Changes in Movement Patterns During Stair Climbing From Two to Eight Years after ACL Reconstruction are Associated with Patient-Reported Outcomes

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Purpose

- To examine changes during a biomechanically demanding task (stair ascent) in the peak knee flexion moment (KFM) and trunk flexion angle (TFA) from 2 to 8 years post-ACL reconstruction (ACLR).
- To determine if adaptive patterns of movement and changes in loading during stair ascent are associated with changes in patient-reported outcomes (PRO) 2 and 8 years post-ACLR (Fig. 1).

Introduction

- Subjects post-ACLR often exhibit abnormal joint loading and motion during gait that may contribute to accelerated development of post traumatic knee osteoarthritis (PTOA)[1–3].
- ACL injuries, one of the most frequent traumatic knee injuries in military service, are associated with a greater incidence of PTOA in veterans relative to the general population[4].
- Reductions in KFM[5], an indication of reduced net quadriceps function[6] is a commonly observed functional deficit after ACLR.
- Analysis of stair ascent[7]:
  - Increases sensitivity in detecting differences in joint loading and motion[5] at a single time point after ACLR.
  - Can help determine if biomechanics change longitudinally past surgery[8] or if they are indicative of clinical outcomes.
- Prior work in an OA population demonstrated a compensatory movement of increased TFA which correlated with reduced KFM during stair ascent[9].
- Analysis of trunk flexion during stair ascent could allow for a simple assessment of post-ACLR recovery.

Methodology

Subjects

- 14 subjects (9 females, 5 males) with unilateral primary ACLR surgery.
- Tested at baseline (2.2 ± 0.3 years post-ACLR) and follow-up (7.8 ± 0.6 years post-ACLR).
- Mean age: 29.9 ± 6.8 yrs; mean BMI: 23.5 ± 2.6 kg/m^2
- A control group of 14 healthy subjects was age-, sex-, and BMI matched to the 8-year post-ACLR cohort.
- All subjects provided IRB approved written informed consent.

Motion Capture

- Stair-ascending mechanics at baseline and follow-up:
  - 10-camera system and force plate, 120 Hz.
  - Two-step staircase.
- Peak KFM calculated with Point Cluster Technique[10].
- Peak TFA calculated as the difference between the pelvis[11] and trunk[12] anatomical frames.

Patient Reported Outcomes

- The Knee Injury and Osteoarthritis Outcome Score (KOOS) questionnaire was completed prior to motion capture at baseline and follow-up.

Statistical Analysis

- Paired t-tests determined significant differences between the peak KFM and peak TFA in the ACLR limb at baseline (2 years) and follow-up (8 years).
- Linear regression determined correlations between changes in gait variables (KFM, TFA) over time and changes in PRO (KOOS).
- Independent t-tests were used to compare the ACLR limb data at both times points with the control data.
- Significance threshold: α=0.05

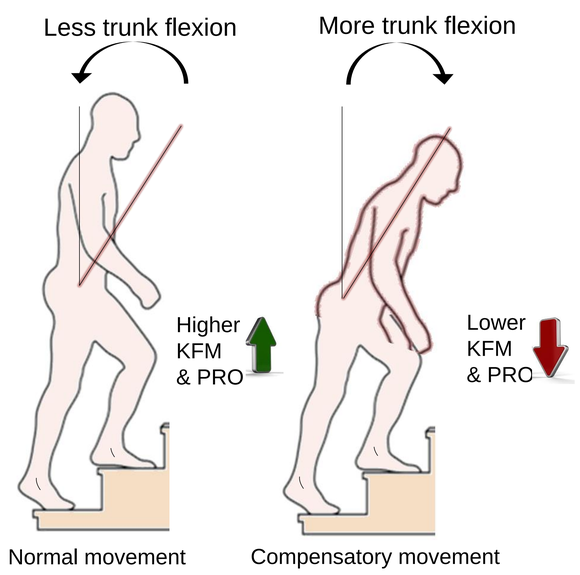

Fig. 1: Adaptive patterns of movement and changes in loading and pain during stair ascent 2 and 8 years post-ACLR.

