

## Evaluation of Two Methods of the Jump Float Serve in Volleyball

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A novel jump-focused (JF) technique of the jump float serve was compared with the conventionally used contact-focused (CF) method. Seven elite male (height:  $195 \pm 6$  cm) and two elite female (height: 181 and 182 cm) volleyball players were videoed at 60 Hz performing both techniques. Horizontal and vertical ball contact coordinates, pre- and postcontact ball velocities, and initial projection angles were determined. The JF technique resulted in a significantly higher mean contact height,  $t(8) = 4.12$ ,  $p = .006$ ,  $d = 0.72$ , initial serve speed,  $t(8) = 4.71$ ,  $p = .006$ ,  $d = 2.03$ , and significantly flatter initial projection angle,  $t(8) = 2.53$ ,  $p = .036$ ,  $d = 0.63$ , relative to the CF technique. The precontact vertical ball velocity was also significantly higher,  $t(8) = 8.04$ ,  $p = .004$ ,  $d = 2.86$ . The higher precontact vertical ball velocity suggests it is more difficult to make accurate contact with the ball during the JF technique. However, this method promotes a more favorable ball trajectory and a greater initial serve speed. When combining the random lateral movement patterns inherent in any float serve, with the reduced flight time associated with the JF technique, a more challenging passing scenario can be presented to the defensive team in comparison with the current CF technique.

**Keywords:** biomechanics, kinematics, sport, performance

In the sport of volleyball, the serve can be considered the first offensive action of each rally (Deprá et al., 1998). The primary goal is to score an ace or make the served ball as difficult as possible for the opposing team to pass. Four primary characteristics of a serve determine the level of difficulty presented to the receiving team: ball speed (Strohmeyer, 1996), flight time (Katsikadelli, 1996), predictability of the trajectory (amount of random movement in the flight path) (Deprá et al., 1998), and the server's ability to conceal the type of serve (Deprá et al., 1998). The two main types of serves currently used in elite volleyball—the jump spin serve and the jump float serve—possess different levels of difficulty in terms of the four characteristics just described.

Research has shown that from the early 1990s until the mid 2000s, the jump spin serve increased in popularity to become the most frequent serve type used in elite volleyball (Agelonidis, 2004; Häyrinen et al., 2007; Moras et al., 2008; Tsivika & Papadopoulou, 2008). The jump spin serve is characterized by a high toss, multistep approach, and near maximum jump including full use of both arms. The ball is struck at the peak of jump height using an arm action that imparts topspin. When traveling through the air with topspin, the ball experiences a primarily downward lift force, causing the ball to 'drop' earlier than would the trajectory of a ball without spin (Mehta, 1985; Mehta & Pallis, 2001; Wei et al., 1988).

Jump spin serves have been shown to generate the greatest ball speeds (Moras et al., 2008; Strohmeyer, 1996) and because the ball is contacted higher above the court relative to other current serve types, a flatter initial projection angle can be imparted to the ball (Strohmeyer, 1996). The lower initial projection angle and increased projection speed both result in a reduced flight time. Together, these factors increase the difficulty of the serve for the receiving team. However, the characteristics of the jump spin serve approach, and toss, make it easy to identify, and the spin imparted to the ball promotes a stable and predictable trajectory relative to a float serve.

According to the International Volleyball Federation (FIVB), the frequency of float serves increased from 15% at the 2004 Olympic Games to 30% at the 2008 Olympic Games, during male competition (Zimmermann & Thorsteinsson, 2008). It has also been shown that float serves are now primarily being used in conjunction with a jump and are referred to as *jump float serves* (Häyrinen et al., 2007; Tsivika & Papadopoulou, 2008). An analysis of serves executed at the 2005 Men's European Volleyball Championship revealed that Spain used the jump float serve more frequently than any other serve type at 52%, and that France also demonstrated a high rate of jump float serve usage at 43% (Tsivika & Papadopoulou, 2008). A float serve requires a sharp contact with an open palm so as to impart no spin to the ball (Huang & Hu, 2007). Nonsymmetrical lateral forces act on a nonspinning volleyball as it travels through the air resulting in unpredictable movement patterns (Mehta, 2008; Mehta & Pallis, 2001; Wei et al., 1988). Although

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the unpredictable trajectory increases the difficulty for the receiving team, the jump float serve is easy to identify early in the execution, and the ball speed is slow relative to the jump spin serve. The relatively slow speed also leads to a longer flight time. However, the authors believe that these shortcomings are a function of the *current* technique used to execute a jump float serve.

