ISSN: 2392-5442
ESSN : 2602-540X
V/13 N/02 Year/2026
P 261 - 271

Sport system journal
International scientific journal published by: Ziane Achour –Djelfa- Algeria
Received: 2026-05-14 A ccepted: 2026-08-09

Kinematic analysis of the spike serve of outstanding female volleyball players

Qasim Mohammed Sayah[1*], Rawaa Abdulameer Abbas[2]

Dhiyaa Ahmed Askar[3], Mayson Abdul jalel Abdul hasan[4], Jasim Salah Jasim[5]

[1]The Department of Students' Activities, the University of Basra, Iraq
qasim.sayah@uobasrah.edu.iq
[2]The Department of Students' Activities, the University of Basra, Iraq
rawaa.abbas@uobasrah.edu.iq
[3]The Department of Students' Activities, the University of Basra, Iraq
dhiyaa.askar@uobasrah.edu.iq
[4]The Department of Students' Activities, the University of Basra, Iraq
mayson.abdulhasan@uobasrah.edu.iq
[5]The Department of Students' Activities, the University of Basra, Iraq
jasim.salah@uobasrah.edu.iq

Abstract:

This study aimed to provide data on the spike serve in order to develop training programs to improve performance. Three elite female athletes participated in the study. The study concluded that the total time required during the third and fourth phases of the serve was the longest. The ball reached a speed of 17.86 meters per second. This resulted in efficient energy transfer and a shift in speed from the near side to the far side of the body at the moment of impact. All participants demonstrated higher speeds on the far side of their bodies compared to the near side. The first athlete recorded the fastest foot speed of 14.90 meters per second, thanks to controlled shoulder joint movement at the point of impact and the transfer of this speed to the far side of the body. Further research targeting female athletes is recommended to consider the various variables.

Keywords: spike serve; female; volleyball; speed; C3D.

***Corresponding author** qasim.sayah@uobasrah.edu.iq*

1. INTRODUCTION

Volleyball is a sport that can be played in a relatively small space without physical contact with opponents, and it requires simple facilities and equipment. Compared to other team sports, volleyball offers the advantage of safe participation. Furthermore, because it can be played by a large number of people simultaneously, it has high participation rates among working adults and office workers (Hu et al., 2023).

Volleyball is a game in which six players share roles according to their positions, aiming to score points by executing repetitive offensive techniques, such as serving and spiking, as well as defensive moves like blocking, receiving, and passing (Wagner et al., 2009).

Current trends in global volleyball can be categorized into three main types: height-based and power-based volleyball, which utilizes the advantage of height; technical volleyball, designed to compensate for shorter stature; and composite volleyball, which combines speed and fast play. Since the 1980s, the world of volleyball has demonstrated that only teams possessing all three attributes—height, strength, and technique—have consistently achieved top rankings (Cho & Ju-haeng, 2007).

The powerful spike is considered the most technically advanced way to score points, and it is one of the most important skills in the game. As an attractive and exciting technique, it thrills audiences (Alsaeed, 2025). The spike consists of four phases: running, jumping, rising into the air, and landing. These techniques are acquired step by step. Raed et al. (2016) discussed training methods for developing the motor skills and physiological variables of junior volleyball players using reciprocal training tests.

The spike serve is a movement where the ball is tossed high from behind the end line, followed by a jump to strike it with force. Because it utilizes the entire body, it possesses explosive power similar to the spike. In modern volleyball, the serve is no longer just a pass; it has become an offensive technique, a crucial skill capable of turning the tide of a match and determining its outcome.

Saad (2015) indicated a statistically significant correlation between referee performance in refereeing courses and the development of balance. Regarding previous research on the smash serve in volleyball, Lomi and Qandaz (2024) noted that an effective movement occurs when the ball is struck immediately after the vertical section of the track. They also suggested that 3-meter volleyball drills

are an effective and efficient method for developing this movement, as the 3-meter volley closely resembles the smash serve.

In local volleyball, the spike was once the domain of male players; however, since 2006, with the influx of foreign professional players into women's volleyball, the use of the spike has also increased among female players. Nevertheless, while foreign players can serve at speeds exceeding 90 km/h, the execution rate and explosive power of the spike are significantly lower among local players. This is attributed to a lack of mastery of the serve technique and the psychological pressure resulting from errors. Furthermore, the application of the exchange point rule, where service errors immediately result in point losses, reduces players' ability to execute bold serves.

