

# Asymmetries in Muscle Strength and Dynamic Knee Function are Correlated after Anterior Cruciate Ligament Reconstruction

Austin Carcia<sup>1</sup>, Scott Tashman<sup>1</sup>, Lauren Watkins<sup>1</sup>, Kristen Seballos<sup>1</sup>, Johnny Huard<sup>1</sup>, Armando Vidal<sup>1,2</sup>, Jonathan Godin<sup>1,2</sup>, Thomas Hackett<sup>1,2</sup>, Matthew T. Provencher<sup>1,2</sup>, Peter J. Millett<sup>1,2</sup>, Colin R. Smith<sup>1</sup>

<sup>1</sup>Steadman Philippon Research Institute, Vail, CO, <sup>2</sup>Steadman Clinic, Vail, CO, acarcia@sprivail.org

**Disclosures:** A. Carcia: None. S. Tashman: None. L. Watkins: None. K. Seballos: None. J. Huard: 1; Cook Myosite. 9; ORS. A. Vidal: 1; Stryker. 5; Arthrex, Inc. 9; AAOS. J. Godin: 3B; Bioventus, Mitek, Smith & Nephew. 4; NICE. 9; ASES, AANA. T. Hackett: 3B; Arthrex, Inc. 4; NICE. 5; Arthrex, Inc. M. Provencher: 1; Arthrex, Inc, Arthrosurface. 3B; Arthrex, Inc, Allosource (JRF). 5; Arthrex, Inc. 7B; Elsevier, SLACK. 8; AAOS, AOSSM, ASES, Arthroscopy, AANA, ISAKOS, Knee, Orthopedics, San Diego Shoulder Institute, SLACK, SOMOS. P. Millett: 1; Arthrex, Inc. 3B; Arthrex, Inc. 4; VuMedi. 5; Arthrex, Inc. C. Smith: None.

**INTRODUCTION:** Asymmetries in knee kinematics, graft elongation, and cartilage contact have been extensively demonstrated in anterior cruciate ligament reconstructed (ACLR) knees during dynamic activities [1]. These differences in dynamic knee function slow return to sport and contribute to post-traumatic osteoarthritis. Asymmetric knee function has been demonstrated in multiple ACL surgical techniques including anatomical methods [2], suggesting that optimizing other factors such as the muscle strength asymmetries commonly reported in ACLR patients may be critical to restore normal structure and function of the knee [3]. We hypothesized that asymmetries in muscle strength are correlated with asymmetries in dynamic knee function.

**METHODS:** Five patients (4 Female, Age = 32.8±3.1 years) who underwent unilateral, anatomical bone-patellar tendon-bone ACLR were included in this study. These patients represent a subset of a larger group participating in an IRB-approved, ongoing clinical trial investigating the use of leukocyte-poor platelet-rich plasma (LP-PRP) and bone marrow concentrate (BMC) to accelerate healing (IRB# 2019-13, NCT04205656). The participants underwent a CT scan, a muscle strength test, and a dynamic stereo x-ray (DSX) assessment of knee joint function at six months after surgery. DSX imaging was collected using 1ms pulsed exposures with a radiographic protocol of 90 kVp and 120mA at 120 frames/s during downhill running (10-degree decline, 2.5 m/s) on an instrumented, dual-belt treadmill (Bertec Co.), with acquisitions triggered just before foot-strike. The CT scans were segmented to generate 3D bone models, which were then registered to the biplanar x-ray images to assess knee joint kinematics. Knee kinematics were determined using the ISB standards, and the asymmetry was calculated between the intact and ACLR knee at corresponding image frames and averaged over time. Isokinetic muscle strength tests (HUMAC NORM) measured quadriceps and hamstrings strength throughout flexion/extension range of motion and were summarized by calculating the asymmetry in the peak torque and total work of the intact and ACLR limbs. Pearson correlation coefficients were computed between the muscle strength and knee kinematics asymmetries across all participants.

**RESULTS:** Subjects demonstrated an average reduction of 38% quadriceps and 11 % hamstrings peak torque in the ACLR limb. Similar to previous ACLR studies, asymmetries in anterior translation, adduction, and internal rotation were observed in the knee kinematics. The strongest correlation was observed between the asymmetries in quadriceps peak torque and anterior tibial translation ( $R = 0.85$ ,  $p = 0.06$ ). A trend was also observed between asymmetries in tibiofemoral adduction and quadriceps ( $R = 0.78$ ,  $p = 0.04$ ) and hamstrings ( $R = 0.57$ ,  $p = 0.31$ ) peak torque.

**DISCUSSION:** This preliminary investigation into our ongoing clinical trial revealed that muscle weakness after ACLR is correlated with altered dynamic knee function. The relationship between asymmetries in quadriceps strength and anterior tibial translation reflects the anterior force application of the quadriceps to the tibia through the patellar tendon. The correlations found between asymmetries in muscle strength and tibiofemoral adduction may reflect the valgus collapse mechanism common in ACL injuries [3]. These findings are based on a small sample size, and will require confirmation using data from the remaining subjects enrolled in this ongoing study.

**SIGNIFICANCE/CLINICAL RELEVANCE:** ACLR patients with larger muscle strength asymmetries demonstrated larger asymmetries knee kinematics during downhill running at 6 months after surgery. This suggests that targeted rehabilitation programs that focus on improving muscle strength may be critical to restore healthy dynamic knee function as well as prevent reinjury and the development of post-traumatic osteoarthritis.

## REFERENCES:

[1] Tashman, CORR, 2007, 454:66-73. [2] Tashman, KSSTA, 2021, 29:2676-83. [3] Schmitt, MSSE, 2015, 47(7):1426

**ACKNOWLEDGEMENTS:** Department of Defense, Office of Naval Research, Contract # N00014-19-C-2052

