RELATION BETWEEN GRIP STRENGTH AND FOREHAND HITTING ACCURACY AMONG AMATEUR TENNIS PLAYERS WITH SCAPULAR INSTABILITY: AN OBSERVATIONAL STUDY

By

SURAJ KUMAR SAMAL

Dissertation Submitted to the

Odisha University Of Health Science, Bhubaneswar, Odisha

In partial fulfillment

of the requirements for the degree of

MASTER OF PHYSIOTHERAPY (M.P.T)

In

SPORTS SCIENCES

Under the guidance of

Dr. ASIFUZZAMAN SHAHRIYAR AHMED (PT)

Associate Professor,

ABHINAV BINDRA SPORTS MEDICINE & RESEARCH INSTITUTE

Bhubaneswar, Odisha

2023-2024

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"RELATION BETWEEN GRIP STRENGTH AND FOREHAND HITTING ACCURACY AMONG AMATEUR TENNIS PLAYERS WITH SCAPULAR INSTABILITY: AN OBSERVATIONAL STUDY"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. Asifuzzaman Shahriyar Ahmed (PT), Associate Professor,** Abhinav Bindra Sports Medicine & Research Institute, Bhubaneswar, Odisha and there are no conflict of interest associated with this dissertation work.

Date: SIGNATURE

Place: Bhubaneswar, Odisha **SURAJ KUMAR SAMAL**

University Registration No: 23MP435043

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Date: SIGNATURE

Place: Bhubaneswar **Dr. ASIFUZZAMAN SHAHRIYAR AHMED (PT)**

Odisha **Associate Professor, ABSMARI**

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Date:

Place: Bhubaneswar, Odisha

SIGNATURE & SEAL OF THE PRINCIPAL

Dr. Chinmaya Kumar Patra (PT)

ODISHA UNIVERSITY OF HEALTH SCIENCES

CERTIFICATE OF ACCEPTANCE

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ACKNOWLEDGEMENT

At the very outset, I express my deepest gratitude to Dr. Apjit S. Bindra, Chairman, Shri Abhinav A. Bindra, Founder, and Dr. Digpal Ranawat, Executive Director of Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar, Odisha, for giving me this invaluable opportunity. I take this opportunity to convey my heartfelt gratitude to my guide, Dr. Asifuzzaman Shahriyar Ahmed (PT), Associate Professor, Abhinav Bindra Sports Medicine and Research Institute, for his constant encouragement, valuable suggestions, and guidance, which gave shape and coherence to this endeavour. I also express my sincere thanks to Dr. Chinmaya Kumar Patra(PT), Principal, Dr. Deepak Kumar Pradhan (PT)and Dr. Joydip Saha (PT), Associate Professor, and all the teaching and non-teaching staff of the Institute for their continuous support and assistance in the successful completion of this dissertation. Furthermore, I would like to extend my deep appreciation to the faculty members of Sri Aurobindo Institute of Medical Sciences, Indore, Madhya Pradesh, for their valuable guidance, encouragement, and support during my undergraduate journey, which laid the foundation for this work. With profound respect, I acknowledge the endless love, sacrifices, and blessings of my beloved parents, my late mother Sarojini Samal and my father Bhaja Gobinda Samal, whose values and support have been the true inspiration behind every step of my academic journey. I also extend my heartfelt gratitude to my family members for their unwavering support, prayers, and encouragement throughout these endeavors. I also acknowledge with deep reverence the moral and mental support of my batchmates, who stood beside me during every stage of this work.

My sincere thanks are also due to Ace Base Tennis Club, Bhubaneswar, and all the participants of this study, for their kind cooperation and valuable contribution, without which this dissertation would not have been possible. And above all, I bow in humility to the divine blessings of Lord Ganesha and Jagannath Ji, whose grace and guidance have helped me to complete this dissertation in time.

Date: **Signature**

Place: Bhubaneswar, Odisha **Suraj kumar Samal**

LIST OF ABBREVIATIONS

1. **CM** – Centimeter
2. **FH** – Forehand
3. **FH-CC** – Forehand Cross-Court Accuracy Score
4. **FH-UTL** – Forehand Up-the-Line Accuracy Score
5. **HGS** – Hand Grip Strength
6. **KG** – Kilogram
7. **SFRT** – Shoulder Flexion Resistance Test

ABSTRACT

BACKGROUND: Grip strength and scapular stability are critical determinants of upper limb function in tennis, influencing both performance and injury risk. Among amateur tennis players, deficits in these areas may directly impact stroke mechanics and forehand accuracy.

OBJECTIVE: The aim of this study was to examine the correlation between grip strength, scapular instability, and forehand accuracy in amateur tennis players.

METHOD: Thirty amateur tennis players were recruited based on predefined inclusion and exclusion criteria. Demographic data were recorded, and informed consent was obtained. Grip strength was assessed using a handheld dynamometer, while scapular stability was evaluated through specific functional tests. Forehand accuracy was measured using a standardized on-court accuracy protocol. Statistical analysis was conducted to determine correlations between grip strength, scapular stability, and accuracy outcomes.

RESULT: The findings revealed a significant positive correlation between grip strength and forehand accuracy ($p<0.05$). Additionally, players with better scapular stability demonstrated superior accuracy scores compared to those with instability ($p<0.05$). Combined analysis suggested that optimal grip strength and scapular control synergistically contributed to improved forehand performance.

CONCLUSION: Grip strength and scapular stability play a pivotal role in determining forehand accuracy among amateur tennis players. These results highlight the importance of incorporating strength and stability training into coaching and rehabilitation programs to enhance performance and reduce injury risk.

KEYWORDS: Amateur players, Forehand accuracy, Grip strength, Performance, Scapular instability, Tennis

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1. INTRODUCTION

Tennis is a complex and physically demanding sport that combines intermittent bursts of high-intensity activity with periods of low-intensity recovery. Unlike many continuous endurance sports, tennis involves repeated accelerations, decelerations, and changes of direction, requiring players to have well-developed agility, speed, and muscular strength . Globally, tennis is played by millions of recreational and professional athletes, making it not only a competitive sport but also a means of promoting lifelong health and fitness.[1] To succeed at any level, players must optimize a blend of technical, tactical, physical, and psychological skills, which collectively determine overall performance outcomes. [2]

Among the technical aspects of the game, stroke execution plays a central role in point construction and match success. The forehand stroke, in particular, is regarded as one of the most dominant and widely used techniques, often serving as a primary weapon for dictating rallies and applying pressure on opponents.[3]

Efficient forehand performance requires precise coordination of the kinetic chain, beginning from the lower limbs through the trunk, shoulder, forearm, and ultimately the hand. Each segment of this chain contributes to energy transfer, which influences ball speed, spin, and placement accuracy.[4] Inadequacies in any component, whether muscular strength, scapular control, or grip stability, can disrupt stroke mechanics and reduce effectiveness on court.

For amateur players, technical inconsistencies are even more pronounced due to limited training experience and incomplete neuromuscular adaptation. These athletes often display reduced shot consistency, weaker stroke production, and higher susceptibility to performance errors compared to elite professionals.[5] Moreover, the physical demands of repetitive forehand strokes, particularly in practice and competitive play, place substantial mechanical loads on the upper limb structures, including the shoulder girdle, scapula, forearm, and wrist.[6]

Another crucial aspect of tennis performance lies in injury prevention and long-term musculoskeletal health. The repetitive overhead and forward arm motions involved in forehand and serving techniques are associated with a high prevalence of overuse injuries, especially in the shoulder complex. Muscular imbalances, improper scapular positioning, and insufficient grip strength may compromise racquet control and accuracy, thereby impacting both performance and injury risk. Consequently, understanding the interplay between strength variables, stroke mechanics, and scapular stability has significant implications not only for enhancing forehand accuracy but also for safeguarding the health of amateur players.[6]

Grip strength is a fundamental component of upper limb function and plays a critical role in racket sports such as tennis. In tennis, the ability to maintain an effective grip on the racquet is essential for controlling stroke power, precision, and consistency during play Strong grip muscles enable players to stabilize the wrist and forearm during ball impact, thereby reducing unwanted vibrations and improving accuracy. Inadequate grip strength, on the other hand, can compromise racquet handling, limit stroke velocity, and increase the risk of overuse injuries in the hand, wrist, and elbow.[7-9]

In the forehand stroke specifically, grip strength contributes significantly to the transfer of energy through the kinetic chain. It allows players to generate sufficient racquet head speed while maintaining fine motor control for ball placement. Stronger grip force also facilitates longer rallies by delaying the onset of muscular fatigue, which is particularly relevant for amateur players who may not have developed high levels of endurance or technical efficiency. Moreover, studies have shown that players with higher grip strength tend to perform better in measures of groundstroke velocity and shot stability.[10-12]

Another important aspect is the role of grip strength in injury prevention. Tennis players frequently suffer from overuse injuries such as lateral epicondylitis (tennis elbow), wrist tendinopathy, and shoulder impingement, all of which may be linked to insufficient grip strength and poor load distribution along the upper limb.

By enhancing grip capacity, players may reduce mechanical stress on the wrist and forearm muscles, thereby improving both performance and musculoskeletal health. This is particularly valuable in amateur populations, who are more vulnerable to technique-related errors that place added strain on the upper extremities.[13]

Lastly, grip strength can be considered a biomarker of general physical performance. Beyond its localized role in racquet control, it correlates with overall muscular fitness, neuromuscular coordination, and even long-term athletic potential. For this reason, testing grip strength provides valuable information for coaches, physiotherapists, and sports scientists in assessing player readiness and identifying areas for targeted intervention. Given its multifaceted influence, grip strength remains an essential determinant of forehand stroke accuracy and overall tennis performance.

