DIFFERENCES BETWEEN MALE AND FEMALE PLAYERS IN THE SAGITTAL PLANE BIOMECHANICS DURING VOLLEYBALL SPIKE LANDING

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The purpose of this study was to investigate the kinematics and kinetics differences between male and female players after a volleyball spike landing. Eight male and eight female university volleyball players were recruited to participate in this study. The kinematic and kinetic data were collected by ten Vicon cameras (300 Hz) and two force plates (1500 Hz). The Visual 3D software was used to analyze the kinematic and kinetic variables. The results indicated that male players exhibited greater peak hip flexion angle, hip range of motion and hip extensor moment compared with female players. Female players exhibited greater peak ankle dorsiflexion and ankle range of motion than male players. These differences demonstrated that male and female players performed different strategies during volleyball spike landing.

KEY WORDS: gender, kinetics, joint moment, injury.

INTRODUCTION: Techniques and tactics are important in volleyball competition. These movements include spiking, blocking, jump serving, and setting. The spike is an active technique to score, and increases the probability of winning. The volleyball landing movement mainly occurred after the spike, block and jump serve. A player with high level technique would perform excellent movement, but it was hidden a risk of injury. Although, volleyball competition is a non-contact sport, but it had a high musculoskeletal injury rate after landing movement (Briner & Kacmar, 1997). The spike is considered a better offensive skill, that results in a higher injury rate than other technique in volleyball competition (Ferretti et al., 1992). Gerberich (1987) reported that a lot of volleyball players had lower extremity injuries which often occurred after landing movement. The increase in jump height is accompanied with a greater ground reaction force, that loading on the musculoskeletal system. Once the impact over loading on the body, the loading was led to musculoskeletal injuries (Dufek & Bates, 1991). Several studies demonstrated that smaller impact ground reaction forces prevented lower extremity injuries (Decker et al., 2003; Kernozek et al., 2005; Mcnitt-Gray et al., 1991; Salci et al., 2004; Schmitz et al., 2007). During landing the lower extremity displayed a more erect posture that would increase the ground reaction force (Decker et al., 2003; Lephart et al., 2002; Schmitz et al., 2007).
Previous studies (Arendt & Dick, 1995; Ferretti et al., 1992) reported that the females possessed a non-contact ACL injury rate four to eight times greater than males in the same competitions such as basketball, handball, and volleyball. Landing movement is one of the primary factor for ACL injury in female. Several studies indicated that females performed landing movement with more erect posture (Colby et al., 2000; Lephart et al., 2002; Rozzi et al., 1999; Schmitz et al., 2007), and exhibited greater knee moment (Salci et al., 2004; Hughes et al., 2010) that produced a great loading on the knee joint. The purpose of this study was to investigate the kinematics and kinetics differences between male and female players after a volleyball spike, in order to understand the mechanism of volleyball spike landing.

METHODS: Sixteen university volleyball players were recruited to participate in this study (8 males and 8 females). Participant information including age, weight, height, and experience are displayed in Table 1. All participants had no previous history of hip, knee or ankle injury, and signed informed consent before the study. Two adjacent force plates (Kistler 9287 & AMTI 5507) embedded into the floor sampling at 1500 Hz were used to measure ground

reaction force to determine initial ground contact of right and left legs on landing. A 10-camera Vicon system (Vicon MX13+, Oxford, UK), sampling at 300 Hz, was used to determine the three-dimensional (3D) coordinates of 61 retro-reflective markers placed directly on the skin of each participant.

The experimental set-up at inside a volleyball court, the standard volleyball net was set at a height of 2.43 m for the male participants and 2.24 m for the female participants.The participants wore their own personal athletic shoes for the testing and asked to warm-up for 10 min. After the warm-up, the participants practiced the spike landing movement until comfortable in the procedure. In the spike landing movement, participants were asked to hit the ball with maximal effort from NO. 3 position to the successful area ($4.5\times9m^2$). Each foot landed on a separate force plate at almost the same time after spike landing. The landing was define from the initial contact with the force plate to the minimal height of centre of mass achieved. The Visual3D V4.0 software (C-motion Inc, USA) was used to calculate kinematic and kinetic parameters. Sagittal plane lower extremity joint angles and moments were calculated for the hip, knee, and ankle during landing phase. Marker trajectories were filtered using a fourth order Butterworth low-pass filter with a cut-off frequency of 10 Hz. Peak vertical ground reaction force was normalized to body weight, and the joint moments were normalized to body mass. An independent t-test was used to test the kinematic and kinetic variables difference between male and female volleyball players. All statistical testing was carried out using the Statistical Package for Social Sciences (SPSS V18.0). The mean and standard deviation were calculated for all variables. Statistical significance was defined with p value less than0.05.

Table 1: Means (SD) of participants information.

	Age (yr)	Height (cm)	Mass (kg)	Experience (yr)
Male (n=8)	20.13 (0.99)	185.88 (4.22)	79 (6.23)	9 (2.77)
Female (n=8)	21.75 (1.03)	170.88 (2.74)	60.75 (3.84)	9.75 (1.66)

RESULTS: The results of means and standard deviations for jump height and joint kinematics are shown in Table 2. Male players were significantly greater jump height than female players. There were no significantly lower extremity joint angles between male and female players at initial contact. Male players exhibited greater peak hip flexion angle and hip range of motion compared with female players. Female players exhibited greater peak ankle dorsiflexion and ankle range of motion than male players.The results of means and standard deviations for peak ground reaction force and joint moments are shown in Table 3. There were no significantly vertical ground reaction force, knee extensor moment and ankle plantarflexor between male and female players. Males exhibited significantly greater hip extensor moment during the landing.

