KINEMATIC ANALYSIS OF VOLLEYBALL JUMP TOPSPIN AND FLOAT SERVE

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The purpose of this study is to describe the kinematic characteristics of the volleyball jump topspin and float serve. Thirteen international players performed jump topspin serves and another three players executed jump float serves participated in this study. Two JVC 9800 cameras (120Hz) recorded the players performed jump serves. The results show the jump topspin serve has greater values than the jump float serve on ball velocity, COM velocities at takeoff, jump height, spike height, takeoff to line distance, and horizontal COM displacement. In addition, the mean 1.0cm and 0.7cm of COM spike difference for jump topspin and float serve indicates that elite volleyball players have good timing control during serve action. It is suggested that results from this study can provide useful information for coaches to train volleyball jump topspin and float serve.

KEYWORDS: Kinematic, Volleyball jump serve, Float serve

INTRODUCTION:

Volleyball has been played around the world for over one hundred years. It is estimated to involve many participants world wide making it the most popular participant sport in the world. The play in Volleyball is initiated with a serve. This is usually an overhand serve and may be performed as a float or topspin serves. Additionally the serve may be performed from a standing or jump start. In international volleyball competition, many elite players use the jump topspin serve and jump float serve. The topspin serves start with the player throwing the ball into the air from the baseline and jumping into court to spike the ball toward the opponents. The ball is hit with heavy topspin (and sometimes with sidespin), which makes it difficult for the opponents to receive the ball correctly to the setter. The jump float serve has a similar preparation motion to jump spin serve and is designed to have minimal spin and float with the erratic air currents before dropping sharply into the opposite court. To perform the float serve, the athlete must strike the ball sharply and retract the arm immediately after contacting the ball. This is to minimize the spin on the ball. Since the new rule Rally Point System was introduced in year 2000, the jump serve is ever more important to decide the outcome of game. For master the volleyball jump serve, the player has to practice the correct serve techniques. Understanding how elite athletes performing the jump serve can provide useful information for training athletes how to learn the correct spiking skills.

Coleman (1997) studied 3D volleyball jump topspin serve. He found that pre-impact maximum elbow angular, humerus angular velocity and impact hand velocity correlated significantly with post-impact ball velocity. No significant correlations were found between maximum pre-takeoff lower limb angular velocities and COM vertical velocity. In general, studies related to the biomechanical analysis of the volleyball jump spike mainly focus on adult male subjects performing the two-foot jump spike The purpose of this study is to describe the biomechanical characteristics of the Jump topspin and float serve by elite international volleyball players.

METHODS:

Subjects are selected during the volleyball competition between Taiwanese and Venezuela men's national team held in Taipei 2002. During two matches, thirteen players from two teams performed jump topspin serves and three players executed jump float serves. The subject's characteristics are listed In Table 1 and Table 2. Two JVC 9800 cameras (120Hz) which have field size resolution of 36x240 were set up on each end of service line to record the players performed jump serves. Successful serves were recorded, and their approximate impact (or reception) point on court was noted. One successful attempt for each subject was chosen for 2-D analysis. A calibration board (60cm by 60cm) was videotaped along the serve line by 1m apart to calibrate the video images.

Table 1 - Subject's characteristics of jump topspin serve:

N=13	Minimum	Maximum	Mean ± SD
Age (years)	21.0	30.0	24.9 ± 2.8
Height (cm)	178.0	202.0	193.3 ± 6.1
Weight (kg)	76.0	97.0	87.1 ± 6.5

Table 2 - Subject's characteristics of jump float serve:

N=3	Minimum	Maximum	Mean ± SD
Age (years)	22.0	24.0	23 ± 1
Height (cm)	194.0	199.0	197.3 ± 2.9
Weight (kg)	76.0	98.0	90.3 ± 12.4

Twenty-one body landmarks (head, ears, shoulders, elbows, wrists, fingers, hips, knees, ankles, heels, and toes) were digitized and analyzed with the Kwon3d motion measurement system. Digitizing began approximately five video fields before the last heel strike of the approach and ended six video fields after the ball contact.
The Butterworth 4th order zero lag digital filter with the 6 Hz cutoff frequency was used to filter the body landmarks data. The second central different differentiation method was used to determine velocities. The segment COM, and body COM were calculated by using the Dempster data provided by Winter (l990). The x and y COM of 2D data were calculated by sum of COM of segment in x and y direction and divided by body mass. The COM jump height was defined as the distance between the COM at takeoff to the highest point in the air. The spike height was defined as the height of impact ball to the floor. The takeoff to line distance was defined as horizontal distance of player's toe to the service line. The COM horizontal distance was defined as the COM at takeoff to COM at contact the ball. The COM vertical spike difference was defined as the distance between COM at ball contact and COM at highest point. Differences between upper limb linear kinematics, COM velocities and vertical displacement between jump topspin serve and jump float serve were then analyzed. Associations between upper limb kinematics, COM velocities, post-impact ball velocities were also examined at correction alpha = 0.01 using Pearson Product Moment Correlations.