Although service errors lead to point losses, volleyball coaches highly value the spike, even considering a point lost due to a spike error as equivalent to a point lost due to a regular serve. For Iraqi women's volleyball, which relies on fast attacks and pre-prepared plans after a tight defense based on teamwork as its basic scoring methods, weakening the opponent's organization with powerful smashing serves is crucial to overcoming the recent decline in international matches.

The aim of this study is to explore the effective spike serve movements of female players by providing scientific information and data on the key phases of the smashing serve movement in professional women's volleyball, and to establish baseline data for improving and developing serving techniques in volleyball.

2. Research methods

2.1 Participants

This study Participants consisted of three professional volleyball players from the Iraqi national team, and was limited to players who excelled at powerful serves during matches and possessed high-level motor skills. Table 1 shows the general characteristics of the participants.

Table 1. Characteristics of participants in the experiment

Participants	Age (years)	Height (cm)	Weight (kg)
Player 1	22	1.85	73
Player 2	21	1.83	68
Player 3	23	1.81	71
M	22	1.83	70.7
SD	1	0.02	2.52

2.2 Equipment and experimental procedures

To capture the powerful serves of female volleyball players, actual matches were filmed during the 2024-2025 Iraqi League season. An iPhone 11 Pro digital video camera was used, recording at 120 frames per second. The footage was limited to the top three players performing powerful serves from the right angle, all of whom used their right arm for the serve. For video data selection, only one shot was chosen where the powerful serve resulted directly in a point without any further ball exchange. The data was processed using Sport 2D software (Pagnon et al.,2024).to extract a C3D file, which was then transferred to PLAViMoP software(Decatoire et al., 2018).to extract joint speed data. Kinovea software was used to extract ball speed data, and the data was then converted to Excel to create tables and graphs, as shown in Figure 1.

					
iPhone 11 Pro	MSI Laptop	Sports2D: Compute 2D human pose and angles from a video	PLAViMoP Software	kinovea software	Microsoft Excel

Fig.1. Digital Transformation

2.3 Definition of stages

The specific phases of the smash serve are analyzed by dividing them into four stages, as shown in Figure 2: phase 1: Preparation, phase 2: Take-off, phase 3: Impact and phase 4: Landing. Figure 3 illustrates a sequence of spike serve movements.

