

# GENDER DIFFERENCES IN MUSCLE ACTIVATION PATTERNS DURING TWO STYLES OF DROP LANDINGS

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## INTRODUCTION

Landing from a drop has been identified as a movement challenging to the anterior cruciate ligament (ACL) (Lephart et al., 2002). Females have a much greater incidence of “non-contact” ACL injury compared with males, (Arendt and Dick, 1995) and studies have reported that females demonstrate muscle activation patterns potentially stressful to the ACL during certain landing tasks (Cowling and Steele, 2001). Females generally have a greater percentage of type I muscle fibers compared with males, and slowness of the quadriceps (QUAD) to de-activate as hamstring (HAM) and or gastrocnemius (GAS) activity begins to build during ballistic activities such as landing from a jump or drop may lead to a brief period where excessive anterior shear force is experienced by the tibia with respect to the femur, placing excessive stress on the ACL (Li et al., 1999).

The purpose of this study was to determine if females demonstrate ACL-compromising muscle activation patterns during two styles of landing from a drop.

## METHODS

Vertical ground reaction force and EMG data on seven lower extremity muscles were measured as four female (mean±SD mass 63.1±4.9 kg, height 1.60±0.05 m) and four male (mean±SD mass 73.0±4.7 kg, height

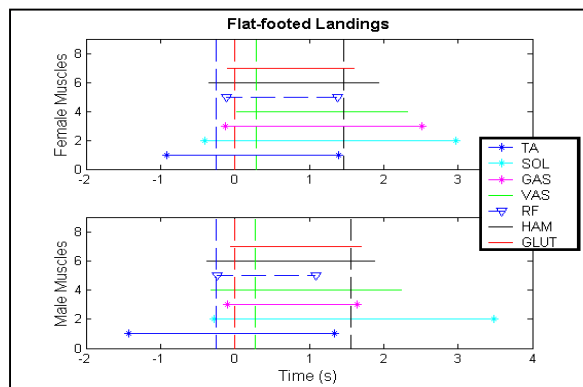
1.79±0.05 m) subjects performed five trials each of flat-footed and toe landings onto a force plate from a 0.40-meter nominal drop height. All data were synchronously sampled at 1920 Hz. Event markers and landing phases were determined from the kinetic data. The filtered EMG data from the landings were normalized with respect to the EMG signals from maximum voluntary isometric contraction (MVIC) for each muscle, and expressed as a percentage of the maximum EMG signal recorded during the MVIC. Isometric knee extension and flexion strength tests were also conducted, with results normalized with respect to body mass. A repeated measures ANOVA ( $P<0.05$ ) was performed.

## RESULTS AND DISCUSSION

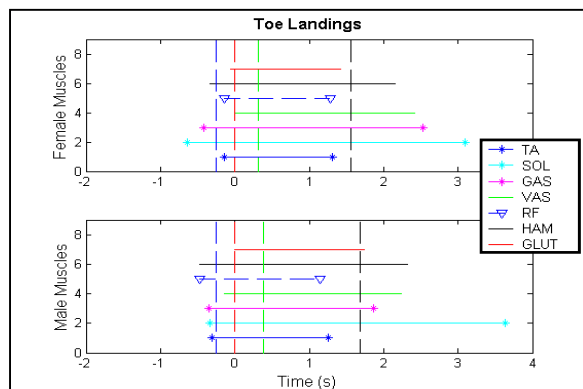
Males produced significantly greater knee extension moments during strength testing compared with females. Females displayed significantly greater HAM to QUAD strength ratios for most strength tests. Males exhibited greater body weight normalized vertical ground reaction force peaks (7.4±2.1 and 4.9±1.7 BW) compared with females (6.5±1.4 and 4.2±0.9 BW) for flat-footed and toe landings respectively, and demonstrated more rapid rates of loading.

EMG activation for the seven muscles for males and females during flat-footed and toe landings are presented in figures 1 and 2. The events of initial contact, peak force,

bottom-most center of mass position, and end of movement are marked on each trace. Mean GAS activity onset occurred earlier and remained active significantly longer in females compared with males, and males exhibited significantly greater mean peak GAS EMG amplitude compared with females. Mean peak rectus femoris (RF), HAM and gluteus maximus (GLUT) EMG amplitudes were significantly greater in females compared with males across all landing conditions, and flat-footed landings resulted in significantly greater mean GLUT EMG magnitude for both genders.



**Figure 1:** Mean EMG muscle activation patterns during flat-footed landings.



**Figure 2:** Mean EMG muscle activation patterns during toe landings.

## SUMMARY

The results indicate that certain aspects of the muscle activation patterns observed in

females differ significantly from those of males. Specific patterns of muscle activation have been associated with contributing to excessive stress on the ACL (e.g. Li et al., 1999). Such compromising muscle activation patterns were not observed in either landing style examined in this study. These data provide no direct evidence that women display muscle firing sequences potentially injurious to the ACL.

Consistent with the findings of Cowling and Steele (2001), males in the present study exhibited slightly delayed hamstring activation onset (+100 ms) across landing styles compared with females, although this delay was not statistically significant. GAS activation tended to occur earlier and remain active significantly longer in females compared with males, while males exhibited substantial bursts in GAS EMG amplitude that occurred slightly ahead of RF activity. These trends suggest that females may demonstrate ongoing GAS activity assisting the ACL in controlling anterior tibial translation relative to the femur, while males exhibit rapid bursts of GAS activity at times during landing possibly enhancing the protection of the ACL at critical instances of excessive anterior shear stress at the knee.

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