RESULTS AND DISCUSSION:

Table 3 lists the selected variables of the jump topspin serve and jump float serve during serve action. The jump topspin serve have greater values than the jump float serve on ball velocity, COM velocities at takeoff, jump height, spike height, takeoff to service line distance, and horizontal COM displacement from takeoff to ball contact. The mean ball velocity of topspin serve was greater than that of Coleman (1997) study (23.7/ms) that used Great Britain international players as the subjects. This indicates that jump topspin serve have greater ball velocity and spike height which increase the serve power, however the jump float serve has a lower serve fault rate than the jump topspin serve and the ball float with the erratic air currents before dropping sharply into the opposite court make it a powerful serve skill. The spike heights of players for topspin and float serve were 303.8 cm and 297.4cm respectively, which was much higher than the rules of 243cm net height. The higher the ball at contact, the greater successful rate of serving into the court.
A smaller takeoff to serve line distance for jump float serve also decreases time for ball traveling into to opposite court. The jump topspin serve have a smaller ball velocity than the Coleman's (1993) front-row jump spike (27m/s) and Huang (1999) back-row jump spike (26.7m/s). However, the field speed of 120Hz may be too slow for the high ball release velocity which may increase the error on ball velocity. Coleman reported the COM horizontal and vertical velocities at takeoff were 2.76 m/s and 2.77 m/s respectively. The vertical velocity of COM at takeoff for this study is smaller than that of reported by Samson and Roy (1976) of 3.5 m/s and Coleman et al. (1993) of 3.59 m/s. The mean horizontal displacement

of COM from takeoff to contact the ball for jump topspin and jump float serve was 92.5 cm and 47.1 cm respectively. This shows that topspin server jump higher and forward for increasing the ball velocity, and float serve jump less high and forward than that of topspin serve for controlling the ball. The mean COM spike difference for jump topspin and jump float serve was 1.0 and 0.7 cm respectively. This indicates that elite volleyball players have good timing control during serve action.

Table 3 - Selected variables of jump topspin and float serve

	Topspin serve (Mean ± SD)	Float serve (Mean ± SD)
Ball velocity (m/s)	25.4 ± 5.1	19.7 ± 3.7
COMx.velocity (m/s)	2.7 ± 0.4	2.2 ± 0.4
COMy.velocity (m/s)	3.3 ± 0.4	2.6 ± 0.2
COMr. velocity (m/s)	4.2 ± 0.4	3.4 ± 0.2
COM angle at takeoff (deg)	52.3 ± 3.1	49.2 ± 5.9
COM jump height (cm)	54.3 ± 9.1	26.7 ± 4.5
Spike height (cm)	303.8 ± 28.2	297.4 ± 32.6
Takeoff to line distance (cm)	95.6 ± 37.1	57.2 ± 29.7
COMx displacement (cm)	92.5 ± 14.1	47.1 ± 23.3
COMy spike difference (cm)	1.0 ± 2.5	0.7 ± 1.3

Table 4 lists the upper extremities joint linear velocity of shoulder, elbow, wrist, and finger of jump topspin and jump float serve at ball impact. The jump topspin serve have higher upper limb joint linear velocities than the jump float serve. This is explained that in order to minimize the spin on ball the jump float serve players must strike the ball sharply and retract the arm immediately after impacting the ball. Coleman reported the similar hand impact velocity (16.3 m/s) for his jump topspin serve players. The increases linear velocities from proximal to distal joints for jump serve action is in agreement with other striking, throwing and kicking motions and following the concept of kinematic chain.

Table 4 - Upper limb Joints linear velocity of topspin and float serve

	Spike serve (Mean ± SD)	Float serve (Mean ± SD)
Shoulder velocity (m/s)	3.9 ± 0.9	2.9 ± 1.4
Elbow velocity (m/s)	6.8 ± 1.3	5.1 ± 2.0
Wrist velocity (m/s)	12.0 ± 2.5	10.5 ± 0.7
Finger velocity (m/s)	16.0 ± 2.4	14.0 ± 0.1

Table 5. lists Pearson correlation among selected jump topspin serve variables on 13 players. Results show that ball velocity was significantly correlated with horizontal velocity of COM at takeoff, and elbow, wrist and finger linear velocities at ball impact. Spike height was significantly correlated with vertical velocity of body CM at takeoff. Coleman (1997) found that hand impact velocity was significantly correlated with ball velocity but not the COM horizontal velocity. He also reported significantly correlated among pre-impact maximum elbow angular velocity, humerus angular velocity with ball velocity. Spike height was also significantly correlated with the horizontal body vertical velocity at takeoff. The high correlation among ball velocity and upper limb linear velocity, spike height and body CM velocity at takeoff is in agreement with other throwing and jumping motion. The jumping serve is a 3-D motion. The 2-D method used in the present study may have possible errors on displacement and velocity which is the limitation of this study.

Table 5 - Pearson correlation among selected topspin serves variables:

	Ball v.	CMx.v.	CMy.v.	Spike height	CM angle	Elbow v.	Wrist v.	Finger v.
Ball v.		.55*	-.17	-.01	-.24	.78*	.053*	.48*
CMx.v.	.55*		-.02	.43	-.21	.76*	.75*	.63*
CMy.v.	-.17	-.02		.70*	.60*	-.01	.22	.26

Spike height	-.01	.43	.70*		.22	.19	.44	.45
CM angle	-.24	-.21	.60*	.22		-.35	-.24	-.39
Elbowv.	.78*	.76*	-.01	.19	-.35		.86*	.78*
Wrist v.	.53*	.75*	.22	.44	-.24	.86*		.94*
Finger v.	.48*	.63*	.26	.45	-3.9	.78*	.94*	

*Correlation is significant at the 0.01 level

CONCLUSION:

The purpose of this study is to describe the biomechanical characteristics of the jump topspin and jump float serve performed by elite international volleyball players. The results show the jump topspin serves has greater values than the jump float serve on ball velocity, body CM velocities at takeoff, jump height, spike height, takeoff to line distance, and horizontal body CM displacement. In addition, the mean 1.0cm and 0.7cm body CM spike difference for jump topspin and float serve indicates that elite volleyball players have good timing control during serve action t. It is suggested that results from this study provide useful information for coaches train volleyball jump topspin and float serve.

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