The scapula plays a central role in the biomechanics of the upper limb, serving as the foundation for shoulder stability and motion. Proper scapular positioning and movement are essential for efficient force transmission from the trunk to the upper extremity during functional tasks such as throwing, serving, or hitting a tennis forehand.. The scapula provides a stable base for the glenohumeral joint, allowing coordinated activation of surrounding muscles, including the serratus anterior, trapezius, rhomboids, and rotator cuff. When this coordinated mechanism is

disrupted, the efficiency of the kinetic chain diminishes, leading to reduced performance and increased risk of injury.[14,15]

Scapular instability, often referred to as scapular dyskinesis, is characterized by abnormal scapular motion or positioning during shoulder movement. It can result from muscle imbalances, fatigue, nerve injuries, poor posture, or repetitive overhead activities commonly seen in racquet sports.[16] Athletes with scapular instability may experience decreased shoulder strength, impaired coordination, and mechanical inefficiency in overhead and forward arm motions.[17] In tennis players, these dysfunctions can significantly compromise stroke accuracy and power output, especially in repetitive tasks such as forehand hitting.

The clinical relevance of scapular instability extends beyond performance deficits. It has been identified as a major contributing factor to shoulder pathologies, including impingement syndrome, rotator cuff tendinopathy, and labral injuries.[18] For amateur athletes, who often have less conditioning and suboptimal training habits compared to elite players, scapular dysfunction can develop easily and remain unnoticed until symptoms or performance limitations emerge. This makes the early identification of scapular instability critical for maintaining musculoskeletal health and optimizing sport-specific skills. Furthermore, research suggests that scapular stability has a direct influence on distal functions such as grip strength and wrist control. Since the scapula acts as the proximal stabilizer of the upper kinetic chain, any instability can compromise energy transfer and fine motor control of the forearm and hand.[19] Thus, scapular dysfunction not only predisposes athletes to injury but also has a cascading effect on technical performance variables such as forehand accuracy, making it a key factor of interest in tennis performance research.

Tennis performance, particularly forehand accuracy, relies on the smooth transfer of force through the kinetic chain, beginning from the lower body and trunk and extending to the upper limb and hand. Both scapular stability and grip strength play critical roles in this sequence. A stable scapula ensures proper positioning of the glenohumeral joint, allowing for efficient shoulder and elbow mechanics, while grip strength provides the distal control needed for precise racquet handling and ball placement.[20] When either component is deficient, the continuity of force transmission is disrupted, resulting in reduced shot accuracy [21]

Scapular instability may further impair grip strength by weakening proximal stability of the shoulder complex, thereby affecting distal motor control in the forearm and hand.[22] This interaction highlights the concept of the proximal-to-distal kinetic chain, where deficits in proximal stability can compromise distal strength and function. In the context of tennis forehand strokes, this can translate into reduced racquet head control, inconsistent impact timing, and lower stroke precision.[23]

Such biomechanical inefficiencies may be especially pronounced in amateur players, whose neuromuscular control and conditioning are still developing.

Although grip strength and scapular stability have been studied independently in relation to sports performance, limited evidence exists on their combined effect on tennis forehand accuracy, particularly in non-elite populations. Previous studies have primarily focused on professional or collegiate-level athletes, leaving a gap in understanding how these variables influence performance in amateur players, who represent a large proportion of the tennis-playing population.[24] Investigating this relationship is important because it may uncover modifiable risk factors that can be addressed through targeted training and rehabilitation programs, ultimately improving performance and reducing injury risk.

Therefore, this study seeks to explore the relationship between grip strength and forehand hitting accuracy among amateur tennis players with scapular instability. By addressing this gap, the findings may provide valuable insights for coaches, physiotherapists, and strength-conditioning professionals in developing evidence-based strategies to optimize tennis performance and prevent upper limb injuries in this population.[25]

2.AIM & OBJECTIVES

AIM OF THE STUDY

To investigate the relation between grip strength and forehand hitting accuracy in amateur tennis players with scapular instability.

OBJECTIVE OF THE STUDY

- To investigate the relation between grip strength and scapular stability on forehand hitting accuracy in amateur tennis players.
- To investigate grip strength in amateur tennis players with varying levels of forehand hitting accuracy with a hand dynamometer.
- To investigate the relationship between scapular stability and forehand hitting accuracy in amateur tennis players by using the Shoulder Flexion Resistance Test (SFRT).

3. HYPOTHESIS

H0: There will be no significant relation between grip strength and scapular stability on forehand hitting accuracy in amateur tennis players.

H1: There will be a significant positive relation between grip strength and scapular stability on forehand hitting accuracy in amateur tennis players.

4. REVIEW OF LITERATURE

- A study “Clinical implications of scapular dyskinesis in shoulder injury: the 2013 consensus statement from the ‘Scapular Summit’” conducted by Kibler, Ludewig, McClure, Michener, Bak, and Sciascia highlighted the accumulated evidence regarding the role of scapular mechanics in shoulder dysfunction. The consensus concluded that scapular dyskinesis is present in a high percentage of shoulder injuries and plays a notable role in exacerbating impingement symptoms and dysfunction. The statement emphasized that scapular dyskinesis should be viewed as a potential impairment affecting shoulder function, which can be identified through reliable observational methods. Importantly, it suggested that rehabilitation programs targeting restoration of scapular position and motion could be effective when incorporated into broader shoulder rehabilitation strategies.[26]

- A study “Isokinetic profile of wrist and forearm strength in elite female junior tennis players” conducted by Ellenbecker, Roetert, and Riewald investigated wrist and forearm strength imbalances in 32 elite female tennis players aged 12–16 years using isokinetic testing. The findings revealed significantly greater dominant-arm wrist extension/flexion and forearm pronation strength, while forearm supination strength was lower compared to the non-dominant side. These results highlighted sport-specific muscular adaptations that occur in tennis due to repetitive forehand and backhand strokes. The study emphasized that restoring dominant-side wrist and forearm strength is essential during rehabilitation to prevent further injuries and maintain optimal performance. [27]

- A study “Effect of wrist and forearm training on linear bat-end, center of percussion, and hand velocities and on time to ball contact of high school baseball players” conducted by Szymanski, McIntyre, Szymanski, Molloy, Madsen, and Pascoe investigated the outcomes of a 12-week stepwise periodized training program on wrist and forearm strength in 43 high school baseball players. Players were divided into two groups: both performed full-body resistance exercises, but one group additionally performed wrist and forearm exercises. Findings showed that while both groups significantly increased bat velocity, hand velocity, and forearm strength, the group performing additional wrist and forearm training achieved greater improvements in strength measures. However, these gains did not directly translate into superior bat velocities compared to the control group. The study concluded that targeted wrist and forearm training enhances muscular strength but may not independently improve sport-specific performance metrics without integration into broader biomechanical factors.[28]

- A study “Reliability and validity of two hand dynamometers when used by community-dwelling adults aged over 50 years” conducted by Huang, Liu, Lin, Hou, Song, Ge, and Yue evaluated the accuracy of the CAMRY EH101 spring-type dynamometer compared with the gold-standard Jamar hydraulic dynamometer. In this cross-sectional study involving 1064 older adults aged 50–90 years, grip strength was assessed with both devices using a randomized crossover design. Results demonstrated strong reliability with intraclass correlation coefficients (ICCs) ranging from 0.815 to 0.854, and only minor underestimation of grip strength values by the CAMRY device compared to the Jamar. The study concluded that the CAMRY EH101 provides excellent reliability and validity, making it a cost-effective and practical option for grip strength measurement in clinical and research settings. [29]

- A study “Measurement of hand grip strength: A cross-sectional study of two dynamometry devices” conducted by Lupton-Smith, Fourie, Mazinyo, Mokone, Nxaba, and Morrow compared the reliability of the Camry Digital Handgrip Dynamometer (EH101) with the gold-standard Jamar Hydraulic Hand Dynamometer in a hospital setting. Fifty-one hospitalized adult patients participated in a randomized single-blind cross-over design, where grip strength was assessed with both devices. Results showed excellent agreement, with a strong positive correlation ($R = 0.94$, $r^2 = 0.88$) and an intraclass correlation coefficient (ICC) of 0.97, indicating high validity and reliability of the Camry device. The study concluded that the Camry Digital Handgrip Dynamometer is a valid, inexpensive, and practical alternative for clinical assessment of grip strength in hospital settings.[30]

- A study “An 8-stage model for evaluating the tennis serve: implications for performance enhancement and injury prevention” conducted by Kovacs and Ellenbecker proposed a comprehensive eight-stage model to analyze the tennis serve. The model divides the serve into three main phases preparation, acceleration, and follow-through and emphasizes evaluation of the entire kinetic chain rather than isolated segments. Findings suggest that this more tennis-specific approach enables better identification of technical weaknesses, potential injury risks, and areas for performance improvement. The authors recommended applying this model across all skill levels to enhance stroke efficiency and reduce injury incidence in tennis players.[21]

- A study “Pediatric and Adolescent Shoulder Instability” conducted by Kay, Heyworth, Milewski, and Kramer reviewed the management of anterior shoulder instability and multidirectional instability (MDI) in pediatric and adolescent populations. The review highlighted that young patients with anterior dislocations are at high risk for recurrent instability, particularly those under 16 years, with multiple preoperative dislocations, or with Hill-Sachs lesions. Arthroscopic Bankart repair showed excellent outcomes, and adjunct procedures such as remplissage or Latarjet coracoid transfer were suggested for high-risk cases. Patients with hyperlaxity or involved in sports like swimming or gymnastics often present with MDI, for which physical therapy is first-line management. Surgical intervention with open or arthroscopic capsulorrhaphy is considered when conservative treatment fails, yielding promising results. The study emphasized careful selection of treatment timing and modality to prevent recurrence and optimize shoulder function in young athletes.[22]