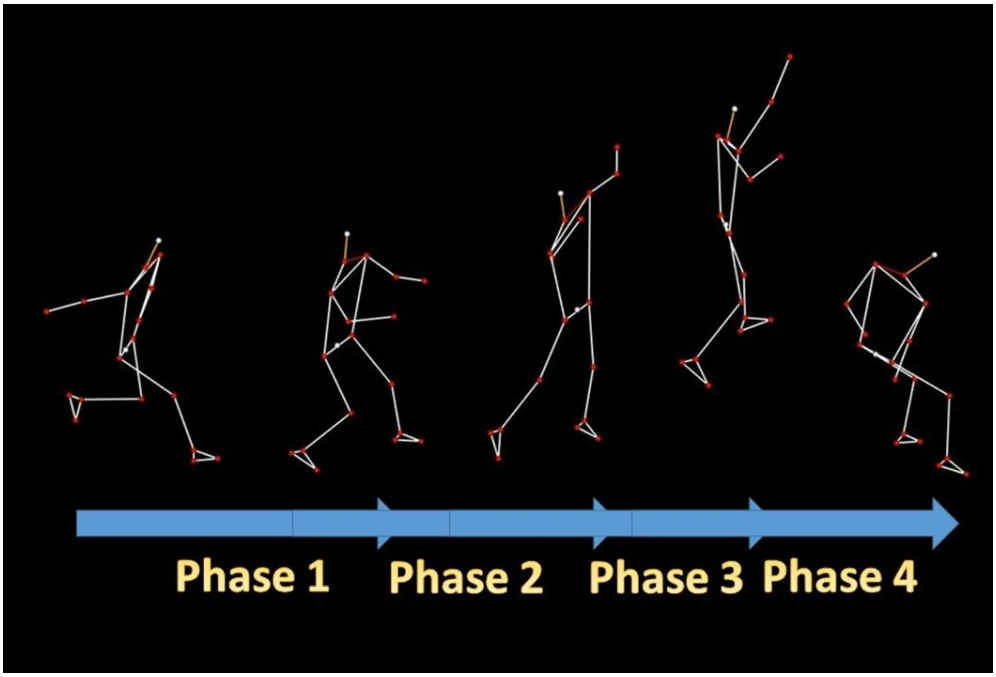


Fig.2. phases of the Spike Serve

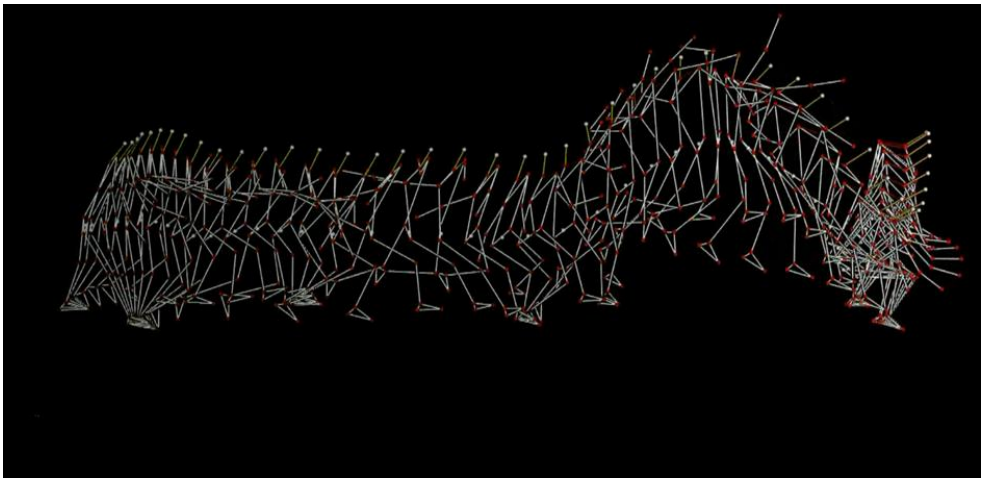


Fig.3. Spike Serve sequence of moves

2.3 Statistical Analysis

The data for this study were analyzed using Minitab software (version 19.0). Descriptive statistics were used to calculate the mean (M) and standard deviation (SD).

3. Results and discussion

3.1 Time factor

Table 2. Time required for each phase (Unit: seconds)

Participants	phase 1	phase 2	phase 3	phase 4	Total
Player 1	0.23	0.14	0.33	0.31	1.01
Player 2	0.19	0.18	0.26	0.24	0.87
Player 3	0.26	0.14	0.31	0.31	1.02
M	0.23	0.15	0.30	0.29	0.97
SD	0.04	0.02	0.04	0.04	0.08

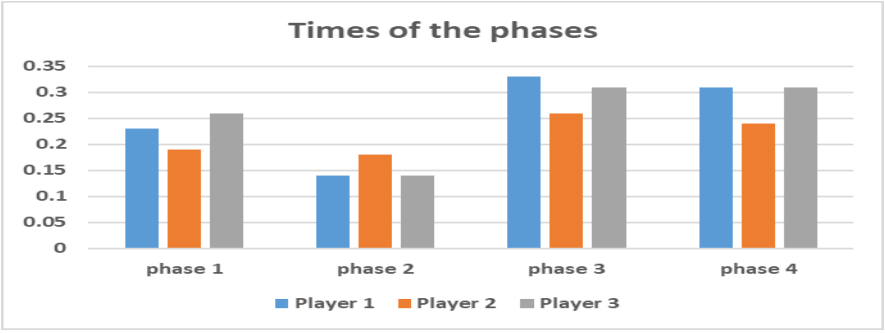


Fig.4. Times of the spike serve phases

Table 2 shows the duration of each phase of the spike serve. The average total duration of the spike serve for professional female volleyball players was 0.97 seconds. Analyzing each phase individually, the preparation phase (phase 1) lasted 0.23 seconds, the launch phase (phase 2) 0.15 seconds, the impact phase (phase 3) 0.30 seconds, and the landing phase (phase 4) 0.29 seconds. Of the total duration, the flight time during the impact and landing phases was the longest, followed by the approach and then the launch. These results indicate that one characteristic of the female spike serve, unlike that of the male players, is that they do not throw the ball high, but rather execute the movement with a technique

more akin to a jump while running. In particular, the approach and flight times of the first female player were shorter compared to the other players; this is attributed to the fact that the movement was performed while moving forward at a higher speed than a vertical jump serve. It has been shown that in order for players to execute a powerful serve, they need to secure time in the zone of influence by making a vertical jump after a sprint and a run.

