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Correlation of Physical and Motor Skills with Smashing Accuracy in Badminton Players

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Abstract

Introduction: A badminton smash is a critical offensive shot that requires exceptional speed, power, and precision to outperform opponents. Successful execution depends on a variety of physical and motor skills, but the specific contributions of agility, eye-hand coordination, dynamic balance, height, and shoulder strength to smashing accuracy have not been thoroughly examined. This study aimed to determine how these physical attributes impact the accuracy of smashes in skilled badminton players, offering insights into improving training regimens.

Methods and Materials: A cross-sectional study was conducted with 87 skilled badminton players aged 16–25 years. Physical attributes were evaluated using standardized tests: agility was measured using the Illinois Agility Test, eye-hand coordination through the Plate Tapping Test, and shoulder strength with a dynamometer. Smash accuracy was assessed through specific skill-based tests designed to gauge shot placement precision. Correlation analysis was employed to examine the relationships between each physical attribute and smash accuracy.

Results: The analysis demonstrated moderate positive correlations between smash accuracy and agility ($r = 0.45$), shoulder strength ($r = 0.42$), and eye-hand coordination ($r = 0.58$), suggesting that players who are faster, stronger, and have better coordination tend to perform more accurately. Eye-hand coordination emerged as the most influential factor, exhibiting the strongest correlation with the smash accuracy. A minimal correlation was observed with height ($r = 0.12$), while dynamic balance showed no significant association with smash precision.

Discussion: The findings underscore the critical role of agility, shoulder strength, and eye-hand coordination in enhancing smash accuracy in badminton. In particular, eye-hand coordination is vital for precise execution. These results suggest that training programs should prioritize agility and coordination exercises to enhance player smash performance. The lack of significant impact from height and dynamic balance indicates that for badminton smashes, coordination and strength-based attributes are more predictive of success than purely physical characteristics such as height.

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Conclusion: This study highlights the importance of specific motor skills, especially agility and eye-hand coordination, in refining smash accuracy in badminton.For coaches and players, these insights provide a basis for targeted training strategies focusing on coordination and strength to enhance game performance. Further research could investigate these relationships in different playing styles or experience levels to broaden the understanding of the physical attributes of badminton success.

Keywords: Badminton; Smash Accuracy; Agility; Eye-Hand Coordination; Shoulder Strength; Motor Skills; Physical Attributes; Performance Training.

INTRODUCTION

Badminton ranks among the world's most popular sports, with an estimated 220 million participants.[1] It is widely played across various regions, particularly in countries such as India, where badminton has earned prominence through numerous international accolades.[2]

The sport's demands are intense: elite players require not only mastery of technical skills but also exceptional physical and physiological conditioning to perform high-speed maneuvers and strategic shots.[3] Among these, the smash shot stands out as a decisive move, often termed the "winning shot" for its ability to conclude rallies through its speed and trajectory.[4] At reaching speeds over 400 km/h in competitive play, a well-executed smash requires a player to possess a unique blend of strength, agility, and coordination.[5]

The effectiveness of a badminton smash depends on several factors. From a technical standpoint, players utilize various smash techniques such as jumping, forehand, and backhand, each involving intricate biomechanical movements and specific skill sets.[6-8] Beyond technique, physical attributes such as height, shoulder strength, and dynamic balance are considered essential for smash accuracy, allowing players to achieve optimal positioning and forceful impact. Motor skills such as agility and eye-hand coordination also contribute significantly, as players must rapidly react to the motion of the shuttlecock and adjust their body position to execute the smash effectively.

Previous research has examined the factors affecting badminton performance, including shoulder strength, agility, and balance. However, a gap remains in understanding how these variables collectively impact smashing accuracy in competitive players.[9-11] This study sought to address this gap by investigating the correlation of agility, eye-hand coordination, dynamic balance, height, and shoulder strength with smash accuracy among trained badminton players.Using a cross-sectional design, this study examined these attributes through standardized physical and functional tests.

This study aimed to assess how height, eye-hand coordination, agility, dynamic balance, and shoulder strength are related to smashing accuracy in badminton players. Specifically, it seeks to understand whether a player's height influences their ability to perform accurate smashes and to evaluate how eye-hand coordination might enhance precision by enabling faster reaction times and tracking of the shuttlecock. The study also examines the role of agility in positioning and how quickly players can set up for a controlled smash, and explores whether dynamic balance contributes to maintaining stability during movement. Additionally, it considers the impact of shoulder strength, hypothesizing that stronger shoulder muscles may support greater power and control during smash execution.

