Longitudinal Changes In Thigh Musculature Following Anterior Cruciate Ligament Tear:

A Between-Subject Matched MRI Quantitative Analysis On Osteoarthritis Initiative Data

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Introduction

The effects of ACL rupture on thigh musculature are not completely understood. Prior research has primarily focused on acute quadriceps dysfunction or cross-sectional comparisons, but the long-term trajectory of muscle adaptations has not been well-documented. Given the critical role of thigh musculature in knee stability post-injury, a longitudinal analysis is essential to assess changes in muscle size, composition, and quality.

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Objective

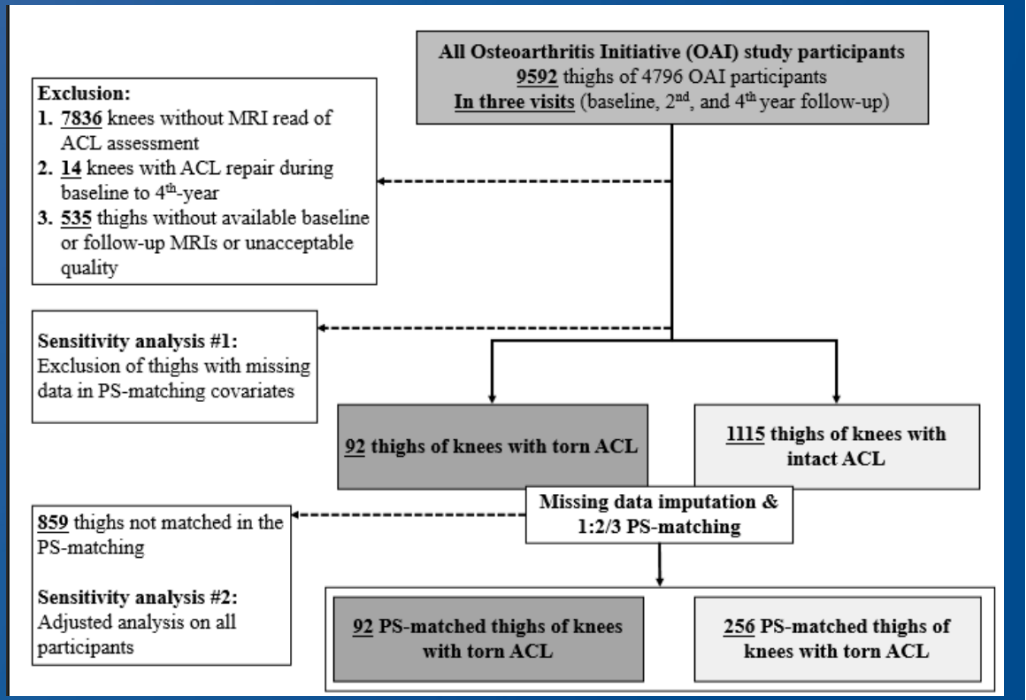
To evaluate longitudinal changes in muscle mass and composition in patients with ACL-deficient individuals compared with ACL-intact controls

Materials and Methods

- We utilized MRI data from the Osteoarthritis Initiative to examine long-term muscle changes in individuals with MRI-confirmed ACL tears who have not undergone surgical repair, compared to ACL-intact controls.
- MRI scans were assessed at baseline, 2 years, and 4 years, with a validated deep learning method used for automated thigh segmentation.
- The analysis focused on changes in muscle mass, including cross-sectional area (CSA), as well as muscle composition biomarkers such as intra-muscular adipose tissue (intra-MAT), contractile percentage (non-fat muscle CSA/total muscle CSA), and specific force (force per CSA) as a marker of muscle quality.
- Propensity-score matching was used to pair ACL-injured individuals with controls, allowing for a comparative assessment of four-year longitudinal muscle deterioration.

Patients

- 348 propensity score-matched (PS-matched) (92 with ACL tears and 256 with intact ACLs) were analyzed.
- Mean age of participants was 61 ± 9 years
- Female-to-male ratio of 0.4



Baseline Differences

- ACL had smaller CSA in all muscle groups, and knee flexor/extensor forces at baseline (standardized mean difference or SMD >0.1)
- Thighs of knees with ACL tear had higher specific force in the quadriceps and lower in flexors.

Significant Baseline Differences, ACL Intact vs ACL Deficient Thighs

Muscle Metric	ACL-Intact Thighs	ACL-Deficient Thighs	SMD
Quadriceps CSA	5619.5	5064	**0.401**
Flexors CSA	3598.27	3691.44	**0.110**
Adductor CSA	1333.05	1243.30	**0.137**
Total Thigh CSA	10957.5	10398.1	**0.214**
Knee extension contractile force	398.12	373.06	**0.193**
Knee flexion contractile force	170.46	161.81	**0.175**

CSA=cross-sectional area(mm^2)

Longitudinal Changes

- Longitudinal assessment of muscle biomarkers showed ACL tear was associated with decreased flexor and Sartorius CSA, and decrease in flexor muscle group force.
- There were no changes in muscle composition(intra-MAT, contractile percentage) or muscle quality biomarkers(force per CSA).

Longitudinal changes in thigh muscle markers between PS-matched thighs of knees with and without ACL tear.

	Average Difference/year				
	CSA (mm2)	**Intra-MAT CSA (mm2)**	**Contractile %**	**Strength (N)**	**Specific strength (N/cm2)**
Total thigh muscles	-18.06, P=0.355	-7.6, P=0.158	0.06, P=0.252	–	–
Quadriceps	0.98, P=0.929	-2.34, P=0.516	0.05, P=0.483	-1.16, P=0.669	-0.03, P=0.550
Flexors	**-28.18, P<0.001**	-4.36, P=0.073	0.07, P=0.334	**-3.49, P=0.029**	-0.07 P=0.113
Adductors	12.14, P=0.091	-0.91, P=0.364	0.11, P=0.197	–	–
Sartorius	**-3.02, P=0.006**	-0.05, P=0.902	-0.12, P=0.294	–	–

Summary

- ACL tear was associated with reduced thigh muscle size and force at baseline
- No significant longitudinal changes were observed in muscle composition or quality following ACL tear
- Similar to previous studies, we found that baseline quadriceps size was smaller in ACL-deficient thighs
- Our study found no longitudinal quadriceps size in ACL-deficient knees
- Further research on the impact of ACL repair on flexor-extensor muscle dynamics is warranted.

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