KINEMATICAL ANALYSIS OF FEMALE VOLLEYBALL SPIKE

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The purpose of this study was to analyze female volleyball players' body centre of mass (CM) displacement and velocity when spiking at front and back row. Six high school players participated in this study. Two JVC9800 digital video cameras (120Hz) were used to collect spiking motion. Kwon 3D motion system was used to analyze the kinematic variables. The results indicated that the back-row spike had greater CM resultant velocity at approach and take-off than front-row spike. The back-row spike had greater jumping height and the CM horizontal displacement than front-row spike. The initial ball velocity and angular velocity of shoulder, elbow, and wrist of the front-row spike were greater than back-row spike. This study provides information for coaches in teaching volleyball spike.

KEY WORDS: female, front-row, back-row.

INTRODUCTION:

The amendments of rules completely change the structure of modern volleyball games and make attack become the main tactic to score. In recently years, the Taiwan women's volleyball team has good performance in international volleyball competition. Saunders (1980) studied the effects of approach velocity, he found that vertical velocity of two-foot jump peaks when the approach speed was up to 50~60%of maximum sprint speed. Sturn (2002) indicated the back-row spike is used about 10%~15% in the women's games. Moreover, the back-row spike in position 1 scored most effectively and was mostly used. With inferior stature and jumping ability, we shall actively evolve the attack tactics from front-row to back-row spike in order to enhance the success of attack and counterattack, aiming at getting good performance in the world. The purpose of this study was to analyze the kinematics of female volleyball front and back-row spike.

METHOD:

The subjects were six players of female high school volleyball champion team (average height 173.3 cm, weight 65.2 kg, age 17.2 years old). Two digital video cameras (JVC9800, 120Hz) were synchronized to record the subjects' performing the front-row and back-row spike. Kwon 3D software and Peak calibration frame (see Figure1) were set up in the spike area. Twenty-five control points were used for direct linear transformation (DLT) calibration. The motion direction was defined as X axis –mid-lateral, Y axis -horizontal, Z axis -vertical (see Figure2).

Figure1 Peak calibration frame

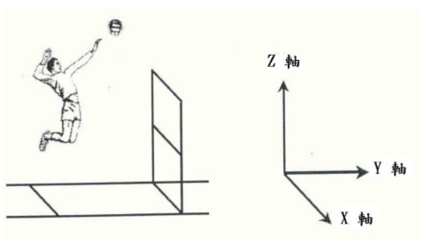
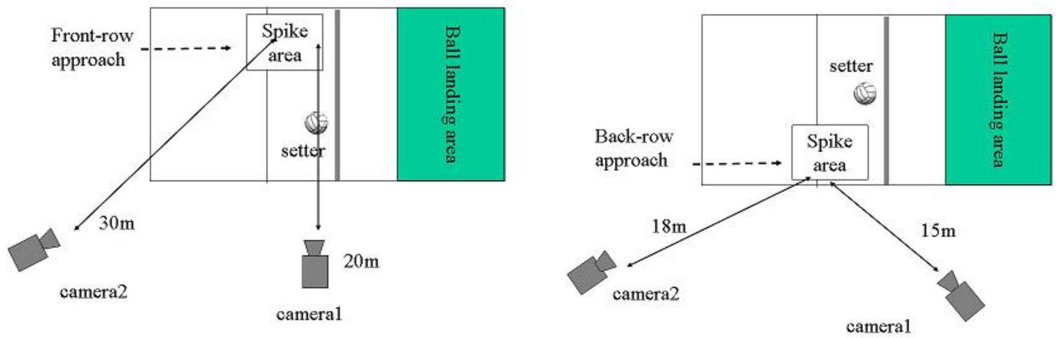


Figure2 Motion directions definition

Each subject performed five successful front-row and back-row spikes into the valid area (see Figure3). Twenty-one body landmarks (head, ears, shoulders, elbows, wrists, fingers, hips, knees, ankles, heels, toes) were digitized with the Kwon 3D software. The Butterworth function with the optimal filtering option was used to filter the data. The segment CM and body CM were estimated by using the Dempster's data that were provided by Winter (1990). The jump height was defined as the height from the vertical displacement of CM at takeoff to the highest point. The CM horizontal displacement was defined from the takeoff to the ball impact. A dependent sample t-test was used to test the variables between front-row and back-row spike.



(a) (b)

Figure3 Experimental setup of the front-row spike (a) and back-row spike (b)

RESULTS AND DISSCUSSION:
Table1 listed the variables of the front-row and back-row spike. The back-row spike had significantly greater resultant CM velocity and horizontal CM velocity than front-row spike at approach and takeoff. The back-row spike also had greater jump height, the horizontal CM displacement and initial ball velocity than front-row spike. The mean vertical CM velocities at takeoff for the front-row and back-row spike were 2.63 m/s and 2.84 m/s respectively. The vertical CM velocity at front-row spike was smaller than the studies reported by Samson and Roy (1976) of 3.5 m/s and Coleman et al. (1993) of 3.59 m/s.

