

The Effect of Preoperative Quadriceps Strength on Strength and Function After Anterior Cruciate Ligament Reconstruction

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Clinical Scenario

Strength deficits of the musculature surrounding the knee can be significant after anterior cruciate ligament reconstruction (ACLR). In patients who have undergone ACLR, regaining quadriceps function is a core focus of therapeutic rehabilitation. Knee stability, which is dependent on neuromuscular control, including quadriceps strength, is necessary for normal coordination of the lower extremity.^{1,2} After ACL rupture, the quadriceps muscle group tends to weaken, presenting a rehabilitation challenge to those waiting for surgery by further decreasing joint stability.² Preoperative rehabilitation to restore quadriceps strength and function has been recommended,^{3,4} but there is a paucity of evidence to demonstrate its effectiveness. The relationship between preoperative quadriceps strength and postoperative strength and function must be understood to determine whether preoperative strengthening will be beneficial to postsurgical outcomes by minimizing deficits and increasing stability after surgery.

Focused Clinical Question

In patients who have undergone ACLR, is there evidence to suggest that preoperative quadriceps strength positively affects postoperative quadriceps strength and lower extremity function?

Summary of Search, “Best Evidence” Appraised, and Key Findings

- We searched the literature for studies of level 2 evidence or higher that investigated the effects of preoperative quadriceps strength on postoperative quadriceps strength and function.
- Three⁵⁻⁷ cohort studies were included, 1 prospective⁶ and 2 retrospective.^{5,7}
- All 3 studies⁵⁻⁷ supported the positive relationship between preoperative quadriceps strength and post-

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operative quadriceps strength or function in ACLR patients.

Clinical Bottom Line

There is strong evidence to suggest that preoperative quadriceps strength positively affects postoperative quadriceps strength and lower extremity function in patients who have undergone ACLR.

Strength of Recommendation: There is level B evidence to support the proposal that preoperative quadriceps strength positively affects postoperative quadriceps strength and lower extremity function in ACLR patients. Level 2 evidence or higher was found in all 3 studies included in this critically appraised topic (CAT).

Search Strategy

Terms Used to Guide Search Strategy

- Patient/Client group: *anterior cruciate ligament*
- Intervention/Assessment: *preoperative quadriceps strength* and *knee function*
- Comparison: none
- Outcome: *quadriceps strength*

Sources of Evidence Searched

- CINAHL
- MEDLINE
- PsycINFO
- SPORTDiscus
- Cochrane Library
- Hand search

Inclusion and Exclusion Criteria

Inclusion

- Studies investigating quadriceps strength before ACLR and quadriceps strength and function postoperatively

- Level 2 evidence or higher (evidence obtained from well-designed cohort or case-control analytic studies)
- Limited to English
- Limited to humans
- Published in the last 10 years (2001–2010)

Exclusion

- Studies that did not report the effects of preoperative quadriceps strength on postoperative quadriceps strength of the affected limb
- Studies investigating quadriceps deficits that compared only side-to-side differences

Results of Search

Three relevant studies were located and categorized as shown in Table 1 (based on levels of evidence, Centre for Evidence Based Medicine, 1998).

Best Evidence

The studies listed in Table 2 were identified as the best evidence and selected for critical appraisal. They were selected because they had a level of evidence of 2 or higher and evaluated preoperative and postoperative ACLr quadriceps strength.

Implications for Practice, Education, and Future Research

The 3 studies^{5–7} selected for this CAT supported the rationale that preoperative quadriceps strength positively affects postoperative knee strength and function (see Table 2). These findings suggested that patients who had poor⁷ or abnormal^{5,6} preoperative quadriceps strength demonstrated lower postoperative quadriceps strength and lower extremity function. Results also indicated that good⁷ or normal^{5,6} preoperative quadriceps strength positively influenced postoperative quadriceps strength and lower extremity function.

All 3 studies evaluated preoperative quadriceps strength with an isokinetic dynamometer in preoperative patients waiting to undergo ACLr; however, only 1 study⁶

was prospective in design. The other 2 studies^{5,7} included in this review were retrospective reviews of prospectively collected uniform data. Although the level of evidence for these studies is lower based on the retrospective design, the results were consistent with the prospective study that was included (see Table 1).