While there are some variations in jump float serve technique among elite players, this type of serve is characterized by a low trajectory toss, late in the service approach, and a submaximal jump height. These characterizations are supported by video data, from actual games, provided by the FIVB from the 2008 Beijing Olympics in which all jump float serves presented conform to the aforementioned characteristics (FIVB, 2008a, 2008c). Collectively the videos show 30 separate male players, from the top eight teams, executing a total of 75 jump float serves as well as 22 separate female players, from the top eight teams, executing a total of 40 jump float serves. The characteristic low toss and subsequent submaximal jump height result in a lower ball contact height. The lower ball contact height limits the amount of speed that can be imparted to the ball, consequently increasing the flight time, both of which make the serve easier for the opposing team to pass. Presumably, the low toss and submaximal jump height increase the probability of contacting the ball in a manner which generates no spin. For this reason, the current method of executing a jump float serve will be referred to as the *contact-focused* (CF) technique.

A revised jump float serve technique, which more closely resembles a jump spin serve, with a high toss and near maximal jump height, may be more advantageous. The proposed method, referred to as the *jump-focused* (JF) technique, incorporates the preimpact approach of the jump spin serve and the postimpact flight patterns of a float serve. The purpose of this study was to compare

the proposed JF technique to the current CF technique. It was hypothesized that the JF method would result in the ball being contacted at a higher point above the court leading to offensively superior postimpact ball kinematics such as a flatter projection angle and greater ball speed. It was also hypothesized that the ability to strike the ball correctly would be reduced, for the JF method, due to the higher toss.

## Methods

### Participants

Nine Canadian Interuniversity Sport (CIS) volleyball players volunteered to participate in the study. Seven were male and attended Dalhousie University, and two were female and attended St. Francis Xavier University (Table 1). All participants were educated on the testing and training procedures before signing an informed consent document which was approved by the Research Ethics Board of St. Francis Xavier University.

### Technique Instruction

Before data collection, the participants were provided with demonstrations and instructed on how to perform the CF and JF techniques (Figure 1). A practice session, which lasted approximately one hour, immediately followed the instruction period to ensure correct and consistent execution of each service technique. Participants first performed five repetitions of each type of serve without a ball to ensure they were employing the correct footwork as described in the following paragraph and shown in Figure 1. This was followed by 10 serves of each technique with a ball. All participants had been using the CF method during competition for at least one season. As such, only minor modifications to

**Table 1** Participant characteristics

Participant	Sex	Age (years)	Spike Touch (cm)*	Height (cm)	Mass (kg)
P1	M	21	358	206	99.5
P2	M	21	338	196	88.6
P3	M	23	329	188	90.8
P4	M	20	333	196	93.2
P5	M	20	339	191	96.1
P6	M	22	319	191	78.2
P7	M	23	359	198	93.8
P8	F	20	287	181	65.2
P9	F	20	297	182	73.7
Mean	—	21.1	328.8	192.1	86.6
SD	—	1.3	24.6	7.9	11.6

\*The maximum height touched during a two-step spike approach.

