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

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The purpose of this study was to investigate differences of kinematic variables between male and female volleyball players after a spiking, to understand the mechanism of volleyball spike landing. Eight males and eight females were recruited to participate in this study from the university volleyball team. The kinematic data were collected by ten Vicon cameras (300Hz) and two force plates (1500Hz). The results presented the right hip joint, and both knee joints are significant differences between male and female volleyball players at initial contact. Similarly, at the moment of peak force during the landing phase, the right hip joint and both knee joints are significant differences between male and female volleyball players. These differences demonstrated that male and female players performed different strategies during volleyball spike landing.

KEYWORDS: gender, kinematic, injury.

INTRODUCTION: Even if volleyball is a non-contact sport, but it has a high musculoskeletal injury rate in landing movement (Briner & Kacmar, 1997). The volleyball landing movement mainly occurs after spiking, blocking, and jump serving, and all these motions are performed by jumping. Some studies demonstrated that volleyball players would jump more than 200 times in a competition (Lobietti, Fantozzi, Stagni, & Merni, 2006). The spike is considered a better offensive skill that results in a higher injury rate than other techniques in volleyball competition (Ferretti, Papandrea, Conteduca, & Mariani, 1992). Gerberich (1987) reported that a lot of volleyball players had lower extremities injuries, which often occurred in landing movement. Several studies showed that smaller impact ground reaction force prevented lower extremities injuries (Decker, Torry, Wyland, Sterett, & Steadman, 2003; Kernozek, Torry, Hoof, Cowley, & Tanner, 2005; Salci, Kentel, Heycan, Akin, & Korkusuz, 2004; Schmitz, Kulas, Perrin, & Riemann, 2007). The ground reaction force will increase due to the jump height, the joints range of motion, and the lower extremities stiffness. Bisseling, Hof, Bredeweg, Zwerver and Mulder (2007) pointed out that the stiff landing strategy may increase the risk of injury. That is to say, a good landing technique generates less ground reaction force, which can effectively avoid injuries.

In the landing phase, it was different between females and males, females prefer using ankle plantar flexion to reduce ground reaction force of vertical, but there was not much flexion in hip and knee joints. This type of landing strategy was easy to make ACL injury (Decker et al., 2003; Kernozek et al., 2005; Schmitz et al., 2007). A few studies had revealed that females performed landing movement with more erect posture (Schmitz et al., 2007), and exhibited greater knee moment (Salci et al., 2004; Hughes, Watkins, & Owen, 2010) that produced a great loading on the knee joint. The purpose of this study was to investigate differences of kinematic and kinetic variables between male and female volleyball players after a spiking, to understand the mechanism of volleyball spike landing.

METHODS: Eight males (age: 20.13±0.99 yrs, height: 185.88±4.22 cm, weight: 79±6.23 kg) and eight females (age: 21.75±1.03 yrs, height: 170.88±2.74 cm, weight: 60.75±3.84 kg) were recruited to participate in this study from the university volleyball team. All participants had no previous history of lower extremities injury and provided written informed consent before participation in 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 collect the three-dimensional (3D) coordinates of 65 retro-reflective markers. Markers were placed directly on the skin of

15 segments for each participant. These segments include: head, trunk, right and left upper arm, right and left forearm, right and left hand, pelvis, right and left thigh, right and left shank, right and left foot. (Figure 1).

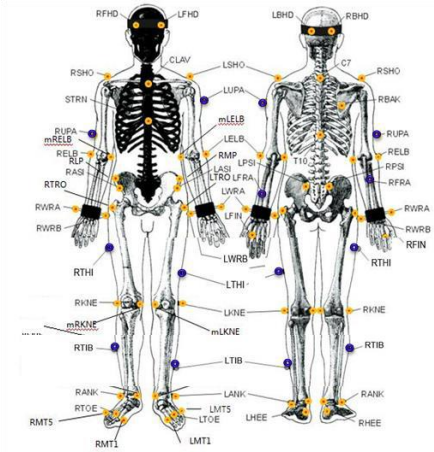

Figure 1: Marker placement.