Table 2: Means (SD) of the jump height and joint kinematics between males and females

Kinematic variables	Males	Females
Jump height (m) *	0.71 (0.06)	0.51 (0.02)
Initial contact (deg)		
Hip flexion (+)	17 (8.3)	9.5 (8)
Knee flexion (+)	15.3 (2.6)	12.8 (4.8)
Ankle dorsiflexion (+)	-27.6 (4.8)	-27.8 (3.4)
Peak joint angle (deg)		
Hip flexion (+) *	57.9 (16.9)	34.6 (9.8)
Knee flexion (+)	73.3 (9)	70.7 (6.8)
Ankle dorsiflexion (+) *	17.9 (4.2)	26.9 (3.7)
Range of motion (deg)		
Hip *	40.8 (10.7)	25.1 (4.4)
Knee	58 (8.6)	57.9 (4.5)
Ankle*	45.6 (1.9)	54.7 (5.8)

*P<0.05

Table 3: Means(SD) of the vertical ground reaction force and joint moments between males and females

Kinetic variables	Males	Females
Vertical ground reaction force (N/BW)	4.79 (0.94)	4.47 (1.1)
Peak joint moment (Nm/kg)		
Hip extensor *	5.71 (1.86)	3.87 (1.54)
Knee extensor	4.09 (0.94)	3.95 (0.69)
Ankle plantarflexor	2.74 (0.66)	2.45 (0.39)

*P<0.05

DISCUSSION: In the present study, the data collected at real volleyball court during volleyball spike landing that was difference previous study. Although, in this study there is no difference in knee joint angle between male and female players, but it may be indicated that they were sufficiently utilized knee joint motion to reduce ground impact. We found that males exhibited greater peak hip flexion angle and hip range of motion than females during landing phase. The result of this study was similar previous studies (Salci et al., 2004; Schmitz et al., 2007). During the landing phase to reduce hip flexion angle, it was accompanied with a greater eccentric quadriceps contraction that was increased knee extension moment results in higher external ground reaction forces, may increased anterior translation of the tibia relative to the femur, that may be occur ACL injury (Ball et al., 1999). If sufficient hip range of motion is available, the ground impact would be reduced during landing phase (McNitt-Gray, 1991). In the present study, male player sufficiently utilized hip motion to reduce ground impact that loading on the lower extremity.

We also found that females exhibited greater peak ankle dorsiflexion angle and ankle range of motion than males during landing phase. There are simlar results have been observed by Decker et al.(2003) and Kernozek et al.(2005), females utilized greater peak ankle dorsiflexion and range of motion to absorb impact and safe landing. It was indicated that females fully utilize the ankle plantar-flexor muscles to increase ankle range of motion, that was reduced ground impact. In our study, we found the kinemtic parameters that male and female players display difference landing stategies. Females displayed a more erect landing strategy that would increase the rate of injury during the unstable landing movement.

The result of this study indicated that male players were significantly greater jump height than female players during the spike movement. But there was no difference between male and female players for the vertical ground reaction force. In this study, we set up a real volleyball competition court, the height of net is 2.43m for males, and 2.24m for females in the formal game. Males required a greater jump height to perform the spike movement. Dufek and Bates (1991) reported that greater jump height is accompanied with a greater ground reaction force, that loading on the musculoskeletal system. If the impact was over loading on the musculoskeletal system, it may increase the rate of injury. But we found there's no difference in the vertical ground reaction force, that indicated male players may utilize difference strategies to reduce impact loading during the spike landing.

The result of joint moments in this study, we found that there was no difference in the peak knee extensor moment and peak ankle plantarflexor moment between male and female players. But males exhibited significantly greater hip extensor moment during the landing phase. A number of studies (Salci et al., 2004; Yu et al., 2006; Hughes et al., 2010) reported that females exhibited a greater knee entensor moment during landing, it may be increase the peak ground reaction force. But the result of peak knee entensor moment was no difference between male and female players in this study. In the present study, the result was similar to previous study (Decker et al., 2003; Kernozek et al., 2005). Despite there were no difference in the knee entensor and ankle plantarflexor moment, the male players exhibited greater peak hip moment than female players. An increase in hip extensor moment are associated with a decrease in knee extensor moment (Shimokochi et al., 2009). Therefore, male players increase the hip entensor moment might be reduce more ground impact during spike landing.

CONCLUSION: This study demonstrated that male and female players sufficiently utilized knee joint motion to reduce ground impact, then male players mainly utilized hip joint motion

and female mainly utilized ankle joint motion to perform spike landing. Male players also exhibited greater peak hip extensor moment during landing. These differences confirmed that male and female players performed different strategies during spike landing, it was indicated that they were loaded difference impact on the musculoskeletal. Differences in females may explain the higher ACL injury rate in playing volleyball. Therefore, if females increase more hip motion that may reduce more external loading during spike landing movement.

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Acknowledgement: This study was funded by a grant from National Science Council (NSC 99-2410-H-003-126) in Taiwan.