METHODS AND MATERIALS

Study Design

This study employed a cross-sectional design to investigate the correlation between specific physical attributes and motor skills and smashing accuracy in a defined sample of badminton players. This design was chosen to assess these relationships at a single point in time, making it feasible to collect data from multiple variables that may influence smashing accuracy.

Study Population and Setting

Participants were selected from a pool of badminton players enrolled in local academies across Surat, including the Yash Badminton Academy, Khelghar Sports Arena, Kalpana Badminton Academy, Athletica Sports and Fitness Center, and Kratos Club.Players were recruited if they met the following

Inclusion criteria:

1. Aged between 16 and 25 years.
2. Engaged in at least one year of formal badminton training.
3. Actively playing badminton for a minimum of four hours per week. Players with recent or recurrent injuries affecting the shoulder, wrist, elbow, ankle, knee, or spine were excluded from the study.

Study Duration

The study was conducted over six months, allowing sufficient time for participant recruitment, data collection, and analysis.

Sampling Technique

Convenience sampling was employed to select participants, as the study aimed to include accessible players with varying degrees of skill, but with a foundational level of training and consistency in play.

Sample Size

The sample size was calculated using G*Power 3.1.9.2 software, based on an estimated 0.50 correlation of, alpha of 0.05 and power (beta) of 0.80. A sample of 29 participants was determined per primary variable; however, to accommodate three primary and two secondary variables, the sample size was increased to 87 participants.

Tools and Measurements

Data collection involved both physical and performance tests conducted under controlled conditions, including standardized protocols for agility, eye-hand coordination, dynamic balance, height, shoulder strength, and smashing accuracy. The testing order was consistently maintained across all participants to minimize performance variability.

Height was measured to examine its potential influence on smashing reach and accuracy, using a stadiometer to record each participant's standing height to the nearest centimeter according to standard anthropometric procedures. Shoulder strength was assessed using the Forward Overhead Medicine Ball Throw Test, which evaluates upper-body power relevant to smash performance. Participants stood with feet shoulder-width apart and held a weighted medicine ball at shoulder height, threw the ball overhead, with the distance measured to assess strength, emphasizing arm extension throughout the throw.

Agility was measured using the Illinois Agility Test (IAT)[12,13] to assess the participants' multidirectional speed and body control, which are essential for the rapid adjustments needed in badminton. The 10x5m course included four cones marking the start, finish, and turning points, along with four additional cones spaced along the centerline. Participants started lying on their stomachs with their hands by their shoulders; then, on command, they navigated the course as quickly as possible, and the completion time was recorded.

Eye-hand coordination was evaluated with the Plate Tapping Test, measuring the reaction time and co-ordination critical for tracking and intercepting the shuttlecock accurately. For this, participants alternated tapping two yellow discs, each 20 cm in diameter and 60 cm apart, as quickly as possible for 25 cycles, with the best time from the two attempts recorded.[14]

Dynamic balance was assessed using the Star Excursion Balance Test (SEBT), which evaluates dynamic postural control. The participants balanced on one leg while reaching eight directions with the opposite foot while maintaining a fixed stance point. Distances were recorded for each direction, normalized to leg length, and averaged into a composite score.[15]

Finally, smashing accuracy was measured on a badminton court with designated target zones to assess players' precision. Participants performed eight smashes (three straight and three diagonal) towards the target cones on the opposite side, with accuracy scored based on proximity to the target cones. The cumulative score reflects the overall smashing accuracy of each player.[16]

Data Collection Procedure

Before testing, the researchers met with the coaches and explained the purpose, protocol, and importance of each test. Following the introduction and consent, participants proceeded through a series of tests in the following order: height measurement, star excursion balance test, Illinois agility test, forward overhead medicine ball throw test, and plate-tapping test. This sequence was maintained to ensure consistent fatigue levels and accuracy across tests. Each test was administered twice, and the best score was recorded.

Statistical analyses were conducted using IBM SPSS Statistics version 20. Descriptive statistics provided an overview of the participant characteristics, including the means and standard deviations for each physical attribute. Pearson's correlation coefficient was used to assess the relationship between smashing accuracy (dependent variable) and each physical attribute (independent variables: height, agility, eye-hand coordination, dynamic balance, and shoulder strength). The correlation coefficient, or Pearson's ranges from -1 to +1, where positive values indicate a direct relationship between variables and negative values signify an inverse relationship.[17] The strength of the correlation was categorized as follows: values between 0.00 and 0.10 indicate a negligible correlation, 0.10 to 0.39 indicate a weak correlation, 0.40 to 0.69 indicate a moderate correlation, 0.70 to 0.89 indicate a strong correlation, and 0.90 to 1.00 indicate a very strong correlation. All analyses were conducted for significance testing, with the significance level set at $p < 0.05$. Variables showing significant correlations were subjected to further analysis to assess the nature and strength of their impact on smashing accuracy.