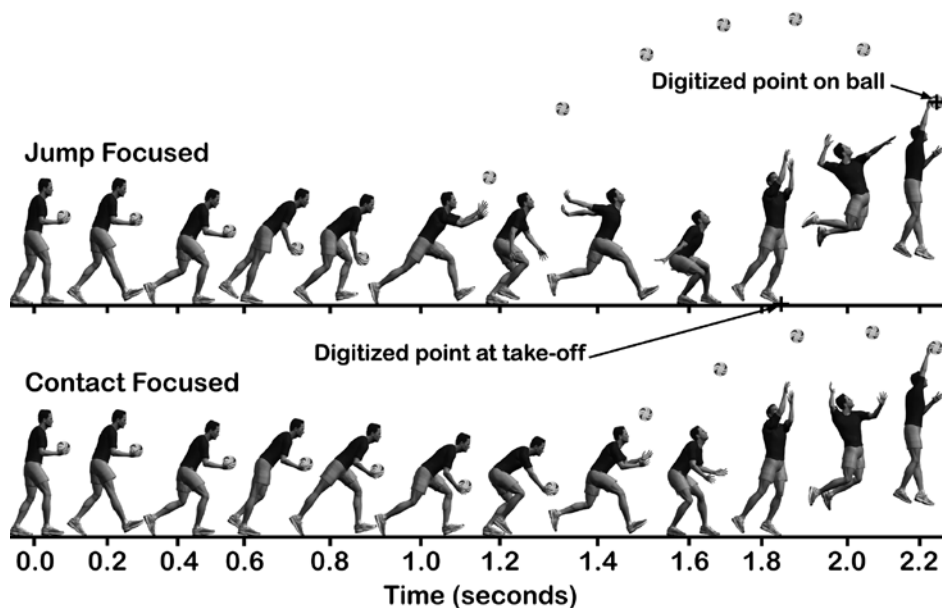
the initial footwork of CF technique were required from a few participants to standardize the testing protocol. Participants were able to correctly execute the JF method approach, and jump, within a couple of repetitions. However, for most participants, consistent contact with the ball at the peak of their jump was not attained until halfway through the repetitions with a ball. The researchers were available for continual feedback throughout the instruction and data collection period which lasted approximately two hours. The number of practice trials used in this study was consistent with previous research (6–10 trials) in which participants were being tested on a new, but somewhat familiar, technique (Gutierrez-Davilla et al., 2006).

The following descriptions of the two methods apply to right-handed servers. For both methods, participants were instructed to start with the right foot one-half-of-a-step ahead of the left and begin the serve approach by completing the forward step of the right foot (Figure 1). For the JF method, when the left foot had moved forward for the second step in the serve approach, the ball was tossed high into the air with two hands and without spin ( $t = 1.0$  s). From this point, the JF method was completed by executing a standard two-step spike approach, which maximizes the use of the arms. For the CF method, the ball was tossed one step later in the approach, as the right foot moved forward for the second time ( $t = 1.4$  s). The ball was tossed with two hands at a low trajectory. The approach was completed with a jumping action, which was abbreviated due to the timing constraints imposed by the toss. For both techniques, contact was made with a maximally outstretched arm and an open palm at the peak of the jump.

## Data Collection

The Beijing Olympic Game Ball, the Mikasa MVA200, was used during all services. An official net was used, which was set at regulation height (2.24 m for women, 2.43 m for men), and all serves were performed on a regulation sized volleyball court (9 m  $\times$  18 m). During all serves, participants were instructed to contact the ball as high above the court as possible and serve the ball with the maximum amount of speed that would yield minimal clearance over the net, but still land in the court. Every serve approach was executed along a line which ran the entire distance of the serving movement and was perpendicular to the end line of the court. A researcher stood behind the server noting if the serving motion was not executed along this line. A second researcher qualitatively assessed the ball flight noting if the ball was spinning, contacted the net, or landed out. Trials were not selected for further analysis if any of the above violations were noted.

