THE EFFECT OF SIDE STEP ON LOWER EXTREMITY BIOMECHANICS DURING BLOCK LANDING IN FEMALE VOLLEYBALL PLAYERS

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The purpose of this study was to examine the effect of block and side step block on lower extremity biomechanics during landing in female volleyball players. Eight female university volleyball players participated in this study. The kinematic and kinetic data were collected by eight Vicon cameras (250 Hz) and two force plates (1000 Hz). The Visual 3D software was used to analyze the kinematic and kinetic of block and side step block landing variables. The results showed a significantly higher knee extensor moment during side step landing than the block landing at the time of peak vertical ground reaction force and peak joint moment. It was concluded that female players displayed greater knee extensor moment during the side step before block landing that may increase the loading on the knee.

KEY WORDS: injury, lateral movement, joint moment, sagittal plane.

INTRODUCTION: Block is the first line of defense and an offensive skill in the volleyball competition. Many volleyball players perform the lateral movement before the block. The volleyball competition showed that players jump over 80% of the time after lateral movement (Lobietti, 2008). Although, volleyball competition is a non-contact sport, but it had a high musculoskeletal injury rate after landing movement (Briner & Kacmar, 1997). Many volleyball players often occurred injuries in lower extremity after landing movement (Gerberich, 1987). ACL repture is a serious lower extremity injury, and landing is one of the primary mechanisms for ACL injury (Ferretti, Papandrea, Conteduca, & Mariani, 1992). Previous studies (Arendt & Dick, 1995; Ferretti et al., 1992) reported that the females had non-contact ACL injury rate four to eight times greater than males in the same competitions such as basketball, handball, and volleyball. Several studies indicated that females performed landing movement with more erect posture (Colby et al., 2000; Lephart et al., 2002; Rozzi, Lephart, Gear, & Fu, 1999; Schmitz, Kulas, Perrin, & Riemann, 2007), and exhibited greater knee extensor moment (Salci et al., 2004; Hughes, Watkins, & Owen, 2010) that produced a great loading on the knee joint. Therefore, it was important to reduce the ground impact more efficiently during landing. Hughes et al. (2010) reported that female displayed greater knee flexion angle than male during volleyball block landing, but it were no differences in the joint moment in the sagittal plane. Previous study (Hughes et al., 2008, 2010) mainly focused on block landing, but players mostly performed lateral movement before block landing. To our knowledge, no study investigates the effect of lateral movement on lower extremity biomechanics during volleyball block landing. The purpose of this study was to examine the effect of stand and side step on lower extremity biomechanics during block and side step block landing in female volleyball players, and to understand the important variable of block and side step block landing movement in the injury risk of lower extremity.

METHODS: Eight females (age: 20.4±1 yrs, height: 170.3±5 cm, weight: 63.6±6.2 kg) were recruited from the university volleyball team. All participants signed informed consent before the study. Two adjacent force plates (Kistler 9287 & AMTI 5507) embedded into the floor sampling at 1000 Hz were used to measure ground reaction force to determine initial ground contact of right and left legs on landing. An 8-camera Vicon system (Vicon T20-S, Oxford, UK), sampling at 250 Hz, was used to collect the three-dimensional (3D) coordinates of 51 retro-reflective markers. Markers were placed directly on the skin of 15 segments for each participants. 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). Cameras and force plates were synchronized to collect kinematics and kinetics data during block jump and block landing after lateral movement.

The experimental set-up was inside a volleyball court, the standard volleyball net was set at a height of 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 stand and side step block landing movement until comfortable in the procedure. A volleyball player spiked opposite to participants on the wooden box. All participants performed block jump block and dominant side step block. The stand block jump was defined as the subject stand each foot on two force plates and block landing on the same two plates. The side step block landing was defined as the subject stand still and move right foot to the first plate and left foot to the second plate and block jump landing on the same two plates. Each foot landed on a separate force plate at almost the same time after block jump and side step block landing. The landing phase was defined from the initial contact with the force plate after the block to the minimal height of center of mass achieved. The Visual3D V5.0 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 10Hz. Peak vertical ground reaction force was normalized to body weight, and the joint moments were normalized to body mass. An paired *t*-test was used to test the kinematic and kinetic variables. All statistical testing was carried out using the Statistical Package for Social Sciences (SPSS V20.0). The mean and standard deviation were calculated for all variables. Statistical significance was defined with p value less than 0.05.

