EFFECTS OF FATIGUE ON LOWER EXTREMITY JOINT KINEMATICS DURING A STOP AND GO LANDING TASK

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INTRODUCTION

Stop and go tasks are involved in the majority of non contact anterior cruciate ligament (ACL) injuries (Arendt and Dick, 1995; Boden, et al., 2000; Gwinn, 2000). Moreover, muscle fatigue can result in noticeable affects on the mechanics of complex motor skills such as walking, running, and jumping (Johnston, et al, 1998; Pinniger, et al., 2000; Rodacki, et al., 2001). However, there is limited literature on the effects of fatigue on the mechanics of landing and cutting tasks (e.g. Chappell, et al., 2005; McNitt-Gray, et al, 1996; Nyland, et al., 1997; Nyland, et al., 1994). Results from these studies suggest that with fatigue, onset of muscle activation is delayed, max knee flexion is decreased, and shear forces are increased (Chappell, et al., 2005; Nyland, et al., 1994).

Considering the link between ACL injuries and stop and go tasks (Arendt and Dick, 1995; Boden, et al., 2000; Gwinn, 2000) and the increased risk for non contact ACL injuries in female athletes (Arendt and Dick, 1995; Delfico and Garrett, 1998; Traina and Bromberg, 1997) it seems that further research is warranted on the effects of fatigue on landing mechanics in male and female athletes. The purpose of this study was to examine joint kinematics in competitive athletes performing stop and go landing tasks in a fatigued state representative of game conditions.

METHODS

Twenty healthy collegiate athletes participated in this study after giving their written informed consent. The testing session involved a warm-up, pre-fatigue testing, a fatiguing protocol, and post-fatigue testing. The stop and go task analyzed during pre and post fatigue testing was a 45 degree cut performed off the subject's preferred leg after landing from a 0.5 m high box.

The fatigue protocol consisted of a 10 minute progressive incline treadmill run immediately followed by a 10 by 12 foot footwork pattern of forward, backward and side ways steps with two vertical jumps. The pattern was repeated until 1) lap time slowed to 150% or 2) completion of 10 laps and inability to achieve maximum jump height.

Ground reaction forces (GRF) were measured with two force plates. Two high speed digital cameras captured the motion of the preferred leg during the 45 degree cut. Three dimensional coordinates of marker arrays were computed and 3D kinematics were calculated of the cutting leg. Subjects completed 3 vertical jumps between each post trial to maintain fatigue. This paper will focus only on the lower extremity kinematics, as the GRF data has been reported elsewhere. To date, data of 7 men and 7 women are included in the analysis. Data were analyzed with a two way repeated measures ANOVA at $\alpha = 0.05$.

RESULTS AND DISCUSSION

The only significant effect from the fatiguing protocol was an increase in time to max knee flexion ($p=0.03$), which supports findings from previous studies (Nyland, et al., 1997). There were no significant changes in ankle or knee angles at contact or in knee range of motion, as has been previously reported (Nyland, et al, 1997; Chappell, et al., 2005). The lack of change in ankle & knee angles with fatigue may be due to the dual emphasis on cardiovascular and muscular fatigue, as compared to studies which focused more on lower extremity muscular fatigue, or the use of competitive athletes versus recreational athletes.

Several male female differences were observed in lower extremity mechanics (Figure 1). At contact, the female athletes were in a position of greater knee flexion and less ankle inversion ($p \leq 0.002$). During the landing phase, the female athletes exhibited less dorsiflexion in their ankle and more valgus in their knee. The increased valgus of the knee for the female athletes is similar to other findings reported in the literature; though the female athletes did not exhibited less knee flexion ROM as has also been reported (Malinzak, et al, 2001). This could be due to the use of competitive collegiate athletes who may be stronger or more powerful than recreational athletes or pre adolescent & adolescent athletes, who are commonly studied (Milinzak, et al., 2001; Chappell, et al., 2002, 2005).

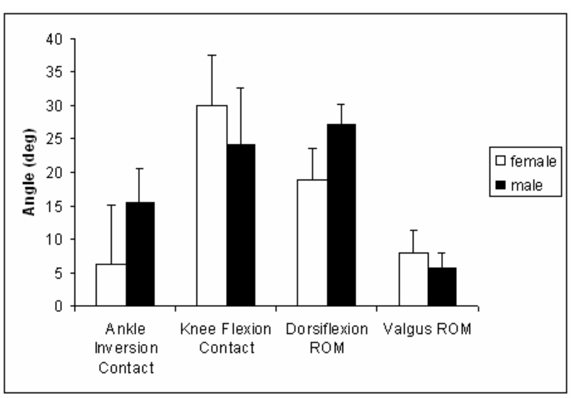

Figure 1. Kinematic variables with significant difference between male and females.

CONCLUSIONS

The collegiate female athletes had increased knee valgus as compared to the male athletes but did not demonstrate decreased knee flexion. Time to max knee flexion was slower in the fatigued state. Combining these results with previous reported results of changes in GRFs and joint kinetics, future research investigating the relationship between lower extremity mechanics, fatigue, and injury incidence appear to be warranted.

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