EFFECTS OF LANDING HEIGHT ON LOWER EXTREMITY JOINT BIOMECHANICS DURING UNILATERAL AND BILATERAL LANDINGS

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The aim of this study was to examine the lower extremity kinematics and kinetics during landing phase, in response to the effects of landing height during unilateral and bilateral landing. Ten young healthy male subjects (age: 26.1±1.8yr, height: 183.2±4.4cm, weight: 76.1±6.9kg) participated in this study. Each subject performed the unilateral and bilateral landing from a 30cm and 45cm wooden platform. The results showed the peak vertical ground reaction force (PVGRF) was increased during unilateral landing and at greater landing height ($p < 0.05$). The knee joint valgus angles were elevated during bilateral landing, the knee joint valgus moment were higher during unilateral landing than bilateral landing ($p < 0.05$). Based on our findings, to minimize the PVGRF and the valgus moment at the knee joint, bilateral landing is recommended for landing maneuvers.

KEY WORDS: unilateral landing, bilateral landing, landing height.

INTRODUCTION: Unilateral and bilateral landings are common athletic maneuvers and typically executed from various landing heights during sports activities (Coventry et al., 2006). Landing-related injuries are common in sports activities due to large landing impacts primarily attenuated in the lower extremity (Dufek & Bates, 1991; Harringe et al., 2007).

Although injuries of the lower extremities can occur during bilateral and unilateral landings, unilateral landings are considered more dangerous, due to the decreased base of support and increased demand required by one limb to absorb the impact of landing (Yeow et al., 2008). Many studies have examined the effects of landing height and landing styles on lower extremity biomechanics (Pappas et al., 2007; Yeow et al., 2008). Understanding how the lower extremity may respond to energy dissipation between unilateral and bilateral landing according to the landing height may help explain why unilateral landing leads to a higher injury risk relative to bilateral landing.

Therefore, the purpose of this study was to examine the lower extremity kinematics and kinetics during the landing phase in response to the effects of landing height during unilateral and bilateral landing.

METHODS: Ten young healthy male subjects (age: 26.1±1.8yr, height: 183.2±4.4cm, weight: 76.1±6.9kg) participated in this study. Healthy was defined as having no previous orthopedic injury or neurological disorder of the lower extremity that impaired performance during recreational activity. Sixteen passive reflective markers (14 mm) were attached to anatomical landmarks of both legs (anterior superior iliac spin, posterior superior iliac spine, mid-thigh, lateral condyle of the femur, mid lower leg, lateral malleolus of the fibula, calcaneus and second metatarsal). Each subject performed unilateral and bilateral landings from a 30cm and 45cm wooden platform placed 20 cm behind the rear edge of a calibrated force platform (AMTI, OR 6–7, Watertown, MA). The movements of the lower extremity segments were tracked with an 8-camera Vicon motion analysis system (MX-F20; Oxford Metrics Ltd, Oxford, UK) collected at 200 Hz. Ground reaction force data were collected at 2000 Hz and synchronized with the motion analysis system for simultaneous collection. The 3Dimensional marker trajectories were recorded and kinematic and kinetic variables were calculated using Plug-in Gait in Nexus software (version 1.6; Oxford Metrics, Oxford, UK). Inverse dynamics analyses were used to calculate joint moments in the lower extremities from kinematic data and force plate data with Plug-in Gait. Positive frontal plane joint moments indicated hip adduction, knee abduction and ankle abduction moments. The collected 3D coordinates of the marker trajectory data were filtered using a Woltering quintic spline filter with a predicted mean square error of 10 mm. The force plate data were filtered using a Butterworth low-pass digital filter with a 100 Hz cut-off frequency. All kinetic data were normalized by body weight (kg) and height (m). Two-way ANOVA (unilateral/bilateral landing style × landing height) with repeated measures were used to test for significant differences in joint angle in the sagittal and frontal planes, total flexion displacement time to peak flexion, energy absorption, and ground reaction forces. The level of significance was set at $p < 0.05$.

RESULTS & DISCUSSION: Results of this study showed that the knee joint angles were greater during bilateral at greater landing height ($p < 0.05$) (Figure 1).

