# A 3D ANALYSIS OF THE VOLLEYBALL SPIKE

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The purpose of this study was to identify and describe the biomechanical characteristics of the high school volleyball players jump spikes. Eleven elite male players participated in this study. Two Peak high-speed cameras (120 Hz) were genlocked to record the spiking action. The results showed that the spiking techniques of male high school volleyball players are quite similar to those of university volleyball players except for contact ball height. It is suggested that coaches should train the young players jumping ability and fast spiking motion in order to improve spiking power.

**KEY WORDS:** volleyball spike, biomechanical analysis

**INTRODUCTION:** Since the new rule Rally Point System was introduced in year 2000, the spike skill is ever more important to decide the outcome of game. To master the volleyball spike skill, the player has to practice the basic movement at an early age. Understanding how elite high school athletes performing the volleyball spike can provide useful information for training young athletes how to learn the correct spiking skills.
Coleman et al. (l993) indicated that the volleyball jump spike can be divided into the following six phases: approach, plant, takeoff, flight, hitting action and landing and recovery. They studied ten male international volleyball players at the 1991 World Student Games. They reported that the mean vertical velocity of the center of mass at takeoff was 3.59 (0.05) m/s and the height of the jump was 0.62 (0.02) m. Saunder (1980) studied the effects of approach speed on one and two-foot vertical jump performances. Three volleyball players and three basketball players served as the subjects. He found that the vertical velocities of the two-foot jump reached a peak when the approach speeds were up to 50-60 % of maximum sprint speed and the vertical velocities of one-foot jumps were up to 60-70 % of maximum sprint speed to reach the peak. Vint and Hinrichs (1996) found the overall jump and reach heights were similar between one-foot and two-foot jumps. He suggested that one-foot jumps benefited from an increased takeoff height that was largely attributed to the elevation of the free swing leg. 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 was to describe the biomechanical characteristics of the spike performance by the elite high school volleyball players.

**METHODS:** Eleven players from the 2001-2002 Taiwan high school volleyball league champion participated in this study. Their mean height, weight, age, and training years, were 1.82 (0.07) m, 72 (7.9) kg, and 17.2 (1.25) years, 6.3 (2.15) years, respectively. Informed consent was obtained from each subject prior to study. The players had been using the jump spike technique in the past competitions. Two Peak Performance high speed video cameras operating at 120 Hz were genlocked and recorded the action of the subjects performing the jump spike. A peak calibration frame was set up in the spiking area and videotaped before and after the subjects performed the jump spike. Twenty-five control points were used for DLT calibration. Table 1 lists the calibration errors.

**Table 1 Calibration errors.**

| | X | Y | Z | Position |
|---|---|---|---|---|
| Average mean square error (m) | 0.0036 | 0.003 | 0.0048 | 0.0067 |
| Average volume error (%) | 0.1639 | 0.1612 | 0.307 | 0.205 |

Following a brief warm up and stretching period, an assistant passed the ball to the setter who set the ball for the subject to spike the ball into the valid area (Figure I). Each subject was asked to perform three successful jump spike trials. Twenty-one body landmarks (head, ears, shoulders, elbows, wrists, fingers, hips, knees, ankles, heels, and toes) were digitized with the Peak Performance motion measurement system. Digitizing began approximately five video fields before the last heel strike of the approach and ended five video fields after the ball contact.

The Butterworth 6th order zero lag digital filter with the optimal filtering option was used to filter the body landmarks data. The Cubic spline filter with the optimal filtering option was used to filter the ball data. The second central different differentiation method was used to determine velocities. The segment center of masses, and body center of mass were estimated by using the Dempster data provided by Winter (I990).

