fats promote systemic inflammation, increasing the production of pro-inflammatory cytokines like interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α), which disrupt the blood-brain barrier and exacerbate neurodegenerative processes [12]. Conversely, anti-inflammatory nutrients such as omega-3 fatty acids, found in fish and nuts, have demonstrated neuroprotective effects by reducing inflammation and supporting synaptic plasticity [13].

2. *Malnutrition and Its Impact on Cognitive Decline*

Malnutrition, defined as an imbalance of nutrient intake relative to the body's needs, is particularly prevalent among individuals with dementia due to factors such as reduced appetite, difficulty swallowing, and behavioral changes affecting eating patterns. A systematic review reported malnutrition rates ranging from 6.8% to 75.6% in dementia patients residing in long-term care settings [14].

The consequences of malnutrition on cognitive function are profound. Insufficient intake of essential nutrients like iron, zinc, and magnesium impairs neurotransmitter synthesis and energy metabolism, leading to cognitive dysfunction and increased neuropsychiatric symptoms [15]. Protein-energy malnutrition, characterized by inadequate protein and caloric intake, has been associated with muscle wasting, frailty, and increased risk of hospitalization and mortality among dementia patients [16]

3. *Nutritional Interventions for Dementia Prevention and Management*

Emerging evidence supports the role of specific dietary patterns and nutrient supplementation in reducing dementia risk and slowing disease progression. The Mediterranean and MIND (Mediterranean-DASH Diet Intervention for Neurodegenerative Delay) diets have gained attention for their protective effects on cognitive health. Both diets emphasize high consumption of fruits, vegetables, whole grains, lean proteins, and healthy fats, providing a rich source of antioxidants, anti-inflammatory compounds, and essential vitamins and minerals [17].

Clinical trials have demonstrated that adherence to the Mediterranean diet is associated with a lower incidence of Alzheimer's disease and improved cognitive performance in older adults. The MIND diet, designed specifically to support brain health, has shown similar benefits, with studies indicating a 53% reduction in Alzheimer's risk among participants with high adherence [18].

Nutrient supplementation also plays a crucial role in dementia management. Omega-3 fatty acids, particularly docosahexaenoic acid (DHA), support neuronal membrane integrity and reduce neuroinflammation, while B vitamins lower homocysteine levels, mitigating vascular damage and cognitive decline [19]. Vitamin D supplementation has been linked to improved cognitive function, potentially through its role in calcium homeostasis and neuroprotection [20]

2. CHALLENGES AND FUTURE DIRECTIONS

Despite the growing body of evidence linking nutrition to cognitive health, several challenges remain in implementing effective dietary interventions for dementia prevention and management. Variability in dietary assessment methods, differences in study populations, and the complex interplay of genetic and environmental factors contribute to inconsistent findings across studies [21].

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Future research should prioritize large-scale, long-term clinical trials with standardized dietary protocols and comprehensive cognitive assessments to establish clear dietary guidelines for dementia prevention. Personalized nutrition approaches, considering individual genetic profiles, metabolic health, and lifestyle factors, hold promise for optimizing intervention outcomes [22].

3. CONCLUSION

The relationship between nutrition and dementia is well-established, with mounting evidence indicating that malnutrition accelerates cognitive decline and exacerbates neurodegenerative processes. Nutritional interventions, including adherence to the Mediterranean and MIND diets and targeted nutrient supplementation, offer promising strategies for dementia prevention and management. Early nutritional assessment and individualized dietary planning are essential to improving quality of life and cognitive outcomes for individuals at risk of or living with dementia.

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AR-GUIDED SIGN LANGUAGE & COMMUNICATION IN DEAF SPORTS

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ABSTRACT

Deaf athletes compete in national and international events on a regular basis, and the majority of them train in clubs alongside hearing athletes. People with deafness or substantial hearing loss claim to have a distinct cultural identity and belong to a sociolinguistic group, however the majority do not consider this a handicap. Hearing loss is linked to challenges with balance control, which can impede functioning. Athletes with hearing impairments face unique communication challenges in sports, where quick decision-making and effective coordination are crucial. AR is described as a technique that combines digital and physical information that occurs in real-time utilizing technological equipment. In particular, AR refers to the loading and merging of virtual items such as video, sound, photographs, text, 3D models, and so on into real-world perspectives. Thus, in the context of athletes who have difficulty hearing, Augmented Reality (AR) technology provides a unique solution that increases sign language interpretation, real-time game strategy communication, and referee signaling. Sign language (SL) is the primary mode of communication between hearing-impaired persons and other populations, and it is represented through both manual (body and hand gestures) and non-manual (facial expressions) characteristics. These characteristics are used to generate utterances, which transmit the meaning of words or phrases. This paper investigates the significance of AR in overcoming communication barriers for deaf athletes by combining wearable gadgets, haptic feedback, and visual overlays. By utilizing AR-driven captioning and gesture detection, deaf athletes may get rapid, context-aware information, enhancing engagement and performance.

1. INTRODUCTION

Deaf (D/deaf) athletes have distinct sports abilities, hearing loss, cultural and educational backgrounds, and communication styles. The way athletes feel about their hearing loss influences their personal identity. Athletes with hearing loss may identify as Deaf, deaf, or hard of hearing. Athletes who were born deaf, use native sign language, and primarily interact with the deaf community may identify as Deaf. Uppercase Deaf refers to a cultural and linguistic minority, whereas lowercase deaf refers to non-signers[1]. Augmented Reality (AR) has been effectively utilized to establish accessible and assistive environments that cater to the needs of Deaf and Hard of Hearing (DHH) individuals[2]. For instance, AR, in conjunction with Automatic Speech Recognition (ASR) and Text-to-Speech (TTS) synthesis, has facilitated the provision of real-time live captions for DHH users. Furthermore, extensive research has concentrated on the positioning[3], auditory identity[4], and personalization[5] of live AR captions within the visual field of DHH users. Additionally, various virtual sign language interpreters have been developed and deployed across diverse contexts, such as home entertainment[6] and educational settings[7], thereby enhancing the

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daily experiences of DHH individuals [8 9]. Deaf athletes frequently have substantial communication obstacles with coaches, teammates, and officials, necessitating the use of interpreters or visual signaling devices to participate in the game. Limited access to specialized training programs and resources suited to their specific requirements might impede skill development and competitive chances. The lack of exposure and comprehension of Deaf sports in mainstream athletics results in less financial possibilities, sponsorships, and media coverage. Social isolation and misunderstandings about Deaf athletes' talents can exacerbate psychological difficulties, reducing motivation and confidence. To guarantee that Deaf athletes have equitable chances in sports, inclusive legislation, improved coaching tactics, and breakthroughs in assistive technology are required.

Research on the athletic performance of D/HH athletes has also looked into the influence on quality of life and self-esteem, albeit research in this area are scarce. The findings show a strong relationship between sports activity, self-esteem, and overall life happiness, with recognition as a hearing-impaired athlete having a significant impact on everyday living quality. Overcoming hurdles in training and competition boosts self-esteem, adding to the psychological advantages of sports involvement. However, it does not appear that age or sport-specific experience have a substantial impact on self-esteem levels. Due to the scarcity of research, more studies using varied approaches are required to increase scientific evidence in this topic[10 11 12 13].

