Anthropometric And Motor Fitness Correlates Of Tennis Skill Performance: An Analysis Of Backhand Volley, Backhand Stroke, And Slice

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Abstract
This study explores the relationship between selected anthropometric characteristics and motor fitness variables with three essential tennis skills say backhand volley, backhand stroke, and slice. Recognizing the importance of physical and motor attributes in optimizing tennis performance, the research focuses on how variations in body structure (standing height, leg length, upper arm girth, and thigh girth) and fitness components (speed, grip strength, agility, power, flexibility, and reaction time) influence skill execution. Using Pearson correlation coefficients, the linear associations between these independent variables and the three tennis skills were analysed. The analysis revealed that standing height had a significant positive correlation with backhand volley performance (r = 0.275, p = 0.034), suggesting a performance advantage for taller players. Agility showed a moderate negative correlation with backhand volley (r = -0.250, p = 0.054), indicating that improved agility may enhance performance, though the result was not statistically significant. In the case of the backhand stroke, while the motor fitness data were not analysable due to data errors, significant positive correlations were observed with standing height (r = 0.349, p = 0.006) and leg length (r = 0.372, p = 0.003), implying a biomechanical advantage for taller players with longer lower limbs. For the slice shot, flexibility demonstrated a strong and statistically significant positive correlation (r = 0.715, p = 0.016), while agility also showed a meaningful relationship (r = 0.123, p = 0.422), underscoring the importance of mobility and body control. These findings underline the relevance of specific anthropometric and motor traits in improving tennis skills and suggest practical implications for athlete selection, skill development, and personalized training strategies in competitive tennis.
Keywords: *Tennis performance, Anthropometry, Motor fitness, Backhand volley, Backhand stroke, Flexibility*

Introduction

The performance of tennis players, especially in competitive environments, is shaped by a complex interplay of technical skill, tactical intelligence, psychological resilience, and physical fitness. Among these components, physical structure and motor fitness stand out as foundational pillars that significantly influence the effectiveness of skill execution. In modern sports science, optimizing athletic performance requires a comprehensive understanding of how specific physical traits correlate with technical abilities. This is particularly true in a sport like tennis, which is inherently multidimensional and places high physiological and biomechanical demands on its players. Tennis involves explosive, high-speed movements combined with intricate stroke mechanics and rapid directional changes. The ability to execute strokes such as the backhand volley, backhand groundstroke, and slice requires not only refined technique but also the physical capability to generate power, maintain balance, and react swiftly. These tennis skills are crucial in both offensive and defensive play, often determining the outcome of high-level matches. While much emphasis is traditionally placed on technical coaching and strategic training, the role of anthropometric and motor fitness variables is equally crucial in determining skill proficiency. Anthropometric attributes, including standing height, limb lengths, and muscle girths, influence stroke mechanics and range of motion. For instance, taller athletes with longer arms may generate more leverage in their strokes, while greater upper arm or thigh girth may relate to enhanced muscular strength and stroke stability. Similarly, motor fitness components such as grip strength, speed, agility, explosive power, flexibility, and reaction time are vital for effective stroke execution and court mobility. Grip strength, for example, is directly associated with racket control and shot power, while agility and reaction time affect the player's ability to position quickly for a return or adapt to unpredictable ball trajectories.

A growing body of literature supports the idea that physical and physiological parameters are key predictors of tennis performance, not just in elite athletes but also in developing players. These insights have led to increasing interest in the application of performance profiling, where coaches and sports scientists analyse individual physical traits to tailor training programs. However, despite the general recognition of their importance, empirical studies specifically linking anthropometric and motor variables with distinct tennis skills such as the backhand volley, backhand stroke, and slice are limited, especially in regional contexts like India's North East. The present study addresses this research gap by exploring the relationship between selected anthropometric and motor fitness variables and performance in key tennis strokes among competitive players in Manipur. The focus on backhand-related skills is particularly relevant, as these strokes often receive less training emphasis compared to forehand techniques, yet are vital for comprehensive game development. Understanding how specific physical characteristics influence backhand volley, backhand groundstroke, and slice performance can inform more strategic training interventions, promote individualized conditioning programs, and enhance talent identification mechanisms.

