Gait Differences between Patients with Primary and Revision Anterior Cruciate Ligament Reconstruction

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INTRODUCTION: Aberrant gait biomechanics present after primary anterior cruciate ligament reconstruction (ACLR) have been associated with joint tissue changes related to the development of knee osteoarthritis (KOA). Recent efforts have sought to correct these aberrant gait biomechanics using real-time gait biofeedback to prevent KOA development. However, between 3 and 12% of individuals who have undergone primary ACLR experience a reinjury to the ACL graft requiring revision ACLR. Often individuals with an ACLR revision are excluded from biomechanically focused rehabilitation trials as it remains unknown if gait biomechanics differ between patients with a primary and revision ACLR. Therefore, the purpose of this study was to compare vertical ground reaction force (vGRF), knee flexion angle (KFA), knee extension moment (KEM), and knee adduction moment (KAM) in the involved limb of individuals with primary and revision ACLR at 6-months post-surgery. We hypothesized that individuals 6-months post revision-ACLR would demonstrate similar vGRF, KFA, KEM, and KAM as individuals 6-months post primary-ACLR, therefore justifying the inclusion of both primary and revision ACLR patients in gait retraining trials.

METHODS: We included 16 individuals who were 6-months post revision-ACLR (50% Female, 26±7 yrs old, 27±6 $kg*m^{-1}$, 4.7±1.0 Tegner score) and matched them to individuals collected as part of a separate cohort who were 6-months post primary-ACLR (50% Female, 25±6 yrs old, 26.0±3.5 $kg*m^{-1}$, 4.6±0.8 Tegner score) based on sex, age, BMI, and Tegner Activity Scale score. Participants were instructed to walk barefoot at their habitual walking speed while gait biomechanics were collected using a 3-D marker-based motion capture system. Waveform analyses were used to construct mean differences and corresponding 95% confidence intervals (CI) of the differences throughout 100% of stance phase for key variables (i.e., vGRF, KFA, KEM, and KAM). Portions of stance phase where 95% CI did not cross zero were deemed to indicate statistically significant differences between groups. The revision-ACLR group (1.18±0.13 m/s) exhibited significantly slower habitual walking speeds compared to the primary-ACLR group (1.31±0.15 m/s), thus a *post hoc* sensitivity analysis accounting for gait speed was conducted. All study procedures were approved by the Institutional Review Board and written consent was obtained from all participants prior to enrollment.

RESULTS SECTION: The revision ACLR group exhibited greater KFA during early stance (1-19%, 2.95±0.58°) and mid-to-late stance (56-75%, 2.35±0.08°) compared to the primary-ACLR group (Figure B1, B2). No statistically significant differences were found between groups for vGRF, KEM or KAM. The gait speed sensitivity analyses demonstrated that the revision-ACLR group exhibited greater KFA in early stance (9-15%, 2.3±0.11°) attenuating some of the differences in KFA but not fully accounting for the observed differences.

DISCUSSION: Agreeing with our hypothesis, individuals with revision-ACLR exhibit few differences in gait biomechanics compared to individuals with primary ACLR. Greater KFA following revision-ACLR suggest that these individuals may not regain full extension during gait, which may cause more localized loading to the posterior articular cartilage. Overall, patients with revision-ACLR and primary-ACLR demonstrate similar aberrant gait biomechanics compared to uninjured controls reported in previous gait biomechanical studies. Consequently, gait retraining interventions typically targeting aberrant gait biomechanics in primary-ACLR patients may be well-suited for prescription to revision-ACLR patients. Further, these data provide justification for including both primary and revision-ACLR patients in future gait retraining studies.

SIGNIFICANCE/CLINICAL RELEVANCE: While revision-ACLR patients walk slower and exhibit increased KFA in select portions of stance compared to patients with a primary-ACLR, most gait biomechanics are similar at 6 months post revision and primary-ACLR. Given that the two groups exhibit similar aberrant gait biomechanics, interventions that target gait retraining for primary-ACLR patients may be well-suited for prescription to revision-ACLR patients.

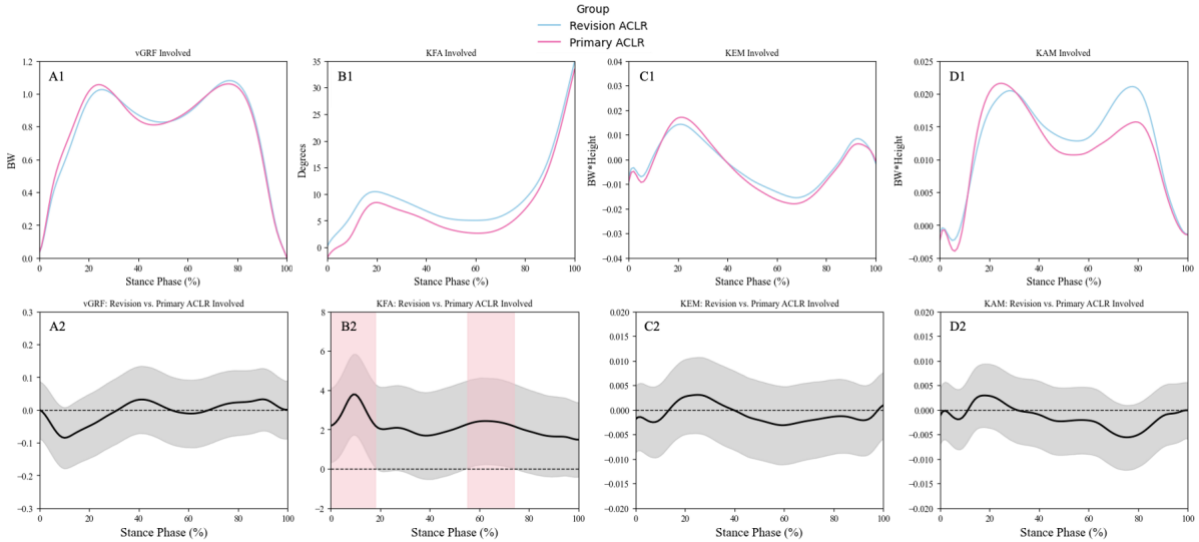

Figure 1: Vertical ground reaction force, knee flexion angle, knee extension moment, and knee adduction moment waveforms (A1-D1) with corresponding mean differences (A2-D2) and 95% confidence intervals (shown in gray) between revision and primary groups at 6 months post ACLR. Significant differences occur when the 95% confidence intervals do not include zero and are shaded in red.