MUSCLE ACTIVATION PATTERNS IN MALES AND FEMALES DURING DROP LANDINGS ONTO THE HEELS

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INTRODUCTION

Landing from a drop has been identified as a movement stressful to the anterior cruciate ligament (ACL) (Lephart et al., 2002). Female athletes are six times more likely to suffer a "non-contact" ACL injury compared with males (Arendt and Dick, 1995). Muscle activation patterns of males and females during the performance of various landing activities have been studied in hopes of providing insight into this phenomenon. Delayed hamstring activation coincident with peak impact force during single-leg ballistic maneuvers have been observed in males (Cowling & Steele, 2001), however few consistent or significant differences supporting a predisposition of women to ACL injury have been found relative to muscle activation patterns.

"Stiff" landings (e.g. drops onto the heels) result in large vertical ground reaction forces that must be dissipated by the individual's musculoskeletal system. Examination of muscle activity during such heel landings would determine if males and females prepared similarly for expected high impact loads. The purpose of this study was to determine if females demonstrate ACL-compromising muscle activation patterns during drop landings onto the heels.

METHODS

Vertical ground reaction force (VGRF) and EMG data on seven lower extremity muscles (tibialis anterior - TA, lateral soleus - SOL, medial gastrocnemius - GAS, vastus medialis - VAS, rectus femoris - RF, hamstrings - HAM, and gluteus maximus - GLUT) were measured as four female and four male subjects performed five trials of 2-footed heel landings onto a force plate from a 0.20 meter nominal drop height. These data were synchronized and sampled at 1920 Hz. EMG signals were differentially amplified (gain x 1000), and band pass filtered (10 to 500 Hz) with BIOPAC software.

The collected EMG signals were later high pass filtered (cutoff = 15 Hz) to remove low frequency movement artefact, full-wave rectified, and low pass filtered using a 2nd order Butterworth filter in forward and reverse directions (cutoff = 20 Hz). The EMG data from the landings were normalized and expressed as a percentage with respect to the maximum EMG signals recorded during maximum voluntary isometric contraction for each muscle. All comparisons were tested utilizing a repeated measures ANOVA ($P<0.05$).

RESULTS AND DISCUSSION

Males exhibited only slightly greater body weight normalized VGRF peaks (6.4 ± 1.4 BW) compared with females (5.9 ± 1.2 BW), while females demonstrated slightly more rapid rates of loading ($P=0.08$).

Kinetically-derived landing phase times (i.e. preparatory, descent and recovery) were not statistically significantly different between the genders. Activation times of all muscles tended to occur earlier in males compared with females (Figure 1). Mean peak EMG amplitudes were similar between males and females, with females demonstrating greater peak amplitude only in the GLUT compared with males (P=0.02).

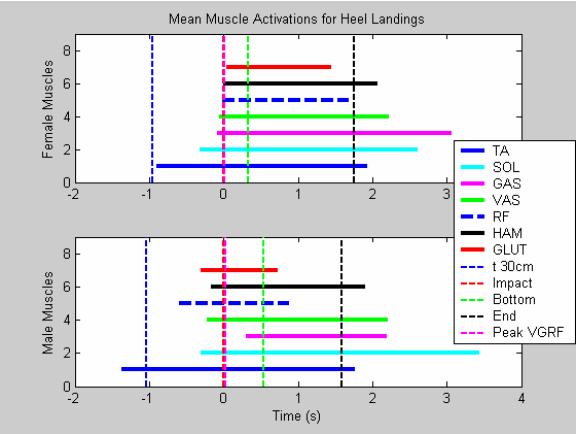

Figure 1: Mean EMG muscle activations for females and males during heel landings.

Females as a group exhibited a "bottom-up" order of muscle activation with onset coincident around initial contact. This sequence suggests the ankle is being stabilized first in preparation for impact, potentially leaving the knee unprotected at the instant of impact when peak shear forces are generally regarded to occur. Conversely, males tended to stabilize the more proximal joints first, demonstrated by an earlier and greater co-contraction across the knee and ankle prior to contact.

The coincident activation across the knee and ankle suggests males were attempting to maintain an upright torso in an effort to reduce resultant joint moments at the hip. A greater resultant joint moment at the hip could lead to an increased risk of knee injury if the heel remains firmly planted, especially if a horizontal acceleration is introduced as occurs during an off-balanced landing.

The relatively low drop height (0.2m) utilized in the present study may not have been sufficient to elicit gender differences in preparatory muscle activation. Performance of "stiff" or high impact landings from slightly greater heights (e.g. 0.4m) may reveal gender differences similar to those reported previously (Boros & Challis, 2003).

SUMMARY

Males and females demonstrated similar body weight normalized VGRF and muscle activation patterns during landings onto the heels from 0.2m, contrary to previous studies (Cowling & Steele, 2001). The more proximally located muscle activation sequence observed in males suggests they may be maintaining a more upright posture during high-impact landings, and therefore minimizing anterior shear at the knee.

REFERENCES

Arendt, E., Dick, R. (1995). *Am. J. Sports Med.*, **23**, 694-701.

Boros, R.L. and Challis, J.H. (2003). *Proceedings of the ASB 2003*.

Cowling, E.J., Steele, J.R. (2001). *J. Electromyogr. Kinesiol.*, **11**, 263-268.

Lephart, S. A., Abt, J.P., Ferris, C.M. (2002). *Curr. Opin. Orthopedics*, **14**, 168-173.

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