All serves were captured using a high definition digital video camera (Sony HDV HDR-HC7 Handycam). The camera lens was oriented perpendicular to the plane of motion (sagittal) at a distance of 15 m. The camera collected images at 60 Hz and the shutter speed was set to 725 Hz. According to the sampling theorem, if the sampling rate is twice that of the highest frequency in the signal, then all of the information from the signal has been captured. Wei et al. (1988) demonstrated that the frequency of the force signal acting on a volleyball during a float serve is around 10 Hz. This strongly suggests that any meaningful power in the displacement signal would be less than 10 Hz which means our sampling rate (60



**Figure 1** — Time sequence images demonstrating the execution of the jump-focused (top) and contact-focused (bottom) techniques of the jump float serve. Examples of the digitized points are indicated. The images were created using animation software to provide visual clarity, and are accurately based on the captured trials for Participant 4 (P4).

Hz) was sufficient. Two 1000 W lights placed behind the camera illuminated the capture area. A telephoto lens (37 mm 1.7x Sony VCL-HG1737C) was affixed to the camera and adjusted to maximize the area of interest, which included take-off, five frames of the ball before contact, and five frames of the ball after contact. Horizontal and vertical scaling was initiated by videoing a 1.5 m × 3 m box with reflective markers placed on the corners. A second video camera was placed nearby with the zoom adjusted so as to capture the entire serving motion and complete trajectory of the toss. A total of 232 serves were recorded, but only the best five CF and best five JF serves, from each participant, were chosen for analysis based on a preliminary qualitative assessment (the serve had to be executed in the correct plane, land in the court, and have nominal spin). This was confirmed by reviewing the video data collected using the second, zoomed out, high-definition video camera. A ball was considered to have a nominal amount of spin if it rotated less than 1/4 of a revolution before it reached the horizontal position of the net. The clear images and multicolored ball facilitated this process. All findings presented in the Results section are based on video data captured with the first camera set-up described above.

## Data Analysis

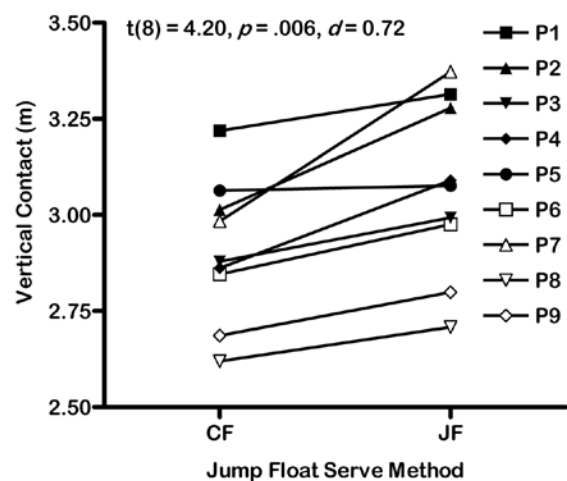
Participant and ball positions were manually digitized using MaxTRAQ software (Innovision Systems Inc., Michigan, USA). Digitized points included the last point of contact between the left foot and floor at take-off as well as the center of the ball for five frames before and five frames following contact (Figure 1). When manually digitizing the ball, the zoom magnification and cross-hair (cursor) size were adjusted so that the edges of the cross-hair extended just to the edges of the ball, which facilitated digitizing the center of the ball. Raw coordinates were input into a customized Matlab program (Mathworks Inc., Massachusetts, USA), which scaled the data and calculated the horizontal and vertical coordinates of the ball at contact (relative to the contact point between the left foot and floor at take-off). The program also determined the vertical velocity of the ball immediately before contact, ball speed immediately after contact, and the initial projection angle of the ball relative to the right horizontal. The central difference method was applied to calculate velocities, and given the small number of data points, the data were not filtered. The best CF and best JF serve, for each participant, were then selected based on the trial which resulted in the highest vertical contact point with the ball. Contact height was chosen as the differentiating variable since it represents the primary theoretical benefit of using the JF method. For example, if contact height was higher with the JF method, then the potential exists, through practice, to improve on other kinematic aspects of the serve such as ball speed and initial projection angle. Only the best serves were analyzed since the maximum potential of each serve technique was of interest.