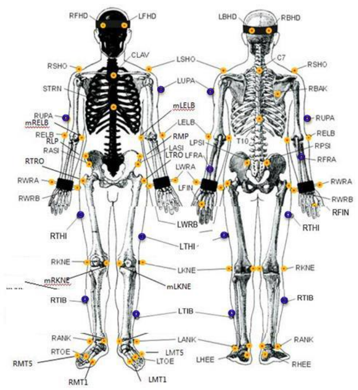

Figure 1: Marker placement

RESULTS: The results of means and standard deviations (SD) for joint kinematics are shown in Table 1. There were no significantly lower extremity joint angles between block jump landing and side step block landing. The results of means and SD for peak vertical ground reaction force and joint moments are shown in Table 2. There were no significantly peak vertical ground reaction force and lower extremity joint moment between two landings at initial ground contact. There was a significantly higher knee extensor moment during side step block landing at the time of peak vertical ground reaction force (PVGRF) and peak joint moment.

Table 1
Means (SD) of the joint kinematics between block and side step block landing

Kinematic variables	Block jump	Side step block
IC joint angle (°)		
Hip flexion (+)	1.4 (4.7)	- 1.1 (3.3)
Knee flexion (+)	10.8 (3.6)	12.3 (3.3)

Ankle dorsiflexion (+)	-28.9 (3.5)	-29.9 (3.2)
PVGRF joint angle (°)		
Hip flexion (+)	13.9 (6.9)	10.9 (7.7)
Knee flexion (+)	45.5 (5.3)	46.4 (5.9)
Ankle dorsiflexion (+)	26.6 (1.6)	27.8 (2.4)
Maximum joint angle(°)		
Hip flexion (+)	24.6 (14.3)	23.1 (17.6)
Knee flexion (+)	62.5 (11.6)	64.3 (11.9)
Ankle dorsiflexion (+)	31.5 (2.6)	32.2 (2.7)
Range of motion (°)		
Hip	23.3 (11.7)	24.2 (14.9)
Knee	51.6 (12.3)	52 (11.9)
Ankle	60.4 (1.9)	62.2 (1.7)

*Significant difference between block and side step block (P<0.05); IC = Initial contact; PVGRF = at the time of peak vertical ground reaction force. Positive values indicate flexion angle and negative values indicate extension angle.

Table 2
Means(SD) of the vertical ground reaction force and joint moments between block and side step block landing

Kinetic variables	Block jump	Side step block
VGRF (BW)	2.89 (0.82)	3.33 (0.77)
IC joint moment (Nm/kg)		
Hip extensor	-0.42 (0.36)	-0.47 (0.27)
Knee extensor	-0.21 (0.20)	-0.24 (0.17)
Ankle plantar flexor	-0.05 (0.07)	-0.05 (0.10)
PVGRF joint moment (Nm/kg)		
Hip extensor	-0.87 (0.78)	-1.06 (0.76)
Knee extensor *	-2.51 (0.86)	-3.08 (0.82)
Ankle plantar flexor	-2.28 (0.71)	-2.27 (0.52)
Peak joint moment (Nm/kg)		
Hip extensor	-2.04 (0.52)	-1.86 (0.44)
Knee extensor *	-3.03 (0.91)	-3.59 (0.81)
Ankle plantar flexor	-2.52 (0.77)	-2.52 (0.54)

*Significant difference between block and side step block (P<0.05); IC = Initial contact; PVGRF = at the time of peak vertical ground reaction force. Positive values indicate flexsor moment and negative values indicate extensor moment.

DISCUSSION: The result showed that there were no significantly lower extremity joint angles between block jump landing and side step block landing. Although, in this study there is no difference in the kinematics between block jump landing and side step block landing, but we found that there were differences in the knee joint moment during landing when female performed side step block landing. The result showed that a greater knee extensor moment during side step landing at the time of peak vertical ground reaction force. It was indicated that knee joint had a greater loading during side step block landing. Chappell et al. (2002) reported that the landing phase generates larger anterior knee shear forces compared with the takeoff phase. And females exhibit greater proximal tibia anterior shear forces and larger knee extension during the landing phase. We also found that a greater peak knee extensor moment during side step landing. A number of studies (Salci et al., 2004; Yu et al., 2006; Hughes et al., 2010) reported that females exhibited a greater knee extensor moment during landing, it may increase the risk of ACL injury. A greater eccentric quadriceps contraction that was increased knee extension moment results in higher external ground reaction forces, which increased anterior translation of the tibia relative to the femur, that might occur ACL injury (Ball et al., 1999). Therefore, females performed lateral side step movement before the block increase loading on knee joint.

CONCLUSION: This study demonstrated that lateral movement may alter lower extremity biomechanics during landing. It was concluded that female players displayed greater knee extensor moment during the side step before block landing that may increase the loading on the knee. It was suggested that volleyball coaches and players to decrease lateral side step movement before block landing while lower extremity muscles fatigue in the training. That might reduce overloading on the knee joint and risk of injury.

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