- A study “A Brief Review of Handgrip Strength and Sport Performance” conducted by McMaster, Cronin, Lawton, Harris, Kilding, and Travis evaluated the role of handgrip strength (HGS) in various sports, including tennis. The review emphasized that HGS is a reliable indicator of upper limb strength and is associated with performance outcomes in sports requiring precision and force application. It highlighted that sub-elite athletes often show lower HGS compared to elite counterparts, suggesting its relevance in training and rehabilitation. The study also recommended standardized testing protocols for accurate assessment of grip strength in athletic populations. [20]

- A study “Comparison of Grip Strength, Forearm Muscle Activity, and Shock Transmission between the Forehand Stroke Technique of Experienced and Recreational Tennis Players” by Rigozzi, Vio, and Poronnik explored biomechanical differences in forehand strokes using wearable sensors. The research found that grip strength at impact did not significantly affect shock transmission, but recreational players exhibited higher extensor muscle activity, increasing their risk of elbow injuries. These findings suggest that grip strength and forearm control are critical in stroke accuracy and injury prevention, especially among amateur players. [21]

- A study “Analysis of Technical Forehand Boys Athlete Junior UNNES Tennis Club” by Pratama examined the relationship between hand grip strength and forehand accuracy in junior tennis athletes. The study concluded that grip strength significantly influences service and stroke precision, reinforcing its importance in tennis skill development. It also noted that biomechanical factors like arm length and muscle coordination contribute to stroke consistency. [29]

- A study “Scapular Dyskinesis and Its Influence on Shoulder Function in Overhead Athletes” by Struyf, Cools, and Baeyens reviewed the prevalence of scapular instability in sports involving overhead movements. The study emphasized that scapular dyskinesis alters shoulder kinematics and may impair force transmission during strokes like the tennis forehand. It advocated for observational screening and targeted rehabilitation to restore scapular control and optimize performance. [30]

- A study “The Relationship Between Scapular Stability and Upper Limb Performance in Tennis Players” by Kumar and Sharma investigated how scapular control affects grip strength and stroke execution. The study found that players with poor scapular stability demonstrated reduced grip force and inconsistent forehand accuracy. It recommended integrating scapular stabilization exercises into tennis training programs to enhance upper limb coordination and reduce injury risk. [30]

- Ahmed (2023) conducted a study on grip and pinch strength in the healthy Indian adult population, providing valuable normative data for hand function assessment. The research focused on evaluating strength parameters in different types of grip, including power grip and various pinch positions (tip-to-tip, lateral, and three-jaw chuck pinch). Their findings highlighted that grip and pinch strength are influenced by factors such as age, gender, hand dominance, and occupational background. Men generally exhibited higher strength values compared to women, and dominant hands showed greater grip and pinch strength than non-dominant hands. This study established reference values that can be used in clinical and sports settings for evaluating hand performance, assessing rehabilitation progress, and comparing with pathological conditions.

  This work is significant in the context of sports physiotherapy, as grip strength plays a critical role in racquet sports such as tennis, where forehand hitting accuracy and overall performance are highly dependent on forearm and intrinsic hand muscle function. By providing baseline normative values in the Indian population, the study serves as a foundation for understanding deviations in players with musculoskeletal dysfunctions, such as scapular instability, which may secondarily affect grip strength and performance.[31]

5. METHODOLOGY & PROCEDURE

Methodology

- Study Design: Observational study
- Study Population: Amateur tennis players
- Sample Size: 37
- Sampling Technique: Purposive sampling
- Study Setting: Ace Base Tennis Club, Bhubaneswar
- Study Duration: 12 months
    - Ethical Clearance & Protocol Approval: 6 months
    - Sample Selection & Data Collection: 3 months
    - Statistical Analysis, Results, and Discussion: 3 months

Ethical Considerations

Prior to commencement, the study protocol was reviewed and approved by the Institutional Ethics Committee of Absmari Bhubaneshwar. Written informed consent was obtained from all participants after they were informed of the nature, objectives, and potential benefits of the study.

Criteria	Details
Inclusion Criteria	- Age 12–18 years old tennis players- -Minimum 2–3 years of competitive play- - Training frequency: ≥3 times per week - Athletes with scapular instability- Both right-hand and left-hand players
Exclusion Criteria	- History of any injury or surgery in the past 6 months Additionally, those who are not in a training period, untrained players, or recreational players are excluded.

Outcome measures

The primary outcome measures of this study included forehand hitting accuracy, scapular stability, and grip strength. Forehand hitting accuracy was assessed using a modified court division protocol, where the tennis court was divided into 12 target zones, and players performed standardized forehand strokes under controlled conditions. Scapular stability was evaluated through the Shoulder Flexion Resistance Test (SFRT) at varying degrees of shoulder flexion (30°, 60°, and 100°), with scapular winging or abnormal motion indicating dysfunction. Grip strength was measured for both dominant and non-dominant hands using a calibrated Camry dynamometer, providing an objective measure of muscular strength in the upper extremities. Together, these variables were analyzed to determine their interrelationship and overall impact on the performance outcomes of amateur tennis players.

MATERIAL REQUIRED

- Camry dynamometer
- Tennis racket
- Tennis ball
- Targeted net
- Cone
- Measuring tape
- Video camera

FIGURE 1: EQUIPMENTS

FIGURE 1.1: TENNIS BALLS & COURT

PROCEDURE -

The research procedure began with obtaining formal approval from the Institutional Research Committee (IRC) to ensure compliance with ethical guidelines. Following this, permission was secured from the college authorities and ACE BASE TENNIS CLUB, for the use of equipment and facilities required to conduct the study.

Once approvals were granted, the process of participant recruitment was initiated. Amateur tennis players were approached at Ace Base Tennis Club, Bhubaneswar, and underwent a screening process. Screening involved evaluating each player against predefined inclusion and exclusion criteria. Only players aged 12 to 18 years, with at least two to three years of competitive playing experience and training at a frequency of three or more sessions per week, were considered eligible. Players with recent injuries, prior surgeries within the last six months, or those not actively engaged in competitive training were excluded to avoid confounding variables.

After final selection, the study objectives, procedures, and potential benefits were explained in detail to all participants. Written informed consent was obtained prior to their participation, ensuring voluntary and ethical involvement. Where applicable, parental or guardian consent was also taken for minors.

Participants were then prepared for the study by familiarizing them with the testing environment and instruments. They were introduced to the Camry dynamometer for grip strength assessment, the standardized setup for forehand accuracy measurement, and the physical examination involved in the Shoulder Flexion Resistance Test (SFRT) for scapular stability. This step minimized performance anxiety and ensured consistency during testing.

Data collection followed a structured approach. Grip strength was measured for both dominant and non-dominant hands using a calibrated dynamometer. Scapular stability was assessed using the SFRT at 30°, 60°, and 100° of shoulder flexion. Forehand accuracy was tested using a modified court division protocol, where the tennis court was marked into 12 zones, and players performed standardized forehand strokes under controlled conditions. Each test was administered with strict adherence to standardized procedures to maintain validity and reliability.

After completion of data collection, all results were compiled and subjected to statistical analysis. Appropriate tests were applied to determine the relationships between grip strength, scapular stability, and forehand accuracy. The outcomes were then interpreted in the context of the study objectives, leading to the formulation of results and conclusions**.**

Shoulder Flexion Resistance Test (SFRT)

It is a physical examination maneuver designed to assess serratus anterior dysfunction by observing the stability of the scapula at specific degrees of shoulder elevation. This test is particularly useful in detecting scapulothoracic abnormal motion.

Positioning:

FIGURE 2: TESTING POSITION SFRT

FIGURE 2.1: TESTING POSITION SFRT

Physio stands at the player's side, slightly behind and facing the posterolateral aspect of the affected shoulder.

The player's shoulder is passively elevated to 30 degrees, 60 degrees, and 100 degrees of flexion relative to the ground, with the elbow extended and the forearm in a neutral position.

Resistance Application:

At each elevation angle (30, 60, and 100 degrees), the clinician applies downward resistance to the patient’s forearm, instructing the patient to resist this force.

Observation of Scapular Movement:

The clinician observes for scapular winging or abnormal motion during each resisted shoulder flexion. A positive SFRT at any angle is indicated by noticeable winging, suggesting serratus anterior dysfunction.

The SFRT has high specificity and sensitivity, especially at 100 degrees, as it minimizes contributions from the pectoralis minor, thereby isolating the serratus anterior. This makes it a reliable test to identify or rule out serratus anterior dysfunction as the cause of STAM and related symptoms like scapular winging.

Eastern Grip:

The Eastern grip is achieved by placing the base knuckle of the index finger on the third bevel of the racket handle.

Implications for Accuracy: This grip allows for a flat trajectory and is effective for hitting through the ball with less topspin. It provides good control and is often favored for its versatility in various shot situations. Players can generate a quick, compact swing, which can enhance accuracy

Semi-Western Grip:

The Semi-Western grip involves placing the base knuckle of the index finger on the fourth bevel of the racket handle.

