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ASSOCIATION OF ANTHROPOMETRIC CHARACTERISTICS AND BIOMECHANICAL PARAMETERS WITH SPIKING ABILITY AMONG UNIVERSITY-LEVEL MALE VOLLEYBALL PLAYERS

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Abstract:

Background: Volleyball spiking is a complex offensive skill influenced by the interaction between anthropometric characteristics and biomechanical performance. Although evidence of their combined relationship with spiking ability, as assessed using field-based tools, remains limited.

Objective: This study examined the relationships among selected anthropometric characteristics, biomechanical parameters, and spiking ability in university-level male volleyball players.

Methods: A cross-sectional correlational study of Nineteen (N = 19) male volleyball players (18-25 years) participated in this study. Body weight, leg length, and height at 90° were recorded, and jump height, flight time, velocity, force, and power were assessed using the My Jump application. Spiking ability was evaluated based on ball speed using the Kinovea software. Pearson's product-moment correlation was used to determine the relationships among the variables.

Results: Height at 90° was positively correlated with ball speed ($r = 0.502$, $p = 0.028$), whereas the other anthropometric and biomechanical variables were not significantly associated with spiking performance ($p > 0.05$).

Conclusion: The findings highlight the importance of an effective preparatory body position during spike execution and support the application of My Jump and Kinovea as practical field-based tools for the objective assessment of volleyball spiking performance.

Key Words: Volleyball; Anthropometry; Biomechanics; Spiking Performance; My Jump; Kinovea; Ball Speed; Vertical Jump

Introduction:

Volleyball is a high-intensity team sport characterised by repeated explosive movements. Its includes jumping, spiking, blocking, and rapid changes in direction, which require a combination of physical, technical, and biomechanical abilities (Keoliya et al., 2024). Among these skills, the spike is the primary offensive technique. It directly contributes to point scoring and often determines the match outcome. Successful spike execution involves a coordinated sequence of movements including a three-step approach, take-off, arm swing, ball contact, and landing, where the players convert body rotation momentum into spike forces in coordination with upper limb propulsion(Oliveira et al., 2020; Tai et al., 2021). Effective force production enables players to jump higher while spiking (Campos et al., 2013). Spiking performance is influenced by the coordinated interaction of anthropometric characteristics, lower limb biomechanical efficiency, and technical skill (Hnaihen & Rahman, 2023). Athletes with ideal body dimensions and higher explosive capabilities are generally able to produce higher jumps and faster ball speeds. Identifying these anthropometric and biomechanical factors associated with spiking performance has become an important focus in present sports biomechanics.

The Anthropometric variables like body weight, limb length, and lower limb dimensions influence movement mechanics, force production, and jumping performance. Height at 90° represents the preparatory lower limb position before take-off. This reflects an athlete's ability to generate effective extension of the hip, knee, and ankle joints during the jump-off phase. Biomechanical parameters, including jump height, flight time, velocity, force, and power, provide objective measures of explosive lower limb performance. All these variables offer valuable information for understanding the mechanical factors that contribute to successful volleyball spiking.

The technological application of portable performance assessment has enabled efficient biomechanical evaluation in the field of play as an alternative to lab environments (Hood et al., 2012; L & P, 2025). In volleyball, objective assessment of lower-limb performance is needed for quantifying the mechanical characteristics in relation to explosive movements like vertical jumping and spiking (Zecirovic et al., 2021). Among the various field-based tools, the My Jump application gives coaches mechanical insight for monitoring large-scale athletes' performance without compromising data. It allows the estimation of jump height and the calculation of biomechanical variables like flight time, take-off velocity, force, and power from high-speed smart phone video recordings (Carlos-Vivas et al., 2016; Driller et al., 2017; Akl & Doma, 2016; Peng et al., 2024). My Jump has enabled researchers and coaches to measure biomechanical data in a low-cost, portable and efficient manner. Previous studies successfully validate the reliability ofthe My Jump application for evaluating lower limb biomechanical performance in sports settings(Dias et al., 2024, 2025; Peng et al., 2024; Gençoğlu et al., 2023).

Despite the growing research on volleyball biomechanics, the important aspects for effective spiking performance remain unclear. Researchers have primarily explored anthropometric characteristics, lower limb power, jumping ability, and movement mechanics as separate determinants of performance, and most studies have involved elite athletes or laboratory-based biomechanical assessments (Marques & Izquierdo, 2014; Vanezis & Lees, 2005). Very few studies have given attention to examining the combined contribution of anthropometric characteristics and biomechanical parameters to volleyball spiking performance. TheMy Jump app has been widely accepted as a reliable tool for measuring vertical jump performance. Also, very few studies examine the relationships between sport-specific performance outcomes. Despite the accessibility of field-based technology, biomechanical evaluation studies are scarce in Indian university-level volleyball players. So, further research is needed to clarify how anthropometric characteristics and lower limb biomechanical parameters are collectively related to ball speed during volleyball spiking.

