

*Original Article*

## ***The Effect of Prehabilitation on the Self-Reported Outcomes of Anterior Cruciate Ligament Reconstruction: A Systematic Review***

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### ***Abstract***

**Background and Purpose:** Quadriceps weakness and disruption of proprioceptive function are common after anterior cruciate ligament (ACL) injury and consequently the surgery. Postoperative self-reported outcomes are affected by the preoperative defect. The purpose of this review study was to examine whether preoperative exercises can affect self-reported outcomes.

**Methods:** The study started searching for papers from the PubMed, Scopus, EMBASE, Cochrane, and Web of Sciences databases and extracted the entered studies from 1990 to 2020. Moreover, the terms “ACL preoperative exercise” or “prehabilitation ACL” and “self-reported outcomes” or “postoperative outcomes” were used in the search titles, where 906 papers were finally found. Then, according to the main topic of the present study, and the inclusion and exclusion criteria, 10 papers met the inclusion criteria of the review. The methodological quality of the studies was also assessed through the Physiotherapy Evidence Database (PEDro) and Critical Appraisal Skills Program (CASP).

**Results:** The presentation of several preoperative intervention programs (traditional, strength, and neuromuscular training) significantly enhanced self-reported knee function in men and women after surgery in the short and long-term. The mean PEDro score for seven randomized controlled trial studies was found to be 6.3, which showed the moderate quality of the methodology. Moreover, the score for three cohort studies using the CASP scale was 7 out of 12.

**Conclusion:** Preoperative rehabilitation consisting of progressive strengthening and neuromuscular training, followed by a criterion-based postoperative rehabilitation program, had greater functional outcomes after Anterior Cruciate ligament reconstruction. Preoperative rehabilitation should be considered as an addition to the standard of care to maximize functional outcomes after ACLR.

**Keywords:** Anterior Cruciate Ligament; Preoperative Rehabilitation; Postoperative; Self-Reports

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## 1. Introduction

The most prevalent knee ligament injury is anterior cruciate ligament (ACL) rupture (1,2). This is one of the commonest traumatic injuries among active people (3). About 70% of its mechanism happening noncontact and 30% contact (4). Therefore, injury prevention exercises consisting of various training factors including strength, balance, core stability, and plyometric are provided (5-7).

Annually, more than 175,000 cases of ACL reconstructions are performed in the United States (8). Reconstruction has remained its value as a golden standard treatment for athletes in returning to high-level sport activities and stability of the knee ligaments. Even if anterior cruciate ligament reconstruction (ACLR) has brought good result in terms of knee stability, the quadriceps strength defect is reported as one of the limiting elements in returning to the pre-injury phase, which can last for more than 2 years after surgery (9). Approximately 23% of the patients with anterior cruciate ligament reconstruction will sustain a second ACL tear (10). And these individuals exhibit alterations in lower extremity kinematics that enhance the risk of future ACL injury (11).

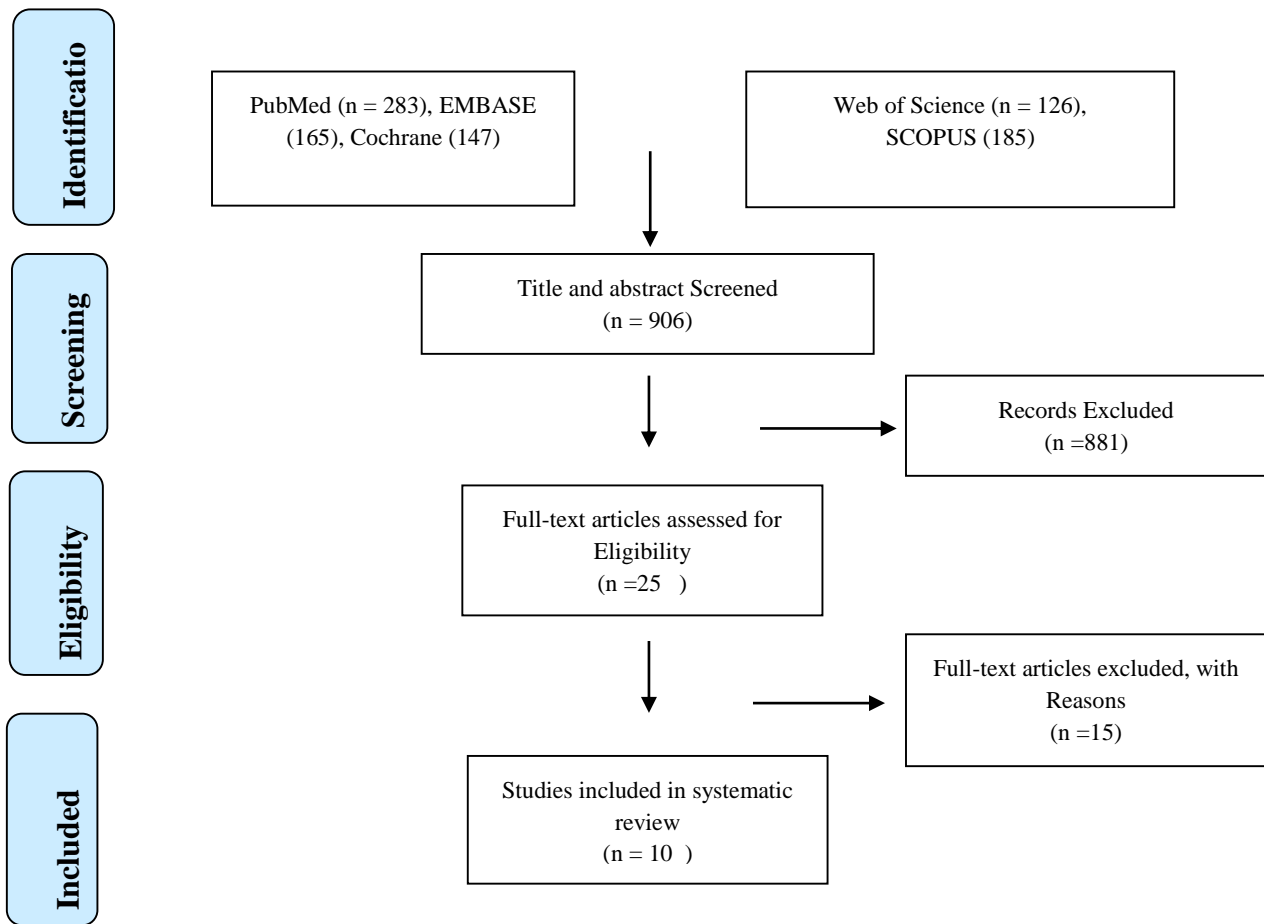
Individuals with ACLR describe deficit in self-reported outcomes which are often overlooked (12), and they experience impaired quality of life (13) and self-reported knee-joint dysfunction at return to activity and in the years after surgery (14). Keays et al. have reported the beneficial effects of 5-week home-based exercise on enhancing quadriceps strength and knee function after ACLR (15). In a randomized controlled trial, Shaarani et al. concluded