Implications for Accuracy: This grip is popular among modern players as it allows for a combination of power and topspin. The Semi-Western grip facilitates a more natural upward swing path, which can help in achieving higher ball trajectories and better control over depth and placement. It is particularly effective for hitting high balls and generating spin, which can enhance accuracy when targeting specific areas of the court 2, 2.

Western Grip:

The Western grip is characterized by placing the base knuckle on the fifth bevel of the racket handle.

Implications for Accuracy: This grip is primarily used for generating heavy topspin. While it can be effective for hitting high balls, it may require more adjustment for low balls. Players using this grip may find it challenging to maintain accuracy on flatter shots, but it can be beneficial for controlling the ball's trajectory and spin

Forehand Hitting Accuracy

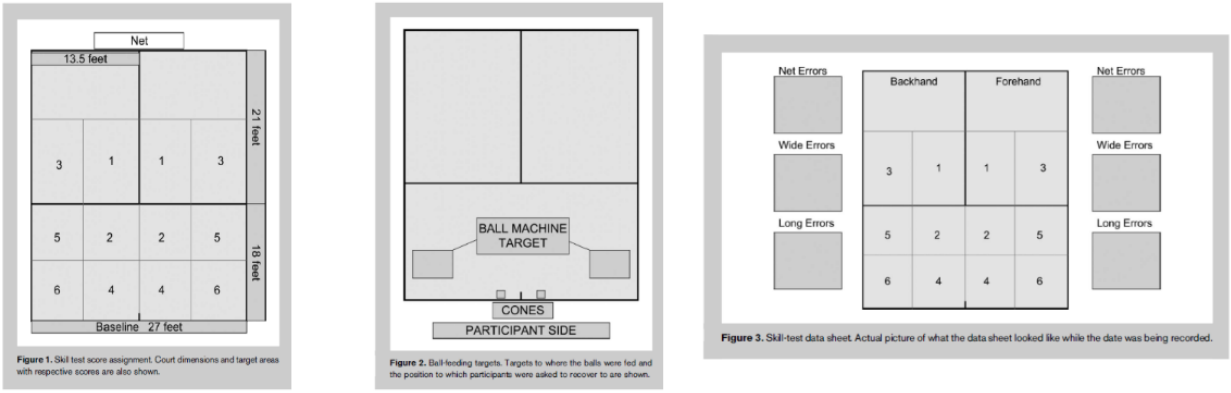

FIGURE 3 : COURT DIMENTIONS ACCORDING TO FOREHAND HITTING ACCURACY TEST

A new protocol in which the tennis court was divided into 12 boxes of similar size 2.06 m wide by 2.74 m long for a total area of 5.64 m2 (see Figure 1), which correspond to approximately 75% of the area in a singles court. The scoring followed Vergauwen's definition of neutral, defensive, and offensive shots . Neutral shots were considered as balls that landed close to the middle of the tennis court (positions 2 and 4), defensive shots were considered as balls that landed inside the service line (positions 1 and 3), and offensive shots were considered as balls that landed close to the singles line (positions 5 and 6). These modifications not only allowed extraction of similar information but also allowed differentiation of changes in accuracy, single shot placement, and recognition of the total number of errors and where those errors were performed.

Participants

Selection Criteria: The test typically involves skilled tennis players according to inclusion, aged 12 to 18

Test Setup

FIGURE 4: TEST SETUP

FIGURE 4.1: TEST SETUP

Court Division: The tennis court is divided into 12 target areas, each assigned a point value ranging from 1 to 6 based on their strategic importance (offensive, defensive, neutral).

Test Procedure

Warm-Up: Participants perform a 15-minute dynamic warm-up followed by a 5-minute hitting warm-up with a partner.

Shot Execution: Players execute 15 consecutive ground strokes, alternating between forehand (FH) and backhand (BH) shots, directed both cross-court and down the line.

Randomization: The order of shot directions is randomized for each participant to minimize bias.

Interval: There is a brief rest period (approximately 45-60 seconds) between different shot directions.

FIGURE 5 : GRIP STRENGTH MEASUREMENT

Scoring System

Point Allocation: Points are awarded based on where the ball lands in relation to the target areas.

Unforced Errors: Any shots that miss the target due to the player's mistake are recorded as unforced errors.

Shot Index Calculation: The shot index is calculated as the total number of successful shots landing in optimal performance areas (5 and 6) minus the total number of unforced errors.

6. RESULTS

The study sample of 47 amateur tennis players had a mean age of 14.6 years, with most participants between 12 and 17 years. Average height was 154.7 cm and weight 46.3 kg, reflecting the adolescent age group. Mean grip strength was 43.0 kg for the right hand and 41.7 kg for the left hand, indicating adequate upper limb function with some inter-individual variation. Forehand hitting accuracy scores showed mean values of 0.8 for both cross-court (FH_CC) and down-the-line (FH_UTL) strokes, suggesting consistent performance despite scapular instability. The data are within expected ranges for this athletic cohort.

Table 4.1 – Descriptive Statistics

Variable	**Mean ± SD**	**Min**	**Max**
Age (years)	14.6 ± 1.5	12.0	17.0
Height (cm)	154.7 ± 10.2	130.0	173.0
Weight (kg)	46.3 ± 8.0	30.0	63.0
Grip Strength (R)	43.0 ± 13.9	18.5	78.6
Grip Strength (L)	41.7 ± 16.3	18.5	72.8
FH_CC Score	0.8 ± 0.1	0.5	1.0
FH_UTL Score	0.8 ± 0.1	0.5	0.9

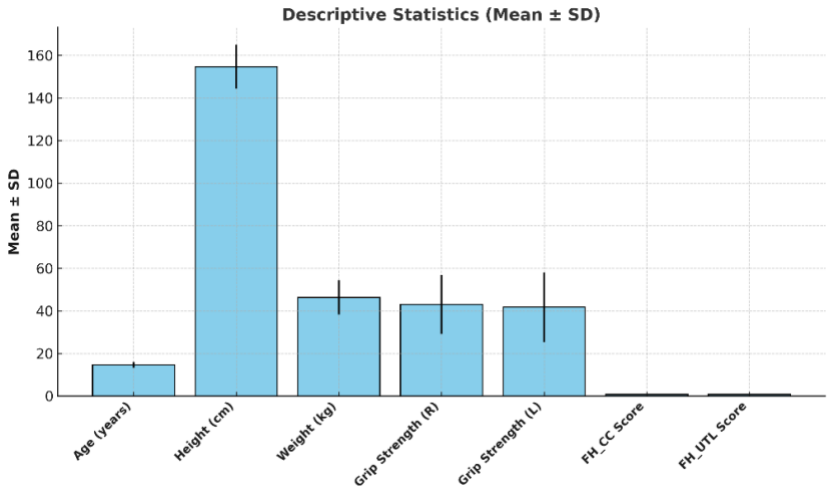

Figure 4.1 – Graphical Representation of Descriptive Statistics

The gender-wise analysis revealed notable differences in grip strength and forehand accuracy among the 47 amateur tennis players. Males demonstrated higher mean grip strength in both right (46.62 kg) and left (44.15 kg) hands compared to females (38.87 kg and 38.98 kg, respectively). Forehand accuracy scores were comparable, with females scoring 0.78 (FH_CC) and 0.75 (FH_UTL), while males scored slightly higher at 0.80 for both. The results indicate that while male players generally exhibit greater grip strength, both genders show relatively similar accuracy levels in forehand strokes, suggesting skill consistency despite physiological differences.

Table 4.2 – Grip Strength & Forehand Accuracy by Gender

Gender	GRIP R (MEAN+SD)	GRIP L (MEAN±SD)	FH_CC (MEAN ±SD)	FH_UTL (MEAN±SD)
Female (n=22)	38.87 ± 12.79	38.98 ± 15.25	0.78 ± 0.11	0.75 ± 0.13
Male (n=25)	46.62 ± 14.08	44.15 ± 17.20	0.80 ± 0.14	0.80 ± 0.12

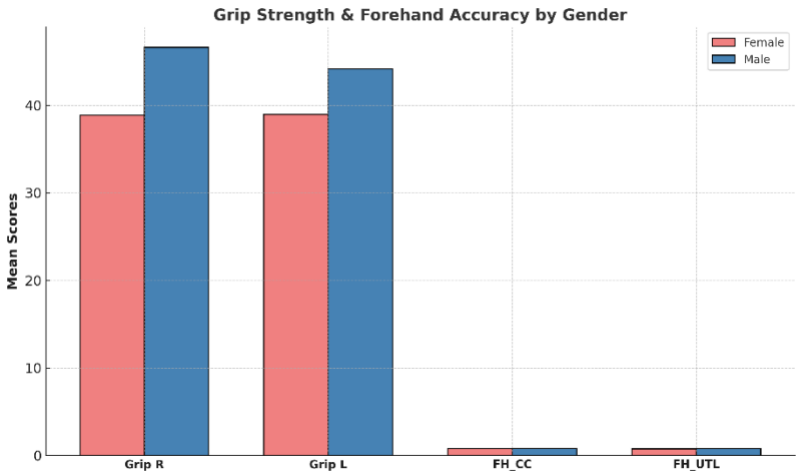

Figure 4.2 – Graphical Representation of Grip Strength & Forehand Accuracy by Gender

The scapular instability subtypes displayed distinct variations in grip strength and forehand accuracy. Players with superomedial border elevation had the highest grip strength (51.37 ± 15.31 R, 53.31 ± 13.60 L) and accuracy (FH_CC 0.88, FH_UTL 0.85), reflecting superior performance. Inferomedial border prominence showed moderate strength and accuracy, whereas medial border prominence demonstrated balanced but slightly lower results. In contrast, scapular winging was associated with the weakest grip strength (33.48 ± 5.56 R, 26.95 ± 7.06 L) and reduced accuracy. These findings highlight the impact of instability type on both muscular capacity and stroke precision in tennis players.