Although there are few published studies directly related to this topic, the studies^{5–7} presented in this CAT suggested that preoperative quadriceps strength has a positive effect on postoperative quadriceps strength and lower extremity function. However, there is still a question as to the efficacy of preoperative quadriceps strengthening on postoperative outcomes. The studies included in this CAT examined the relationship of quadriceps strength to knee outcomes but not the effect of intervention on those outcomes. The ability to improve quadriceps function post-ACLR was beyond the scope of the included studies.^{5–7} One previous study that did not meet the inclusion criteria of this CAT demonstrated that a preoperative home exercise program was able to reverse deficits resulting from ACL injury, such as “giving way” and knee instability.³ It can be speculated that rehabilitation to increase preoperative quadriceps strength would lead to increased postoperative quadriceps strength and knee function.

In the course of clinical practice, ACL injury is often seen in active individuals and athletes. After critical appraisal of 3 studies,^{5–7} we conclude that preoperative quadriceps strength positively influences postoperative quadriceps strength and function. Monitoring preoperative quadriceps strength may help clinicians identify patients who may be at a disadvantage for positive knee outcomes after surgery. Furthermore, preoperative rehabilitation that focuses on quadriceps strength gain might be considered for those awaiting ACLr. Future research might focus on conducting well-designed clinical studies assessing the efficacy of quadriceps strengthening on post-ACLR outcomes.

References

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4. Noyes F, Mooar P, Matthews D, Butler D. The symptomatic anterior cruciate-deficient knee. Part 1: the long-term functional disability in athletically active individuals. *J Bone Joint Surg.* 1983;65:154–162.
5. de Jong S, van Caspel D, van Haeff M, Saris D. Functional assessment and muscle strength before and after reconstruction of chronic anterior cruciate ligament lesions. *Arthroscopy.* 2007;23(1): 21–8, 28.e1–3.

Table 1 Summary of Study Designs of Articles Retrieved

Level of evidence	Experimental design	Number located	Reference
1b	Cohort (prospective)	1	Eitzen et al ⁶
2b	Cohort (retrospective)	2	de Jong et al ⁵ Shelbourne and Johnson ⁷

Table 2 Characteristics of Included Studies

Characteristic	de Jong et al ⁵	Eitzen et al ⁶	Shelbourne and Johnson ⁷
Participants	191 ACL-deficient patients (29 women, 162 men; mean age 29 ± 7 y). Subjects were eligible if there was a diagnosis of unilateral ACL rupture and a history of subjective instability despite rehabilitation. Subjects were excluded if they had bilateral injuries, other ligament injuries in the same knee, or previous ACL reconstruction or extra-articular procedures.	73 ACL-deficient patients (26 women, mean age 26.8 y; 47 men, mean age 29.5 y). Subjects were eligible if there was a diagnosis of unilateral ACL rupture, with a maximum injury date of 3 y before scheduled surgery and within the Oslo area. Subjects were excluded if they had a history of injury or surgical intervention in either knee, meniscal injury that required repair, or full-depth cartilage defects affecting subchondral bone.	540 ACL-deficient patients (192 women, mean age 23.6 ± 9.1 y; 348 men, mean age 26.4 ± 8.5 y). Subjects were eligible if there was a diagnosis of unilateral ACL rupture and ACLr with bone-patellar-tendon-bone autograft. Subjects were excluded if they had bilateral ACL injuries or did not have a preoperative quadriceps strength evaluation within 60 d before surgery.
Intervention investigated	Bilateral assessment of quadriceps and hamstring strength at 60°/s and 180°/s with a Cybex II dynamometer preoperatively and 6, 9, and 12 mo postoperatively. Functional activities were assessed by the 1-legged timed hop for distance, 1-legged timed hop backward, and crossover hop for distance and represented by a calculation the limb symmetry index (LSI).	Bilateral assessment of quadriceps and hamstring strength at 60°/s and 240°/s on the Cybex dynamometer at baseline (preoperatively) and 2 y postoperatively. Functional activities were assessed by the 1-legged hop for distance, the triple hop for distance, and the stair-hop test for time. The Cincinnati Knee Score (CKS), two visual analog scales for pain and global rating of knee function, and the Short Form-36 (SF-36) were used as knee-specific self-assessment tools. Static knee-joint laxity (anterior tibial translation) was measured by a KT-1000 arthrometer.	Bilateral assessment of quadriceps strength at 180°/s on the Cybex dynamometer preoperatively (within 60 d of surgery) and 1, 2, 3, 12, and 24 mo postoperatively. Patients were grouped according to good strength (>90% of uninjured leg) and poor strength (<75% of uninjured leg) according to preoperative measures. Patients with measures between 90% and 75% were excluded. Knee range of motion (ROM) of flexion and extension was evaluated preoperatively and postoperatively with a goniometer. Static knee-joint laxity (anterior tibial translation) was measured by a KT-1000 arthrometer. Patellar tendon width was measured intraoperatively in millimeters and classified into 3 groups: small, medium, and large.
Outcome measures	Primary outcome: The relationship between preoperative strength deficit and postoperative functional progress. Secondary outcomes: The relationship between preoperative quadriceps and hamstring strength, percentage of patients with abnormal score for strength (deficit >20%) or functional assessment (LSI <85) preoperatively and postoperatively, influence of gender, and influence of graft.	Primary outcome: Predictors for knee function, comparisons among patients with >20% quadriceps strength deficits. Secondary outcomes: Comparisons among patients with meniscal injury with CKS. Relationship of the SF-36 BP subscale with the CKS.	Primary outcome: The relationship between preoperative quadriceps strength and postoperative strength. Secondary outcomes: patellar tendon width, knee ROM, and KT-1000 arthrometer measuring tibial displacement.
Main findings	Primary findings: Patients with a quadriceps strength deficit >20% preoperatively had significantly lower LSI 6 and 9 mo postoperatively than patients with a preoperative quadriceps strength deficit <20%. There was no clear difference at 12 mo between groups.	Primary findings: Preoperative quadriceps strength explained 15.6% of the regression of the variation. Patients with >20% quadriceps strength deficits had significantly lower CKS scores 2 y postoperatively ($P = .008$) and had lower quadriceps strength 2 y postoperatively than patients who had low preoperative quadriceps strength (<20%).	Primary findings: Patients with “good” preoperative strength (>90% of normal leg) had statistically higher postoperative strength than patients with “poor” preoperative strength (<75% of normal leg).