One of the most common challenges faced in deaf sports is that of communication due to minimal awareness of effective interaction with deaf individuals. Effective communication between athlete and coach is critical for effective collaboration, particularly among D/HH athletes who experience vestibular dysfunction-related challenges. Research repeatedly shows that strong communication with the coach is critical for great athletic performance, with characteristics such as coach type, gender, and communication strategies all playing important roles. D/HH athletes prefer hearing coaches, particularly those who can sign, to coaches who have hearing problems. Female athletes with vestibular problems typically communicate better than their male counterparts. Both sign language and spoken communication are well received, however hard-of-hearing athletes tend to favor oral communication. [14 15 16 17] Deaf athletes confront several obstacles in sports, including communication issues with coaches and teammates, restricted access to adequate training tools, and social prejudices about their talents[18]. The absence of hearing-specific accommodations, such as sign language-proficient coaches and visual signaling systems, significantly limits their participation and performance[19]. Overcoming prejudices and limiting media exposure is a continuing issue that affects financing and recognition in the sports community[20].

2. SELECTION CRITERIA

Articles were chosen based on their relevance to AR applications in sports, deaf athlete communication, and assistive technologies. Studies published in English were included, while non-English research was excluded. The review focused on the years covering AR advancements in wearable technology, biofeedback, and deaf-inclusive sports strategies.

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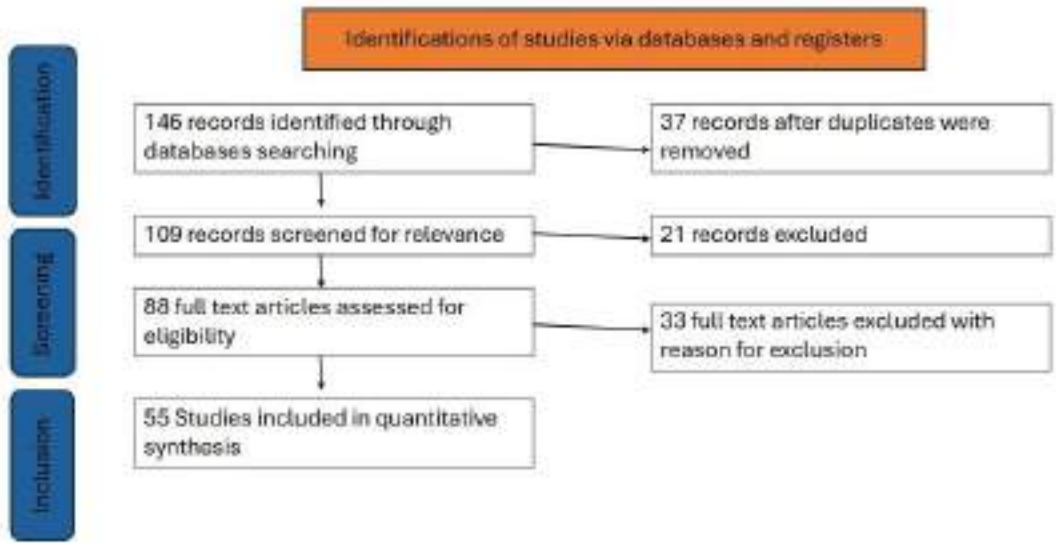

3. METHODOLOGY

The Deaf Sport

D/deaf individuals began participating in sports before persons with disabilities did. Since the establishment of residential schools for the Deaf in the 18th century, sign-language communities have grown. In the early 1900s, six deaf sport clubs were created in Britain, followed by others in Western Europe, including Nordic nations and Australia. These clubs enabled deaf managers and leaders to get vital experience and improve their leadership abilities in sign-language situations, which was not available in the non-deaf population. Deaf sports have helped develop sign-language communities and support social groups for the deaf. Eugene Rubens-Alcais of France and Antoine Dresse of Belgium established the International Silent Games, often known as the Deaflympics, in Paris in 1924. At the time of its creation, there were six established national federations for deaf sports[21]. To compete in Deaflympics and other deaf-specific sports, athletes must have a minimum hearing loss of 55dB in their better ear. This includes global and regional championships, as well as Deaf Champions Leagues. Hearing Aids and Cochlear Implants are Not permitted to be used in competition to level the playing field. Referees and officials employ visual tools during competitions, such as flashing lights, hand gestures, and flags, rather than aural communications[22 23].

AR and its Applications in Sports

The AR concept dates back to the 1950s, with the term being coined by Tim Caudell and David Mizell in 1990. In recent years, a few firms have expressed interest in employing AR at large-scale sporting events. However, there is currently no such system accessible. The landscape of sports has always been defined by a never-ending pursuit for perfection, the testing of human boundaries, and the investigation of strategies to better performance without sacrificing safety. As technology has become more prevalent in the sports business, new approaches to training, rest, and injury

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prevention have arisen [24]. Augmented reality refers to technology that enhances people's views of the actual world through sensory input [25]. For example, Apple demonstrated the usage of augmented reality in a baseball game, but there is no additional information regarding the practicality or technology employed. Panasonic showcased the notion of deploying augmented reality in stadiums in 2018 with large-scale projection mapping. This used augmented reality technologies to recreate the genuine stadium experience. Similar to the baseball AR application, it is unclear when it will be marketed and made available to the public. A recent study simulated an AR experience at a stadium using a theater setting to see if it might benefit sport viewers[26]. Research indicates that augmented reality applications in sports primarily focus on developing expert systems to assist trainers in training athletes, managing competitions more fairly, and presenting competitions to audiences in an engaging manner. An example of this is PingPongPlus, a sports training and analysis software, analyzes ping pong players' tactics and promotes interactive competition. Augmented Reality with Live Sports is another example of a large-scale AR use. Popular sports transmitted to millions provide viewers with a wealth of information and statistics. Some other examples of AR in sports include AR sports equipment designed to boost training. AR glasses for swimmer training and AR apps for soccer training may combine hundreds of data points into real-time training feedback[27 28]. Even traditional sports broadcasting now incorporates Mixed and Augmented Reality technology to visually combine complicated information into video footage. Visual overlays can display player names, paths, ball possessions, heat-maps, and game signals (e.g. offside lines in football). These visualisations have the feature of being replays rather than real-time. Visualizations, especially in 3D, need perfect registration of cameras or sensors, which are becoming more common in modern stadiums[29].

Wearable Gadgets In Sports

Wearable technology enhances sports performance with real-time data processing and tracking. Both professional and amateur athletes use wearable sensors to improve training efficiency and competitive results. Wearable Technology (WT) has been utilized in healthcare, sports, entertainment, electronics, textiles, and defense industries for many years. Wearable technology includes non-invasive gadgets and sensors that may monitor health parameters without the need for subcutaneous applications. WT transforms sports by giving real-time data for players to better training, coaches to customize plans, and industry insights. WT devices are Internet of Things (IoT) with three layers: sensor, computation, and network. The first two layers, sensor and processor, comprise all processes performed purely on the WT's electrical hardware. WT includes external devices, processing processes, and communication protocols in the network layer[30].

