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The Relationship Between Some Kinematical Variables and Accuracy of the Spike in Volleyball for Ages (14–16)

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Abstract

The volleyball spike has been widely recognized as one of the fundamental skills that influence match outcomes. The performance of this skill is largely a function of the orchestration of several biomechanical factors including: angular and linear velocity of the power-arm, launch angle, ball height to the point that it is struck and step stop technique. The purpose of this research was to investigate the influence of these variables in accuracy of spike related to volleyball players in the age group 14-16. The study was descriptive in nature, involving a sample of 7 players from the National Talent Development Centre. Spike accuracy was assessed with the modified high spike test, which evaluates the speed as well as the accuracy of the spike. Biomechanical parameters - i.e. angular speed, peripheral speed, launch angle, ball height at the moment of the strike and foot deviation - were recorded using technological equipment such as high-speed video imaging systems and Kinovea software. The results demonstrates high and significant correlation between biomechanical variables and the accuracy of the spike and equipment contributed to increase angular speed (r = 0.899, sig = 0.006) peripheral velocity (r = 0.965, sig =.000), by ensuring increased accuracy with a projectile in the construction phase. There were also positive outcomes for launch angle and ball height at impact, indicating the significance of these factors for spike accuracy enhancement.

Keywords: Biomechanics, diagonal spike, motion analysis, kinematic variables, ball height.

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Introduction

The spike is one of the basic technical skills in which the execution accuracy and coordination to a number of biomechanical variables are mainly influence match results. A number of things can impact this and timing including angular velocity it is imparted to the back arm, the tangential velocity along an arm release accident, back hand release angel ball height as contacted for payoff and stopping step. The purpose of this study is to determine how these biomechanical variables influence the spike accuracy in 14-16 year old volleyball players.

The angular and tangential velocities of the striking arm plays important role in determining power and speed of the hit that effect ultimately in accuracy of ball's direction (Al-Fahd, 2014). Based on a number of studies it has been reported that stronger spike can be generated when the ball's angle is consistent with the optimal ball angle at wrist-cock position (Al-Zahrani, 2016). A study by Kugel et al. (2019) also showed that the higher angular velocity of the striking arm contributed to efficient production of force used in spike, affecting the ball's accuracy and direction.

In terms of the ball release angle, it is regarded as one of the crucial factors to drive a ball in the direction toward the target, since launching a ball at an appropriate angle can result in enhancing spike accuracy (Al-Tuwaijri 2017). It has been reported that the correlation between release angle and ball's height at the impact moment was significant for enhancing spike accuracy among novice and intermediate players in this age group of interest (Al-Mutairi, 2018). In this connection, Filaire et al. (2020), the angle of ball release in spiking is critical for the final velocity direction of the ball, which in turn affects its accuracy.

Moreover, the stopping action is identified as one of the basic mechanical elements of controlling his balance before performing spike, which efficiently stabilizes the body and increases spike accuracy (Al-Salem, 2015). It has been found that by bettering the stopping step, overall stability and control of the striking action is enhanced such that consistent performance accuracy becomes more likely. Hughes et al. (2016) also reported that the stopping phase promotes balance and implies force distribution throughout the body, increasing the efficiency to perform precise and powerful spikes.

It is of course, known that some biomechanical factors influence spike accuracy. There are, however, relatively few studies considering the influence of these variables in young volleyball players aged 14–16 years. Thus, the present was undertaken to identify the degree in which angular velocity and tangential speed of the striking arm (our independent variables), ball release angle, ball height at contact and stopping step (control variables) influence spike performance in this age

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group. It's a pivotal time for the budding and shaping of motor skills. Additionally, findings from this study are anticipated to inform coaches and researchers toward training practices that could enhance technical performance of players by targeting these kinematic variables.

Methodology

The purpose of this study was to describe the relationship between spike accuracy in volleyball and a set of selected biomechanical variables for young players affiliated with the National Center for Sports Talent Development aged 14–16 years during the 2024–2025 season. The sample was composed of seven players who presented dominance in the spike, 50% of the population selected.

Modified High Spike Test (Kadhim & Atea, 2023)

The purpose of the test was to measure the effectiveness and image velocity of high diagonal spike coming from position (4). The test was performed with a standard volleyball court, official volleyballs, and machine ball thrower as well as colored tape on the floor to delimit the movement area of the player (from which volition jump) and the ball landing zones (130 × 130 cm). A time limit of the ball was obtained using a high-speed camera (120 frames/s).

Performance specifications

The examined player completed the spike from a marked position to the opposing court on a diagonal of it, so that due to over-net trajectory speed, the ball landed within specific zones depending on prescribed accuracy. Non-recorded attempts failed when the ball did not fall into the accuracy zones, hit the net or a legal fault in terms of skill requirements. The player had to jump from the marked area in order to have the same base of movement for all participants.

Each player was given five attempts. Scoring was as follows:

- 4 points for the farthest accuracy zone
- 3 points for the next zone
- 2 points for the nearer zone
- 1 point for the nearest and largest zone
- 0 points for attempts that did not meet the specified conditions

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The total score was calculated from the score of each accuracy zones by the time (s) taken by ball flight from hitting to arriving at accuracy zone using camera observation that analyzed Kinovea software. The measurement unit was (a score/second).