So, this study aimed to examine the relationship between selected anthropometric measurements, biomechanical parameters, and spiking ability among university-level male volleyball players. In this study, the researchers investigated the association of body weight, leg length, and height at 90° with jump height, flight time, velocity, force, and power measured using the My Jump application. Spiking ability was assessed through ball speed using the Kinovea software. The findings may provide evidence-based information for athlete evaluation, talent identification, and the development of individualised training programs to enhance performance in volleyball.

Materials and Methods:

Study Design:

The authors used a cross-sectional correlational research design to examine the relationships among selected anthropometric characteristics, biomechanical parameters, and spiking ability in university-level male volleyball players. Anthropometric measurements and biomechanical variables were obtained under standardised testing conditions. Their relationship with spiking performance was subsequently analysed. This study followed the ethical guidelines outlined in the Declaration of Helsinki, and informed consent was obtained from all participants before data collection.

Participants:

Nineteen (N=19) male volleyball players from the Department of Physical Education and Sport Science, Visva-Bharati University, India, voluntarily participated in this study. Participants were selected using purposive sampling based on the following inclusion criteria: (i) aged between 18 and 25 years; (ii) actively representing the university-level volleyball competitions; (iii) free from musculoskeletal injury during the past 1 year; and (iv) capable of performing maximal-effort jumping and spiking without discomfort. Athletes with a previous injury inthe lower limb, neurological disorders, or any condition that could affect jumping performance were excluded from the study.

Anthropometric Measurements:

Anthropometric measurements included body weight, leg length, and height at 90° were taken using appropriate instruments. Body weight was measured to the nearest 0.1 kg using a calibrated digital weighing scale. Leg length was measured using a standard anthropometric measuring tape from the anterior superior iliac spine to the medial malleolus, with the participant lying in an anatomical position. Height at 90° was measured with the participant assuming approximately 90° knee flexion before take-off, representing the preparatory lower limb position used during the vertical jump. All measurements were recorded by the same investigator following standardised measurement procedures to minimise measurement error.

Assessment of Biomechanical Parameters:

Biomechanical performance was assessed using the My Jump smart phone application for evaluating vertical jump performance from high-speed video recordings (Dias et al., 2024, 2025). Before testing, each participant completed a standardised warm-up. This included light jogging, dynamic stretching, and sub maximal jumping exercises. The participants then performed maximal countermovement jumps with unrestricted arm swings. These movements were recorded using a smart phone camera placed perpendicular to the sagittal plane. The camera was mounted on a tripod at an appropriate distance to ensure complete visualisation of the jumping movement throughout take-off and landing phases. The recorded videos were imported into the My Jump application. After that, the take-off and landing frames were manually identified. Based on flight time analysis and participant body mass, the application calculated jump height, flight time, take-off velocity, force, and power (Balsalobre-Fernández & Varela-Olalla, 2024).

Assessment of Spiking Ability:

Spiking ability was evaluated by measuring the ball speed during a standardised volleyball spike. The participants performed maximal spikes under identical testing conditions following a consistent approach and ball toss. Spike performance was recorded using a smart phone camera positioned perpendicular to the ball flight direction. Video recordings were analysed using Kinovea motion analysis software to determine ball speed (Adityatama et al., 2022; Rahman Marpaung et al., 2025). The participants completed three successful trials, and adequate recovery was given between attempts to minimise fatigue. The highest ball speed was used for statistical analysis.

Experimental Procedure:

Data collection was completed in a single testing session with similar environmental conditions. Anthropometric measurements were collected before the performance tests. After the standardised warm-up, the participants completed the vertical jump assessment using My Jump, followed by the volleyball spiking assessment. Sufficient recovery time was provided between trials to avoid fatigue. All measurements were recorded by the same investigator. Standard equipment and testing protocols were used to ensure consistency and reliability of the data.

Statistical Analysis:

The data were analysed using the Jamovi statistical software. Descriptive statistics are presented as means and standard deviations. The normality of the data distribution was assessed using the Shapiro-Wilk test. The relationships between anthropometric variables, biomechanical parameters, and spiking ability were examined using Pearson's product-moment correlation coefficient.