Polar, a Finnish firm founded in 1977, is widely regarded as the pioneer of professional sports wearable devices. They are well recognized for their heart rate monitoring equipment. Polar now offers GPS and Fitness Trackers, as well as software for data analysis. The Polar Sport Tester PE2000, launched in 1982, was the first wireless wearable heart-rate monitor. It consisted of a transmitter worn on the chest and a receiver worn on the wrist. These devices were designed for elite athletes who want to improve their training[31]. Another such example of wearable technology

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we use on a daily basis while working with athletes is accelerometers. Accelerometers monitor acceleration and can assess physical activity intensity over time. Accelerometers are popular wearable sensors for activity identification due to their precision, compact size, and low battery consumption[32, 33]. Vibrating wristbands alert players to referee whistles or game-start signals, allowing them to stay involved in play despite aural difficulties[34]. Smart glasses provide visual signals or captions for coaching input, improving communication between Deaf athletes and their teams[35]. Sensor-equipped vests use haptic feedback to direct movement and location during games[36].

4. HAPTIC TECHNOLOGY

Haptic technology simulates touch using forces[37], vibrations[38], movements[39, 40], and electrical impulses[41]. Haptic technology, which arose in the mid-20th century, was largely used to boost mechanical and flying operations. The main goal was to enhance physical control while promoting safety and precision in these sectors [42].

Haptic feedback can be tactile or kinesthetic, providing a sense of touch (e.g., texture and vibration) or kinesthetic feedback (e.g., weight and resistance).As the haptic feedback field widely deals with the tactile sensations of the human body resulting in biofeedback, it is essential to have adequate understanding of the psychophysics of the human tactile system to create a successful tactile communication interface that produces genuine sensations. The human touch system is well-developed, with the skin at its heart. The human sensation of touch is classified as cutaneous or kinesthetic, depending on where the sensory input occurs[43]. The cutaneous sense has a variety of sensory receptors, including mechanoreceptors (respond to mechanical stimulation), thermoreceptors (react to temperature stimulation), and nociceptors. The cutaneous sense gets sensory input from receptors implanted in the skin (cold, warm, pain receptors, and mechanoreceptors), whereas the kinesthetic sense receives sensory input from receptors located in muscles, tendons, and joints. The human skin is densely packed with many types of mechanoreceptors, which are among the sensory receptors that transmit tactile inputs to the brain in the form of electric nerve impulses [44, 45].

Haptics have been used to improve interaction in various contexts, such as distributed groupware systems, where haptic awareness has been found to improve task performance. In a recent study, a device named HaptStarter which is a haptic stimulus start system was used to improve the starting performance of the Deaf and Hard of Hearing (DHH) sprinters by replaces standard auditory start signals with vibrating indications.The system comprises a wearable device (such as a haptic band or vest) outfitted with vibration motors. When the race begins, an electrical trigger sends a wireless signal to the gadget, which activates a pre-programmed vibration pattern that simulates the rhythm of a starting gun. These vibrations give time feedback, allowing athletes to anticipate the start and respond faster. According to studies, haptic signals minimize reaction time when compared to visual cues, allowing DHH athletes to compete on the same level as hearing athletes. The gadget is in line with official timing systems, making it a fair and effective option for inclusive sports contests[46].

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Villamarín & Menéndez (2021) designed a haptic glove that integrates with a sports broadcast system to improve the experience of Deaf viewers by converting audio signals into tactile vibrations[47]. Molina et al. (2024) conducted a study on vibrating wristbands designed to help Deaf athletes detect referee whistles in recreational sports. These wristbands provided real-time haptic feedback, ensuring athletes could respond promptly to game signals. The study highlighted the effectiveness of this technology in improving accessibility and inclusivity in sports for Deaf individuals. The researchers emphasized the potential for further development to enhance the accuracy and usability of such wearable devices.

Inculcating Sign Language In Deaf Sports

Deaf persons meet real problems to know sports results unless they are not watching TV or not present on site as stadiums.Sports were first introduced to the deaf community in the 20th century. Deafness, often known as hearing impairment, is the inability to perceive certain frequencies of sound. For almost a century, there has been no specific sport for the deaf. However, several sports rely mostly on noises as signals. As more deaf individuals participate in sports, other terminology has emerged to reflect their perceived engagement by able-bodied athletes worldwide. On one level, deaf sport is described as a sport in which deaf athletes compete. Deaf sports should be viewed culturally. The Disabled People's Organizations also known as DPO have advocated for sports. Some DPOs, such as the International Committee of Sports for the Deaf, are overly active. They arrange the Deaflympics and provide an online site for results and updates. Illiterate deaf individuals may struggle to read and understand findings without the assistance of a sign language interpreter. An example of a technological advancement in the use of sign language with regard to the field of sports include Sign language animation synthesis. It is a cutting-edge technique that employs artificial intelligence (AI), motion capture, and computer graphics to translate text or spoken words into animated sign language for deaf athletes and viewers. This technology works by analyzing linguistic patterns and transforming them into 3D avatars that can make realistic sign language motions. Natural language processing (NLP) models are used to read and decipher sports comments or directions, followed by gesture synthesis algorithms that create precise hand gestures, face expressions, and body postures. Motion capture data from human signers is commonly utilized to improve realism and fluidity. In sports, real-time sign language synthesis can be integrated into stadium screens, sports broadcasts, or wearable AR/VR devices, allowing deaf athletes to get game instructions quickly and spectators to follow live matches without depending on captioning. This invention makes sports more accessible, engaging, and inclusive for the hearing-impaired community [48].

Visual Feedback

Visual scanning jobs in augmented reality include carefully monitoring and analyzing both the real-world surroundings and virtual overlays using devices such as smartphones or AR glasses. Visual scanning tasks include searching for and identifying both physical and virtual elements in the augmented space, distinguishing between real and virtual objects, interpreting visual cues and

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indicators overlaid on the real environment, adapting to changes in both the physical surroundings and the digital overlays, and maintaining spatial awareness of the real environment while engaging with virtual elements [49].

Delivering digital overlays in large-scale locations, such stadiums or sports fields, presents unique problems that differ from standard AR applications. This is especially noticeable when providing material in the appropriate location and context for the user. It is crucial to understand the user's position and orientation in relation to the graphic material. Additionally, the displayed material must be spatially represented (e.g., GPS coordinates in the field[50].

Deaf and Hard of Hearing (DHH) persons have difficulty understanding particular auditory cues in diverse real and virtual contexts while doing these jobs. They rely on visual and tactile clues and regularly change their focus to maintain spatial awareness[51 52 53].

Several research on visual scanning have been undertaken in both real and virtual contexts, with a focus on eye-tracking among DHH users. Eye gaze plays critical functions in visual languages such as sign language (e.g., gaze patterns accompanying kinds of verbs[54], locative pronouns[55], gaze fixation on the face and upper-body[56], etc., as evidenced by eye-tracking studies. Furthermore, the perception of emotions by DHH users utilizing facial characteristics under varied situations[57] and face and body postures has been studied using visual scanning[58].