## Statistical Analysis

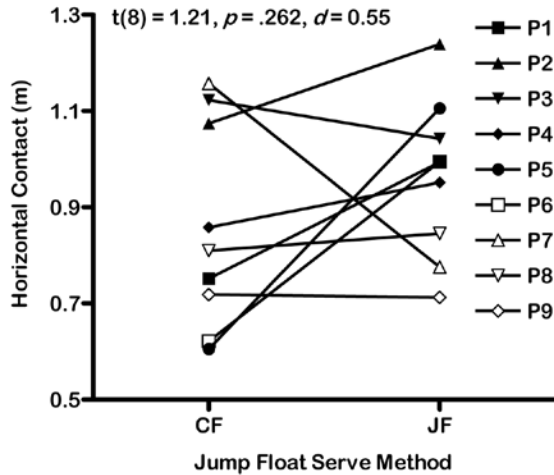
Paired *t* tests were used to detect any statistical differences between the best CF serves and the best JF serves as differentiated by contact height. Contact height, horizontal contact position, precontact vertical ball velocity, initial ball speed, and initial angle were compared between the CF and JF service methods. The formula presented by Dunlap et al. (1996),  $d = t[2(1 - r)/n]^{1/2}$ , which corrects for biases due to the correlation between CF and JF measures, was used to determine effect sizes. In this equation, *t* is the *t*-statistic, *r* is the correlation between the set of pairs, and *n* is the number of pairs. The Holm–Sidak step-down multiple comparison procedure, explained by Ludbrook (1998), was used to ensure that the probability of a Type I error was maintained at  $\alpha = .05$ . All reported *p*-values represent the Holm–Sidak adjusted value. The error associated with the data collection and analysis process was assessed by performing repeated measures on each serve. The video data for each of the 18 serves were analyzed on three separate occasions to determine the coordinates of the volleyball at the moment of server contact. A standard deviation was determined for both the *x* and *y* coordinates across the three measurement occasions. The average of these standard deviations was used as an estimate of the measurement error associated with the process (Bland & Altman, 1996). All statistical calculations were completed with the software package SPSS 15 (SPSS Inc., Chicago, IL).

## Results

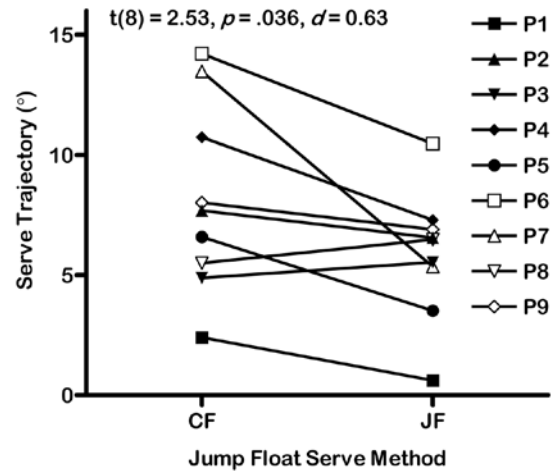
On average, participants contacted the ball 6% (16 cm) higher using the JF method in comparison with the more common CF method (Figure 2). This difference was statistically significant,  $t(8) = 4.20, p = .006$ , and the associated effect size ( $d = 0.72$ ) suggests that the higher contact



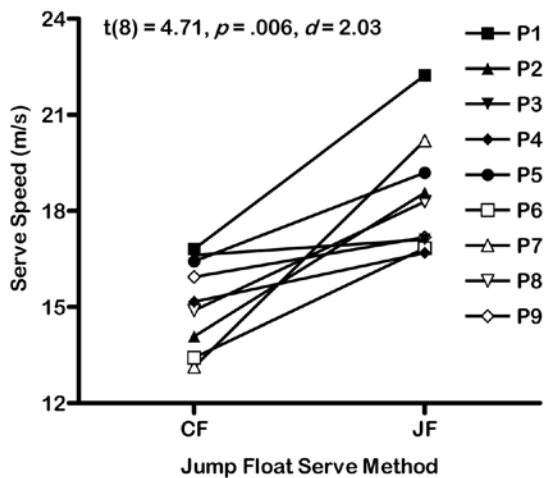
**Figure 2** — Height of the volleyball at time of contact is shown separately for each participant for both the jump-focused (JF) and contact-focused (CF) techniques. Results of the paired *t* test are shown at the top of figure.