Table1 Variables of the front-row and back-row spike

	front-row spike		back-row spike		t	p
	Mean	S.D	Mean	S.D		
$V_{Rapproach}$ of CM(m/s)	2.70	0.20	3.17	0.24	-7.99*	.001
$V_{Zapproach}$ of CM(m/s)	0.25	0.08	0.38	0.24	-1.78	.095
$V_{Yapproach}$ of CM(m/s)	2.13	0.38	2.99	0.29	-9.43*	.002
$V_{Rtakeoff}$ of CM(m/s)	3.01	0.17	3.45	0.21	-8.62*	.004
$Vz_{takeoff}$ of CM(m/s)	2.63	0.15	2.84	0.19	-6.41*	.002
$V_{Ytakeoff}$ of CM(m/s)	1.32	0.16	2.26	0.25	-12.41*	.001
Jump height(cm)	30.20	2.61	33.74	3.46	-7.27*	.004
CM horizontal displacement(cm)	40.47	6.39	63.58	6.74	-8.74*	.001
Shoulder angular velocity (rad/s)	13.62	1.22	11.34	1.3	6.64*	.000
Elbow angular velocity (rad/s)	17.32	0.41	16.75	0.88	2.04*	.044
Wrist Angular velocity (rad/s)	18.64	0.66	17.98	0.80	3.78*	.001
Ball velocity(m/s)	18.93	1.32	18.08	1.04	3.25*	.005

* $p < .05$

Optimal approach velocity improves the jump height and the horizontal power before volleyball jump spike takeoff. Back-row spike required more horizontal power, and a longer CM displacement could increase the approach velocity. Many researches also showed the positive relationship between body CM horizontal velocity and CM displacement during approach run. In this study, back-row spike have greater CM resultant, vertical, and horizontal velocity at takeoff, which contributed the greater jump height and CM horizontal displacement than front-row spike. The greater jump height can help the spiking ball velocity; however, the result showed that the initial ball velocity of back-row spike was slower than front-row spike, which may be a contradiction to the result shown by the study, but it is not. The velocity of the ball does not only depend on the jump height and CM horizontal displacement. The angular velocity of shoulder, elbow, and wrist is also a critical factor, deciding the velocity of the ball. Table1 showed a comparison of the different angular velocities of shoulder, elbow, and wrist when spiking at the front row and the back row respectively. The front-row spike has greater angular velocity of all the three than the back-row spike, which explains the seeming contradiction and indicated that the subjects on the back-row did not spike the ball at the optimal time.

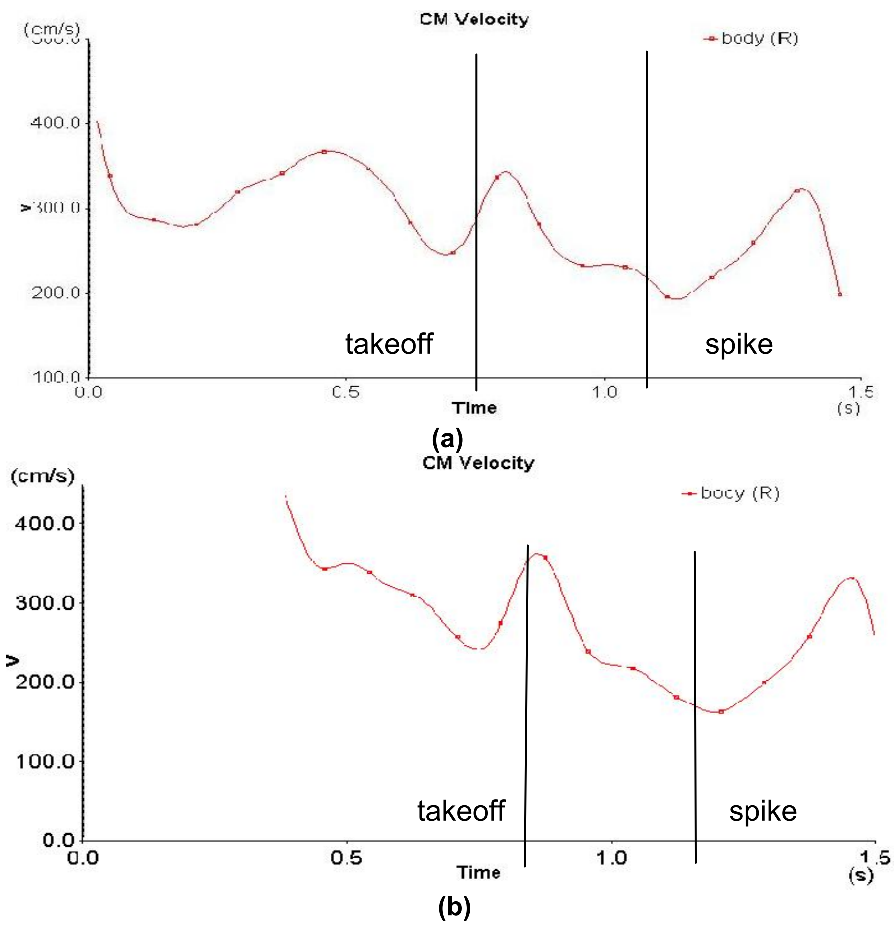


Figure 4: CM velocity variations of the front-row spike (a) and back-row spike (b)

CONCLUSION:

This study described the kinematics characteristics of the female volleyball spike at the front-row and back-row. It was noted that the back-row spike had greater CM velocity (resultant and horizontal) at approach and CM velocity at takeoff than front-row spike. However, the back-row spike had greater jump height and horizontal displacement than the front-row spike, but front-row spike had a greater initial ball velocity than back-row spike. In other words, the subjects' spike technique was better in front-row than back-row. Therefore, players should improve their back-row takeoff timing and swinging arm technique to increase the initial ball velocity. In today's volleyball, the back-row spike plays an important role for winning the game. If the player can improve of back-row spike technique by training, the whole attacking power during the game will be enhanced.

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