Kinematic Variables

- **Angular velocity of the striking arm:** The angular velocity of player's arm rotation during spike performance, is the rate of change of angular displacement in degrees per second. It is a measure of the velocity of the arm rotation and a strong correlate with performance power and accuracy (Hall, 2015).
- **Tangential velocity of the striking arm:** The rate at which the distal point (hand or wrist) is moving along its linear path during the spike, m/s. It is this velocity that determines how quickly the hand moves through space, and it is a product of angular velocity (ω) and arm length (Knudson, 2007).
- **Ball release angle:** The orientation of the ball relative to the ground at any instant after leaving a player's striking hand. This angle is crucial in hitting the ball, being able to hit over the block and consistency (Bartlett, 2007). The angle was defined by the line connecting across multiple frames of a ball's center of mass and to a vertical reference line and normalized to account for differences between positive and negative release angles.
- **Ball height at the moment of contact:** The vertical height of the ball from ground level at the instant of contact by the player in spiking (m). This feature is associated with the contact point of the player and the ball, which would directly affect the attack angle and aiming (Lees 2002).
- **Stopping step:** The value of the angle between front and rear forefeet-hooves line and ground.

A pilot study to check the assumption was performed with two players who were not part of the sample on Friday, 22 March, 2024 at time 10:00 a.m. at National Center for Sports Talent Development court. The aims of the pilot test were to confirm the capabilities of ball-throwing machine, estimate the number of cameras, distance and height setting for the camera system; prepare ready-made court conditions, indicate assisting team members, their quantity as well establishing their functions during testing process; specify execution time of exercise (the actual test) and validate effectiveness of assisting staff.

The actual test was then administered in the auditorium of the National Center for Sports Talent Development in Baghdad on Monday, the 24/3/2025 at 4:00 p.m., and it took about an hour and a half.

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Results

Table 1. *Correlation coefficients between biomechanical variables and spike accuracy*

Variables	Correlation coefficient with accuracy	Sig. value
Angular velocity	0.899**	0.006
Tangential velocity	0.965**	0.000
Release angle	0.791*	0.034
Ball height at moment of contact	0.790*	0.035
Foot deviation	0.878**	0.009

Significant at Sig. < 0.05.
Coefficients marked with (**) are statistically significant at the 0.01 level.
Coefficients marked with (*) are statistically significant at the 0.05 level.
Sample size (N = 7) for all variables.

Discussion

There was a positive, significant correlation between angular velocity and accuracy in the results (r = 0.899**, sig = 0.006) suggesting that performance becomes more precise at faster velocities of movement. This may be attributed to the function of angular velocity in its acceleration of joint rotation during arm and shoulder movements, hence facilitating efficient transfer of kinetic energy from body to ball at throw. This improves spike effectiveness and reduces movement dispersion, increasing accuracy. Bartlett (2007) stated that angular velocity was important for sports in which precise control of the direction and magnitude of limb movement was necessary, like volleyball. The higher the angular velocity, the more effectively kinetic energy is transferred from muscles to the ball for spiking and serving in volleyball. These results are consistent with those of the present work, which showed that angular velocity was significantly correlated with accuracy.

The correlation of accuracy with tangential velocity was the strongest when compared to other variables (r = 0.965**, sig = 0.000) implying that enhancing the linear motion speed of body segments especially upper limb naturally leads to increased performance in terms of high precision movements. Tangential velocity, in biomechanics, refers to the speed of a point on an arm or hand as it travels along its linear path. Consequently, regulating this speed better regulates the direction and distance of striking and the force applied during striking-all important to precision. Knudson (2007) supports the results of the present study indicating that with control over tangential velocity, direction and distance control can be higher in sports such as volleyball, leading to greater accuracy of execution. As well, the transfer of energy by the upper limbs also depends on average tangential velocity, which directly affects impact onto the ball in hitting. Salama (2009) also found

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that tangential velocity plays a major effect in the accuracy of team sports through influencing direction and strength of the ball; thus it is a critical effectiveness factor toward accuracy.

A strong positive statistically significant correlation was observed between accuracy and release angle (r = 0.791*, sig = 0.034), which suggests the importance of an optimum release angle for good ball trajectory accuracy. Biomechanically, release angle of the projectile has a specific effect on the path and trajectory of the ball such that any differentiation from this angle leads to changes in ball height and range affecting target accuracy (Hay, 1993; Al-Kubaisi,2013).

Moderate and statically significant correlation between the ball height (at the impact instant) and precision (r=0.790*, sig = 0.035), suggests that point of impacts also plays an important role in predicting the behavior of ball on its release. The height of the ball at the time of impact has a significant influence on release angle and force placement and timing. Landing errors may also lead to a loss of ball control and thus accuracy (McGinnis, 2013; Hameed, 2014).

There is a strong, significant relationship in foot deviation with accuracy (r = 0.878**, sig = 0.009) suggesting that the alignment of the foot in the execution has an effect on ball placement and where it goes. It emphasizes the need to coordinate body axes and alignment of the foot towards the target. A movement of the foot in advance or during striking will carry energy out of a best line and thus reduce precision (Zatsiorsky & Kraemer, 2006).

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