Tibial Articular Cartilage Strain is Associated with Shear Forces During Normal Gait Following Anterior Cruciate Ligament Reconstruction

Kelly Kang[1,2], Ashley Buck[1], Caroline Lisee[1], Cortney Armitano-Lago[1], Elizabeth Bjornsen[1], David Lalush[2], Jason Franz[2], Brian Pietrosimone[1]

[1]Department of Exercise and Sport Science, University of North Carolina at Chapel Hill

[2]Joint Department of Biomedical Engineering, University of North Carolina at Chapel Hill and North Carolina State University

BACKGROUND

- Posttraumatic knee osteoarthritis (PTOA) is associated with aberrant gait biomechanics after anterior cruciate ligament reconstruction (ACLR).[1-3]
- During gait, the knee joint is exposed to both compressive and shear loading due to vertical and horizontal ground reaction forces (GRFs), respectively.
- Aberrant compressive and shear loading patterns have been linked to deleterious changes to tibiofemoral articular cartilage in patients with idiopathic osteoarthritis,[4] yet the associations between cartilage health and shear loading have not been explored in individuals post-ACLR.
- Articular cartilage deforms in response to loading forces such as walking (i.e., strain) to transmit loads across the knee joint.
- Greater cartilage strain is associated with osteoarthritis development and severity.[4]

PURPOSE

Purpose: To determine associations between shear (i.e., anterior-posterior [AP] and medio-lateral [ML]; Figure 1) GRFs during habitual gait and medial and lateral epicondyle tibial cartilage strain (Figure 3) in ACLR individuals.

Hypothesis: Greater shear (AP/ML) GRFs will be associated with greater tibial cartilage strain.

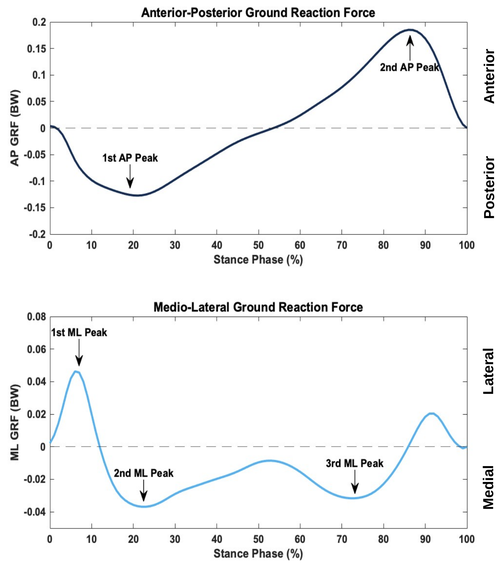
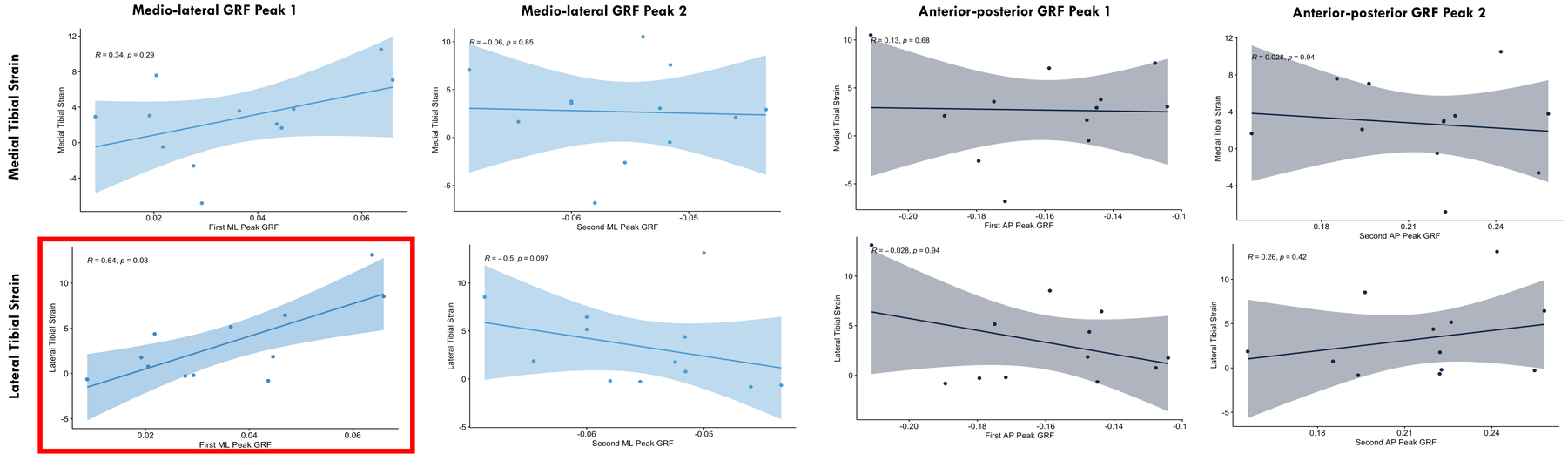