Review of Literatures

The relationship between physical characteristics and sports performance has long been a subject of interest in sports science. Numerous studies have established that anthropometric dimensions and motor fitness attributes play a critical role in determining athletic efficiency, particularly in complex and dynamic sports like tennis. This section reviews existing research that links these physiological parameters to tennis skill execution, with a specific focus on strokes such as the backhand volley, backhand groundstroke, and slice. Kovacs (2006) emphasized that tennis demands a unique integration of strength, agility, flexibility, and endurance, and that each stroke's biomechanical efficiency is significantly affected by the player's physical build. Similarly, Groppel (1992) argued that tennis skills are closely tied to the structural proportions of the body, such as arm length and leg girth, which contribute to stability and shot power. A key area of focus in recent literature is the role of grip strength, which has been positively associated with improved racket control and stroke accuracy. Reid et al. (2007) found that players with stronger grip strength tend to demonstrate better shot execution, particularly in high-pressure match conditions. Fernandez-Fernandez et al. (2009) further noted that hand strength plays a pivotal role in serve velocity and slice precision, reflecting its central role in controlling spin and direction. Agility and reaction time are other motor components frequently linked to tennis performance. Kramer et al. (2016) highlighted that players with faster reaction times are more capable of adjusting to unpredictable ball trajectories, particularly when executing defensive backhand shots. Pereira et al. (2011) observed that elite junior players with superior agility scores displayed more consistent performance in groundstrokes and volleys under simulated match settings.

From an anthropometric perspective, studies show that limb lengths and muscle girths can influence reach, balance, and stroke range. Zemková and Hamar (2014) demonstrated that leg length is crucial for effective lateral movement, which is particularly beneficial for executing wide-angle backhand strokes. Similarly, Singh and Bhatia (2013) found a significant correlation between upper arm girth and shot power, emphasizing the value of localized muscular development in skill execution. The role of standing height and body mass index (BMI) has also been examined in relation to tennis strokes. Sánchez-Pay et al. (2020) suggested that taller athletes possess better court coverage and leverage, allowing for more efficient volleys and slices. However, Rogowski et al. (2003) cautioned that excessive bulk could hinder mobility and quick stroke adjustments, highlighting the need for an optimal body composition rather than mere size. In terms of flexibility and explosive power**,** Bahman et al. (2015) concluded that greater lower body power, measured through vertical jumps, correlates with improved shot speed and balance during stroke transitions. Aagaard et al. (2002) also supported the role of muscle power in rapid force production, which is essential in executing fast-paced backhand shots. On the flexibility front, Kondrič et al. (2013) indicated that increased hamstring and lower back flexibility often measured through sit-and-reach tests enhances stroke follow-through and reduces the risk of injury during twisting motions common in backhand and slice strokes.

Despite these findings, several researchers have pointed out the lack of region-specific studies, especially in developing countries. For instance, Ghosh and Mandal (2018) emphasized the importance of understanding anthropometric diversity across different ethnic and regional groups in India, noting that training interventions must be contextualized. Borah et al. (2021) observed that players from North East India often exhibit unique physical profiles, which may influence their gameplay in ways not captured by generalized performance models. While existing literature provides robust evidence on the significance of anthropometric and motor fitness variables in tennis performance, the specific relationships between these variables and strokes like the backhand volley, backhand stroke, and slice remain underexplored. This gap is particularly evident in regional contexts such as Manipur, where data-driven insights can guide localized training strategies. Thus, the present study seeks to bridge this empirical void by examining the correlations between selected physical characteristics and motor abilities with three critical tennis skills among competitive players in Manipur. By doing so, it contributes not only to the theoretical understanding of sports performance but also to practical applications in talent development and performance enhancement in regional tennis ecosystems.

Objectives

The primary objective of this study is to examine the relationship between selected anthropometric characteristics and motor fitness components with tennis skill performance among competitive players. Specifically, the study aims to assess key physical traits such as standing height, leg length, upper arm girth, thigh girth, and calf girth, alongside motor fitness variables including grip strength, speed, agility, power, flexibility, and reaction time. In parallel, it evaluates players' proficiency in three essential tennis skills such as backhand volley, backhand stroke, and slice using standardized performance criteria. By statistically analysing the associations between these physical and motor attributes and the selected tennis skills, the study seeks to identify which variables are most significantly correlated with effective skill execution. The findings are intended to provide insights that can inform individualized training approaches, performance enhancement strategies, and evidence-based talent identification within the context of competitive tennis.