**Figure 3** — Horizontal position of the volleyball at time of contact, relative to the jump take-off point, is shown separately for each participant for both the jump-focused (JF) and contact-focused (CF) techniques. Results of the paired  $t$  test are shown at the top of figure.

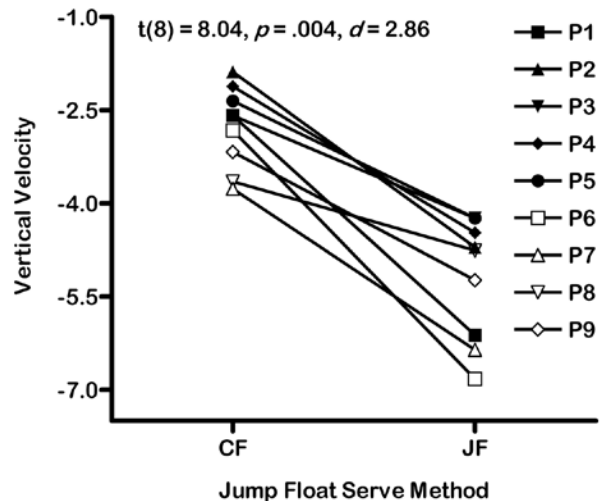


**Figure 5** — Initial projection angle of the volleyball, relative to the right horizontal, is shown separately for each participant for both the jump-focused (JF) and contact-focused (CF) techniques. Results of the paired  $t$  test are shown at the top of figure.



**Figure 4** — Speed of the volleyball immediately after contact is shown separately for each participant for both the jump-focused (JF) and contact-focused (CF) techniques. Results of the paired  $t$  test are shown at the top of figure.

height achieved with the JF technique was meaningful from a practical perspective. As expected, the female participants, P8 and P9, had noticeably lower contact heights. The difference in horizontal contact distance between methods was less consistent as three of the nine participants jumped further in contacting the ball with the CF method (Figure 3). However, on average, participants contacted the ball 12% (10 cm) further from their take-off position while using the JF method,  $t(8) = 1.21$ ,  $p = .262$ ,  $d = 0.55$ . It is of note that, P5, the participant with the greatest difference in horizontal contact (50 cm), had the least increase in vertical contact (1 cm).



**Figure 6** — Vertical velocity of the volleyball, just before server contact, is shown separately for each participant for both the jump-focused (JF) and contact-focused (CF) techniques. Results of the paired  $t$  test are shown at the top of figure.

On average, the speed of the ball immediately after contact was 24% greater (+3.3 m/s) using the JF technique in comparison with the CF method. This difference was statistically significant,  $t(8) = 4.71$ ,  $p = .006$ , and the associated effect size ( $d = 2.03$ ) indicates that the increased speed was meaningful from a practical perspective (Figure 4). The JF method also yielded significantly “flatter” initial projection angles ( $5.9^\circ$ ) relative to the CF technique ( $8.2^\circ$ ),  $t(8) = 2.53$ ,  $p = .036$ ,  $d = 0.63$  (Figure 5).

The vertical velocity of the ball, just before server contact, was measured as an indication of the challenge

presented to the server, to contact the ball as intended, and produce the desired velocity with minimal spin. On average, the vertical velocity of the tossed ball, just before contact, was nearly twice as fast for the JF method ( $-5.2$  m/s) in comparison with the CF method ( $-2.8$  m/s) (Figure 6). This difference was statistically significant,  $t(8) = 8.04$ ,  $p = .004$ , and practically meaningful ( $d = 2.86$ ), illustrating the potential difficulty in contacting the ball with the JF method.

The error ( $\pm 1.2$  cm) associated with the data collection and analysis process was small, relative to the differences found between conditions, signifying that the assessment method used in this study was sufficiently reliable.

