Chronic Adaptions In Quadricep Fascicle Mechanics Are Related To The Magnitude And Rate of Joint Loading After ACL Reconstruction

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DISCLOSURES: NONE. **INTRODUCTION**: Recent work has highlighted that quadriceps muscle weakness following anterior cruciate ligament reconstruction (ACLR) is part of a broader profile of muscle dysfunction, characterized by changes in muscle's mechanical behavior. The mechanical behavior of a muscle is crucial as it plays a fundamental role in generating force and facilitating shape changes during movement, thereby enabling effective force transmission. While abnormal fascicle mechanics have been reported in the acute phases following ACLR, their persistence in chronic stages of recovery remains unexplored. Given the lingering long-term consequences of ACLR, we sought to provide insights into how the altered mechanical behavior of the vastus lateralis (VL) muscle's fascicles persists or evolves in individuals with an extended history of traumatic knee joint injury. Additionally, we aimed to investigate potential relationships between fascicle mechanics and knee joint loading. **METHODS**: Twenty-four individuals with a protracted history of primary ACLR (male/female = 15/9, Age = 22.8 ± 3.6 years, body mass index = 23.2 ± 1.9, time since surgery = 3.3 ± 0.9 years), and 24 healthy controls (male/female = 14/10, Age = 22.0 ± 3.1 years, body mass index = 23.3 ± 2.6) underwent a single testing session. Lower extremity biomechanics were recorded during walking at a self-selected speed on a split-belt instrumented treadmill (Bertec), that captured ground reaction force data at 2000 Hz and was synchronized with a 10-camera motion capture system (Qualisys) recording at 200 Hz. Patients acclimated to the split-belt treadmill for 5 minutes. After acclimation, three 12 second trials of simultaneous gait, force plate, and ultrasound data were collected. B-mode ultrasound videos (Telemed) of the VL were recorded at 100 frames/second at a depth of 50 mm. Ultrasound data were synced with motion capture and force data using a 5V trigger signal to indicate the start and end of the ultrasound recordings. Analysis of the VL fascicle length and angles involved a combination of open-sourced and custom-written software. Fascicle length and angles were measured at every frame from heel strike to peak knee extension moment (KEM). Fascicle length and angle excursion was measured as the total cumulative change in angle or length between every frame. Linear mixed effects models were used to assess between-limb group differences in fascicle and knee mechanics, including peak KEM and the rate of moment development (RMD). Regression analyses were also conducted to examine the relationship between fascicle mechanics and knee joint loading. **RESULTS**: Fascicle mechanics (i.e., length and angle excursions) following ACLR did not differ from that of healthy controls (p = 0.355- 0.730). However, during the peak demand of quadriceps force production, a reduced fascicle angle at peak KEM was observed in the ACLR-involved limb (p < 0.017; Figure 1) which was associated with a slower rate and magnitude of joint loading (p = 0.020-0.031; Figure 2). **DISCUSSION**: Individuals with a prolonged history of ACLR exhibit gait deviations that are related to altered fascicle mechanics, particularly during peak quadriceps force production. These findings reveal abnormalities in muscle architecture that highlight the necessity to probe intrinsic muscle factors that that may contribute to ineffective force transmission (e.g., tissue composition, neural activity).
SIGNIFICANCE/CLINICAL RELEVANCE: The findings of the current study add to the growing body of literature suggesting that there are factors at the intrinsic level that may underlie both gait and muscle abnormalities following ACLR that warrant further investigation.

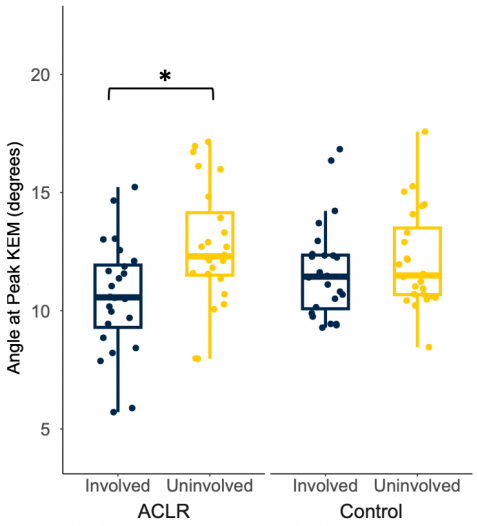

Figure 1. Fascicle Angle At Peak knee extension moment (KEM). There was a significant group by limb interaction at peak KEM, where the ACLR-involved limb exhibited 2.14 degrees less than the ACLR-uninvolved limb.*, significant difference between limbs identified post hoc in the presence of a significant group by limb interaction, p < 0.05

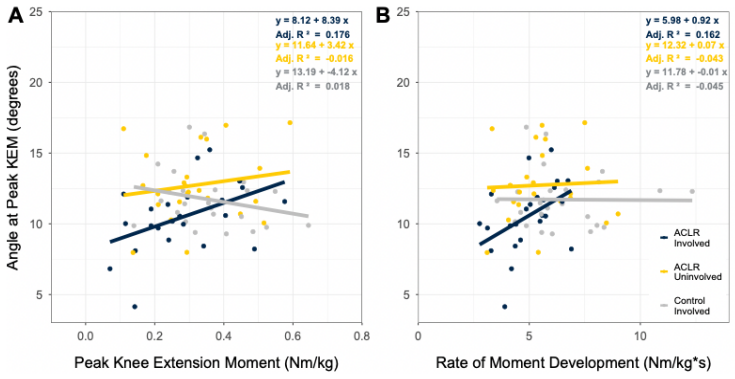

Figure 2. Associations Between Fascicle Angle at Peak Knee Extension Moment (KEM) and Peak KEM (Panel A) and Rate of Moment Development (RMD; Panel B). There was a significant interaction between the ACLR-involved and Control-involved limb for the associations of fascicle angle at peak KEM and peak KEM (Panel A; p = 0.031). Post hoc analyses revealed the association was significant in the ACLR-involved limb (p = 0.03) but not the Control-involved limb (p = 0.29). Peak KEM accounted for 18% of variance of fascicle angle in the ACLR limb (Panel A). There was a significant interaction between the ACLR-involved and Control-involved limb for the associations of fascicle angle at peak KEM and rate of moment development (RMD; Panel B; p = 0.020). Post hoc analyses revealed the association was only significant in the ACLR-involved limb (p = 0.01). RMD accounted for 16% of variance in fascicle angle in the ACLR limb (Panel B).