(continued)

Table 2 (continued)

Secondary findings: There were preoperative strength differences between the injured and uninjured legs (17% at 60°/s and 12% at 180°/s for quadriceps, 5% at 60°/s and 4% at 180°/s for the hamstrings). At 6 mo postoperatively quadriceps strength was 36% at 60°/s and 25% at 180°/s and at 9 mo postoperatively 25% and 18%, respectively (all at $P < .01$). Patients with large preoperative quadriceps strength deficit ($>20\%$ deficit) had a statistically significantly higher hamstring strength deficit than patients with a small preoperative quadriceps deficit ($<20\%$) who had an insignificant hamstring strength deficit. Functional assessment as measured by LSI improved significantly postoperatively ($P < .01$). The number of patients with abnormal strength deficit ($>20\%$) increased postoperatively, but patients with functional deficit (LSI $<85\%$) increased at 6 mo but were improved at 9 and 12 mo postoperatively compared with preoperatively. Patients with a high quadriceps strength deficit ($>20\%$) also had a poor functional assessment as measured by LSI ($P < .01$). Patients with an LSI below 85 performed statistically worse on quadriceps strength testing ($P < .01$).	Secondary findings: Meniscal injury explained 8.4% of the regression model, and the SF-36 BP explained 6.7% of the variation of the regression model. Patients with a meniscus injury scored significantly lower on the CKS ($P = .036$) and the SF-36 BP subscale ($P = .028$) 2 y postoperatively than patients with no meniscal injury. There was no difference in SF-36 BP subscale scores between the quadriceps groups ($>20\%$ deficit or $<20\%$ deficit) 2 y after surgery.	Secondary findings: Significant but weak correlation between patellar tendon width and quadriceps muscle strength at each follow-up time postoperatively. Patellar tendon width and preoperative quadriceps strength significantly affected the return of postoperative quadriceps strength at 1 and 3 mo ($P < .001$ for each) but was not a factor 1 y after surgery. Mean knee ROM was 6/0/144 in the injured knee compared with 6/0/146 in the normal leg. Mean KT-1000 difference between knees was 1.9 ± 1.3 mm.	
Level of evidence	2b	2b	
Validity score	STROBE 14/21	STROBE 20/22	STROBE 17/21

BP, bodily pain.

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