## Discussion

As predicted, the proposed JF jump float serve technique resulted in participants striking the ball significantly higher (+16 cm) than with the traditional CF method. This increase is in agreement with previous research which determined that jump spin servers, who use a similar approach as the JF method, jumped meaningfully higher off the ground (54 cm) in comparison with jump float servers (26 cm) (Huang & Hu, 2007). The toss is perhaps the main cause of the difference between the CF and JF service methods. The higher toss that is characteristic of the JF method allows the server more time to execute the jump. The time from ball release to contact, averaged across all participants, was longer for the JF method ( $1.3 \pm 0.1$  s) in comparison with the CF ( $0.9 \pm 0.1$  s). A clear indication of this increase in time was the full use of the arms in the JF method, which can be seen at  $t = 1.4$  s in Figure 1. Based on a review of jumping research, Harman (1990) reported that arm swing has been found to increase jump height by 10–27% and that it is widely accepted that this is because the arm swing increases the impulse from the ground reaction force. From a Newtonian perspective, jump height is determined by the impulse ( $\Sigma F\Delta t$ ) exerted on the participant by the ground during the upward push-off phase of the jump. An increase in time ( $\Delta t$ ) of force application can result in a greater impulse, leading to a greater vertical take-off velocity and consequently a higher jump. The higher jump heights achieved with the JF method resulted in the ball being struck at a higher point above the surface of the court. The magnitude of the increase in contact height was very meaningful from a practical perspective. For example, the 16 cm difference is much higher than jump height improvements reported by studies focused on increasing jump height through physical conditioning (e.g., resistance training and plyometrics) which rarely exceed 10 cm (Ebben & Watts, 1998; Markovic, 2007). It seems logical to assume that volleyball players are jumping when executing float serves in an effort to contact the ball higher. Therefore, it follows that it would be beneficial to use a technique which results in a substantial increase in contact height.

Although the serves included in the statistical analysis were selected based on maximum contact height, the

results indicate that the higher contact points achieved with the JF method were associated with increased ball speeds (+3.3 m/s) and flatter initial projection angles ( $-2.3^\circ$ ) compared with the CF method (Figures 4 and 5). Although flight time was not directly measured, these post impact kinematics (speed, projection angle) indicate that the ball would spend less time traveling from the server to the receiver with the JF method. Although minor, the fact that the ball was contacted on average 10 cm further into the court with the JF method also contributes to the supposition that flight time would be reduced (Figure 3). Therefore, it is reasonable to contend that the JF method generates superior post impact ball kinematics, relative to the current CF technique, which would increase the difficulty for the receiving team to pass the ball. These results were generated following a limited amount of practice with the JF technique, which suggests that the full potential may not have been realized. To determine the true merit of the JF technique, players would need to practice and compete, while implementing the technique, for an extended period of time. In addition, forward dynamic simulation work, such as that conducted on spiking (Kao et al., 1994), should be conducted on ball flight trajectories to specifically determine the theoretical benefit of contacting the ball at higher heights above the court when implementing a jump float serve. Forward dynamic simulations allow the confounding factors of human variability (e.g., variability in toss, jump height, and ball contact) to be controlled and permit the researcher to ask “what if” questions (MacKenzie & Sprigings, 2009).