Table 4.3 – Grip Strength & Accuracy by Scapular Instability Type

Scapular Instability	Grip R (Mean±SD)	Grip L (Mean±SD)	FH_CC (Mean±SD)	FH_UTL (Mean±SD)
Inferomedial border prominence (n=11)	42.34 ± 14.9	39.49 ± 18.16	0.74 ± 0.10	0.73 ± 0.09
Medial border prominence (n=13)	41.44 ± 8.84	40.17 ± 13.05	0.79 ± 0.11	0.74 ± 0.14
Superomedial border elevation (n=15)	51.37 ± 15.31	53.31 ± 13.60	0.88 ± 0.09	0.85 ± 0.09
Scapular winging (n=4)	33.48 ± 5.56	26.95 ± 7.06	0.70 ± 0.16	0.78 ± 0.15

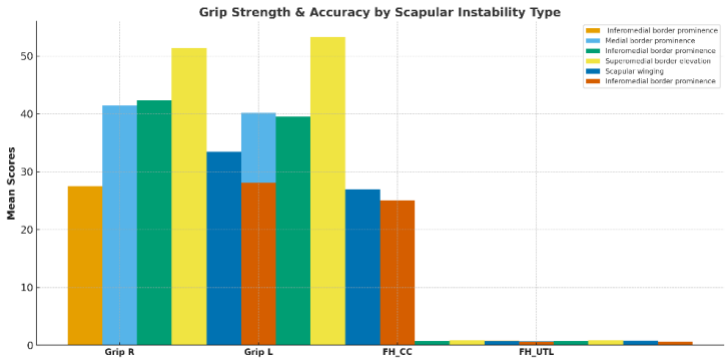

Figure 4.3 – Graphical Representation of Grip Strength & Accuracy by Scapular Instability Type

The correlation analysis of the 47 amateur tennis players demonstrated strong positive relationships between right and left-hand grip strengths (r = 0.92), indicating bilateral muscular consistency. Grip strengths showed moderate correlations with forehand accuracy scores (FH_CC: r = 0.35–0.39, FH_UTL: r = 0.49–0.50), suggesting that stronger players may achieve slightly better accuracy. A notable positive association was found between the two accuracy measures (r = 0.59), reflecting internal consistency of performance tests. These findings highlight that while grip strength influences stroke precision, other technical and biomechanical factors also significantly impact forehand accuracy in players with scapular instability.

Table 4.4 – Correlation Matrix

Variables	Grip R	Grip L	FH_CC	FH_UTL
Grip Strength (R)	1.00	0.92	0.35	0.49
Grip Strength (L)	0.92	1.00	0.39	0.50
FH_CC Score	0.35	0.39	1.00	0.59
FH_UTL Score	0.49	0.50	0.59	1.00

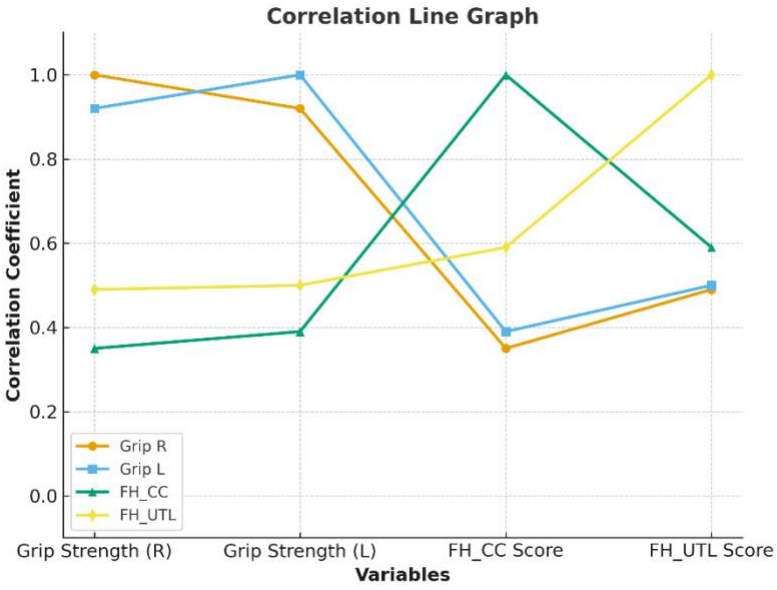

Figure 4.4 – Graphical Representation of Correlation Matrix

When players were divided into high and low accuracy groups using the median split on FH_CC scores, clear differences emerged in grip strength. The high-accuracy group demonstrated superior mean grip strength in both right (45.43 kg) and left (45.30 kg) hands compared to the low-accuracy group (39.06 kg and 35.97 kg, respectively). This suggests that stronger grip may support greater forehand control and accuracy, particularly in players with scapular instability. However, overlaps in standard deviations indicate that grip strength alone does not entirely determine accuracy, highlighting the importance of other biomechanical and technical factors in stroke performance.

Table 4.5 – Grip Strength in High vs Low Accuracy Groups (Median Split on FH_CC)

Group	Grip R (Mean±SD)	Grip L (Mean±SD)
High Accuracy	**45.43 ± 14.18**	**45.30 ± 15.78**
Low Accuracy	**39.06 ± 12.86**	**35.97 ± 16.00**

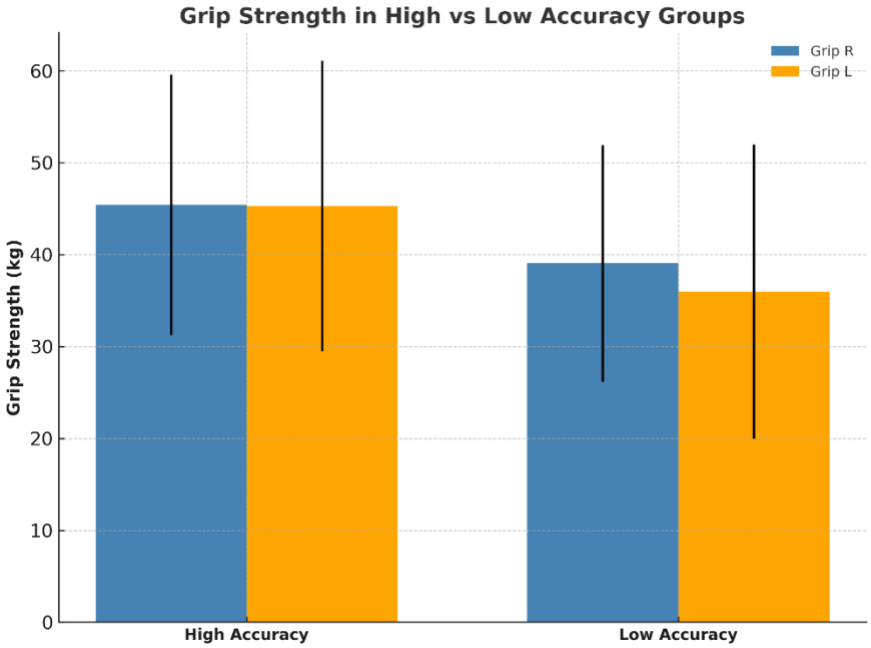

Figure 4.5 – Graphical Representation of Grip Strength in High vs Low Accuracy Groups (Median Split on FH_CC)

8. DISCUSSION

The present study aimed to investigate the relationship between grip strength and scapular stability on forehand hitting accuracy in amateur tennis players. Specifically, it sought to explore whether grip strength, assessed using a hand dynamometer, and scapular stability, evaluated through the Shoulder Flexion Resistance Test (SFRT) and classification of scapular instability, were associated with variations in forehand accuracy. The findings provide valuable insights into the interplay between upper limb strength, scapular control, and stroke execution in young athletes, while also extending current knowledge in tennis biomechanics and rehabilitation sciences.

Grip Strength and Forehand Accuracy

The results demonstrated a positive, albeit modest, correlation between grip strength and forehand hitting accuracy. Players with higher grip strength scores tended to perform more consistently in both *cross-court* (FH_CC) and *up-the-line* (FH_UTL) shots. Although the correlation was not very strong, it aligns with the principle that forehand performance in tennis is influenced by the ability to generate and transfer force effectively through the kinetic chain (Roetert et al., 2014). Grip strength plays a role in stabilizing the racket during ball impact, reducing vibration, and maintaining directional control.

These results are comparable to those of **Joshi and Sathe (2018)**, who found significant associations between grip strength and scapular muscle activity, suggesting that both distal and proximal muscle functions are important in shoulder and upper limb performance. Similarly, **Colomar et al. (2020)** reported that strength and muscular stiffness were predictive of stroke velocity in junior players, reinforcing the idea that muscular performance contributes not only to speed but also to technical accuracy. While velocity and accuracy are often distinct performance measures, the biomechanical underpinnings are shared, and stronger athletes may exert better control over racket dynamics.

However, our findings partially diverge from those of **Arif and Yousif (n.d.)**, who argued that biomechanical variables such as segmental kinematics contributed more strongly than grip force to stroke accuracy. This discrepancy could be attributed to methodological differences: our study focused on young amateur players, where foundational strength may be a limiting factor, whereas Arif and Yousif analyzed broader biomechanical contributions in more advanced players. At the amateur level, grip strength may thus exert a relatively greater impact due to incomplete technical mastery.