The experimental set-up was inside a volleyball court, and the standard volleyball net was set at the 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. Participants were required to do their best to hit the ball to the successful area ($4.5\times9\mathrm{m}^2$) in the spike landing movement. (Figure 2). Each foot landed on a separate force plate about the same time after spike landing. The landing phase was defined as the initial contact with the force plate to the lowest point of the center of mass. The Visual3D V4.0 software (C-motion Inc, USA) was used to calculate kinematic parameters. Frontal plane angles of lower extremities, including hip, knee, and ankle joints were calculated during the landing phase. Marker trajectories were filtered using a fourth-order Butterworth low-pass filter with a cut-off frequency of 10Hz. An independent *t*-test was used to test whether the arithmetic mean of kinematic variables between male and female volleyball players reached statistically significant differences. All statistical analyses were completed using the Statistical Package for Social Sciences (SPSS V18.0). The significance level was set at 0.05.

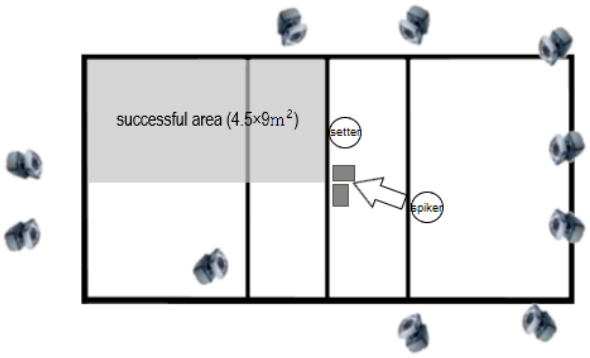

Figure 2: Experimental volleyball court layout.

RESULTS: The results of means and standard deviations (SD) for jump height and lower extremities joints angle at the specific event between males and females are shown in Table 1. The jump height of male volleyball players is significantly higher than female volleyball players. The right hip joint and both knee joints are significant differences between male and female volleyball players at initial contact. Similarly, at the moment of peak power during the landing phase, the right hip joint and both knee joints are significant differences between

male and female volleyball players. The maximum angles of both knee joints are also significant differences between male and female volleyball players during the landing phase. There are no significant differences in the range of joints motion between male and female volleyball players.

Table 1
Means (SD) of the jump height and lower extremities joints angle between males and females.

Variables			M	F
Jump height (m)		*	0.71（0.06）	0.51（0.02）
Joints angle at Initial contact (deg)				
Hip (negative: abduction)	Left		-17.2 (4.5)	-13.6 (4.7)
	Right	*	-1.0 (6.3)	6.8 (3.8)
Knee (negative: valgus)	Left	*	-6.4 (2.2)	-9.9 (2.2)
	Right	*	-2.4 (4.3)	-8.6 (3.5)
Ankle (negative: eversion)	Left		1.4 (3.7)	1.8 (3.3)
	Right		7.2 (4.7)	7.3 (3.4)
Joints angle at peak force (deg)				
Hip (negative: abduction)	Left		-13.3 (6.1)	-10.9 (5.1)
	Right	*	-3.2 (4.5)	7.6 (3.7)
Knee (negative: valgus)	Left	*	-12.6 (4.4)	-17.0 (3.4)
	Right	*	-1.5 (5.0)	-7.0 (4.7)
Ankle (negative: eversion)	Left		-1.0 (2.2)	-0.4 (4.6)
	Right		2.6 (5.0)	3.1 (4.7)
Maximum angle (deg)				
Hip (negative: abduction)	Left		-17.9 (4.9)	-13.8 (4.7)
	Right		-8.6 (3.9)	11.0 (3.1)
Knee (negative: valgus)	Left	*	-18.4 (4.3)	-24.5 (4.5)
	Right	*	-4.3 (7.3)	-12.0 (6.6)
Ankle inversion	Left		3.5 (1.4)	4.8 (1.6)
	Right		6.8（4.4）	7.3（3.3）
Ankle eversion	Left		-4.1 (1.4)	-4.0 (2.8)
	Right		-6.4 (2.0)	-3.9 (4.3)

***p-value<0.05**

DISCUSSION: Previous studies have investigated the kinematic of the frontal plane of the lower extremities during the landing phase (Kernozek et al., 2005; Hughes, Watkins, & Owen, 2008), and most studies focus on the knee joint. Among them, some studies have shown that the large knee valgus angles increase the risk of ACL injury (Kernozek et al., 2005; Hughes et al., 2008). This study found no significant differences between the two gender when their left hip joints presented abduction in the landing phase. However, at the right hip joint, it's significant differences between two gender during the landing phase. Males presented abduction, but females presented the adduction. Ferber, Davis and Williams (2003) pointed out that female runners had more hip adduction when they landed than male runners, and the more hip adduction movement in females may cause knee valgus that could increase the risk of knee injuries. The study also found that females appeared more knee valgus than

males in the landing phase. Some studies have conjectured that females appeared more knee valgus might due to the smaller hip abductor (Ferber et al., 2003; Earl, Monteiro, & Snyder, 2007).