Interestingly, some researchers might contend that an increase in ball speed beyond a certain magnitude may not be advantageous for a float serve. The erratic movement characteristic of a float serve has been associated with a phenomenon known as the drag crisis, which is thought to be caused by the asymmetric boundary layer separation that occurs when the airflow over the surface of a sphere changes from laminar to turbulent (Achenbach, 1972; Frohlich, 1984; Mehta & Pallis, 2001). The drag crisis is identified by a sudden drop in the drag coefficient ( $C_d$ ), which varies with the velocity of the ball, and is typically measured during wind tunnel experiments. The drag crisis for a volleyball occurs around 14.5 m/s (Mehta, 2008; Mehta & Pallis, 2001; Wei et al., 1988). Serving speeds in this study ranged from 16 to 21 m/s for the JF method. While researchers have effectively demonstrated that the drag coefficient for volleyballs drops at  $\sim 14.5$  m/s, none have explained from a mechanistic perspective how this drop results in erratic motion. There is also evidence suggesting that volleyballs experience large erratic forces, which act perpendicular to the airflow, at speeds beyond the drag crisis region. Wei et al. (1988) measured lateral forces which fluctuated by an amount equivalent to the magnitude of the mean drag over a range of velocities up to 25 m/s, suggesting that volleyballs would move erratically at very high float serve speeds. Although anecdotal, noticeable erratic behavior in all serves included in the final analysis of the present investigation were noted by

the experimenters during data collection. Future research should quantitatively measure the three-dimensional movement patterns of nonspinning volleyballs at speeds such as those demonstrated with the JF method (16–21 m/s), which were above the documented drag crisis region.

Although most types of services can be recognized through the server's actions when executing the serve (Deprá et al., 1998), the JF technique provides the potential for an increased level of deception. This is due to the similarity between the JF method and the standard jump spin serve approach. In baseball, emphasis is placed on a pitcher's ability to foil the batter's expectations (Gray, 2002). Analogous to a batter waiting to see the type of pitch that leaves the pitcher's hand, a volleyball team on the defensive may be misled on the type of serve that is pending. Incorrectly identifying the serve type could have negative repercussions in returning the ball because of the different defensive strategies used to receive spinning versus 'floating' serves. It might be argued that jump spin serves are typically tossed with one hand and that topspin is imparted to the ball during the toss so as to contribute to the topspin supplied by the serve contact. Therefore, some may contend that these attributes would still distinguish a jump spin serve from a JF jump float serve. While tossing the ball with one hand is standard practice, it has not been shown in the literature that the topspin generated by a serve is related to the amount of spin the ball had before contact. In addition, it has been demonstrated that volleyball players are able to generate a high amount of topspin (8 rev/s) during a spike, which consists of hitting a ball that was not previously spinning (Kao et al., 1994). Perhaps of more practical relevance is the jump spin serve technique used by Yanelis Santos of Cuba during the 2008 Beijing Olympics. Santos, who was rated the top female server at the Olympic Games, used a jump spin serve, but tossed the ball from two hands and without spin (FIVB, 2008b). It is the contention of the authors that, in the future, volleyball players should be instructed to use Santo's technique when executing a spin serve, thus making it compatible with the JF jump float serve. Deceiving elements have not been prevalent in the serving strategies of competitive volleyball in the past, exemplifying further the potential benefit of the JF technique.

We predicted that the JF serve would be more difficult to execute because of a higher vertical ball velocity associated with the higher toss. The results supported this prediction, as the ball fell on average 2.45 m/s (88%) faster just before contact with the JF technique. Since JF tosses peaked higher than the CF tosses, the ball had more time to undergo downward acceleration due to the force of gravity. As a result, much practice may be required with this new serve technique to develop a consistent coordination of impact with the greater downward velocity of the ball. Furthermore, when striking the ball with maximum velocity, more difficulty may arise in contacting the ball sharply without imparting spin; further demonstrating the importance of practice.

Despite the clear statistical findings, some limitations should be noted. Future research could involve a higher number of participants from several teams playing at the professional level and the practice time could be extended over several weeks. The entire three-dimensional trajectory of each serve could have been measured to quantify the ball's random movement and confirm that the ball would spend less time traveling from the server to the receiver with the JF method.

In conclusion, the current study provides evidence that the JF technique can present a more difficult passing scenario to the defensive team relative to the conventionally used CF method. The fundamentally different approach in the JF technique yielded higher contact heights, which translated into flatter initial projection angles and greater initial ball speeds. Future consideration should be directed toward modeling the two service techniques to confirm that the improved postimpact kinematics associated with the JF method are a direct result of the higher contact heights.

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