Informed consent was obtained from all participants, and the study followed ethical guidelines for research involving human subjects. This study was approved by the Institutional Ethics Committee of the Sarvajanik College of Physiotherapy, Surat.

RESULTS

This study presents findings on the relationship between physical attributes and motor skills (agility, eye hand coordination, dynamic balance, height, and shoulder strength) and smash accuracy among badminton players. Descriptive statistics summarized participant characteristics, while Pearson's correlation analysis examined the relationship between each independent variable and smashing accuracy. Relevant tables and figures illustrate these results.

DESCRIPTIVE ANALYSIS

A total of 87 participants (69 males and 18 females), aged 16–25 years, were assessed. Table 1 presents the means and standard deviations for age, height, agility, eye-hand coordination, shoulder strength, and dynamic balance scores for both right and left legs.

Table 1: Descriptive Statistics of Participant Characteristics (N=87)

Variable	Mean	SD
Age (Years)	19.13	2.86
Height (cm)	164.55	19.63
Agility (Seconds)	19.71	2.24
Eye-Hand Coordination (Seconds)	15.69	2.88
Shoulder Strength (cm)	485.08	144.55
Dynamic Balance - Right Leg (%)	95.21	11.72
Dynamic Balance - Left Leg (%)	95.70	12.70

The mean smashing accuracy score, measured on a scale of 1 to 6, was 4.00 with a standard deviation of 1.34, indicating a moderate level of accuracy among the participants.

Correlation Analysis

Pearson's correlation coefficients were calculated to determine the association between physical and motor skills and smashing accuracy, as detailed in Tables 1 through 8. The relationship between each variable and smashing accuracy, including the significance levels and effect sizes, is discussed below.

Height and Smashing Accuracy

Table 2: Correlation between Height and Smashing Accuracy

Variable	Pearson's Correlation (r)	p-value	Interpretation
Height (cm)	0.276**	0.010	Weak positive correlation, significant

Height was positively correlated with smashing accuracy ($r = 0.276$, $p < 0.01$), indicating a statistically significant, yet weak correlation. This suggests that while height may aid in achieving the optimal reach for smashing, it is not a primary determinant of accuracy.

Shoulder Strength and Smashing Accuracy

Table 3: Correlation Between Shoulder Strength and Smashing Accuracy

Variable	Pearson's Correlation (r)	p-value	Interpretation
Shoulder Strength	0.238*	0.027	Weak positive correlation, significant

Shoulder strength was weakly but positively correlated with smashing accuracy (r=0.238, $p < 0.05$). This finding suggests that greater shoulder strength contributes to improved smash accuracy, likely owing to increased power and control in overhead shots.

Agility and Smashing Accuracy

Table 4: Correlation Between Agility and Smashing Accuracy

Variable	Pearson's Correlation (r)	p-value	Interpretation
Agility	-0.254*	0.017	Weak negative correlation, significant

A moderate negative correlation was observed between agility (measured by completion time in the Illinois Agility Test) and smashing accuracy ($r = -0.254$, $p < 0.05$). This indicates that players with better agility (shorter test completion times) performed more accurate smashes because agility allows faster and more precise positioning.

Eye-Hand Coordination and Smashing Accuracy

Table 5: Correlation Between Eye-Hand Coordination and Smashing Accuracy

Variable	Pearson's Correlation (r)	p-value	Interpretation
Eye-Hand Co-ordination	-0.479**	0.000	Moderate negative correlation, significant

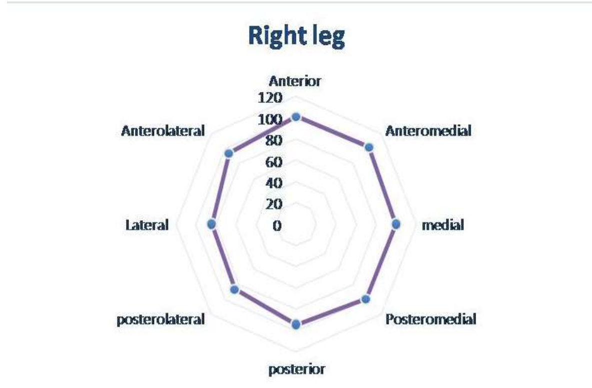
Eye-hand coordination showed a strong negative correlation with smashing accuracy ($r = -0.479$, $p < 0.01$), highlighting it as a significant predictor. Players with faster reaction times in the plate-tapping test demonstrated higher smash accuracy, suggesting that a quick visual-motor response is essential for accurate smash execution.