A research conducted in 2024 recruited 11 DHH volunteers who played seven rounds of the AR game Angry Birds AR. Following the game, each participant took part in a brief structured and a longer semi-structured interview. Their study found that both modest audio cues and overwhelming visual clues had a detrimental influence on participants' performance. Alternative techniques, including dynamic surroundings and user-friendly haptic and textual signals, can help reduce this issue. Participants had to compromise on AR visibility to retain real-world spatial awareness. Incorporating spatially aware methods in AR can improve performance without diverting attention[59].

5. CONCLUSION

By combining real-time sign language translation, captioning, visual and haptic feedback, and wearable technology, Augmented Reality (AR) offers a revolutionary way to improve communication and accessibility in Deaf sports.

Key findings emphasize how AR inculcated in Deaf sports can improve athlete-coach interactions, facilitate real-time game strategy communication, and improve referee signaling through visual and tactile cues.

However, despite its potential, there are still some obstacles to overcome, such as high costs, technological limitations in gesture recognition, and the need for standardized AR solutions across different sports. Future research should concentrate on improving multi-sensory AR integration (visual, haptic, and AI-driven auditory substitutes), and guaranteeing wider accessibility through affordable solutions. To guarantee equitable chances and improved performance for Deaf athletes in competitive sports, sports organizations, tech developers, and accessibility advocates must work together to overcome these challenges.

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REVOLUTIONIZING ESPORTS PHYSIOTHERAPY: THE TRANSFORMATIVE ROLE OF HAPTIC FEEDBACK IN REHABILITATION

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ABSTRACT

Background: Concerns over the players' physical health and wellbeing have grown as a result of esports' explosive growth. Long-term gaming sessions and repetitive fine motor exercises can lead to musculoskeletal diseases, such as carpal tunnel syndrome, wrist strain, and postural problems.

Objective: With an emphasis on motion retraining, injury prevention, and ergonomic improvement, this study investigates the function of haptic feedback in physiotherapy for esport participants.

Methods: A comprehensive analysis of peer-reviewed research from 2019 to 2025 was carried out. Information was obtained from sources like Google Scholar, PubMed, and Science Direct in order to find pertinent research on the use of haptic feedback in esport players' physiotherapy.

Results: The results show that among esport athletes, postural abnormalities and repetitive strain injuries (RSIs) are highly prevalent. Effective posture correction, injury risk reduction, and ergonomic habit enhancement have all been demonstrated with real-time haptic feedback interventions. Strategies for preventing injuries were further reinforced by the use of wearable motion capture sensors for risk assessment and individualized feedback.

Conclusion: An inventive and useful tool for physiotherapy in esport is haptic feedback technology. It enhances long-term musculoskeletal health, improves motor control, and speeds up rehabilitation results. Player performance can be improved while injury risks are reduced by incorporating haptic feedback into physiotherapy exercises.

Key Words: sports, Haptic Feedback, Physiotherapy, Injury Prevention, Posture Correction, Musculoskeletal Health, Wearable Technology, Motion Retraining, Ergonomics, Rehabilitation.

1. INTRODUCTION

Interest in the performance, involvement, and general well-being of esports players has grown as a result of the recent exponential increase in esports participation.[1]Over the past ten years, esports have grown significantly and quickly in many different fields.[2]With many institutions establishing intercollegiate eSports departments, competitive video gaming is likewise becoming more and more popular. Injuries as are beginning to become increasingly common as the live streaming community and competitive eSports industry continue to expand. [3]esports exposes

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players to physical and psychological dangers, such as competing in competitive conditions, long sitting sessions, repetitive fine motor motions.Six to eight hours of sitting may increase all-cause mortality, cardiovascular disease mortality , and orthopedic injuries caused by bad posture .[4] Neuropathic and tendinopathic disorders, such as epicondylopathies (wrist flexor and extensor tendinopathies), de Quervain's tenosynovitis, and intersection syndrome, can also result from esport[5].Anterior trunk inclination, forward-head or flexed-neck posture, and higher thoracic kyphosis and lumbar lordosis were the spine kinematics of mobile gaming posture. The increased exposure from these atypical poses may result in increased stresses on extensor muscles[6].The athletes' risk of musculoskeletal issues and possible injuries should be reduced by physical training regimens and other ergonomic factors.[7]One interesting method for motion retraining is real-time feedback. Knee and impact loading have been changed through the use of tactile or visual feedback.[8] . Haptics is the study of sensation, interaction, and communication through touch. Sensations like phone vibrations or the sense of pushing a button can be included in haptic technology. Both kinesthetic and tactile elements are included in haptics. Systems that allow people to communicate and feel the sensation of touch over physical distances are referred to as technology-mediated touch. The emergence of haptic distant communication tools has opened up fascinating possibilities for technology-mediated touch, allowing for a better comprehension of mediated social touch and how it affects interpersonal communication in virtual spaces. [9] Esport performance is generally agreed to be dependent on players' motor capabilities (such as keyboard and mouse motions) and cognitive abilities .[10]Objective measures can be obtained by investigating kinematics (3-D motion capture, inertial measurement units, goniometers), kinetics (force plates, pressure mats), and muscle activity.[11]

The purpose of this study is to investigate how haptic feedback can help esports players recover from the special musculoskeletal issues brought on by extended gaming. It focuses on how motion retraining, injury prevention, and ergonomics can be improved using real-time tactile input, which will maximize esport performance and physical well-being.

2. METHODOLOGY

Data on haptic feedback for esport injury prevention was collected for this study from sources like Science Direct, PubMed, and Google Scholar. English-language, peer-reviewed, full-text publications with an emphasis on haptic feedback, ergonomic interventions, injury prevention, and rehabilitation in esports that were published between 2019 and 2025 were included in this review. Non-peer-reviewed sources, research unrelated to haptic feedback or esport, and studies that only addressed psychological issues without addressing physical rehabilitation were excluded.

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Review of Literature

S1. No	Title/author/year	methodology	conclusion
1	WK Lam, RT Liu, B Chen, XZ Huang, J Yi, DWC Wong conducted study on health risk and musculoskeletal problems in elite players in the year 2022.	The questionnaire included two parts and was written in Chinese. In the first part, the participants were given a list of symptoms/health problems, including eyestrain/dry eyes, headache/dizziness, somnipathy, anxiety neurosis, sleep disturbance, shoulder pain, scapula pain (periscapular pain), lumbar muscle strain, hemorrhoids, varicose veins, stomach pain/upset, angina pectoris, loss of appetite, and rhinitis. The list was selected on the basis of previous studies on mobile gaming.	high prevalence of headache, neck pain, and finger pain and a high occurrence of head and trunk injuries among elite mobile-gaming athletes.
2	Nicholas nalic pierides Jr. conducted a study on ergonomic approach for esport athletes. The potential for less injury and increased occupational performance.In the year 2023.	This eight-week capstone project involved a single esports athlete selected based on criteria including age (18-30 years), at least one year of structured esports experience, competitive gameplay at an above-average level, self-reported discomfort from prolonged play, and enrollment in a college with an esports program. The study implemented an ergonomic protocol focusing on posture correction, workstation setup, and injury prevention, supported by real-time haptic feedback to alert posture deviations. Data collection included weekly observations, self-report logs, and pre- and post-assessments of posture, discomfort, and performance metrics.	This project highlights the vital role of therapists in enhancing ergonomics for esports athletes. Therapeutic interventions, including posture training, muscle strengthening, and personalized ergonomic advice, significantly reduced discomfort and improved gaming performance. Feedback from the case study emphasized the positive impact of