3.2 Joint speed and ball speed

Table 3. Main joints and ball speed upon impact (Unit: m/s)

Participants	joints	The moment the feet are lifted off the ground	moment of impact	The speed of the ball immediately after the impact
Player 1	Shoulder	2.9	2.94	19.23
	Elbow	3	6.18	
	Wrist	2.39	9.61	
	Foot	2.02	14.87	
Player 2	Shoulder	2.91	3.2	16.40
	Elbow	1.41	5.82	
	Wrist	0.83	9.94	
	Foot	1.95	14.03	
Player 3	Shoulder	2.64	3.87	17.94
	Elbow	2.55	5.95	
	Wrist	2.83	10.08	
	Foot	2.68	14.68	
M	Shoulder Player 1,2,3	2.82	3.34	17.86
	Elbow Player 1,2,3	2.32	5.98	
	Wrist Player 1,2,3	2.02	9.88	
	Foot Player 1,2,3	2.22	14.53	
SD	Shoulder Player 1,2,3	0.15	0.48	1.417
	Elbow Player 1,2,3	0.82	0.18	
	Wrist Player	1.05	0.24	

	1,2,3			
	Foot Player 1,2,3	0.40	0.44	

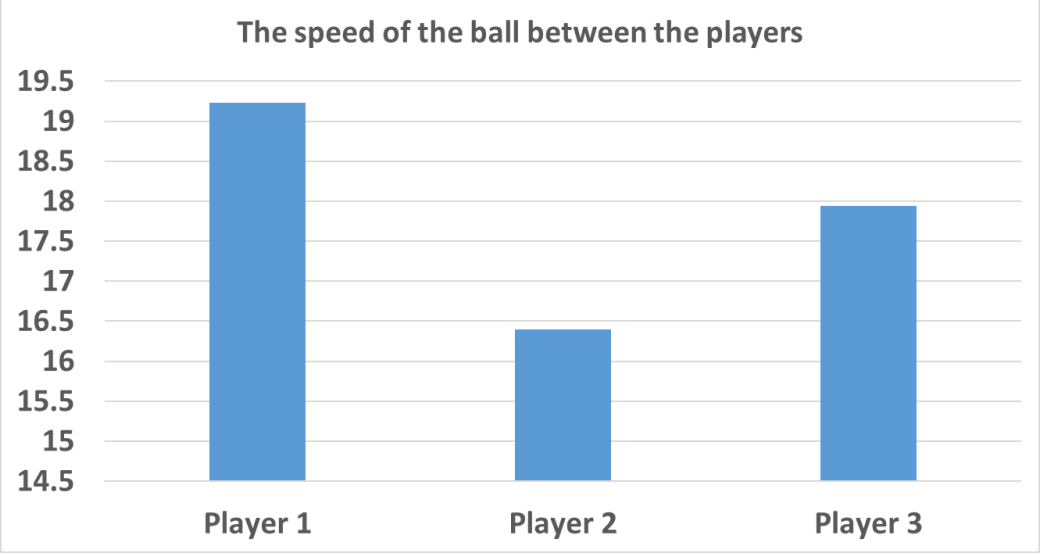


Fig.5. The speed of the ball immediately after the impact

When examining the average velocities of the major joints and the ball at the jump (the moment the feet lift off the ground) and the impact (the moment of impact), the shoulder velocities were 2.82 m/s and 3.34 m/s, the elbow velocities were 2.32 m/s and 5.95 m/s, the wrist velocities were 2.02 m/s and 9.88 m/s, and the fingertips velocities were 2.22 m/s and 14.53 m/s. The average ball velocity immediately after impact was 17.86 m/s. All participants exhibited higher velocities in the distal joints compared to the proximal joints. In the case of the first player, the foot velocity was the fastest at 14.87 m/s due to the control movement of the shoulder joint velocity at the impact point and the transfer of this velocity to the distal joints; consequently, the ball's velocity immediately after impact was also the fastest. In the case of the second and third players, the shoulder joint velocity at the moment of impact was 3.20 m/s and 3.87 m/s, respectively, indicating that the shoulder joint velocity was not under control. Consequently, the velocity of the fingertips and the ball appeared slow. Tayeb et al. (2019) indicated a correlation between the ball's launch velocity and its flight time in the execution of the volleyball spike. The ball's speed was reported to be

20 m/s. Wagner et al. (2009) analyzed the importance of the connection between the upper and lower limbs in the smashing motion, and Tilp,et al. (2008) conducted a comparative analysis of the kinematic differences between spike serve in volleyball and beach volleyball.

