GENDER DIFFERENCES IN UNILATERAL LANDING MECHANICS FROM ABSOLUTE AND RELATIVE DROP HEIGHTS

Zach A. Sievert, Bobbie Irmischer, Yashona Robinson, Justin Seligman, Joshua T. Weinhandl

Old Dominion University, Norfolk, VA, USA
email: zsiev001@odu.edu

INTRODUCTION
The growth of female participation in sport has led to an increase in ACL injuries in female athletes. Gender differences in landing mechanics may be due in part to decreased muscle strength, increased flexibility, and delayed hamstring activation relative to the quadriceps often observed in women [1]. These differences may place the knee in a dangerous position, reducing the stabilization and increasing forces transmitted through the joint.

Landing mechanics have been reported using absolute and relative drop. Females exhibited increased knee abduction and vertical ground reaction forces compared to males in unilateral and bilateral landings from absolute heights [2]. Further, gender differences in frontal plane knee have been reported in absolute height unilateral landings [3]. However, when relative drop heights were employed, a gender effect was only reported for hip and knee sagittal plane kinematics [4]. It appears that absolute jump heights may inflate gender differences in landing mechanics. Increased landing height has been associated with increased vertical GRF in unilateral landings [5]. As height increases, the amount of force that must be dissipated increases as well. Thus, landing from a height greater than the participant’s jumping ability, may not capture natural landing mechanics. The purpose of this study was to compare ground reaction forces, as well as lower extremity kinetics and kinematics of males and females when landing from absolute heights and a height equal to their maximum jumping ability.

METHODS
Five healthy, recreationally active men (81.2 ± 10.4 kg, 1.78 ± 0.03 m) and five healthy, recreationally active women (59.6 ± 7.4 kg, 1.62 ± 0.11 m) aged 18 to 30 years volunteered to perform unilateral landings onto a force plate. Prior to data collection, participants were informed of study procedures and provided written informed consent in accordance with institutional guidelines. Single reflective markers were placed on specific anatomical landmarks [4] and a static standing calibration trial (neutral position) was collected. Participants were asked to complete five right side unilateral drop landings from 30, 40 and 50 cm, as well as a box set to their vertical jumping ability. Three dimensional marker coordinate data were collected at 200 Hz using an eight-camera Vicon motion analysis system. Synchronously, three-dimensional force data was collected at 1000 Hz using a Bertec force plate.

Raw three-dimensional marker coordinate and GRF data were low-pass filtered using a fourth-order, zero lag, recursive Butterworth filter with cutoff frequency of 15 Hz. A kinematic model comprised of eight skeletal segments (trunk, pelvis, and bilateral thighs, shanks, and feet) was created from the standing calibration trial [4]. Three-dimensional ankle, knee, and hip angles were calculated using a joint coordinate system approach [6].

To compare lower extremity joint dynamics between the landing heights peak posterior and vertical GRF, and initial contact (IC) knee joint angles were identified. A 2×4 repeated measures ANOVA (gender×landing height) was performed for each dependent variable (p<0.05).

RESULTS AND DISCUSSION
Gender differences were observed as men landed with 0.68 N·kg⁻¹ significantly more peak posterior GRF compared to women (p=0.004) (Table 1), and women landed with 4.1° significantly less IC knee adduction then men (p<0.001) (Figure 1).

When comparing the absolute landing heights to the relative landing height differences were only
observed between the peak vertical GRF and IC knee adduction angle. Compared to the 50 cm landing height, landings from a relative height were performed with 6.16 N·kg⁻¹ significantly less peak vertical GRF \( (p=0.005) \) and 1.4° significantly more knee adduction at IC \( (p=0.018) \).

Changes were also observed as absolute height increased. These included decreased knee flexion and external rotation at IC, as well as increased peak posterior and vertical GRF.

The results of the current study support the findings of Yeow et al. [5] who reported an increase in resultant GRF as landing height was increased from 30 cm to 60 cm. These authors also reported a decrease in knee flexion angle as landing height increased which is consistent with the current findings. The observed increases in peak posterior and vertical GRF may be a result of the decreased knee flexion at IC [4]. This stiffer landing style is likely to result in increased loading of the ACL [7].

The decreased knee adduction at IC demonstrated by women in the current study is consistent with findings of Russell et al. [3]. Furthermore, as landing height increased women exhibited a shift towards knee abduction at IC, a position that has been associated with increased ACL injury risk [1]. However, since the average jump height of women in the current study was 27 cm these higher landing heights may have represented a task that is unlikely to occur in a natural environment.

**CONCLUSIONS**

The observed differences in peak vertical GRF and knee adduction angle at IC suggest between the highest landing height (50 cm) and a height specific to each individuals jumping ability suggest that extreme heights create a task that is unrealistic for many individuals. Future studies investigating landing mechanics should consider implementing drop heights that are scaled based on participants’ jumping abilities. Such comparisons are likely to provide a better representation of landing mechanics during game situations when injuries most commonly occur and may help elucidate gender differences responsible for gender disparities in ACL injury rates.

**REFERENCES**