LATERAL HAMSTRINGS ARE STRETCHED MORE THAN THE MEDIAL HAMSTRINGS DURING SPRINTING

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INTRODUCTION

Acute hamstring strains are one of the most frequent injuries in sports involving sprinting [1,2]. Radiological analyses have shown that a large majority of hamstring injuries occur in the lateral hamstrings (BF-biceps femoris), while the medial hamstrings (ST-semitendinous, SM-semimembranous) are less frequently involved [3,4]. However, there is currently limited scientific data to understand injury mechanisms during sprinting and differences in injury rates between muscles.

The objective of this study was to characterize medial and lateral hamstring kinematics across sprinting speeds. We hypothesized that the BF would be subjected to greater stretch than the ST or SM. Our secondary hypothesis was that increasing sprinting speed would both increase and delay the occurrence of peak hamstring stretch within the gait cycle.

METHODS

Fourteen athletes (6 female, 8 male, 16-31 yr old) participated in this study. Subjects had no previous hamstring injuries within one year prior to being tested. Whole body kinematics were recorded at 200 Hz while each subject sprinted on a high-speed treadmill at 80, 85, 90, 95, and 100% of his/her maximum sprinting speed. Hamstring kinematics were estimated using a 3-D, 29 degree-of-freedom model that included geometric descriptions of the BF, ST and SM muscles (Fig. 1). Model predictions of hip extension and knee flexion moment arms for the individual hamstring muscles were consistent with published data. [5,6].

Figure 1: Musculoskeletal model shown with markers and in posture of peak hamstring muscle stretch

The model was scaled to individual subjects. An optimization-based inverse kinematics routine was employed to compute joint angles from marker kinematics. At each time step, muscle-tendon lengths were determined by computing the distance from origin to insertion and accounting for wrapping about structures at the knee. Muscle stretch was defined as the lengthening of the muscle-tendon unit relative to the length in an upright posture. Repeated measures ANOVA were used to test for the significance ($p < 0.01$) of the effects of speed and muscle on peak stretch and the time at which peak stretch occurred within the gait cycle (GC).

RESULTS AND DISCUSSION

Average maximum sprinting speed was 9.4 m/s for the males and 8.1 m/s for the females. Peak muscle-tendon stretch occurred at ~90% GC (Fig. 2a). The BF was stretched an average of 9.5% beyond the nominal upright length, which was significantly more than the peak stretch of the SM (7.4%) and ST (8.1%). However, there was no significant variation in peak hamstring stretch with speed (Fig. 2b). There was a slight delay (~2% of the GC) in the occurrence of peak hamstring stretch at the maximum sprinting speed.

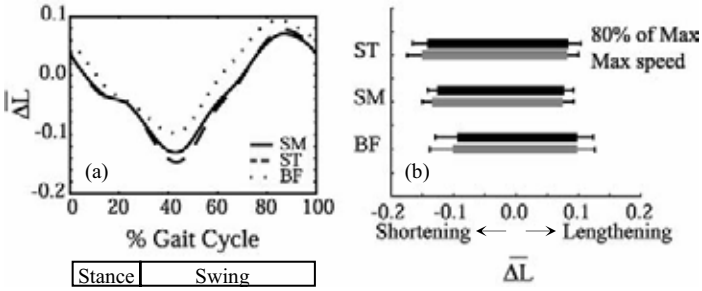

Figure 2: a) Peak hamstring muscle-tendon stretch ($\Delta\bar{L}$) occurs during late swing prior to foot strike. b) Overall excursions of the hamstrings over a sprinting gait cycle ranged from 19 to 23%, but did not vary with sprinting speed over the range (80-100% max) considered.

The differences in peak stretch between the medial and lateral hamstrings found in this study are primarily a result of differences in knee flexion moment arms between muscles. The ST and BF have similar hip extension moment arms [5], and thus each undergo similar stretch due to hip flexion. However, because the BF has a smaller knee flexion moment arm than the ST and SM muscles, knee flexion during late swing (Fig. 1) reduces the BF length less than the medial hamstrings. The net effect is that the BF experiences greater overall stretch, relative to the upright length, than ST or SM

SUMMARY

Animal models of muscle-tendon injuries have shown that mechanical strain is a strong indicator of injury potential [7]. Therefore, the muscle-tendon stretch measures reported in this study provide insights into hamstring injury potential during sprinting. Our data support the idea that the potential for a lengthening strain injury to the hamstrings is greatest during the late swing phase of sprinting, when the muscles are maximally stretched and active [8]. Furthermore, we conclude that the higher injury rates for the BF may in part arise from differences in knee flexion moment arms between the hamstring muscles.

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