Results:

Table 1: Descriptive table of selected anthropometric and biomechanical variables of volleyball players

	N	Mean	Std. Deviation
Weight	19	64.37	8.565
Leg length	19	113	6.716
Height at 90-degree	19	71.68	5.012
Jump Height (Cm)	19	59.66	7.565
Flight time(M/s)	19	704.79	57.668
Velocity (M/s)	19	1.71	0.119
Force (N)	19	1470.23	244.308
Power (W)	19	2483.82	480.257
Speed (M/Sec)	19	22.78	5.862

Table 1 presents the descriptive statistics of the selected anthropometric and biomechanical variables of the participants. The participants had a mean body weight of 64.37 ± 8.57 kg, mean leg length of 113.00 ± 6.72 cm, and mean height at 90° of 71.68 ± 5.01 cm. The mean jump height was 59.66 ± 7.57 cm with a corresponding flight time of 704.79 ± 57.67 m/s. The mean take-off velocity, force, and power were 1.71 ± 0.12 m/s, 1470.23 ± 244.31 N, and 2483.82 ± 480.26 W, respectively. The mean of the ball speed was 22.78 ± 5.86 m/s. Overall, the descriptive statistics indicated variability in both anthropometric characteristics and biomechanical performance among the participants.

Table 2: Correlation between Anthropometric variables and Biomechanical parameters

		Weight (Kg)	**Leg length (CM)**	**Height At 90 degrees (cm)**	**Jump Height (CM)**	**Flight time (ms)**	**Velocity (m/s)**	**Force (n)**	**Power (w)**	**Speed (m/sec)**
Weight	Pearson Correlation	1								
(kg)	Sig. (2-tailed)									
Leg length	Pearson Correlation	0.193	1							
(cm)	Sig. (2-tailed)	0.428								
Height at 90 degrees	Pearson Correlation	0.395	.738**	1						
(cm)	Sig. (2-tailed)	0.094	0							
Jump height	Pearson Correlation	0.217	0.331	0.386	1					
(cm)	Sig. (2-tailed)	0.372	0.166	0.102						
Flight time	Pearson Correlation	0.265	0.259	0.338	.972**	1				
(m/s)	Sig. (2-tailed)	0.272	0.285	0.157	0					
Velocity	Pearson Correlation	0.227	0.321	0.389	.995**	.987**	1			
(m/s)	Sig. (2-tailed)	0.349	0.181	0.1	0	0				
Force	Pearson Correlation	.820**	0.033	0.434	0.268	0.251	0.265	1		
(n)	Sig. (2-tailed)	0	0.894	0.064	0.268	0.299	0.273			
Power	Pearson Correlation	.785**	0.184	.525*	.519*	.467*	.497*	.925**	1	
(w)	Sig. (2-tailed)	0	0.45	0.021	0.023	0.044	0.03	0		
Speed	Pearson Correlation	0.18	0.414	.502*	0.226	0.195	0.218	0.216	0.319	1
(m/sec)	Sig. (2-tailed)	0.46	0.078	0.028	0.353	0.424	0.37	0.374	0.183	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 2 presents the Pearson correlation coefficients for the selected anthropometric characteristics, biomechanical parameters, and spiking performance. Among the anthropometric variables, height at 90° showed a significant positive correlation with ball speed (r = 0.502, p = 0.028), whereas body weight (r = 0.180, p = 0.460) and leg length (r = 0.414, p = 0.078) were not significantly correlated with ball speed. The biomechanical parameters, including jump height (r = 0.226, p = 0.353), flight time (r = 0.195, p = 0.424), velocity (r = 0.218, p = 0.370), force (r = 0.216, p = 0.374), and power (r = 0.319, p = 0.183), did not show significant relationships with ball speed (p> 0.05). Significant positive correlations were also observed among several independent variables, including leg length and height at 90° (r = 0.738, p< 0.001), body weight and force (r = 0.820, p< 0.001), body weight and power (r = 0.785, p< 0.001), jump height and flight time (r = 0.972, p< 0.001), jump height and velocity (r = 0.995, p< 0.001), flight time and velocity (r = 0.987, p< 0.001), and force and power (r = 0.925, p< 0.001). Among all the variables, height at 90°

was the only variable significantly associated with ball speed. The remaining anthropometric and biomechanical variables showed no significant relationships with spiking performance.

Discussion:

In this investigation, the association between selected anthropometric characteristics, biomechanical parameters, and spiking ability among university-level male volleyball players was examined. It was found that height at 90° demonstrated a positive relationship with ball speed. While body weight, leg length, jump height, flight time, velocity, force, and power were not positively associated with spiking performance. These findings highlight that the preparatory body position before take-off may play a more important role in spike execution than isolated anthropometric or biomechanical variables in this group of athletes.

