Post-Rehabilitation Analysis of Quadriceps and Hamstrings Strength Following Anterior Cruciate Ligament Reconstruction With or Without Meniscal Repair

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Abstract

Many athletes sustain injury and undergo surgical repair, often with multiple repairs occurring at once. This may contribute to additional post-surgical muscular deficits. **PURPOSE**: The purpose of this study was to determine if concurrent meniscal repair (MSR) during anterior cruciate ligament reconstruction (ACLR) influences any gender-specific differences in quadriceps or hamstring strength between the operative and non-operative limbs in athletes. **METHODS**: This retrospective observational study included 85 (48 men, 37 women; 19.0±6.6 years old) patients that were evaluated after undergoing ACLR with and without additional MSR. Primary outcome measures included maximal voluntary isometric contractions (MVICs) during knee flexion and extension to represent hamstring and quadriceps strength, respectively, using a handheld dynamometer. During the measurement, patients were seated upright with knee flexed at ~100° and the dynamometer on the distal leg. Patients performed three, 3-second MVICs with the highest value recorded. Charts were evaluated based on surgical code and included patient gender, age, and MSR. Three, 3-way [leg (OP v. NOP) x gender (men vs. women) x meniscus repair status (yes v. no)] mixed factorial analyses of variance (ANOVA) were used to assess differences in quadriceps and hamstrings strength separately and the hamstring-to-quadriceps ratio (H:Q), and all subsequent follow-up analyses were completed with an alpha level of $p<0.05$. **RESULTS**: The ANOVA models for the hamstring and quadriceps strength indicated no significant 3- or 2-way interactions and no main effect for MSR ($p>0.05$ for all comparisons). However, there was a main effect for gender in the hamstrings ($p<0.001$) and quadriceps ($p<0.001$), where the men were stronger for both flexion (mean difference=7.33 kg) and extension (mean diff.=10.41 kg). Likewise, there was a main effect for leg where the NOP limb demonstrated greater strength for both hamstrings/flexion ($p<0.001$; mean diff.=1.10 kg) and quadriceps/extension ($p=0.003$; mean diff.=2.58 kg). There was a 2-way interaction for H:Q gender x MSR ($p<0.001$) but no other significance indicated ($p>0.05$). Decomposition of the 2-way model revealed that women with MSR had higher H:Q ($p=0.044$) than those without and women without MSR had higher H:Q than men without MSR ($p=0.009$). No gender difference existed for H:Q of patients with MSR ($p=0.198$). **CONCLUSION**: Following rehabilitation, the operative leg had lower MVIC strength than the non-operative leg across all factors. The inclusion of MSR in conjunction with ACLR did not compound muscle strength deficits following surgery although there were slight differences in H:Q. There were gender-specific differences in limb strength, as women had lower quadricep and hamstring strength than the men. Conversely, women had a superior strength ratio compared to men that did not have MSR with their ACLR, meaning more comparable or balanced hamstring and quadriceps strength. Women that had MSR had a greater strength ratio than those with ACLR only. **PRACTICAL APPLICATIONS**: There may always be apparent gender differences in leg strength. However, those differences may be limited when a strength ratio is considered. Practitioners and clinicians should continually evaluate strength of the involved musculature and ratios to ensure symmetry as a means to prevent subsequent reinjury or predisposition to injury in healthy athletes.

Introduction

- Anterior cruciate ligament (ACL) injury is the most common ligamentous knee injury that frequently occurs during sports[3].
- ACL injuries are commonly accompanied by meniscus, cartilage, and medial collateral ligament injuries[2,4].
- These injuries can alter the recovery of knee kinematics[4].
- Negative consequences associated with the surgery include quadricep and hamstring weakness that can persist for years[1].
- Restoring muscle strength is a crucial for recovery of function and return to sports (RTS) while also reducing risk of reinjury[1].

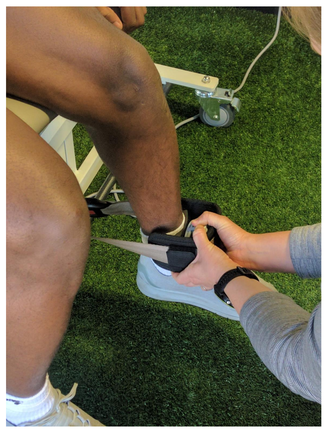
Purpose

The purpose of this study was to determine if concurrent meniscal repair (MSR) during anterior cruciate ligament reconstruction (ACLR) influences any gender-specific differences in quadriceps or hamstring strength between the operative and non-operative limbs in athletes.

Table 1. Participant characteristics (mean±SD).