Scapular Stability and Forehand Accuracy

The analysis by scapular instability type revealed that players with **superomedial border prominence** displayed superior forehand accuracy compared with those exhibiting **inferomedial or medial border patterns**. This observation suggests that certain scapular dyskinesis patterns may impair stroke execution more severely than others. The scapula plays a pivotal role in the kinetic chain by serving as the stable base for glenohumeral motion, facilitating both force generation and energy transfer during strokes (Saini et al., 2020). Disruptions in scapular kinematics may compromise racket control and reduce stroke efficiency.

These findings resonate with the systematic review by **Burn et al. (2016)**, which highlighted the high prevalence of scapular dyskinesis among overhead athletes and its association with impaired performance. Similarly, **Gillet et al. (2018)** reported that adolescent players with a history of shoulder problems demonstrated altered scapulothoracic and humerothoracic kinematics during the serve, which could undermine stroke precision. In line with our results, these studies emphasize that scapular instability may translate into functional deficits in shot accuracy.

Furthermore, the work of **Deniz et al. (2022)** compared scapulothoracic muscle properties between young tennis players with and without scapular dyskinesis. Their results showed altered activation and mechanical properties in dyskinesis groups, supporting our finding that instability may impair functional outcomes such as forehand accuracy. The presence of instability not only influences biomechanics but also places compensatory demands on distal segments, potentially reducing stroke reliability.

Integrating Grip Strength and Scapular Stability

The novelty of the present study lies in examining grip strength alongside scapular stability. Our findings suggest that while grip strength contributes positively to forehand accuracy, the presence of scapular instability can moderate this effect. Players with higher grip strength but poor scapular control may still struggle with consistent accuracy. This reflects the interdependence of distal and proximal components of the kinetic chain, consistent with the conceptual model proposed by **Saini et al. (2020)**, who emphasized the need to assess scapular dyskinesis within the broader kinetic framework of tennis.

Biomechanically, the scapula provides the foundation for energy transfer from the trunk to the arm. Without adequate stability, even high grip force may not translate into optimal racket control. Conversely, adequate scapular positioning facilitates efficient muscle recruitment in the forearm and hand, allowing grip strength to be used effectively. This interaction highlights the importance of holistic conditioning programs that target both grip and scapular stability rather than focusing exclusively on one component.

The findings of Ahmed et al. (2023) add substantial depth to the existing knowledge of grip and pinch strength within the Indian context, an area that has historically lacked population-specific normative data. Their results are consistent with global literature that indicates higher grip strength in men compared to women and in the dominant hand compared to the non-dominant hand. Importantly, their work underscores the need for **culturally and regionally relevant benchmarks**, since anthropometric, nutritional, and occupational differences can significantly influence strength outcomes.

In the context of tennis performance research, such normative data are critical. Amateur tennis players with **scapular instability** may demonstrate altered kinetic chain function, which can indirectly compromise grip strength and, consequently, stroke accuracy. Comparing grip values from pathological or athletic populations with normative baselines like those established by Ahmed et al. allows for **objective quantification of impairment and recovery**. Furthermore, their inclusion of pinch strength adds an extra dimension, since pinch mechanisms contribute to fine motor control, racquet handling, and shot precision.

Thus, the study by Ahmed and colleagues (2023) not only enriches the literature on hand strength but also provides **a valuable comparative framework** for clinicians and researchers assessing the relationship between grip strength, scapular stability, and functional sports outcomes such as forehand hitting accuracy in tennis.

Comparison with Energetics and Stroke Biomechanics Literature

Classic works on tennis energetics and biomechanics (Elliott et al., 1985; Davey et al., 2003) emphasized the high physical demands of tennis match play, including repeated forceful strokes requiring endurance and precision. While these studies did not directly examine grip strength or scapular stability, they underscore the broader physiological demands under which these biomechanical variables must operate. Our results complement these insights by identifying specific musculoskeletal factors—grip strength and scapular control—that may underpin effective stroke production within the energetic framework described.

Elliott (2020) further noted that stroke execution is shaped by both equipment and biomechanical technique, suggesting that strength and stability are only part of a multifactorial equation. Nevertheless, our data confirm that these elements contribute meaningfully to accuracy, especially in developing players who may lack refined technical adaptations.

Clinical and Training Implications

From a practical standpoint, the findings have implications for coaching, conditioning, and rehabilitation. First, the results underscore the value of **grip strengthening exercises** as part of tennis conditioning, especially for younger players still developing racket control. Second, the importance of scapular stability training is reinforced; exercises targeting the **serratus anterior and lower trapezius** may correct dyskinetic patterns and improve functional performance (Castelein et al., 2016). Integrating such training into youth development programs may enhance both performance and injury prevention.

The recognition of scapular instability as a performance limiter also aligns with clinical perspectives. **Saini et al. (2020)** emphasized that untreated scapular dysfunction can propagate through the kinetic chain, increasing injury risk in the shoulder, elbow, and wrist. Our results suggest that instability also compromises accuracy, strengthening the case for early detection and intervention.

Reliability of Measurement Tools

This study also supports the use of validated tools for assessing grip strength and scapular function. The use of a hand dynamometer, supported by the reliability studies of **Huang et al. (2022)**, ensures accurate quantification of grip force. Likewise, methods assessing scapular stability, such as the SFRT, complement the broader clinical reliability literature on goniometers and inclinometers (Hanks & Myers, 2023). Incorporating such standardized tools enhances reproducibility and strengthens confidence in the observed associations.

Contradictions and Alternative Explanations

While positive correlations were observed, the strength of association between grip strength and accuracy was moderate. This suggests that factors beyond muscular strength also play key roles. Technical proficiency, neuromuscular coordination, and anticipatory timing are likely equally important, as emphasized in the systematic review by **Sharma and Chaware (2023)**, which identified anthropometric, physical, and kinematic determinants of forehand performance. Our findings may therefore reflect only part of the broader performance equation.

Moreover, while players with superomedial border instability showed relatively higher accuracy, this result should be interpreted cautiously. It may reflect compensatory strategies or sampling variations rather than a protective effect of this instability type. Further research is needed to clarify whether certain dyskinesis patterns are less detrimental than others.

9. CONCLUSION

This observational study examined the relationship between grip strength and forehand hitting accuracy among amateur tennis players with scapular instability. The findings demonstrated that while grip strength was generally higher in male players, accuracy levels were relatively consistent across genders. Moreover, specific types of scapular instability, particularly superomedial border elevation, were associated with superior grip strength and accuracy, whereas scapular winging indicated weaker muscular capacity and poorer stroke precision. Correlation analysis highlighted a moderate association between grip strength and accuracy, reinforcing the idea that muscular factors contribute to performance but do not entirely determine it. Collectively, these results suggest that tennis performance in the context of scapular instability is influenced by both physiological strength and technical control, underlining the need for integrated conditioning and rehabilitation strategies.

Theoretical Contributions

This research contributes to sports science theory in several ways.

- Kinetic Chain Reinforcement: The study provides empirical evidence for the interdependence of distal grip strength and proximal scapular control in determining stroke accuracy. This supports the kinetic chain model, emphasizing that dysfunction at one link compromises overall output.
- Scapular Instability Typology: By distinguishing performance outcomes between inferomedial, medial, and superomedial border dyskinesis, the study suggests a nuanced view of instability types. Not all dyskinesis has the same performance cost, opening avenues for classification-based rehabilitation.
- Accuracy vs. Power Debate: Much research has focused on velocity (Colomar et al., 2020; Delgado-Garcia et al., 2019). By emphasizing accuracy, this study shifts the focus to precision, a quality equally essential in match play, especially for amateur athletes still building tactical consistency.

- Adolescent Amateur Population: The focus on amateur adolescents fills a gap in literature, which is often dominated by elite or adult samples. This population faces unique developmental challenges, making the findings highly relevant for youth coaching and sports medicine.

Practical Implications

The practical applications of this research span coaching, conditioning, and rehabilitation.

- Grip Strengthening: Hand dynamometer results confirm that stronger grip contributes to accuracy. Coaches should incorporate exercises such as hand grippers, rice bucket drills, and resisted pronation/supination to enhance racket stability.
- Scapular Stability Training: Given the influence of scapular control, targeted interventions for the serratus anterior, lower trapezius, and rhomboids should be included. Closed-chain exercises like push-up plus, wall slides, and resistance band protraction are recommended (Castelein et al., 2016).
- Screening and Early Detection: Coaches and physiotherapists should implement routine scapular screening, as instability predicts not only injury risk but also performance deficits. Early correction may yield competitive advantages.
- Holistic Conditioning: Training should not treat grip strength and scapular stability in isolation. Integrated programs that progress from proximal control to distal power are most effective.
- Amateur Player Development: For adolescents, the findings suggest prioritizing fundamentals of stability and strength before emphasizing velocity or spin. Accuracy is a performance foundation upon which advanced tactics are built.

10.Limitations & Recommendations for Future Studies

Despite valuable insights, the study has limitations.

- Cross-Sectional Design: The correlational nature prevents causal inference. Future longitudinal or interventional designs are needed.
- Sample Size and Demographics: The sample was modest and limited to adolescent amateurs, restricting generalizability. Elite, adult, or professional populations may yield different patterns.
- Scapular Assessment Method: Visual classification of dyskinesis, while clinically relevant, lacks the precision of three-dimensional motion capture.
- Stroke Specificity: Only the forehand was analyzed. Backhand, serve, and volleys may show distinct relationships.
- Psychological Factors: Confidence, anxiety, and decision-making also influence accuracy but were beyond the scope of this study.

Future Directions

Future research should expand the scope and precision of inquiry.

