CHANGES IN RUNNING LEG MECHANICS DUE TO MUSCLE SORENESS

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INTRODUCTION

Downhill running can produce muscle soreness/damage. Delayed onset muscle soreness has been found to alter leg kinematics 2 days following a 30-min downhill run (Hamill, et al.1991; Braun & Dutto, 2001). In particular, observed maximum knee flexion during stance tends to decrease with muscle soreness. For a given running velocity, stride rate tends to increase with soreness (Braun & Dutto, 2001)

Stride rate changes at constant speed are associated with changes in stiffness properties of the leg (Farley & Gonzalez, 1996). Leg stiffness can be determined using kinematics (Li, 1999). The purpose of this study was to determine leg stiffness prior to and after a downhill run.

METHODS

Seven, well-trained runners (m = 73 ± 6 kg; VO_2 peak = 59.8 ± 8.1 ml/kg/min) were recruited to 4 runs at various conditions of intensity and grade. During the first test session, VO_2 peak was measured. The second test consisted of three level runs at speeds corresponding to 65%, 75%, and 85% of VO_2 Peak. Each run lasted for 5-min, with 5-min between runs. During the third testing session, the subject ran at a 10% downhill grade for 30-min at approximately 70% of VO_2 peak. The fourth test, exactly 48 hours post downhill run, was the same as the second testing session.

During the second and fourth testing sessions, reflective spheres were secured on the subject's left leg at points representing the hip, knee, and ankle joints. For each 5 min test run, 10 sec of data were recorded at 120 Hz after 2.5 minutes. From the 10 sec of data, 13-15 consecutive strides were identified. From each stride, the stance period was found. Knee angle and angular velocity were calculated from the kinematic data.

For each stance period, three phases were identified, and leg stiffness estimated for each phase (Li, 1999). Phase 1 represented the period from foot contact to maximum knee flexion velocity. Phase 2 lasted from the end of phase 1 to the point of maximum knee flexion. Phase 3 was from the end of phase 2 to toe-off. For each phase, knee rotational stiffness was determined using the equation:

$$\mathbf{k_R = I\frac{\omega^2}{\theta^2}},$$

where I is ml^2. For a given subject, m is body mass and l is the distance from the hip to the knee joint. As illustrated by Li (1999), in the plot (θ^2, ω^2) (Figure 1), the slope represents k/I.

Leg stiffness was estimated from knee rotational stiffness for each phase using the equation,

$$\mathbf{k_L = \frac{k_R}{l^2 \sin\Delta\theta}},$$

where $\Delta\theta$ is the change in knee angle for a given time interval.

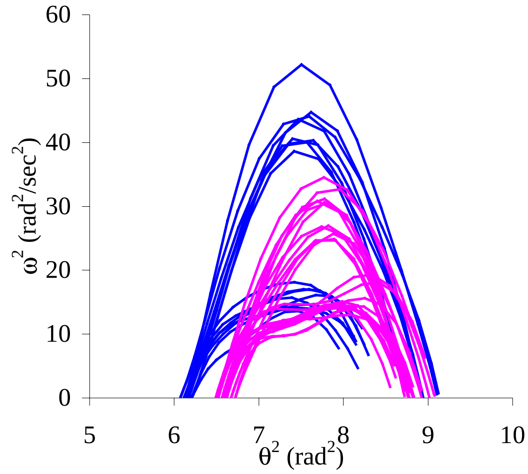

Figure 1: Stance phase knee kinematics. Dark curves represent pre- and light curves post- downhill run.

RESULTS AND DISCUSSION

Figure 1 shows the plot (θ^2, ω^2) for one subject pre- and post- downhill run at the speed corresponding to 65% VO_2 peak. For this subject, definite changes in leg kinematics are observed. Leg stiffness increased 28% during phase 1 and decreased 2% and 10% during phases 2 and 3 relative to the pre-downhill session.

Table 1: Percent change in leg stiffness. (Range of percent change)

Effort	Phase 1	Phase 2	Phase 3
65%	20 (-5 - 82)	1 (-11 - 15)	1 (-29 - 34)
75%	13 (-13 - 72)	5 (-22 - 50)	0 (-16 - 15)
85%	9 (-16 - 32)	-1 (-25 - 20)	-4 (-13 - 17)

Table 1 gives the average percent change in leg stiffness from pre to post across all subjects. Statistical comparisons have not been run due to differences in running speeds between individuals. The greatest differences generally occurred during phase 1 of the stance phase, with a large degree of variability, as denoted by the observed ranges. Generally, leg stiffness increased with muscle soreness, particularly during phase 1, the initial impact phase. Most subjects (6 of 7) experienced increased leg stiffness during phase 1 at the 65% speed, as seen in Figure 2.

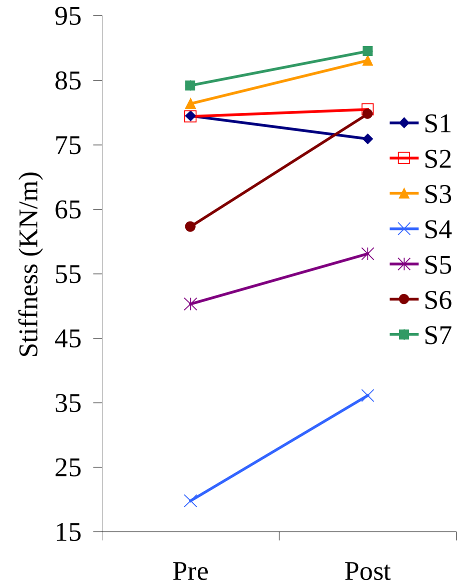

Figure 2: Change in leg stiffness during phase 1 at 65% of VO_2 peak.

It is unknown what affect increased leg stiffness has for the runner. Increased stiffness during impact (phase 1) may relate to increased accelerations on the body that must be absorbed, possibly increasing the risk of injury. Increased stiffness may reflect a strategy that balances minimization of pain with increased lower limb loading.

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