CONCLUSION: This study demonstrated that females appeared more knee valgus than males in the landing phase, and presented adduction movement at the right hip joint. The more hip adduction movement may cause knee valgus. Therefore females may have a higher risk of injury than males during the spike landing.

REFERENCES:

Ball, K. A., Brooks-Hill, A. L., Richards, D., Mark, P., & Evans, R. J. (1999). Lack of hip flexion: A mechanism for ACL injury. *Medicine & Science in Sport & Exercise.* 31(5), S295.

Bisseling, R. W., Hof, A. L., Bredeweg, S. W., Zwerver, J., & Mulder, T. (2007). Relationship between landing strategy and patellar tendinopathy in volleyball. Br J Sports Med, 41(7), e8. doi:10.1136/bjsm.2006.032565

Briner, W. W., & Kacmar, L. (1997). Common injuries in volleyball. *Sports Medicine,* 24(1), 67–71.

Chappell, J. D., Yu, B., Kirkendall, D. T., & Garrett, W. E. (2002). A comparison of knee kinetics between male and female recreational athletes in stop-jump tasks. *The American Journal of Sports Medicine*. 30, 261-267.

Earl, J.E., Monteiro, S.K., & Snyder, K.R. (2007). Differences in lower extremity kinematics between a bilateral drop-vertical jump and a single-leg step-down. *The Journal of Orthopaedic and Sports Physical Therapy*. 37, 245-252.

Ferber, R., Davis, I.M., & Williams, D.S. (2003). Gender differences in lower extremity mechanics during running. *Clinical Biomechanics*. 18, 350-357.

Ferretti, A., Papandrea, P., Conteduca, F., & Mariani P. P. (1992). Knee ligament injuries in volleyball players. *The American Journal of Sports Medicine,* 20(2), 203-207.

Gerberich, S. G. (1987). Analysis of severe injury associated with volleyball activities. *Physical and Sports Medicine,* 15(8), 75-79.

Hughes, G., Watkins, J., & Owen, N. (2008). Gender differences in lower limb frontal plane kinematics. *Sport Biomechanics,* 7(3), 333-341.

Hughes, G., Watkins, J., & Owen, N. (2010). Differences between the sexes in knee kinetics during landing from volleyball block jumps. *European Journal of Sport Science,* 10(1), 1-11.

Kernozek, T. W., Torry, M. R., Hoof, H. V., Cowley, H., & Tanner, S. (2005). Gender differences in frontal plane and sagittal plane biomechanics during drop landings. Medicine and Science in Sports and Exercise, 37(6), 1003-1012.

Lobietti, R., Fantozzi, S., Stagni, R., & Merni, F. (2008). Kinematics analysis of landing from volleyball block. *Gait & Posture,* 28(1), 19.

Rozzi, S.L., Lephart, S. M., Gear, W. S., & Fu, F. H. (1999). Knee joint laxity and neuromuscular characteristics of male and female soccer and basketball players. The American Journal of Sports Medicine. 27(3), 312–319.

Salci, Y., Kentel, B. B., Heycan, C., Akin, S., & Korkusuz, F. (2004). Comparison of landing maneuvers between male and female college volleyball players. *Clinical Biomechanics, 19*, 622-628.

Schmitz, R. J., Kulas, A. S., Perrin, D. H., & Riemann, B. L. (2007). Sex differences in lower extremity biomechanics during single leg landings. *Clinical Biomechanics,* 22(6), 681-688.

Yu, B., Lin, C. F., & Garrett, W. E. (2006). Lower extremity biomechanics during the landing of a stop-jump task. *Clinical Biomechanics.* 21, 297-305.

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