- Longitudinal Training Studies: Implement grip and scapular strengthening programs to assess causality and training effects on accuracy.
- Advanced Biomechanics: Use motion capture, electromyography, and isokinetic testing to precisely quantify scapular and grip contributions.
- Comparative Populations: Include elite, recreational adults, and wheelchair tennis players (Cavedon et al., 2014) to test generalizability.
- Broader Performance Metrics: Examine not only accuracy but also velocity, spin, endurance, and tactical decision-making.
- Instability Typologies: Investigate whether different dyskinesis types truly have differential performance effects, as suggested by our exploratory findings.

- Injury-Performance Nexus: Longitudinally assess whether improving scapular stability reduces both injury risk and enhances performance simultaneously.

This study advances the understanding of how grip strength and scapular stability contribute to tennis forehand accuracy. It affirms that performance cannot be reduced to isolated strength measures but must be viewed through the integrated lens of the kinetic chain. The results validate earlier biomechanical theories (Elliott et al., 1985; Roetert et al., 2014) and extend them to show that accuracy—a quality as decisive as velocity—is contingent on both distal grip and proximal scapular mechanics.

For amateur adolescent players, the implications are profound. Rather than focusing prematurely on power, developing a foundation of scapular control and grip strength may yield greater benefits in long-term skill progression. For clinicians and coaches, the findings reinforce the necessity of comprehensive training programs that integrate conditioning, screening, and corrective strategies.

Ultimately, this study underscores the dual truth of tennis performance: a strong grip without stability falters, and stable scapulae without strength are insufficient. Only when the two operate synergistically does accuracy—the essence of tactical effectiveness—emerge reliably. This conclusion situates grip strength and scapular stability not as peripheral variables, but as central determinants of tennis skill, worthy of continued scholarly and practical attention.

11. SUMMARY and source of funding

This observational study explored the relationship between **grip strength and forehand hitting accuracy** in 47 adolescent amateur tennis players with scapular instability. The sample, comprising both male and female players aged 12–17 years, demonstrated average grip strengths of **43.0 kg (right hand)** and **41.7 kg (left hand)**, with mean forehand accuracy scores of **0.8** for both cross-court and down-the-line strokes.

Gender-wise comparisons revealed that males possessed significantly greater grip strength than females; however, accuracy levels remained largely comparable between groups. This suggests that while males enjoy a physiological advantage in strength, **forehand accuracy depends on technical consistency as much as muscular power**. Analysis of scapular instability subtypes showed that players with **superomedial border elevation** displayed the highest grip strength and accuracy, while those with **scapular winging** exhibited the weakest performance, underlining the clinical and functional impact of instability patterns.

Correlation analysis highlighted a **strong bilateral association between right- and left-hand grip strength (r = 0.92)** and moderate positive correlations between grip strength and accuracy (r = 0.35–0.50). A significant relationship was also found between cross-court and down-the-line accuracy (r = 0.59), confirming internal consistency of performance measures. Dividing players into high- and low-accuracy groups further revealed that stronger grip strength contributed to better accuracy, though overlapping standard deviations indicated that strength alone does not fully explain performance.

Normality testing showed that most variables were normally distributed, except **left-hand grip strength**, justifying the use of both parametric and non-parametric analyses. Overall, the findings suggest that while **grip strength enhances accuracy**, tennis performance in players with scapular instability is multifactorial, shaped by muscular capacity, biomechanical control, and technical execution. These insights hold implications for targeted training, rehabilitation, and future sports science research.

STATEMENT OF FUNDING

Source of Funding: not applicable

Nature of funding: not applicable

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13.ANNEXURE

ANNEXURE:1

CONSENT FORM

I 25, aged years, confirm that I have understood about the "**RELATION BETWEEN GRIP STRENGTH AND FOREHAND HITTING ACCURACY AMONG AMATEUR TENNIS PLAYERS WITH SCAPULAR INSTABILITY: AN OBSERVATIONAL STUDY"** as explained by Suraj Kumar Samal and is as mentioned in his study which is taking place under the guidance of Dr. Asifuzzaman Shahriyar Ahmed, (PT), Associate professor, Abhinav Bindra sports medicine and research institute (ABSMARI).

I understand that my participation is voluntary and I'm free to withdraw at any time, without giving any reason.

I understand that confidentiality will be maintained.

I voluntarily agree to and give my consent to be a part of the above-mentioned study.

Signature

Date

INFORMED PARENTS CONSENT

Informed Consent form to participate in a observational study

Study Title: Relation Between Grip Strength and Forehand Hitting Accuracy among Scapular Instability on Amateur Tennis Player **:** An Observational Study

Study Number:

Subject ‘s Name: _____ parent‘s Initials: _____

Date of Birth / Age: _____

Address of the Subject_____

Qualification _____

Occupation: Student/Self-Employed/ Service/Housewife/Others (Please tick as appropriate)

Annual Income of the subject _____ if applicable

Name and address of the nominee(s) and his relation to the subject _____ (for the purpose of compensation in case of trial related death).]

Please initial box

(Subject)

(i) I confirm that I have read and understood the information sheet dated _____ [ ] for the above study and have had the opportunity to ask questions.

(ii) I understand that my participation in the study is voluntary and that I am [ ]
free to withdraw at any time, without giving any reason, without my
medical care or legal rights being affected.

(iii) I understand that the Sponsor of the clinical trial, others working on the [ ]
Sponsor ‘s behalf, the Ethics Committee and the regulatory authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw from the trial. I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published.

(iv) I agree not to restrict the use of any data or results that arise from this [ ] study provided such
a use is only for scientific purpose(s)

(v) I agree to take part in the above study. [ ]

Signature (or Thumb impression) of the Subject/Legally Acceptable Representative:

_____

Date: _____/ ____/ _____

Signatory ‘s Name: _____

Signature of the Investigator: _____

Date: Study Investigator ‘s Name: _____

Signature of the Witness: _____

Date: _____/ _____/ _____

Name of the Witness: _____

*Copy of the Patient Information Sheet and duly filled Informed Consent Form shall be handled over to the subject or his/her attendant.

ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE, BHUBANESWAR, ODISHA

CDSCO Reg. No.: ECR/1981/Inst/OD/24

ABSMARI

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2025/179

Date: 12/05/2025

APPROVAL LETTER
APPENDIX- VIII

MEMBERS

Dr. Smaraki Mohanty
Clinician

Dr. Satyajit Mohanty
Scientific Member

Mr. Shib Shankar Mohanty
Legal Expert

Ms. Annie Hans
Social Scientist

Ms. Subhashree Samal
Lay Person

Mr. Deepak Ku. Pradhan
Scientific Member

IEC-SECRETARIAT

Mr. Gouranga Ku. Padhy
Mr. Susant Ku. Raychudamani

To,

SURAJ KUMAR SAMAL
ABSMARI
273, PAHAL, BHUBANEWAR-752101

Protocol Title: Relation between Grip Strength and Forehand Hitting Accuracy among Amateur Tennis Players with Scapular Instability: An observational study

Protocol ID.: ABS-IEC-2025-PHY-084

Subject: Approval for the conduct of the above referenced study

Dear Mr./**Ms.**/Dr **Suraj Kumar Samal**
With reference to your Submission letter dated 06/01/2025 the ABSMARI IEC has reviewed and discussed your application for conduct of the study on dated 26/04/2025.

The following documents were reviewed and discussed

S.N.	Documents	Document (Version/Date)
1	IEC Application Form	26/04/2025
2	Informed Consent Form	26/04/2025
3	Undertaking form PI	26/04/2025
4	CRF	26/04/2025
5	COI from the Investigators	26/04/2025

The following members were present at meeting held on 26-04-2025

ABSMARI ETHICS COMMITTEE * BHUBANESWAR * Dt. 12/05/25

1

ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE,
BHUBANESWAR, ODISHA

CDSCO Reg. No.: ECR/1981/Inst/OD/24

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2025/179

Date: 12/05/2025

MEMBERS

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Social Scientist

Ms. Subhashree Samal
Lay Person

Mr. Deepak Ku. Pradhan
Scientific Member

IEC-SECRETARIAT

Mr. Gouranga Ku. Padhy
Mr. Susant Ku. Raychudamani

S.N.	Name of the Member	Designation & Qualification	Representation as per NDCT 2019	Gender (M/F)	Affiliation with the institution (Y/N)
1	Prof. Dr. E. Venkata Rao	Professor (MBBS, MD, Dept. of Community Med.) IMS & Sum Hospital, BBSR	Chair Person	M	N
2	Dr. Smaraki Mohanty	Asst. Prof-IMS & Sum Hospital/MBBS, MD (Community Med)	Clinician	F	N
3	Mr. Shiba Sankar Mohanty	Junior Counsel-Lt. Ramachandra Sarangi's Chamber / BA LLB	Legal Expert	M	N
4	Mr. Chinmaya Kumar Patra	Principal-ABSMARI, MPT	Member Secretary	M	Y
5	Ms. Annie Hans	Disability Inclusive Development Co-Ordinator in Humanity and Inclusion (India/Nepal/Srilanka). /MA in Social Work	Social Scientist	F	N
6	Ms. Subhashree Samal	Ret. Reader-Pol Sc.	Lay Person	F	N
7	Mr. Deepak Kumar Pradhan	Asst. Prof-ABSMARI, MPT	Scientific Member	M	Y

This is to confirm that only members who are independent of the investigator and the Sponsor of the trial have voted/ provided opinion on the trial.

This Committee approves the documents and the conduct for the study in the presented form with necessary recommendation.