The angular momentum of the near part is transferred to the adjacent far part, causing the near part to decelerate and the far part to accelerate by the same amount as the near part decelerates (Elin and Katherine, 1981). Therefore, the arm swing motion in the spike should exhibit a whip-like pattern, with momentum being transferred sequentially.

4. CONCLUSION

The total time required during the impact (phase three) and landing (phase four) phases is the longest, followed by the preparation phase (phase one) and then the launch phase (phase two). It was concluded that the players perform the smash serve with a running jump. The ball's speed was found to be 17.86 m/s. This resulted in efficient energy transfer from the legs to the arms during the launch phase, and the transfer of speed from the near to the far body at the moment of impact. All participants showed higher speeds in the far body compared to the near body. In the first player's case, the foot speed was the fastest at 14.90 m/s due to the control movement of the shoulder joint speed at the point of impact and the transfer of this speed to the far body. Although the kinematic variables mentioned in the previous conclusions are closely related to athletic performance, further research in experimental settings targeting female athletes is recommended to account for the various variables.

References

Alsaeed, R. (2025). Analysis of some mechanical factors of the approach phase and their effect on the accuracy and speed of the ball during the spike in volleyball. Journal of Studies and Research in Physical Education.613-622, 35(4), https://doi.org/10.55998/jsrse.v35i4.1260

Cho, Ju-haeng (2007). Comparative analysis of kinematic variables for volleyball left spike and right spike motions. Korean Journal of Kinesiology. 16(4). 125-134

Decatoire, A., Beauprez, S.A., Pylouster, J., Lacouture, P., Blandin, Y., & Bidet-Ildei, C. (2018). PLAViMoP Software: How to standardize and simplify the use

of point-light displays, Behavior Research Methods, doi: 10.3758/s13428-018-1112-x.

Hu, Lejun & Zhao, Kai & Jiang, Wei. (2022). Biomechanical Analysis of Volleyball Players' Spike Swing Based on Deep Learning. Computational Intelligence and Neuroscience. 2022. 1-10. 10.1155/2022/4797273.

Loumi Y., & Qandaz A. (2024). Three-dimensional kinematic analysis of the spike serve skill in volleyball and its comparison with different types of attack: A field study of senior national volleyball team players. Journal of Excellence in Physical and Sports Sciences and Techniques, 9(2), 368-386. https://asjp.cerist.dz/en/article/260002

Raed Abdul-Amir Abbas A., Nabil Kadhim Haribed A., & Ben Zidan H. (2016). The effect of reciprocal training on developing some physiological variables and motor abilities of volleyball players. Journal of the Sports System, 3(1), 119-139. https://asjp.cerist.dz/en/article/58663

Pagnon et al., (2024). Sports2D: Compute 2D human pose and angles from a video or a webcam. Journal of Open Source Software, 9(101), 6849, https://doi.org/10.21105/joss.06849

Saad Abbas A. (2015). Refereeing courses and their relationship to the development of emotional balance among volleyball referees. Al-Manzuma Al-Riyadiya Journal, 2(4), 87-103. https://asjp.cerist.dz/en/article/58651

Tayeb Q., Bouabdallah S., & Ahmed T. (2019). Ball flight time and its relationship to the variables of speed and launch angle in the performance of the spiking skill in volleyball. Journal of Physical Activity and Sports, Society, Education and Health, 2(2), 78-86. https://asjp.cerist.dz/en/article/99047

Tilp, M., Wagner, H., & Müller, E. (2008). Differences in 3D kinematics between volleyball and beach volleyball spike movements. Journal of Sports Biomechanics, 7(3), 386-397.

Wagner, H., Tilp, M., Duvillard, S. P., & Mueller, E. (2009). Kinematic Analysis of Volleyball Spike Jump. Department of Sport Science and Kinesiology, University of Salzburg: Hallein/Rif, Austria.

Wagner, H., Tilp, M., von Duvillard, S. P., & Mueller, E. (2009). Kinematic analysis of volleyball spike jump. International journal of sports medicine, 30(10), 760–765. https://doi.org/10.1055/s-0029-1224177