Results

- Peak KFM during stair ascent significantly increased from baseline to follow-up (p=0.01).
- The ACLR population demonstrated a significantly (p=0.006) lower KFM during stair ascent at baseline when compared to healthy controls.
- No significant difference in TFA between 2 and 8 years (p=0.84) over all the subjects.
- Subjects who decreased their TFA during stair ascent from 2 to 8 years post-ACLR significantly increased their peak KFM (Fig. 2).
- Improvements in PRO were significantly associated with increased peak KFM (Fig. 3) and decreased TFA observed 8 years post-ACLR (Fig. 4).

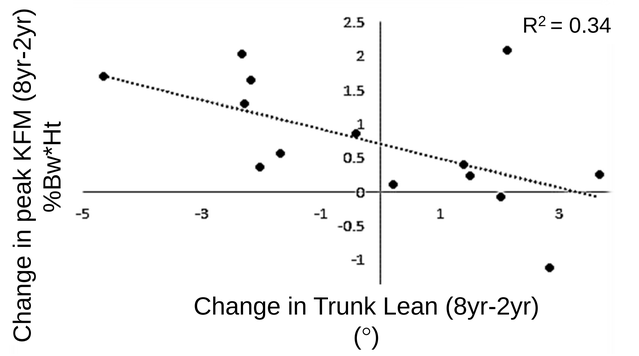

Fig. 2: Changes in peak TFA are correlated with changes in KFM between 2 and 8 years post-ACLR (p=0.029).

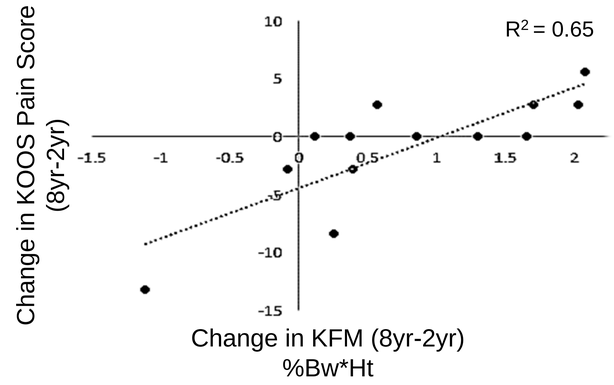

Fig. 3: Changes in peak KFM are correlated to improved KOOS scores between 2 and 8-years post-ACLR (p=0.001).

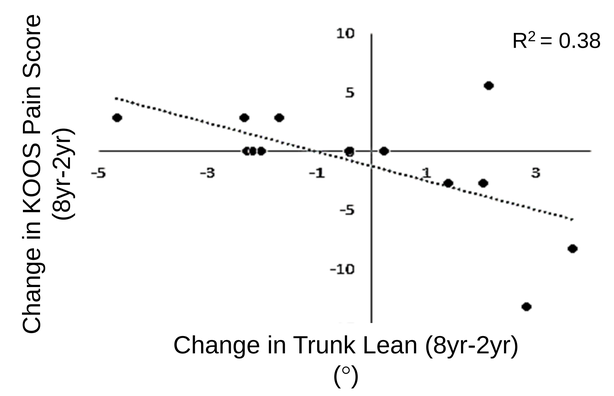

Fig. 4: Reductions in peak TFA are correlated to improved KOOS scores between 2 and 8-years post-ACLR (p=0.024).

Discussion & Conclusions

- This work demonstrated adaptive patterns of movement and changes in loading during stair ascent 2 and 8 years post-ACLR (Fig. 1).
- Forward trunk lean appears to be a compensatory mechanism to reduce quadriceps demand in this ACLR population.
- KFM increases from 2 to 8 years may indicate improved quadriceps function in patients with improved PRO.
- KFM and TFA during stair ascent may be useful functional markers for evaluating ACLR recovery status and quadriceps function.
- Reduced quadriceps function (KFM) that remains in some patients following ACLR is likely associated with the development of knee OA in this high risk population.
- The rate of ACL injury in the military population is more than four times that of the civilian population and among the leading causes of PTOA.

References

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Acknowledgements

This study was funded by NIH AR039421 and AR052784.