The ABSMARI IEC must be informed about the progress of the study in the prescribed format attached, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent/assent and request to provide a copy of the final report.

The ABSMARI IEC follows procedures that are in compliance with the requirements of ICH (International Conference on Harmonization) guidance related to GCP (Good Clinical Practice) and applicable Indian regulations.

Yours sincerely,

Mr. Chinmaya Kumar Patra
Member Secretary
ABSMARI Ethics Committee
Pahal, Bhubaneswar

Member Secretary
ABSMARI ETHICS COMMITTEE

ABSMARI ETHICS COMMITTEE * BHUBANESWAR * Dt. 12/05/25

2

Utkal Signature, Plot No.-273,
Ground Floor, Pahal, Bhubaneswar-752101 +91-63707-03654 iec@absmari.com

ABHINAV BINDRA
Sports Medicine & Research Institute
A Unit of the Abhinav Bindra Foundation Trust
Recognised by DMET, Health & FW Dept., Govt. of Odisha. Affiliated to Utkal University
Recognised by Odisha State Council for Occupational Therapy and Physiotherapy
Affiliated to Odisha University of Health Sciences, Bhubaneswar

Head Office:
Plot No.-107, Sector-82
JLPL Industrial Area,
Sahibzada Ajit Singh
Nagar, Punjab - 140306
+91 99156 31755
principal@absmari.com

Date-17.05.2025
Letter no-ABSMARI/ADMIN /2025/2628

TO WHOM SO EVER IT MAY CONCERN

This is to certify that Mr. **SURAJ KUMAR SAMAL** is a bonafide student of ABSMARI M.P.T. 2ND Year batch of ABSMARI bearing Roll No ABS-MPT-2023-52 With reference to his requisition this institute has no objection in allowing him to carry out his research work as per the following details under the guidance of Dr. ASIFUZZAMAN SHAHRIYAR AHMED.

Ref: ABSMARI/IEC/2025/179

Title -" RELATION BETWEEN GRIP STRENGTH AND FOREHAND HITTING ACCURACY AMONG AMATEUR TENNIS PLAYERS WITH SCAPULAR INSTABILITY: AN OBSERVATIONAL STUDY."

Population – Amateur Tennis Players (12-18 years old)

study settings – ACE BASE TENNIS ACADEMY, BBSR

Duration – 6 Weeks From - dt 20.05.2025 to dt.01.07.2025

under the following conditions subject to thorough permission from their end -

1. He has to produce his official engagement plan issued by the study setting
2. He has to submit his certificate of attendance at last
3. He is liable to respond to institute when required
4. He must attend all examinations scheduled by the institution or university during this period
5. Daily report to Research- Guide and CC to Course-Coordinator is highly required

This NOC is effective from – dt. 20.05.2025 to dt.01.07.2025

CC –The Research Head, ABSMARI, The Course -Coordinator, The Research- Guide, Admin office

Principal, ABSMARI

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE
ABSMARI BHUBANESWAR

Utkal Signature, Plot No 273, NH-5, Pahal, Bhubaneswar, 752101
Phone: 6370703650, 6370703651

MASTERCHART

S.no	Name	Age	Gender	hand dominancy	Height	weight	Playing experience	Type of Scapular Instibality	Grip Strength (R)	Grip Strength (L)	FH CC	FH UTL
1	Priyanshi Mohanty	13	Female	Right	153	40	2 years	Inferomedial border prominenc	27.5	22	13/15	12/15 .
2	Brijesh padhy	12	Male	Right	140	36	3 years	Medial border prominence	35	28.3	13/15	12/15.
3	Sagnika Jena	12	Female	Right	132	38	2 years	Inferomedial border prominence	23.8	20.1	11/15.	9/15.
4	Ahana Nishank	13	Female	Left	130	32	4 years	Medial border prominence	28.4	29.2	9/15.	8/15.
5	Ayush Patnaik	14	Male	Right	155	56	3 years	Medial border prominence	33.5	28	13/15	10/15.
6	Priyanshu Jena	12	Female	Left	143	40	3 years	Superomedial border elevation	18.5	32.1	14/15	13/15
7	Vivaan Pattniak	17	Male	Left	173	63	6 years	Superomedial border elevation	56.8	61.5	15/15	14/15
8	Prisha Jena	15	Female	Left	160	53	4 years	Superomedial border elevation	42.8	46.8	12/15.	11/15.
9	Tanishqa	14	Female	Right	136	48	3 years	Inferomedial border prominence	26.8	18.5	12/15.	10/15.
10	Saanvi Dash	14	Female	Right	158	50	5 Years	Inferomedial border prominence	24.8	18.6	11/15.	12/15.
11	Eashan Pattanaik	15	Male	Right	154	42	4 years	Inferomedial border prominence	30.5	29.5	12/15.	10/15.
12	Ishaan Rout	16	Male	Right	168	57	4 years	Medial border prominence	43.5	41	14/15	13/15
13	Myra Panda	16	Female	Right	167	55	7 Years	Superomedial border elevation	43.5	39.2	13/15	11/15.
14	Yuvraj Naik	14	Male	Right	155	48	4 years	Medial border prominence	48.6	45.5	14/15	13/15
15	Devjeet Rout	17	Male	Right	172	62	7 Years	Superomedial border elevation	59.2	57.4	15/15	14/15
16	Kavya Behera	16	Female	Left	165	56	6 years	Inferomedial border prominence	42.4	46.8	14/15	13/15
17	Ananya Mishra	13	Female	Left	153	46	4 years	Superomedial border elevation	33.6	39	12/15.	11/15.
18	Rudra Swain	13	Male	Right	151	44	4 years	Medial border prominence	37.4	30.4	12/15.	10/15.
19	Nikhil Swain	14	Male	Left	152	42	3 years	Inferomedial border prominence	61.5	66.4	9/15.	10/15.
20	Arjun nayak	14	Male	Left	150	44	6 years	Inferomedial border prominence	49.8	59.3	10/15.	11/15.
21	Priya Behera	14	Female	Right	151	42	2 years	Superomedial border elevation	43.8	37.2	11/15.	12/15.
22	Ankita Rout	15	Female	Left	160	48	6 years	Medial border prominence	58.4	63.3	13/15.	12/15.
23	Sneha Samal	15	Female	Right	155	46	6 years	Superomedial border elevation	46.2	42.8	11/15.	12/15.
24	Rohan Jena	16	Male	Right	165	52	7 Years	Inferomedial border prominence	66.4	61.5	9/15.	10/15.
25	Tushar Panda	17	Male	Right	168	60	8 years	Superomedial border elevation	78.6	72.6	14/15	14/15
26	Ishita Rout	14	Female	Right	149	41	3 years	Medial border prominence	52.2	48.6	10/15.	11/15.
27	Abhishek Senapat	15	Male	Left	159	47	5 Years	Superomedial border elevation	61.4	69.8	13/15.	14/15.
28	Nandani Sethi	16	Female	Right	156	49	6 years	Superomedial border elevation	69.5	62.7	14/15	14/15
29	Aaditya Pradhan	16	Male	Left	164	55	7 Years	Superomedial border elevation	68.6	72.8	14/15	14/15
30	Swati Parida	15	Female	Left	153	45	4 years	Medial border prominence	48.6	57.4	11/15.	11/15.
31	Kavya Padhy	14	Female	Left	157	43	4 years	Medial border prominence	45.8	58.3	12/15.	13/15.
32	Suresh Pattnaik	13	Male	Right	146	48	4 years	Inferomedial border prominence	38.3	25.7	10/15.	11/15.
33	Ishita sahoo	15	Female	Left	160	53	4 years	Superomedial border elevation	42.8	46.8	12/15.	11/15.
34	Karan Rout	17	Male	Left	173	63	6 years	Superomedial border elevation	56.6	61.5	15/15	14/15
35	parmanada padhy	15	Male	Right	158	50	5 Years	Inferomedial border prominence	46.8	38.6	12/15.	12/15.
36	Abhijeet Samal	17	Male	Right	159	49	4 years	Inferomedial border prominence	54.6	49.4	12/15.	13/15
37	Trishna Behera	13	Female	Left	150	40	5 years	Superomedial border elevation	48.6	57.4	13/15	13/15
38	Rohan Sahu	14	Male	Right	141	39	2 years	Medial border prominence	39	33.3	11/15	11/15
39	Anika Dash	15	Male	Right	155	40	2 years	Scapular winging	30.8	29	13/15	9/15
40	Vivek Mishra	14	Male	Right	148	39	4 years	Scapular winging	36.2	22.3	9/15	11/15
41	Meera Lenka	13	Male	Right	151	39	3 years	Inferomedial border prominence	26.8	27	8/15	10/15
42	Karan Rout	13	Male	Right	142	44	2 years	Inferomedial border prominence	30	27.3	9/15	12/15
43	Ishita Nayak	17	Male	Right	166	39	3 years	Scapular winging	39.7	36	12/15	14/15
44	Sudarshan Behera	16	Female	Right	169	48	5 years	Scapular winging	27.2	20.5	8/15	13/15
45	Tania Pradhan	14	Female	Right	145	30	2 years	Inferomedial border prominence	27.5	20.9	10/15	7/15
46	Aditya Kar	15	Male	Right	153	43	4 years	Medial border prominence	35.8	29.6	13/15	14/15
47	Nisha Sethi	16	Female	Right	150	33	3 years	Medial border prominence	32.5	29.3	10/15	7/15

Suraj Kumar Samal

RELATION BETWEEN GRIP STRENGTH AND FOREHAND HITTING ACCURACY AMONG AMATEUR TENNIS PLAYERS WI...

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