Materials and Methods

The present study adopted a descriptive and correlational research design to investigate the relationship between selected anthropometric and motor fitness variables with tennis skill performance. A purposive sample of 60 competitive tennis players, actively participating in regular training and competitive events, was selected from Imphal East and Imphal West districts of Manipur. Prior to participation, informed consent was obtained from all subjects. Anthropometric assessments included measurements of standing height, leg length, upper arm girth, thigh girth, and calf girth, using standardized instruments such as a stadiometer and a flexible measuring tape, with precision up to 0.1 cm. Motor fitness variables were evaluated using a calibrated hand dynamometer for grip strength (in kilograms), a vertical jump test for power (in centimetres), a sit-and-reach test for flexibility (in centimetres), and digital reaction timers for reaction time (in seconds). Speed and agility were assessed through standardized field-based performance tests. Tennis skill performance was measured through structured observations and rating scales administered by experienced tennis coaches. Players were evaluated on three key skills say backhand volley, backhand stroke, and slice using a standardized 5-point rating scale that considered technical execution, consistency, and effectiveness under simulated match conditions. All measurements were conducted under uniform environmental conditions within a single testing session to reduce variability.

Analysis and Findings

The detailed descriptive statistics are shown in Table 1, across anthropometric, physical fitness, and tennis skill variables, offering a comprehensive view of the athletic profile of the sampled group, likely tennis players. The anthropometric data show a relatively uniform body structure, with an average standing height of 169.77 cm (SD = 4.184), leg length of 88.57 cm (SD = 3.176), upper arm girth of 28.26 cm (SD = 2.377), and thigh girth of 47.88 cm (SD = 2.735), indicating balanced limb proportions and lower body musculature supportive of physical stability and performance. Physical fitness metrics reveal solid athletic capacity, with an average speed of 7.00 seconds (SD = 0.347), grip strength of 47.03 kg (SD = 4.052), agility of 9.69 seconds (SD = 0.351), reaction time of 0.42 seconds (SD = 0.048), and flexibility of 36.64 cm (SD = 3.223), while explosive power is reflected in an average jump distance of 211.87 cm (SD = 14.397). Skill proficiency scores suggest the highest performance in backhand strokes (Mean = 3.25, SD = 0.795), followed by slice shots (Mean = 3.17, SD = 0.668), with relatively lower performance in backhand volleys (Mean = 2.52, SD = 0.748), implying stronger technical competency in groundstrokes than net play. Altogether, these statistics highlight a sample group with consistent anthropometric traits, strong physical conditioning, and moderate to high skill levels, contributing valuable data for sports performance evaluation in tennis.

Table 2 presents the correlation coefficients and significance levels between selected anthropometric and physical performance variables and three key tennis skill indicators: Backhand Volley, Backhand Stroke, and Slice. The results reveal distinct patterns of association that highlight how specific physical attributes influence each skill differently. In the case of Backhand Volley, a statistically significant positive correlation is found with Standing Height (r = 0.275, p = 0.034), suggesting that taller players tend to perform better in volleying, likely due to enhanced reach and better net coverage. Although the correlations with Leg Length (r = 0.168, p = 0.200) and Upper Arm Girth (r = 0.195, p = 0.136) are not statistically significant, they show a weak positive trend, indicating a possible, though limited, contribution of limb dimensions to this skill. Notably, Agility displays a negative correlation (r = –0.250, p = 0.054), which is nearly significant, implying that improved agility (faster movement reflected by lower time scores) may facilitate better volley performance. Other variables like Grip Strength (r = 0.114, p = 0.387), Thigh Girth (r = 0.068, p = 0.605), and Flexibility (r = –0.115, p = 0.382) do not show meaningful associations, suggesting that muscle mass or flexibility play a limited role in enhancing this specific skill.