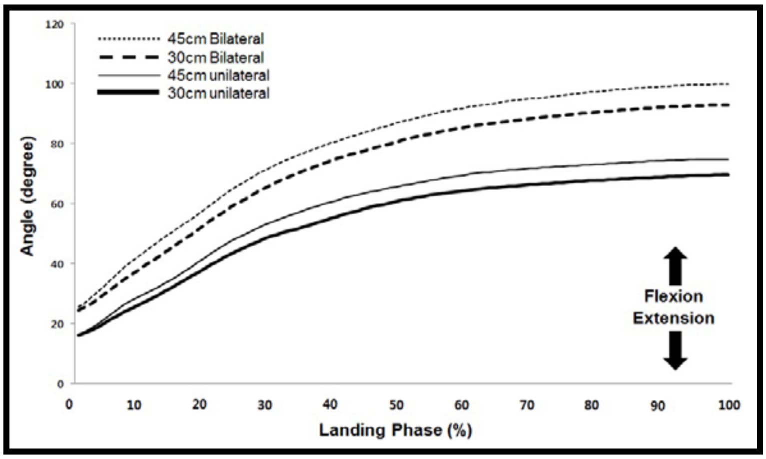

Figure 1: Knee joint angle in the sagittal plane.

Reduced vertical ground reaction force during landing can be achieved through increased flexion at the hip and knee joints (Yu et al., 2006; Zhang et al., 2000). Thus, the peak vertical ground reaction force was increased during unilateral and/or at greater landing height ($p < 0.05$) (Figure 2).

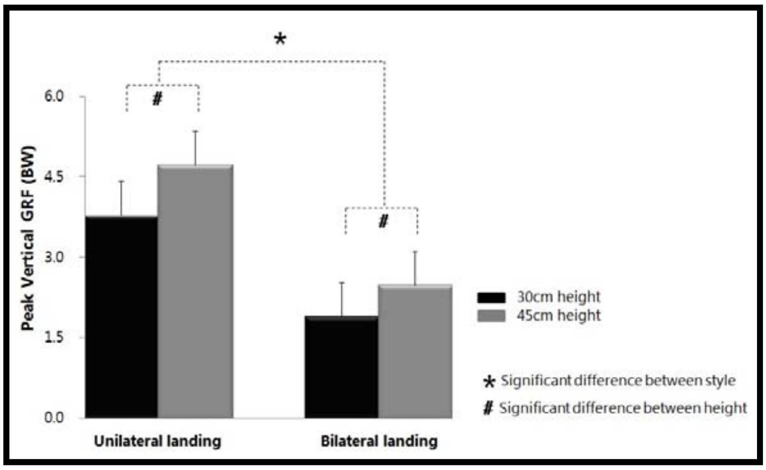

Figure 2: Peak vertical ground reaction force.

Previous research has shown that the magnitude of vertical ground reaction force is an important risk factor for lower extremity injuries (Dufek and Bates, 1991). Our results indicated that the drop landing with bilateral might be better for absorbing the landing impact than unilateral landing.

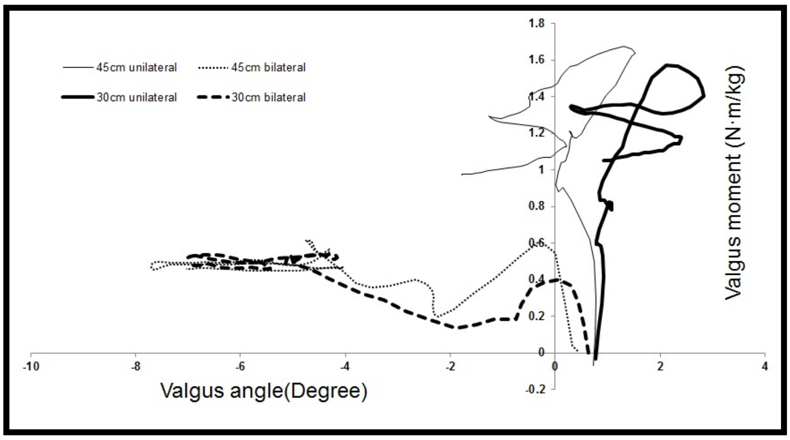

Figure 3: The angle to moment at the knee joint.

We also found that the ankle joint eversion angle and eversion moment were higher during unilateral than bilateral landings ($p < 0.05$). While the knee joint valgus angle was elevated during bilateral, the knee joint valgus moment was about 2.6 times higher during unilateral than bilateral landing (Figure 3). Hewett et al. (2005) reported that the presence of large knee joint valgus moment during landing could increase the risk of sustaining ACL injury. Our results implied that it is highly probable that unilateral landing would place the knee joint at a greater risk for injury.

CONCLUSION: In conclusion, the knee joint and hip joint flexion angle were lower during unilateral landing. The vertical ground reaction force was greater during unilateral landing.
Also, the knee joint valgus angles were elevated during bilateral landing, the knee joint valgus moment were higher during unilateral landing than bilateral landing. Based on these results, to minimize the peak vertical ground reaction force and the valgus moment at the knee, bilateral landing is recommended and injury prevention training may be needed to correct strategies for landing maneuvers.

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