Figure 1. Anterior-posterior (AP) and medio-lateral (ML) ground reaction force (GRF) profiles during stance phase of gait.

RESULTS

Figure 2. Spearman rank correlation and 95% confidence interval between shear (AP; navy/ML; light blue) GRFs and medial (top row) and lateral (bottom row) tibial cartilage strain.



Greater laterally-directed loading during gait is associated with greater lateral tibial cartilage strain post-ACLR.

METHODS

- MRI data were collected on the ACLR limb following a 45-minute unloading period (pre-walking).
- Participants then underwent a standardized, 3000 step walking protocol at the habitual speed.
- A second MRI scan was conducted immediately following the walking protocol (post-walking).
- Cartilage strain was calculated as the change in cartilage thickness from pre- to post-walking relative to pre-walking thickness:

  Strain = [pre-walking cartilage thickness – post-walking cartilage thickness] / pre-walking cartilage thickness
- Spearman's rank correlation coefficients were calculated to determine the associations between AP/ML GRFs during habitual walking and articular cartilage strain of the medial and lateral tibial condyles.

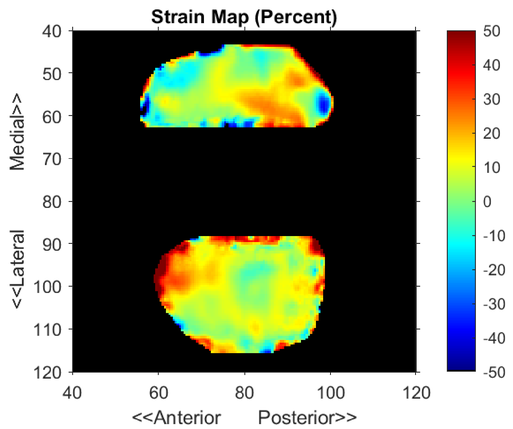


Figure 3 (left). Articular cartilage strain map of the medial (top) and lateral (bottom) tibial condyles (transverse cross-sectional view). Warm colors (yellow-red) indicate greater cartilage strain and cool colors (blue) indicate less cartilage strain.

TABLE 1. Participant Demographics

	All Participants (n=12)
Age (years)	22.9 ± 3.9
Sex (% Female)	58%
BMI (kg/m²)	25.6 ± 2.7
Walking Speed (m/s)	1.21 ± 0.18

DISCUSSION

- Greater laterally-directed stress during gait is associated with greater lateral tibial cartilage strain post-ACLR.
- Future research should further assess how shear loading influences long-term cartilage health.
- Previous research has successfully modified vertical GRF in ACLR individuals to improve cartilage health.
- Future research should determine whether interventions can reduce shear loading to decrease cartilage strain and PTOA risk.

REFERENCES

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Contact Information:
Kelly Kang
kykang@unc.edu