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A COMPARISON OF STRATEGY BETWEEN MALE AND FEMALE DURING SPIKE LANDING

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SUMMARY
The purpose of this study was to investigate the kinematics differences between male and female players after a volleyball spike, in order to understand the mechanism of volleyball spike landing. Eight males and eight females university volleyball players were participate in this study. The kinematic and kinetic data were collected by ten Vicon cameras (300Hz) and two force plates (1500Hz). The Visual 3D software was used to analyze the kinematic and kinetic variables. The results indicated that male players exhibited greater hip flexion angle than female players at peak VGRF and maximum joint angle. Female players exhibited greater maximum ankle dorsiflexion and knee valgus angle than male players. These differences demonstrated that male and female players performed different strategies during volleyball spike landing.

INTRODUCTION
The volleyball landing movement mainly occurred after the spike, block and jump serve. Although, volleyball competition is a non-contact sport, but it had a high musculoskeletal injury rate after landing movement [1]. The spike is considered a better offensive skill that results in a higher injury rate than other technique in volleyball competition [2]. Most of lower extremity injuries, the anterior cruciate ligament (ACL) injury is one of the serious injuries in the sport competition. Previous studies [2,3]. 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. ACL injuries are often occurred in sudden deceleration movement, such as landing movement. During the landing phase to reduce hip flexion angle in the sagittal plane, it was accompanied with a greater eccentric quadriceps contraction that was increased higher external ground reaction forces, may increased anterior translation of the tibia relative to the femur, that may be occur ACL injury [4]. In addition, lower extremity joint angle in the frontal plane was contributed on the landing movement. The greater knee joint movement in the frontal plane, that might be results in greater the possibility of strain on associated ligaments. Previous studies reported that Females exhibited a greater knee valgus angle during landing [5,6]. The abnormal valgus knee movement is a high risk factor for ACL injury. The purpose of this study was to investigate the kinematics 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, 8 females (age = 21.75 ± 1.03, height = 170.88 ± 2.74, weight = 60.75 ± 3.84) and 8 males (age = 20.13 ± 0.99, height = 185.88 ± 4.22, weight = 79 ± 6.23), were recruited to participate in this study. All participants had no previous history of lower extremity 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. Markers were 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 defined 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. Frontal plane lower extremity joint angles 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 10Hz. Peak vertical ground reaction force was normalized to body weight. 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.

RESULTS AND DISCUSSION

The results of means and standard deviations for jump height and joint kinematics are shown in Table 1. The result of this study indicated that male players were significantly greater jump height than female players during the spike movement. 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. The increase in jump height is accompanied with a greater ground reaction force, but there was no difference between male and female players for the vertical ground reaction force. It was indicated that males and females utilized different strategies during spike landing movement.

In the sagittal plane, there were no significantly lower extremity joint angles between male and female players at initial contact. Male players exhibited greater hip flexion angle at peak VGRF and maximum joint angle compared with female players. The result of this study was similar previous studies [7,8]. Female volleyball players exhibited lower hip flexion and muscular strength during landing were considered to be a leading factor for increased ACL injuries [7]. In addition, this study found that female players exhibited greater maximum ankle dorsiflexion than male players. This difference was indicated that females sufficiently utilized ankle dorsiflexion to reduce ground impact and perform safely landing movement [6].

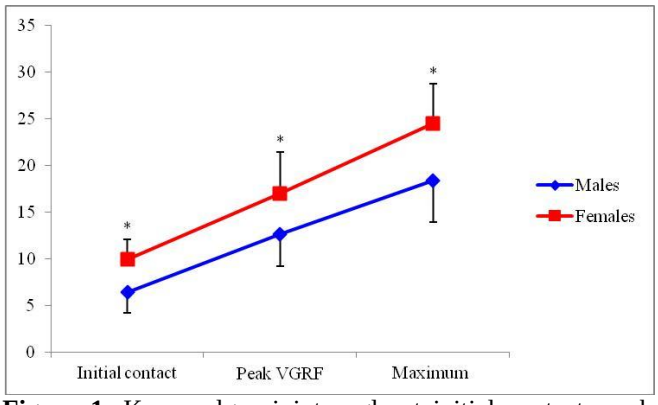

Figure 1: Knee valgus joint angle at initial contact, peak VGRF and maximum joint angle for males and females. *Significant difference ($P < .05$).

Although we found that there was no difference between males and females for the knee joint angle during the landing phase in the sagittal plane, but females exhibited greater knee valgus angle than males (Figure 1). In the frontal plane, there were no difference in the hip and knee joint angle between males and females during landing phase. Females exhibited greater knee valgus angle than males at initial contact, peak VGRF and maximum angle. The result of this study was similar the previous studies [5,6]. Many studies reported that exhibited greater knee valgus angle might increase the risk of ACL injury. Females displayed a greater knee valgus angle than males at peak VGRF. At the time of peak vertical ground reaction force, it was indicated that lower extremity load maximal ground impact. Therefore, an excessive strain on the ligament at peak VGRF was accompanied with a greater risk of ACL injury.

During the landing phase to reduce hip flexion angle, it was accompanied with a greater eccentric quadriceps contraction that combined with a greater knee valgus angle might increase to strain on the ACL [4,5,6].

CONCLUSIONS

In this study, males exhibited greater hip flexion angle, then females exhibited greater ankle dorsiflexion and knee valgus angle. These differences confirmed that male and female players performed different strategies during spike landing. Females exhibited a less hip flexion angle and a greater knee valgus angle than males during the spike landing, it might increase risk of ACL injury. These differences might explain the higher ACL injury rate in playing volleyball.

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Table 1: Means (SD) of the jump height, vertical ground reaction force and sagittal plane joint kinematics (at initial contact, at peak VGRF, at maximum joint angle) between males and females.

Kinematic variables	Males	Females
Jump height (m) *	0.71 (0.06)	0.51 (0.02)
VGRF (N/BW)	4.79 (0.94)	4.47 (1.1)
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 VGRF (deg)		
Hip flexion (+) *	28.1 (5.6)	18.1 (4.7)
Knee flexion (+)	37.4 (8.3)	39.5 (8.9)
Ankle dorsiflexion (+)	7.4 (7.5)	12.8 (10.5)
Maximum 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)

*$P<0.05$

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