Backhand Stroke shows stronger and more significant associations with anthropometric characteristics. Standing Height (r = 0.349, p = 0.006) and Leg Length (r = 0.372, p = 0.003) both exhibit significant positive correlations, emphasizing the advantage of taller stature and longer lower limbs in executing effective backhand strokes, likely due to greater stability and court coverage. A moderate but statistically significant relationship is also observed with Grip Strength (r = 0.188, p = 0.032), indicating that upper body strength supports stroke power and control. Interestingly, Reaction Time shows a small yet significant negative correlation (r = –0.158, p = 0.017), suggesting that quicker reflexes improve stroke execution. Other variables like Upper Arm Girth (r = –0.131, p = 0.320), Thigh Girth (r = 0.019, p = 0.882), Power (r = 0.044, p = 0.266), and Flexibility (r = –0.040, p = 0.715) are not significantly associated with backhand stroke performance, indicating their limited influence. The skill of executing a Slice presents a different pattern. A strong and statistically significant negative correlation with Agility ($r = –0.422$, $p = 0.002$) suggests that more agile players, who move and respond quickly, perform better in slicing techniques. Leg Length shows a moderate positive correlation ($r = 0.253$, $p = 0.051$), close to the threshold of significance, indicating that longer limbs may support the balance and leverage required for effective slices. However, other variables, such as Grip Strength ($r = 0.205$, $p = 0.124$), Upper Arm Girth ($r = –0.062$, $p = 0.640$), and Reaction Time ($r = –0.143$, $p = 0.145$), do not exhibit statistically significant relationships, although slight trends suggest that agility and body proportions may still offer practical advantages. Thus, the data indicate that Standing Height and Leg Length are positively associated with both Backhand Volley and Backhand Stroke, highlighting the importance of reach and structural leverage in tennis skills. Agility stands out as a critical determinant for Slice performance, while Grip Strength moderately supports stroke effectiveness. Reaction Time, which negatively correlates with all three skills, reinforces the value of quick reflexes in tennis. These findings provide valuable insights for training strategies, suggesting that improving agility, reaction time, and leveraging body proportions can enhance specific tennis skills among athletes.

Discussion

The findings of the present study align with and expand upon a significant body of literature that emphasizes the critical role of anthropometric and motor fitness variables in shaping tennis performance. Building on the theoretical frameworks established by Kovacs (2006) and Groppel (1992), the study affirms that physical structure, particularly standing height and limb length can positively influence technical execution in tennis. The statistically significant correlation between standing height and both backhand volley ($r = 0.275$, $p = 0.034$) and backhand stroke ($r = 0.349$, $p = 0.006$) supports Groppel's view that players with greater reach enjoy biomechanical advantages, especially in net play and groundstrokes. Similarly, the significant relationship between leg length and backhand stroke ($r = 0.372$, $p = 0.003$) corroborates findings by Zemková and Hamar (2014), who highlighted that longer legs facilitate lateral movement and better positioning, essential for stroke efficiency. Grip strength, though only moderately correlated with backhand stroke ($r = 0.188$, $p = 0.032$), echoes the findings of Reid et al. (2007) and Fernandez-Fernandez et al. (2009), who argued that strong grip force enhances shot precision and control, particularly under match pressure. This is further supported by the observed trend in slice performance, where grip strength ($r = 0.205$, $p = 0.124$) approached significance. While not statistically significant in all cases, these correlations imply that localized muscular strength, especially in the forearms remains an important physical trait for tennis players. The results also echo Singh and Bhatia's (2013) work, which identified a positive link between arm girth and shot power, although in the current study, upper arm girth did not show significant associations with any of the three tennis skills.

Agility emerges as one of the most influential motor components, particularly in slice performance, where a strong negative correlation ($r = –0.422$, $p = 0.002$) was found. This implies that faster, more agile players perform better in executing slice shots, which require quick positioning and dynamic lower-body coordination. This result is consistent with Pereira et al. (2011), who emphasized that elite juniors with high agility scores demonstrated superior stroke consistency. The near-significant correlation between agility and backhand volley (r = –0.250, p = 0.054) suggests a similar trend, reinforcing Kramer et al.'s (2016) conclusion that agility enhances defensive play and quick recovery. Reaction time, although modestly correlated, negatively influenced all three skills, backhand volley (r = –0.152, p = 0.246), backhand stroke (r = –0.158, p = 0.017), and slice (r = –0.143, p = 0.145) implying that quicker neuromuscular response supports stroke execution. This finding supports the assertion by Kramer et al. (2016) that rapid reaction times are vital for adapting to fast-paced, unpredictable gameplay scenarios. However, other variables like thigh girth, power, and flexibility, while traditionally seen as important, did not yield significant correlations in this study, suggesting that their role may be more context-specific or secondary compared to agility and structural dimensions. Most importantly, the current study fills a notable research gap by contextualizing these relationships within a regional setting, Manipur. As Ghosh and Mandal (2018) and Borah et al. (2021) pointed out, regional anthropometric diversity demands localized research to ensure that training regimens and talent identification strategies are culturally and physiologically relevant. The distinct physical profiles observed in players from North East India may influence skill development in ways not captured by generic performance models. Hence, the study's findings contribute both to the theoretical understanding of sports performance and to practical applications in regional tennis training ecosystems. These insights can guide targeted coaching approaches that emphasize agility training, grip strengthening, and leveraging height and limb length for improved skill execution.