Dynamic Balance (Right Leg) and Smashing Accuracy

Table 6: Correlation Between Right Leg Dynamic Balance and Smashing Accuracy

Variable	Pearson's Correlation (r)	p-value	Interpretation
Right Leg Dynamic Balance	-0.035	0.744	No correlation, not significant

No significant correlation was found between dynamic balance of the right leg and smashing accuracy ($r = -0.035$, $p = 0.744$), indicating that balance on this leg did not affect the accuracy of smash performance.



Graph 1: The right leg's Star excursion balance test results for the right leg

Dynamic Balance (Left Leg) and Smashing Accuracy

Table 7: Correlation Between Left Leg Dynamic Balance and Smashing Accuracy

Variable	Pearson's Correlation (r)	p-value	Interpretation
Left Leg Dynamic Balance	-0.019	0.858	No correlation, not significant

Similarly, no significant relationship was observed between dynamic balance of the left leg and smashing accuracy ($r = -0.019$, $p = 0.858$). This suggests that while balance is essential for general movement, it may not directly affect the precision of smashing.

Graph 2: The left leg's Star excursion balance test results for the left leg

Table 8: Summary of Pearson's Correlation Coefficients

Variable	Pearson's r	Interpretation	Significance
Height	0.276	Weak positive correlation	$p < 0.01$
Shoulder Strength	0.238	Weak positive correlation	$p < 0.05$
Agility	-0.254	Weak negative correlation	$p < 0.05$
Eye-Hand Co-ordination	-0.479	Moderate negative correlation	$p < 0.01$
Dynamic Balance (Right)	-0.035	No correlation	$p = 0.744$
Dynamic Balance (Left)	-0.019	No correlation	$p = 0.858$

INTERPRETATION OF FINDINGS

4. **Height and Shoulder Strength**: These variables had weak positive correlations with smashing accuracy, implying that taller players with greater shoulder strength may achieve better smash accuracy, although these factors alone are insufficient for achieving high precision.
5. **Agility**: The significant negative correlation with agility suggests that faster movement in response to a stimulus contributes positively to smashing accuracy. Players capable of quickly changing direction and controlling body movement can optimize their position to achieve a well-executed smash.
6. **Eye-Hand Coordination**: This variable had the strongest correlation with smashing accuracy, underscoring the importance of rapid reactions and visual tracking skills in successfully executing smashes. Players with faster coordination are significantly more accurate.
7. **Dynamic Balance**: Both the right and left leg dynamic balance scores showed negligible correlations, indicating that balance might play a secondary role in smash accuracy. Balance may be more critical for general stability and injury prevention than for achieving accuracy in a fast, single movement such as a smash.

The results indicate that eye-hand coordination, agility, and shoulder strength are essential predictors of smashing accuracy in badminton. Eye-hand coordination emerged as the most critical factor, whereas dynamic balance showed no significant effect. These findings provide a basis for refining badminton training, suggesting that improving agility, coordination, and shoulder strength can enhance performance.

DISCUSSION

This study explored how essential physical and motor skills-height, and shoulder strength, agility, eye-hand coordination, dynamic balance-relate to smash accuracy in trained badminton players. Given the sport's demands for speed, precision, and control, understanding these factors is crucial for developing effective training. The results highlight agility, eye-hand coordination, and shoulder strength as strong predictors of smash accuracy, while height had less influence and dynamic balance played a minor role.

Height and Smashing Accuracy

The study found a weak positive correlation between height and smash accuracy, suggesting that height provides some advantages, but is not a primary factor in precision. Taller players may benefit from greater reach, allowing higher contact points for steeper smashes that are harder for opponents to return.[18] Studies in other racquet sports, such as tennis and volleyball, also indicate that height can boost biomechanical leverage for power and angle, enabling players to cover more court area with less movement.[19] However, these advantages appear to have limited impact on accuracy alone in badminton, which relies more on agility, rapid directional shifts, and fine motor control than on height.

In badminton training, although taller players may have certain strategic advantages, height alone should not be the focus when aiming to improve smash accuracy. Our findings align with those of Asif *et al.*[16], who also found no strong link between height and smash accuracy in male players, highlighting that attributes such as eye-hand coordination and agility play a more crucial role in achieving precision.

