LACK OF HAMSTRING TENSION CAUSES INCREASED ACL STRAIN IN A SIMULATED JUMP LANDING

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INTRODUCTION

An anterior cruciate ligament (ACL) injury can significantly affect short and long-term physical activity and health in an athlete[4]. ACL injuries have been associated with abrupt deceleration while running, pivoting, awkward landings, and "out of control" play[3]. A factor in these injuries may be the state of lower extremity muscle recruitment at the time of impact. For example, for a given quadriceps activity, a decrease in hamstring muscle activity has long been viewed as hazardous for the ACL. Previous experimental studies have demonstrated the protective effects of hamstring muscle force, but only at low and non-physiologic loading magnitudes and rates[1,2]. In these experiments we investigated ACL strain under more physiological loading levels associated with landing a jump with precontracted quadriceps and gastrocnemius muscles. We tested the (null) hypothesis that, compared with the presence of a hamstring force, lack of hamstring forces would not affect the peak strain measured in the anteromedial bundle of the ACL

METHODS

Ten fresh cadaveric limbs were studied [mean (SD): 74 (17) years; 5 males; 5 females; age 45 to 100 years]. Specimens were divided 15 cm proximal and distal to the knee joint and potted using polymethylmethacrylate. A testing apparatus was constructed to simulate the position of a single extremity as it strikes the ground while landing on one leg from a jump or run/stop maneuver. Pre-impact muscle preloads of the quadriceps, medial and lateral hamstrings, and medial and lateral gastrocnemius muscle-equivalents, the initial angle of knee flexion, and impact force magnitude and its direction about the knee joint could all be preset. The stiffness of each muscle-equivalent was 7 kN/mm. In all trials, an initial knee flexion angle of 25 degrees was used and the impact loading direction was standardized.

A 150 N weight was released from a fixed height to strike an impact rod in series with the proximal femur. This exerted an impulsive compressive force (peak < 30 ms) resulting in an increase in knee flexion angle. Two 3-axis load cells measured the 3-D forces and moments delivered to the construct. A 3 mm DVRT (Microstrain, Burlington, VT) was mounted on the ACL anteromedial bundle to record its relative strain[1]. Impact forces, quadriceps muscle force, and ACL strain data were recorded at 2 kHz using a 16-bit A/D board, while tibiofemoral kinematics were tracked using an Optotrak 3020 system (Northern Digital, Inc, Waterloo, Canada) and recorded at 400 Hz to the nearest mm and degree. Using a repeated measures trial design, three sets of ten trials were run with ("With Hamstring 1"), without ("No Hamstring") and with hamstring ("With Hamstring 2") pre-tension, in that order. The last five trials of each condition were then analyzed for each specimen. The peak relative strains for individual specimens are then normalized by dividing them by the mean peak relative ACL strain in the 'W/ Hamstring' tests. A non-parametric paired Wilcoxon signed rank test was used to test the null hypothesis with $p<0.05$ being considered significant.

RESULTS AND DISCUSSION

The mean (SD) peak impact force was 1,460 (260) N. The impact forces were not significantly different in the 'No Hamstring' and 'With Hamstring' tests [1,410 (210) vs. 1,480 (280) N, respectively]. The mean peak (SD) relative strain in the 'No Hamstring' conditions was 3.1 (1.3)%, whereas the corresponding data was 2.5 (0.8)% in the 'With Hamstring' condition. There was no order effect in that there was no significant difference in peak relative ACL strain between the two 'With Hamstring' conditions.

Most importantly, the null hypothesis was rejected in that the peak normalized relative ACL strain in 'No Hamstring' condition was significantly higher than the corresponding ACL strain in the 'With Hamstring 1' condition ($p=0.004$) or 'With Hamstring 2' condition ($p=0.022$). These results were obtained with loading levels exceeding bodyweight and impact loading rates typical of landing from a jump. Our results under these more physiological loadings corroborate earlier results at low loads and quasistatic loading rates[1,2].

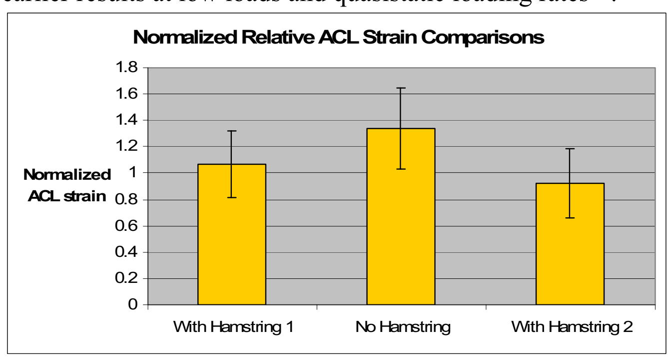

Figure 1: Comparison of the normalized mean (SD, denoted by vertical bars) peak relative ACL strain in the two test conditions.

CONCLUSIONS

At physiological loading levels, decreased hamstring tension (and stiffness) led to increased peak relative ACL strain when simulating landing on a flexed knee with precontracted quadriceps and gastrocnemius muscle-equivalents. Lack of an order effect precludes this result having been due to the sequence of testing or cumulative soft tissue damage.

REFERENCES

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