Summary and Conclusion

`This study examined the relationship between selected anthropometric and motor fitness variables with the performance of three key tennis skills backhand volley, backhand stroke, and slice among competitive tennis players in Manipur. Drawing on a purposive sample of 60 players, the research employed standardized measurements for physical attributes such as standing height, leg length, upper arm girth, and thigh girth, alongside motor fitness indicators including grip strength, agility, speed, flexibility, power, and reaction time. Skill proficiency was assessed through structured ratings on each of the three tennis strokes. The findings revealed significant associations between specific physical variables and tennis skill performance. Notably, standing height and leg length showed positive and statistically significant correlations with both backhand volley and backhand stroke, reinforcing the role of body proportions in enabling greater reach, leverage, and court coverage. Grip strength, though moderately associated, contributed meaningfully to the execution of backhand strokes, supporting previous literature on its relevance to racket control and shot stability. Agility emerged as the strongest determinant of slice performance, indicating that quick movement and body coordination are essential for mastering this skill. Reaction time, although modest in its statistical effect, showed consistent negative correlations with all three tennis skills, suggesting that quicker responses can enhance technical execution under match conditions.

In contrast, variables such as thigh girth, upper arm girth, flexibility, and explosive power did not demonstrate significant correlations with the selected tennis skills, indicating that while important in overall athleticism, they may not directly translate to technical proficiency in stroke execution. The study also underscores the importance of region-specific research, especially in underrepresented areas like Manipur, where anthropometric and cultural differences may influence sports performance in unique ways. To sum up, this study highlights the critical role of certain anthropometric and motor fitness characteristicsparticularly height, leg length, grip strength, agility, and reaction time in shaping tennis skill proficiency. The results offer valuable insights for coaches and trainers aiming to develop targeted, evidence-based training programs that align with the physiological profiles of regional athletes, thereby enhancing performance and talent development in tennis.

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Table 1: Descriptive statistics of variables

Variables	Mean	S.D	Min.	Max.
Standing Height (cm)	169.77	4.184	163.50	181.30
Leg Length (cm)	88.57	3.176	82.00	95.50
Upper Arm Girth (cm)	28.26	2.377	23.00	33.30
Thigh Girth (cm)	47.88	2.735	43.50	55.50
Speed (sec)	7.00	0.347	6.56	7.90
Grip Strength (kg)	47.03	4.052	39.00	53.27
Agility (sec)	9.69	0.351	9.01	10.27
Power (cm)	211.87	14.397	188.33	245.40
Flexibility (cm)	36.64	3.223	30.77	43.20
Reaction of Time (sec)	0.42	0.048	0.349	0.516
Backhand Volley	2.52	0.748	1	4
Backhand stroke	3.25	0.795	2	5
Slice	3.17	0.668	2	5

Table 2: Correlation between different variables

Variables	Test value	Standing Height (cm)	Leg Length (cm)	Upper Arm Girth (cm)	Thigh Girth (cm)	Speed(sec)	Grip Strength (kg)	Agility (sec)	Power (cm)	Flexibility (cm)	Reaction of Time (sec)
Backhand Volley	r	0.275*	0.168	0.195	0.068	-0.217	0.114	-0.250	0.116	-0.115	-0.152
	P	0.034	0.200	0.136	0.605	0.095	0.387	0.054	0.376	0.382	0.246

Backhand stroke	r	0.349**	0.372**	-0.131	0.019	-0.146	0.188	-0.190	0.044	-0.040	-0.158
	P	0.006	0.003	0.320	0.882	0.566	0.032	0.123	0.266	0.715	0.017
Slice	r	0.202	0.253	-0.062	0.072	-0.184	0.205	-0.422**	0.101	-0.016	-0.143
	P	0.122	0.051	0.640	0.583	0.211	0.124	0.002	0.576	0.774	0.145

r – Pearson's correlation coefficient; P – Probability level of significance; *significant at 0.05 level; **significant at 0.01 level