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			physiotherapy in promoting healthier habits and preventing RSIs. Integrating physiotherapy into esports health models can enhance both the quality of life and competitive performance of athletes.
	Ivanova violeta has conducted a study on carpal tunnel syndrome symptoms in esports players.In the year 2020.	literature review was conducted on Carpal tunnel syndrome definition, testing, risk factors and treatment. For the practical implementation, measurements were recorded in collaboration with 6 players from Tikka eSports and 2 independent players. For 7 days, the players filled a symptom and performance diary with attached software recording of mouse movement.	Gathered data has shown is an example of physical wrist stress and potential Carpal Tunnel syndrome risk factors an Esports player could have.
	A Frasie, M Houry, C Plourde, MT Robert, LJ Bouyer conducted a study on feedback for the prevention and rehabilitation for the work related musculoskeletal disorders.In the year 2023.	Studies of various designs assessing the effects of extrinsic feedback during work tasks on three outcomes (function, symptoms, sensorimotor control) in the context of prevention and rehabilitation of WRMSDs were included.	Extrinsic feedback is an interesting complementary tool for the prevention and rehabilitation of WRMSDs in controlled environments.
	A Ferrone, A Garcia Patiño, C Menon conducted study on low back pain-behaviour correction by providing haptic	We divided the study into four sessions. The first session (session zero) let the participants familiarize themselves with the device and setup. At the beginning of each session, an operator explained the study purpose,	The haptic feedback was shown to have an important impact on the participants' posture. Moreover, the participants tried

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	feedbacks.	device features, tasks, and objects that were used for the tasks. During this phase, we used a script to provide consistent information to each of the participants. All participants had the opportunity to inspect the device and ask questions. An operator was available to help them place the device on their back following the positioning illustrated in **Figure 2**a. The forward/backward bending correspond to rotations about the roll axis. The left/right lateral bending correspond to rotations about the pitch axis. Finally, the left/right twisting correspond to rotations about the yaw axis. A positive value corresponds to the movements forward bending, right lateral bending, and right twisting.	to immediately correct their posture when the device gave them haptic feedback. Finally, this study shows that the participants were able to learn to avoid dangerous postures after the training session.

3. DISCUSSION

A study conducted by WK Lam et al. found that sports gaming had a detrimental effect on athletes' spinal health. Its ability to guide the development of therapeutic therapies and preventive training programs intended to reduce these risks accounts for its use.[12]The prevalence of chronic musculoskeletal pain among ordinary mobile phone users was found to range between 4.2% and 13.3%.[13]Physical wrist stress and potential. Carpal Tunnel Syndrome risk factors that an Esports player may have.presents preliminary findings on the efficacy of therapist-guided use of a low-cost gaming station with haptic feedback for hand/arm motor rehabilitation in esports participants.[14]In today's digital world, electronic sports, or esports, have developed into a significant competitive arena that has drawn the attention of well-established businesses and is rapidly expanding. The performance of e-athletes is greatly influenced by cognitive function, which includes motor time, reaction time, and eye-hand coordination..[15]The more consistent and informative multi-sensory feedback especially related to the motor task and the greater involvement within the virtual scenario make haptic feedback a positive supplement to the treatment.[16]Different sensory modalities, such as tactile, visual, or audio (e.g., voice or alarm), can be used separately or in combination to provide feedback. Additionally, they can be programmed to run at different frequencies—continuous, intermittent, or faded—during or after an activity. Furthermore, a health expert may enforce input or it may be self-controlled . Lastly, the user may receive feedback on movement features (e.g., joint angle, muscle activation) throughout the task or movement outcomes (e.g., accuracy, time) after the conclusion of the activity.[17]There are

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several possible applications for wearable motion capture devices and systems in risk management for preventing musculoskeletal injuries. This comprises exposure data (kinematic measurements, such as postures and wrist, arm, and trunk movements) that can be utilized as input for risk assessment, risk analysis, and hazard identification.[18]

This study emphasizes the serious physical risks—such as persistent wrist tension, carpal tunnel syndrome, and posture-related injuries—that come with long-term esports engagement. Promising results in posture correction and injury prevention were shown when haptic feedback was incorporated as an ergonomic intervention. Real-time tactile input decreased the incidence of repetitive strain injuries (RSIs) by enabling prompt detection and correction of bad posture. This method supports earlier research showing that multisensory input improves motor control and recovery results. A unique approach to motion retraining and player-specific ergonomic adaptations is provided by the use of haptic technology in conjunction with physical therapy. Furthermore, the development of tailored intervention programs can be further supported by the useful data that wearable motion capture equipment can offer for risk assessment and injury prevention tactics.

4. CONCLUSION

The study's findings emphasize the importance of haptic feedback and physical therapy in treating the musculoskeletal issues that esports competitors encounter. In order to avoid RSIs, promote improved posture, and lessen discomfort, physiotherapy therapies backed by real-time tactile feedback were successful. Using haptic technology with ergonomic techniques is a promising way to improve athlete well-being and esport performance. Future studies should concentrate on extending these interventions to group environments and investigating cutting-edge wearable technology for all-encompassing risk management and injury prevention.

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TECH DRIVEN RELIEF: INNOVATIVE TECHNOLOGIES FOR PRESSURE SORE PREVENTION AND MANAGEMENT

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ABSTRACT

Introduction: Localized skin and tissue damage brought on by prolonged pressure or shear is known as a pressure ulcer (PU), and it is more common in people who are bedridden or rely on wheelchairs. Advanced technology solutions are required because traditional preventative approaches frequently fail. In order to prevent and manage pressure ulcers, this review assesses developments like smart mattresses, sensor-based systems, AI-driven analytics, sophisticated biomaterials, and telemedicine.

Methodology: The usefulness of cutting-edge technology in improving pressure redistribution, infection control, risk identification, remote monitoring, and adherence to preventative methods was evaluated through a comprehensive review of clinical and observational studies.

Results: Adaptive support surfaces, AI-driven solutions, and smart sensors all considerably lower the risk of pressure ulcers. Together, advanced biomaterials and telemedicine improve patient outcomes and lower healthcare costs by accelerating healing and increasing remote monitoring and adherence to care protocols.

Conclusion: Technological advancements provide efficient methods for managing and preventing pressure ulcers, improving patient care, lowering complications, and making the most of medical resources. In order to optimize their clinical impact, broader usage and additional research are advised.

