

KINETICS AND KINEMATICS OF MALES AND FEMALES DURING TWO STYLES OF DROP LANDING

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INTRODUCTION

Female athletes are six times more likely than males to suffer a “non-contact” anterior cruciate ligament (ACL) injury [1], and landing from a drop has been identified as a movement stressful to the ACL [2]. The kinematics and kinetics of landing from a drop have been studied extensively. The consensus is that males demonstrate greater body weight normalized vertical ground reaction forces (VGRF) compared with females, while females tend to land on more extended knees with greater trunk lean [3] and exhibit longer landing phase durations [4]. Specific gender comparisons across more than one style of landing are lacking; and many studies selected a single trial for analysis, potentially skewing performance characteristics and statistical comparison.

Previous studies typically assumed a rigid body model and thus ignored skin-mounted marker movement, compromising the accuracy of subsequent kinetic calculations [5]. Efforts to minimize this error have been made previously [6] and similar efforts were adopted in the present study. The purpose of this study was to examine kinetic and kinematic differences between males and females during two styles of landing from a drop (flat-footed and toe) utilizing an externally affixed rigid link device as representative of underlying skeletal motion.

METHODS

Simultaneous 2D kinematic (240 Hz) and kinetic (1920 Hz) data were collected as 10 subjects (5 male, 5 female) performed 5 trials each of two-footed hanging drop landings onto flat feet and toes. A rigid link device was secured to the right lower extremity of the subjects, and the intersection of the lines representing the two segments of the device served to determine the knee joint center for kinematic analysis. Torso and foot kinematics were obtained from markers placed on the acromion process, greater trochanter, lateral malleolus, calcaneal tuberosity and fifth metatarsal. Two additional markers were placed on the anterior portion of the thigh in an effort to quantify the magnitude of soft tissue motion relative to the rigid link. The instant of impact was considered time zero for all parameters, and kinetic and kinematic data were time-synched to this instant. Peak VGRF, loading rate, joint angles, angular velocities, angular accelerations, resultant joint moments (RJM), and phase durations were calculated and compared across gender. All comparisons were tested utilizing a repeated measures ANOVA ($P < 0.05$).

RESULTS AND DISCUSSION

No significant differences were observed between the genders across landing conditions in force plate derived temporal variables. Mean landing duration for both styles ranged from 1.5 to 1.7 seconds. Both groups demonstrated significantly greater VGRF during the flat-footed compared with toe landings (7.4 ± 2.1 and 4.9 ± 1.7 versus 6.5 ± 1.4 and 4.2 ± 0.9 BW

for males and females, respectively). Males also demonstrated slightly greater rates of loading.

Contrary to the literature, males had significantly greater knee extension at impact and at the time of peak VGRF for both landing styles. Toe landings resulted in significantly greater ankle joint angular velocities compared with flat-footed landings, and such velocities were significantly greater for males during toe landings, perhaps indicative of an alternate ankle joint strategy compared with females. Flat-footed landings resulted in more rapid onsets of peak RJM for both genders compared with toe landings. Males exhibited significantly greater RJM at the hip during toe landings and experienced these greater moments later in the landing phase compared with females. Albeit not statistically significant, females demonstrated substantially greater resultant joint moments at the hip during flat landings compared with males. Greater RJM at the hip during impact could lead to an increased risk of knee injury if the heel were to remain firmly planted and a horizontal acceleration were introduced, as occurs during an off-balanced landing. Females also demonstrated significantly greater horizontal and vertical displacement of the soft tissue compared with males across landing styles, possibly affecting true joint kinetics. No other kinematic differences were observed.

CONCLUSIONS

Methodological differences (e.g. knee joint center kinematics, repeated versus single trial analysis) may account for the discrepancies between the present kinematic results and the literature. Considering the rigid body assumption for kinetic analysis, gender differences in soft tissue motion suggest that females may be experiencing different joint loads compared with males. Quantification of this soft tissue motion and its contribution to knee joint load may provide some insight into the predisposition of females to ACL injury.

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