Age	18.3 ± 1.3
Height (cm)	185.1 ± 6.6
Mass (kg)	83.2 ± 8.7

Methods



Study Design

- Retrospective chart review of university-affiliated hospital database for patients that underwent ACLR and rehab between 2018-2022

Rehabilitation Protocols:

- Five-phase post-operative protocol prior to completing RTS testing
- **Phase 1** (weeks 0-2): unloaded mobility exercises and electrical stimulation
- **Phase 2** (weeks 2-6): more intensive exercises added
- **Phase 3** (weeks 6-12): advanced strengthening and stability exercises added
- **Phase 4** (weeks 12-20): running progression added
- **Phase 5** (weeks 20-24): sports specific activities added

Patients:

- Total of 85 patients (48 males, 37 females)
- Underwent arthroscopically aided ACL repair/augmentation or reconstruction (CPT 29888)

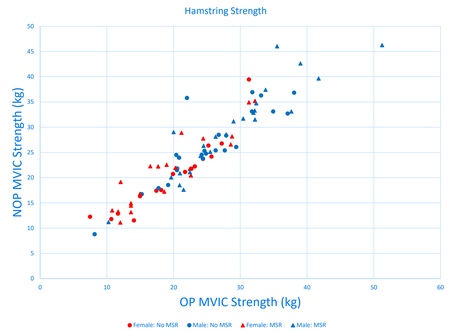
Functional Performance Assessment:

- PT used an isometric handheld dynamo meter to assess hamstring and quadricep strength (maximal voluntary isometric contractions [MVIC])
- NOP leg scored first
- Seated upright with knee flexed at 90° and dynamometer on distal leg
- Knee extension assessed quadriceps strength
- Knee flexion assessed hamstrings strength
- Each patient performed two 3 sec MVCs with highest value recorded

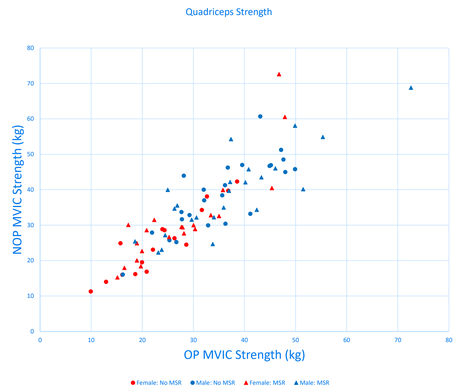
Statistical Analysis:

•Three 3-way [leg (OP vs. NOP) x gender (male vs. female) x surgical status (MSR vs. ACLR Only)] repeated measures ANOVAs
•Data considered significant at $p < 0.05$
•SPPS version 27.0

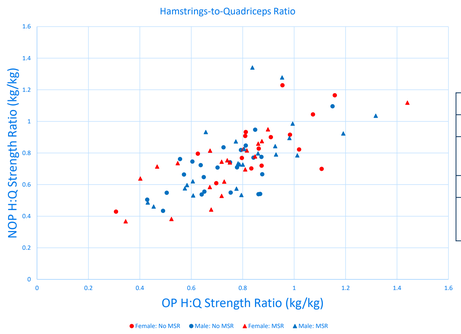
Results



HAMSTRING STRENGTH							
Meniscus Repair				No Meniscus Repair			
Operative Leg		Non-Operative Leg		Operative Leg		Non-Operative Leg	
Male	Female	Male	Female	Male	Female	Male	Female
28.79 ± 8.73#	19.33 ± 6.71*#	29.63 ± 8.99	21.26 ± 7.01*	25.31 ± 17.11#	19.73 ± 6.64*#	26.28 ± 7.07	20.38 ± 7.21*



QUADRICEP STRENGTH							
Meniscus Repair				No Meniscus Repair			
Operative Leg		Non-Operative Leg		Operative Leg		Non-Operative Leg	
Male	Female	Male	Female	Male	Female	Male	Female
36.91 ± 12.32#	27.82 ± 9.99*#	38.89 ± 11.72	31.44 ± 13.47*	35.47 ± 9.14*#	23.70 ± 8.35#	38.56 ± 10.19	25.29 ± 9.56*



H:Q STRENGTH RATIO							
Meniscus Repair				No Meniscus Repair			
Operative Leg		Non-Operative Leg		Operative Leg		Non-Operative Leg	
Male	Female	Male	Female	Male	Female	Male	Female
0.78 ± 0.45#	0.69 ± 0.50#*‡	0.76 ± 0.43	0.68 ± 0.54 *‡	0.71 ± 0.72#	0.82 ± 0.49*$#	0.68 ± 0.38	0.81 ± 0.52*$

* indicates significant difference between sex
\# indicates significant difference between limb
‡ indicates a 2-way interaction between women + MRS
$ indicates significant difference between women w/ NMR and men w/ NMR

Conclusions

- **Following rehabilitation, the operative leg had lower MVIC strength than the non-operative leg across all factors**
- **The inclusion of MSR in conjunction with ACLR did not compound muscle strength deficits following surgery although there were slight differences in H:Q**
- **Gender specific differences in limb strength persisted (men stronger than women)**

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