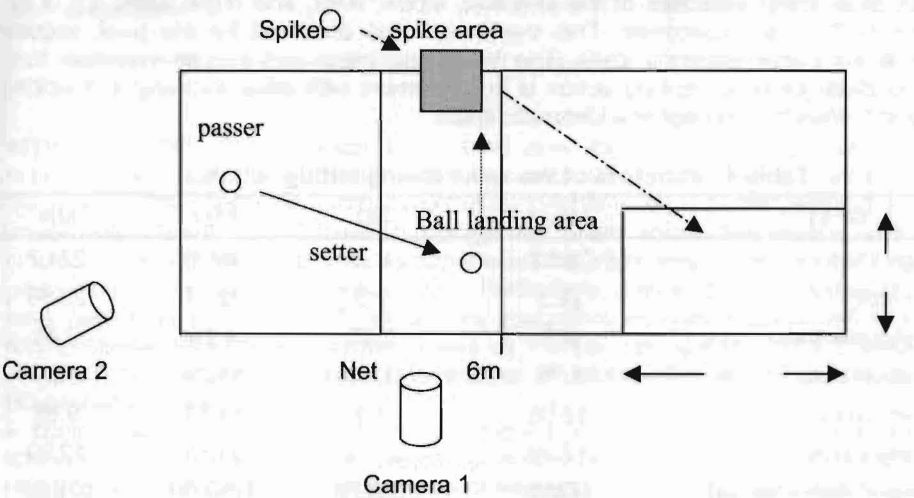


**Figure 1 Experimental setup of volleyball spike.**

**RESULTS AND DISCUSSION:** Table 2 lists the selected variables of the spike during takeoff, The mean vertical velocity of the center of mass (CM) at takeoff for the spike was 3.47 m/s. The values is similar to that reported by Samson and Roy (1976) of 3.5 m/s and Coleman et al. (1993) of 3.59 m/s. The mean CM angle at takeoff was 71.6 degs. The CM velocity and angle at spike takeoff indicated the elite high school players performed the spike motion similar to adult players.

**Table 2 Variables of the spike during takeoff.**

| N=11 | Mean | SD | Max | Min |
|---|---|---|---|---|
| Horizontal velocity of CM at takeoff (m/s) | 1.15 | 0.36 | 1.71 | 0.27 |
| Vertical velocity of CM at takeoff (m/s) | 3.47 | 0.17 | 3.71 | 3.1 |
| Resultant velocity of CM at takeoff (m/s) | 3.86 | 0.19 | 4.29 | 0.35 |
| CM angle at takeoff (deg) | 71.63 | 5.85 | 85.25 | 61.21 |

Table 3 lists the horizontal distance and CM height during the spiking phase. The CM height is a little smaller than the adult male spiking reported by Coleman et al (1993) and Huang et al (1999) studies. The CM horizontal distance was less than the previous study (Huang et al, 1999) as they investigated backrow spiking.

**Table 3 Variables of the spike during flight.**

| N=11 | Mean | SD | Max | Min |
|---|---|---|---|---|
| Horizontal distance of CM at flight (cm) | 49.6 | 12.8 | 70.9 | 21.4 |
| Height of CM at flight (cm) | 58.4 | 7.9 | 71.6 | 41.3 |

Table 4 lists the selected variables of the spike action. The hitting height of the players was 290.2 cm, which was 47.2 cm higher than the rules of 243 cm net height. The higher the spiking point, the higher the spiking height, the harder for the opponent to block the ball, and increased spiking ability. The ball velocity 26.16 m/s of the jump spike was also similar to that reported by Coleman et al. (1993) of 27 m/s who used international players as the subjects. The mean peak linear velocities of the shoulder, elbow, wrist, and finger were 3.7, 8.79, 12.06 and 12.29 m/s respectively. This trend was also observed for the peak angular velocities of the upper extremity joints. The increasing linear and angular velocities from proximal to distal joints for spiking action is in agreement with other throwing and kicking motions and follows the concept of a kinematic chain.

**Table 4 Variables of the spike during hitting action.**

| N=11 | Mean | SD | Max | Min |
|---|---|---|---|---|
| Spiking height (cm) | 290.2 | 8.5 | 305.6 | 271.7 |
| Ball velocity (m/s) | 26.2 | 2.9 | 32.17 | 22.06 |
| Velocity of shoulder (m/s) | 3.7 | 0.55 | 4.76 | 2.48 |
| Velocity of elbow (m/s) | 8.79 | 1.67 | 11.24 | 6.89 |
| Velocity of wrist (m/s) | 12.06 | 1.3 | 14.53 | 9.86 |
| Velocity of finger (m/s) | 17.29 | 2.13 | 21.41 | 12.99 |
| Shoulder angler velocity (deg/s) | 909.3 | 186.78 | 1292.96 | 578.87 |
| Elbows angler velocity (deg/s) | 1229.77 | 299.85 | 2099.89 | 743.66 |
| Wrist angler velocity (deg/s) | 1414.91 | 958.52 | 4042.22 | 415.97 |

**CONCLUSION:** The results show the spiking techniques of male high school volleyball players are quite similar to those of the players from university volleyball team except for contact ball height. It is suggested that coaches should train the young players jumping ability and fast spiking motion in order to improve spiking power.

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