Keywords: - pressure ulcers, pressure sores, technologies, management, prevention, sensors, mattress

1. INTRODUCTION

The PU/PI (pressure ulcers or pressure injury) is defined as localized damage to skin and/or underlying tissue, as a result of pressure or of pressure in combination with shear; PUs/PIs usually occur over a bony prominence, but may also be related to a medical device or other object. Tissue damage occurs during loading by very high and/or prolonged mechanical strains acting on soft tissue.[1] Patients who are bedridden or wheelchair-reliant spend long time in sedentary postures and develop pressure ulcers (PUs). For caregivers, manually repositioning, transferring and lifting immobile patients can be physically strenuous work.[2] The hospital- acquired wounds may lead to: an increased risk of sepsis and/or other severe and possibly life-threatening infections; other

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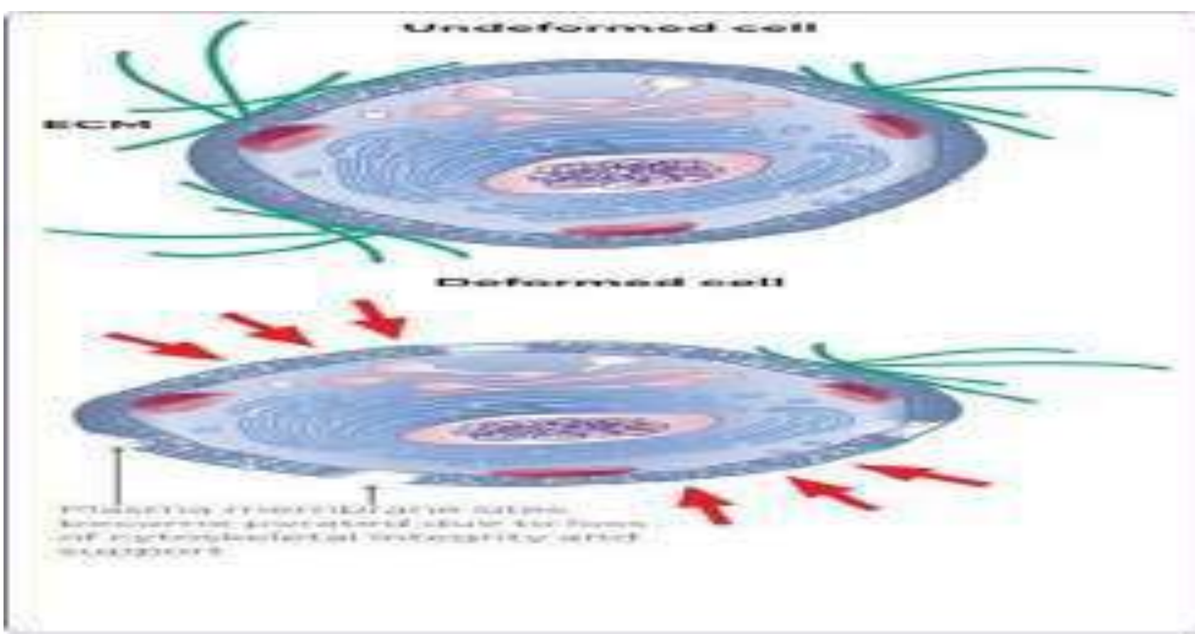
symptoms including pain and scarring which might be highly visible and disturbing; altered body image and/or reduced quality of life; increase in hospital stay and consume extra resources (time and products).[3] Utilizing pressure-relieving support surfaces, such smart mattresses and cushions, which monitor pressure, temperature, and humidity to enable adjustable firmness and contour redistribute pressure, provides a technology-based preventative strategy for bedsores. Technology-driven initiatives are emerging as helpful supplements to traditional methods to solve their shortcomings[4]. By synthesizing many data sources and utilizing intelligent analysis, we can seamlessly combine technology with compassionate care, resulting in enhanced and individualized chronic illness management services.[5] These developments seek to enhance the quality of life and health outcomes for patients by providing more dependable, efficient, and individualized therapy alternatives.[6]Choi, H., & Tak, S. H. study indicates that tailored mattresses, cushions, and other support surfaces can markedly decrease the occurrence of pressure ulcers in high-risk groups.[7] Treatment expenses were higher for younger individuals. [8] This study's main goal is to investigate and assess cutting-edge technology-based approaches for the management and prevention of pressure ulcers (PUs) in patients who are susceptible to extended periods of inactivity, such as those who are bedridden or reliant on wheelchairs. Pressure ulcers pose serious health and financial problems since they are caused by prolonged mechanical strain that is impacted by variables like pressure, temperature, humidity, and shear forces. The complex nature of PU formation and progression is sometimes overlooked by traditional preventive strategies. Thus, the goal of this research is to examine how cutting-edge interventions—like smart mattresses, sensor-based monitoring systems, AI-integrated solutions, and sophisticated wound dressings—may improve early identification, individualized treatment, and general preventative tactics. These technologies have the potential to lower the prevalence of pressure ulcers, enhance patient outcomes, and maximize healthcare expenditures by combining data synthesis, real-time monitoring, and intelligence analysis.



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2. METHODOLOGY

This review involved a systematic search of Science Direct, PubMed, and Google Scholar using keywords like pressure ulcers, pressure sores, technology in PU management, and smart mattresses guided the search to gather data on technological advancements in pressure ulcer (PU) prevention and management, focusing on interventions like smart mattresses, sensor-based systems, AI-driven solutions, and advanced wound dressings. Inclusion criteria were peer-reviewed, full-text articles published in English between 2019 and 2025, emphasizing technological strategies for PU prevention in immobile patients. Exclusion criteria included non-peer-reviewed articles and studies outside the specified date range, non-English publications, research focusing on non-technological approaches.

3. TECHNOLOGICAL INNOVATIONS IN PRESSURE ULCER PREVENTION

1. *Smart Sensor Based Monitoring System*

Wearable devices have markedly improved the efficacy and precision of chronic disease monitoring through the integration of sensors, the Internet of Things, and artificial intelligence technology.[9] The wearable sensing unit consists of a pressure sensor based on a liquid metal microchannel in combination with a thermistor-type temperature sensor incorporated into a flexible printed circuit board. The array of the wearable sensing units is connected to a readout system board for the transmission of measured signals to a mobile device or PC over Bluetooth communication. We evaluate the pull-through-profiles of the sensor unit and the feasibility of the wireless and wearable body-pressure-monitoring system through indoor testing and preliminary clinical testing in the hospital. The results show that the presented pressure sensor exhibits high-performance quality and exceptional sensitivity in detecting both high and low pressure. The proposed system is able to continuously measure six hours of pressure at bony sites on the skin with no disconnection or interruption, while the PTI-based alarming system functions successfully in the clinical setup.[10]An IoT-based system with a smart fabric sensor mat monitors and logs the patient's sitting and lying pressure in real time. It uses machine learning to interpret posture while all subsequent data are stored in the cloud, accessible by caregivers. Caregivers can remotely manage repositioning schedules via a smartphone or tablet. The new works not only to improve efficiency of care but also the quality for wheelchair- and bed-bound patients.[11]

2. *Advanced biomaterials as wound dressings for pressure ulcer prevention and care*

a) Collagen

The APZC dressings have an interconnected microporous structure and superb physiochemical properties, in addition to good blood coagulation performance and well cytocompatibility. APZC dressings are characterized by persistence and a broad spectrum of antimicrobial activity, which helps in the reduction of the inflammatory reaction by killing pathogenic bacteria and inducing blood vessel formation and orderly collage deposition at the wound site, thereby promoting infected full-thickness wound healing without conspicuous scar formation. All in all, the functionalized collagen-based nanocomposite dressings hold great promise in the Clinical Treatment of bacteria-associated wound infections.[121314]