Shoulder Strength and Smashing Accuracy

This study found a weak positive correlation between shoulder strength and smash accuracy, suggesting that, while shoulder strength does contribute, it is not a dominant factor. Strong shoulders help players to generate power and maintain control during high-speed smashes, making them essential for stability and precision. Sakurai and Ohtsuki[20] similarly highlighted that shoulder muscle activity is vital for accurate smash execution, supporting the role of shoulder strength in both power and control.

Shoulder strength alone does not guarantee top accuracy because effective smashing relies on a coordinated kinetic chain involving both the upper and lower body.[21-23] The modest correlation in this study likely reflects that smashing accuracy depends on combining shoulder strength with precise timing and positioning skills rooted more in agility and eye-hand coordination than in strength alone. Therefore, training should blend shoulder strength exercises with agility and coordination drills to optimize smash accuracy.

Agility and Smashing Accuracy

This study found agility to be a strong predictor of smash accuracy, with faster agility test times being linked to higher accuracy scores. Agility, defined as a quick adjustment of direction and speed, helps badminton players swiftly position themselves to intercept the shuttlecock for an optimal smash. Players with greater agility can achieve ideal positioning more efficiently, thereby enabling more powerful and precise smashes.

Previous research has highlighted agility as crucial in competitive badminton. Young *et al.*[24] noted that agility combines physical speed and direction-changing ability with cognitive quick decision-making. In badminton, this agility allows players to adapt quickly to the movement of the shuttlecock, positioning themselves for an accurate smash. Our findings align with those of Zhang *et al.*[25], who found that optimal body positioning improves attack angles and smash effectiveness, emphasizing the role of agility in enhancing smash accuracy.

This study supports agility training as an essential component of badminton preparation. Drills that simulate quick shuttlecock changes can build the physical responsiveness and cognitive speed required for smash accuracy. Training that includes forward, lateral, and reaction based movements can help players adapt swiftly to game dynamics, enabling more precise smashes.

Eye-Hand Coordination and Smashing Accuracy

Eye-hand coordination is crucial for accurate badminton smashes. Players who could quickly track the shuttlecock's path and adjust their hand positions accordingly landed the most precise shots. This was supported by their faster times in the Plate Tapping Test, showing how quick visual motor skills translate directly to better smash performance.

Research has shown that elite badminton players develop exceptional visual-motor skills through constant practice tracking and hitting fast-moving shuttlecocks. This matches what we see in other quick-reaction sports, such as table tennis, where players must instantly read and respond to the ball's movement.[26-28] Their brains get really good at connecting what they see with how they move-it is like their eyes and hands learn to work as one, as demonstrated in Dube's research.[29]

During training, players can boost eye-hand co-ordination through drills, such as quick-tap exercises, tracking drills, and fast-moving target practice.[27] For smashing skills, coaches often have players track shuttlecocks from different angles while making precise movements. Drawing from the "quiet eye" method, where players focus intently on their target before striking, can help improve smash accuracy by reducing the reaction time and boosting precision.[30]

Dynamic Balance and Smashing Accuracy

In this study, dynamic balance did not show a significant correlation with smashing accuracy, suggesting that while balance is crucial for overall game play and injury prevention, it does not directly affect the precision of a smash. This is surprising, given that badminton requires players to maintain stability during rapid and asymmetric movements. However, it seems that other factors, such as agility and co-ordination, may compensate for the balance in the context of smash execution.

Research using the Star Excursion Balance Test shows that while balance helps with overall stability, it does not directly impact smash accuracy; players seem to rely more on anticipation and visual tracking for executing powerful smashes. Towel *et al.*[31] found that although balance training helps prevent injuries, it doesn't necessarily improve specific skills like smashing. However, including balance work in training makes sense - it helps players stay stable and injury free during complex gameplay, even if it does not directly boost their smash precision.

Practical Implications for Training

This study found that smash accuracy was most strongly predicted by agility and eye-hand coordination. Positioning can be enhanced through directional change drills and shuttle response exercises, while reaction time and control can be improved by tapping and tracking drills.

Training the shoulder muscles is helpful, but it works best when combined with agility and coordination drills rather than simply lifting weights alone. Think of it this way-while strong shoulders give you the power to smash, you need strength to work smoothly with your other movements to nail those precise shots. Even though balance training does not directly make your smashes more accurate, it is still crucial for keeping you stable and injury free in court.

CONCLUSION

In conclusion, agility, eye hand coordination, and shoulder strength significantly impact smash accuracy in badminton, whereas height and dynamic balance are less influential. This study emphasizes the need for targeted agility and visual-motor coordination training to improve smash performance, offering a basis for specialized training to sharpen players' competitive edge.

Conflict of Interest: None

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