Hypotheses

- Maximum ACL bundle elongations would be greater during running than walking.
- ACL relative elongation during walking and running would independently correlate with tibiofemoral kinematic parameters in addition to knee flexion angle.

Methods

Data Collection

- Ten healthy volunteers without prior knee injury (5 M, 5 F; age: 27±4 years) walked (1.4 ± 0.2 m/s) and ran (2.6 ± 0.4 m/s) at a self-selected pace on an instrumented treadmill while synchronized biplane radiographs of the knee were acquired at 100 Hz (walking) and 150 Hz (running) in this IRB-approved study.
- Each subject underwent a CT scan and 3T MRI scan.
- Full gait cycle tibiofemoral kinematics were determined using a validated tracking process that matches subject-specific 3D bone models to the biplane radiographs.

Data Processing

- ACL insertions were identified on MRI and divided into AM and PL bundles6,7 (Figure 1).
- The AMB and PLB centroid-to-centroid distance was calculated from the tracked motion of the femur and tibia.
- ACL bundle lengths were normalized to their respective lengths during MRI (ACL relative elongation).

Data Analysis

- Differences in maximum ACL bundle elongation during walking and running were identified using paired t-tests with significance set at p<0.05.
- Stepwise multiple regression was used to identify relationships between the ACL bundle elongations and the 6 degree-of-freedom kinematics.

Results

- ACL elongation was correlated with several kinematic parameters.

Results (cont.)

- ACL elongation and knee flexion demonstrated a complex relationship (Figure 3).

Discussion

- Maximum relative elongations were much lower than previously reported (peak 12-13% elongation) and occurred during the impact phase, rather than midstance.
- Maximum relative elongations were similar to maximum strains recorded using invasive techniques (peak 4% strain).
- ACL strain is region-specific during walking and running in the native ACL. In terms of ACL reconstruction, it is not clear if two bundles are necessary or if a single bundle with varying properties would suffice to replicate this native ACL function.
- Knee flexion alone is not sufficient to predict the complex elongation pattern of the ACL during dynamic functional activities. This demonstrates the important role that loading plays in ACL elongation.

Clinical Significance

- The findings highlight the importance of reproducing the in vivo loading condition and 6 DOF kinematics when evaluating ACL function.
- Observed differences in AM and PL bundle deformation during walking and running may be used to optimize rehabilitation after one bundle augmentation.

References and Acknowledgements


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