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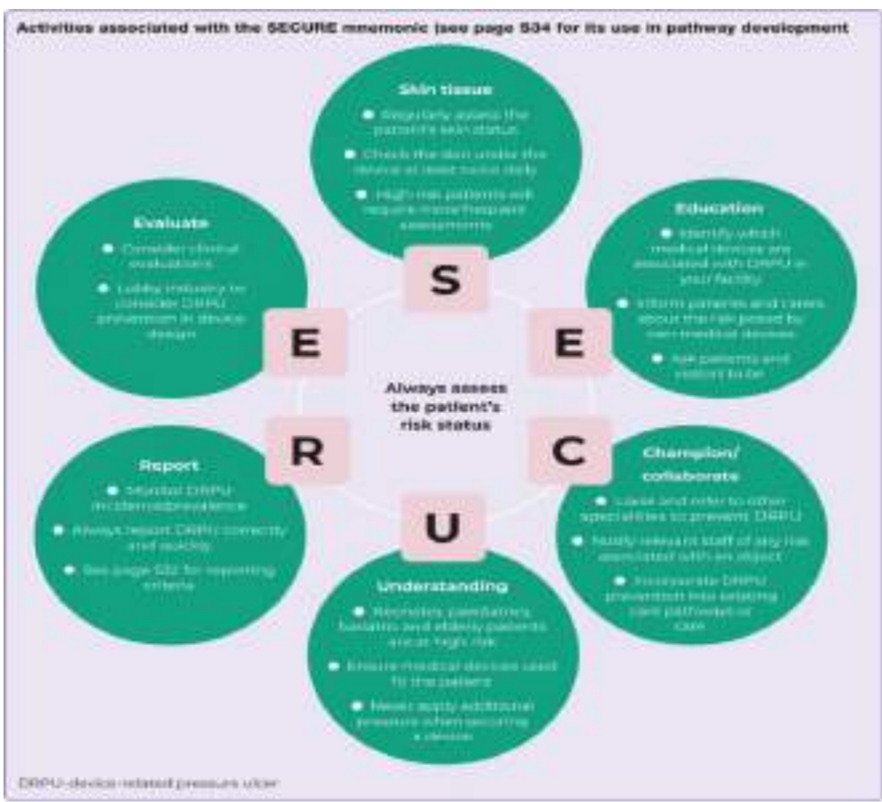
b) advanced biomaterials for pressure ulcer prevention and care- Nanomaterials Nanomaterials are increasingly being used in medicine, with nano-silver and nano-zinc oxide particularly notable for their potent antibacterial capabilities. These compounds have broad- spectrum activity against bacteria, viruses, and fungi, making them useful in medical devices, wound dressings, antimicrobial coatings, and other items. [15] [16]

3) Smart Mattresses and Cushions

4) AI based solution in the prevention of pressure ulcers

The deep learning approach justifies patients' motion activity identification and addresses the problem concerning PU generation due to constant pressure on the skin for prolonged time intervals. In this scenario, it is demonstrated that the use of sensors could well represent a valid solution by putting together non-invasive, low-cost, human-centric systems with minimal constraints related to hardware and installation. A deep learning algorithm for such an approach was designed and run in a real-world context test, evaluating system performance over several patients to check for correct functioning and feasibility of the proposing methodology. Outcomes are encouraging, demonstrating that deep learning techniques outperform techniques such as SVMs and RF, bearing clinical relevance supporting patient health even in PU prevention. Future work will further delve into comparisons with other solutions, both from research and an industrial point of view, and the topic of further investigation into cutting-edge techniques for bolstering performance features of the overall system. These features will pay attention to not only the responsiveness but also real-time behavior of data passing and subsystem functions with emphasis on battery life issues of embedded sensors.[17]



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5) Telemedicine and Remote Monitoring

The role of e-health clinical decision support in enhancing pressure ulcer-related outcomes cannot be overemphasized. Numerous results point to electronic health decision tools as being very usable and precise in pressure ulcer prevention and management. Postimplementation of electronic health decision interventions, evidence has shown increased clinician adherence to pressure ulcer prevention practices and declining healthcare costs. More studies need to be done that provide greater detail on what forms of electronic health decision support might be efficacious in promoting sustainable improvements in patient outcomes.[18] An effective resource for nurse education and pressure ulcer prevention is the HAPUs (Hospital-acquired pressure injuries) E-book app. It is appropriate for clinical usage and ongoing professional development due to its excellent sensitivity, specificity, and validated content.[19] According to the results, healthcare professionals are receptive to mobile e-books and chatbots, and perceived utility and usability are important determinants of their uptake. Clinical decision-making can be aided by these technologies, which can also lower medical errors and enhance patient outcomes. [20]

4.DISCUSSION

Patients suffer from pressure ulcers that lower their quality of life, while healthcare professionals suffer as they burn out with constant monitoring, resulting in an increase in costs to the healthcare system. [21] The technologies explored in this article are solemnly outlined and presented as capable of steering healthcare into an appropriate direction, promoting specific preventative initiatives and assessments [22] Moisture is critical in healing. Dry wounds lose their liquid, which is rich in growth factors that stimulate angiogenesis, so they will slowly heal due to low vascular supply and thick blood responsibility within crust.[23] An effective resource for physiotherapy education and pressure ulcer prevention is the HAPUs E-book app. It is appropriate for clinical usage and ongoing professional development due to its excellent sensitivity, specificity, and validated content.[24] For people with Spina Bifida, especially those who use wheelchairs, pressure mapping technology could be developed to evaluate and enhance surfaces. In this susceptible group, ensuring ideal surface support may be essential to lowering the risk of PIs.[25] Smart mattresses and pillows are becoming into essential healthcare instruments as biomaterial technology develops. Furthermore, customized clothing and wearable technology with biomaterials improves PU prevention by offering patients who are limited to extended sitting or bed rest customized pressure reduction and skin protection. [26] Targeted interventions and self-management of posture, mobility, and pressure ulcer risk can be supported by intelligent systems; pressure-sensitive air cell technology may offer proactive pressure point relief and postural support.[27] The new PrUMS (Pressure related ulcer monitoring system)instrument utilized in this investigation was shown to be useful in clinical wound care procedures and offered objective, non-contact wound assessment.[28] Enhancing PU prevention and control is made possible by the combination of these technological innovations. These technologies are guiding healthcare toward more sustainable and effective PU care solutions by lowering the burden on caregivers, enhancing patient outcomes, and optimizing healthcare resources. For clinical practices to advance and

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patients at risk of pressure ulcers to have a higher quality of life, more research and wider use of these devices are necessary.

5.CONCLUSION

The health of patients and healthcare systems are seriously hampered by pressure ulcers. The incorporation of cutting-edge technical advancements presents encouraging prospects for successful PU control and prevention. Advanced biomaterials, telemedicine platforms, AI-driven analytics, and smart monitoring systems all greatly improve patient outcomes, save healthcare costs, and provide more individualized care. These devices offer both preventative and reactive methods to reduce PU-related dangers.