The positive correlation between height at 90° and ball speed indicates that the athlete's body position during the countermovement phase may influence the efficiency of force generation during take-off. Height at 90° reflects the preparatory position, which is used to enhance explosiveness by extension of the hip, knee, and ankle joints (Fox et al., 2019). An effective preparatory position allows the lower limbs to utilise the stretch-shortening cycle more efficiently. Which enhance vertical impulse and improves transfer of mechanical energy through the kinetic chain (Fukutani et al., 2021; Tomalka et al., 2020). Athletes who useda more optimal preparatory position could effectively generate higher ball speed during the spike (Yousif & Yasir, 2026; Forthomme et al., 2005). This result supports the biomechanical principle that during the preparatory phase, movement quality is more important for enhancing the effectiveness of explosive sporting actions. Past studies have demonstrated that lower limb mechanics substantially influence volleyball performance. Kumar & Kumar (2020) reported that biomechanical aspects during the take-off phase contribute significantly to spike execution. Ikeda et al. (2018) identified vertical jump ability as an important aspect of attacking performance in university-level volleyball players. Christensen et al. (2021) also indicated that optimal lower limb joint positioning enhances jump performance by improving force transmission during take-off. The current investigation extends these observations by suggesting that the preparatory lower-limb position, represented by height at 90°, may be an important determinant of spiking performance among university-level players under field-based testing conditions.

In opposition to the authors' suggestion, body weight and leg length were not associated with ball speed. Although anthropometric characteristics play an important role in enhancing volleyball performance, they may not independently determine successful spike execution. Anthropometric advantages are meaningful when neuromuscular coordination, technical proficiency, skill acquisition, and explosive strength are present together. In the current study, all participants had homogeneous characteristics, and all were university-level male volleyball players. This may have reduced the variability in body dimensions, which may limit the strength of these relationships. The previous researchers also highlight that the anthropometric characteristics alone were insufficient to explain differences in performance without considering technical and neuromuscular factors (Goun, 2025; Mikołajec et al., 2025).

The results also suggested that the jump height, flight time, take-off velocity, force and power collected by the My Jump application had no positive correlation with ball speed. Although these variables are important indicators of explosive lower-limb performance. Volleyball spiking is a complex, multi-joint movement that depends on the coordinated interaction of the lower limbs, trunk, shoulder, arm, and wrist. So, higher jumping ability does not necessarily result in a higher ball speed unless the generated force is effectively transferred through the kinetic chain at the instant of ball contact (Duan et al., 2025). Ball velocity is also influenced by approach speed, arm swing mechanics, trunk rotation, shoulder internal rotation, timing of ball contact, and technical execution, which were not quantified in the present investigation (Orishimo et al., 2023). Due to this, isolated lower limb biomechanical measures may not fully explain variations in spiking performance. The participants were university-level athletes with similar training backgrounds and competitive experiences, resulting in relatively small variability in biomechanical performance. The sample size used was modest (n=19), which may have reduced the statistical power to detect moderate correlations.

Despite the lack of significant associations for most biomechanical variables, the My Jump application demonstrated the feasibility of field-based biomechanical assessments in volleyball. The application provides objective measurements of jump height, flight time, velocity, force, and power using a practical and cost-effective approach. Together with the Kinovea software for ball-speed assessment, these tools offer coaches and practitioners an accessible method for monitoring athlete performance outside laboratory settings (Hudha et al., 2025; Rahman Marpaung et al., 2025). Although the measured biomechanical variables were not directly associated with ball speed in the present study, they remain valuable for evaluating lower limb explosive capacity and monitoring training adaptations over time. From a practical perspective, these findings show that coaches should not rely solely on improvements in vertical jump performance when attempting to enhance spiking ability. Training programmes should integrate lower-limb power development with technical refinement of the approach, countermovement, arm swing, trunk coordination, and ball-contact mechanics. Emphasising movement quality during the preparatory phase of the spike may contribute more effectively to improvements in spiking performance than focusing exclusively on isolated physical capacities.

The current findings may limit the generalizability because of the relatively small sample of university-level male volleyball players from a single institution. The cross-sectional design prevents causal inference, and several important aspects of spiking performance, like approach speed, arm swing mechanics, trunk rotation, shoulder kinematics, and neuromuscular coordination, were not evaluated. Future research should include larger and more diverse samples and incorporate comprehensive biomechanical analyses to provide a more complete understanding of the factors that influence volleyball spiking performance.

Conclusion:

The objective of this study was to examine the relationship between selected anthropometric characteristics, biomechanical changes, and spiking ability in university male volleyball players. The results revealed that height at 90° was the only variable that had a positive relation with ball speed. This demonstrates the importance of an effective preparatory body position during spike execution. No observable relationship between other variables was shown, indicating the multifactorial nature of the volleyball spike. It involved a combination of biomechanical efficiency and technique to perform successfully. My Jump app and Kinovea were feasible field-based biomechanical tools for objectively evaluating the volleyball spike performance.

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