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WE ARE THRILLED TO UNVEIL HYGEAR, A COMPANY FOUNDED WITH A PASSIONATE MISSION TO INSPIRE INDIVIDUALS TO ACHIEVE WELLNESS THROUGH TINY, HEALTHY HABITS AND BY UPLIFTING OTHERS. WE ARE A REVOLUTIONARY SMART WELLNESS SOLUTION POISED TO REDEFINE THE WELLNESS LANDSCAPE IN INDIA. WITH STATE-OF-THE-ART TECHNOLOGY AT ITS CORE, HYGEAR EMPOWERS USERS TO SEAMLESSLY TRACK AND MONITOR THEIR WELLNESS JOURNEY, OFFERING REAL-TIME INSIGHTS, PROGRESS TRACKING, AND HEALTH METRICS THROUGH OUR INTUITIVE APP AND DASHBOARD INTERFACE.

FES
FRAGOMEN
EDUCATIONAL SERVICES
YOUR STUDY ABROAD PARTNER

ESTABLISHED IN 1951, FRAGOMEN HAS GROWN FROM A RESPECTED DOMESTIC U.S. IMMIGRATION LAW PRACTICE TO A TRULY GLOBAL ORGANIZATION. OUR PEOPLE ARE AS INTELLIGENT AND DRIVEN AS THEY ARE PASSIONATE AND CARING. WE WORK IN A FAST-PACED, DYNAMIC AND FORWARD-THINKING ENVIRONMENT WITH TALENTED PROFESSIONALS WHO SHARE PRIDE AND ENTHUSIASM FOR WHAT THEY DO.

OUR PARTNERS

MC CREATIONS SPECIALIZES IN HIGH-QUALITY TROPHIES, AWARDS, MEMENTOS, AND CUSTOM GIFTS WITH PRECISION LASER ENGRAVING. TRUSTED FOR EXCELLENCE, WE CRAFT ELEGANT RECOGNITION SOLUTIONS FOR ALL OCCASIONS.

SMILE CAPTURER PHOTOGRAPHY IS A CREATIVE PHOTOGRAPHY BRAND DEDICATED TO CAPTURING LIFE'S MOST PRECIOUS MOMENTS WITH ARTISTRY AND PRECISION. WITH A KEEN EYE FOR DETAIL AND A PASSION FOR STORYTELLING, SMILE CAPTURER PHOTOGRAPHY SPECIALIZES IN TURNING FLEETING SMILES, EMOTIONS, AND EXPERIENCES INTO TIMELESS MEMORIES. WHETHER IT'S PORTRAITS, EVENTS, OR COMMERCIAL SHOOTS, THE BRAND ENSURES EVERY FRAME REFLECTS AUTHENTICITY AND BEAUTY. LET YOUR MOMENTS BE CAPTURED WITH A SMILE!

PHYSIOZINE IS INDIA'S FASTEST GROWING E-MAGAZINE FOR PHYSICAL THERAPIST, YOUR ULTIMATE RESOURCE FOR ALL THINGS RELATED TO PHYSICAL THERAPY AND REHABILITATION. EXPLORE EXPERT ARTICLES, IN-DEPTH INTERVIEWS WITH LEADING PROFESSIONALS, LATEST RESEARCH FINDINGS, INNOVATIVE TECHNIQUES, AND PRACTICAL TIPS TO ENHANCE YOUR UNDERSTANDING AND PRACTICE IN THE FIELD OF PHYSIOTHERAPY. WHETHER YOU'RE A SEASONED PRACTITIONER OR JUST STARTING YOUR JOURNEY, OUR E-MAGAZINE IS YOUR GO-TO DESTINATION FOR STAYING UPDATED, INFORMED, AND INSPIRED IN THE WORLD OF PHYSIOTHERAPY.

OUR PARTNERS

TEAM WAKAYAMA , BANGALORE IS A DEDICATED MARTIAL ARTS COMMUNITY AND AN OFFSHOOT OF WAKAYAMA KARATE-DO INDIA. ESTABLISHED 11 YEARS AGO, THE ORGANIZATION GOES BEYOND KARATE TRAINING, ACTIVELY ENGAGING IN EDUCATION, ENVIRONMENTAL INITIATIVES, AND SPORTS-RELATED ACTIVITIES.

ROOTED IN THE CORE VALUES OF LOVE, PEACE, PASSION, AND PROSPERITY, TEAM WAKAYAMA FOCUSES ON DISCIPLINE, SELF-DEFENSE, AND PERSONAL GROWTH. WITH A COMMITMENT TO NURTURING STRONG, SKILLED MARTIAL ARTISTS, THE ORGANIZATION ALSO CONTRIBUTES TO SOCIAL DEVELOPMENT, FOSTERING A WELL-ROUNDED AND EMPOWERED COMMUNITY.

UNI SCIENCE FOUNDATION: EMPOWERING EDUCATION, RESEARCH, AND ENVIRONMENTAL AWARENESS

THE UNI SCIENCE FOUNDATION IS A NON-PROFIT ORGANIZATION (NPO) AND NON-GOVERNMENTAL ORGANIZATION (NGO) REGISTERED UNDER THE MINISTRY OF CORPORATE AFFAIRS. DRIVEN BY THE PASSION AND DEDICATION OF STUDENTS, THE FOUNDATION PLAYS A CRUCIAL ROLE IN PROMOTING EDUCATIONAL SERVICES, RESEARCH INITIATIVES, ENVIRONMENTAL CONSERVATION, AND EXPERIENTIAL LEARNING FOR SCHOOLS AND COLLEGES ACROSS INDIA.

SCHOOL OF SPORTS EDUCATION AND RESEARCH)

SCHOOL OF SPORTS EDUCATION AND RESEARCH ADVANCING EXCELLENCE IN SPORTS SCIENCES, PHYSICAL EDUCATION, AND PHYSIOTHERAPY, WHERE INNOVATION MEETS EXPERTISE TO SHAPE FUTURE LEADERS IN SPORTS PERFORMANCE, EDUCATION, AND REHABILITATION."

SITUATED AMIDST THE VERDANT AND TRANQUIL ENVIRONS OF KANAKAPURA ROAD, OUR CAMPUS PROVIDES AN INSPIRING SETTING FOR SCHOLARLY ENDEAVOURS. WE PRIDE OURSELVES IN OFFERING A RIGOROUS ACADEMIC PROGRAMMES THAT CULTIVATES BOTH INTELLECTUAL AND PROFESSIONAL GROWTH, PREPARING STUDENTS TO BECOME PIONEERS IN THE EVOLVING REALMS.

"KONVERGE 2025: UNITING MINDS, EXPANDING HORIZONS – INTEGRATING SPORTS SCIENCE, PHYSIOTHERAPY, ALLIED HEALTH, PHYSICAL EDUCATION, SPORTS PSYCHOLOGY, ESPORTS, AYURVEDA, AND EMERGING TRENDS FOR A HOLISTIC FUTURE."

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