that a 6-week preoperative training program enhanced self-reported function up to 12 weeks after reconstruction (8). It has been reported that increased quadriceps strength may preoperatively enhance the outcomes for patients undergoing ACLR. All of these rehabilitation programs, mainly focusing on enhancing proprioception and muscular strength, are known as prehabilitation (8, 16).

Generally, few studies have investigated the effects of preoperative training on outcomes after ACLR. To our knowledge, this is the first systematic review that has been undertaken to investigate the effectiveness of prehabilitation protocols on the self-reported knee function after Anterior cruciate ligament reconstruction.

## 2. Material and Methods

This systematic study was reported using PRISMA guidelines (17). Relevant papers were searched through the keywords listed and combination of terms on the mentioned databases: “Preoperative ACL exercise” or “pre-habilitation ACL” and “Self-Reported outcome” or “postoperative outcomes”. In addition, the list of all papers was examined according to the inclusion and exclusion criteria to identify additional records and one author searched in the relevant journals. (e.g., The American Journal of Sports Medicine, Journal of Orthopedic & Sports Physical Therapy, Medicine and Science in Sports and Exercise, British Journal of Sports Medicine, Journal physical therapy science). Also, the search was limited to articles published from 1990 to 2020 in English. The full search strategy is shown in Figure 1.



**Figure 1.** Flow diagram of PRISMA

The two reviewers (MT, AE) examined the abstracts and titles independently according to inclusion criteria, and they mentioned the relevant reason in case they were rejected. A third reviewer (AY) did the arbitration if there were disagreements. The inclusion criteria were limited to studies examining

the effect of prehabilitation on the outcome of ACLR, and study designs were RCT and observational cohort. The studies with no preoperative exercises, case reports, and review papers were excluded. Table 1 shows the inclusion criteria according to the PICO acronym.

**Table 1.** Inclusion criteria according to the PICO acronym\*

Pico Indicators	Results according to PICO
<b>Design</b>	Randomized control trial and observational studies
<b>Population</b>	Participants with acute ACL injury (both male and female) without restriction to a particular age
<b>Intervention</b>	Preoperative Rehabilitation
<b>Comparisons</b>	No operative Rehabilitation, Conventional preoperative exercises
<b>Outcome measures</b>	Postoperative outcomes, self-reported outcomes

\*The PICO process (an acronym for patient problem or population (P), intervention (I), comparison (C) and outcome(s) (O)).

The methodological quality randomized controlled trial studies was evaluated through Physiotherapy Evidence Database (PEDro) scale (18). The scores of each study were assigned by two authors. PEDro scale has 11 items, 1 criteria evaluates the external validity of the experiment. This point is usually ignored in the study evaluation. Hence, evaluation based on items from 2 to 11 in this study was done according to the recommendation of Moher et al. (18). These cases have been specified as 1 for "yes" and 0 for "no," respectively. The studies with this scale ranged from 0 to 4 as poor methodological quality, 5 or 6 moderate, and those with scores of 7 and above had high methodological quality. On the other hand, the Critical Appraisal Skills Program (CASP) was used to evaluate cohort studies. On the 12 key criteria, the maximum score is 12. Methodological quality was categorized into three levels of "high" [ $9 \leq$ ], "moderate" [ $8 \geq 5$ ], or "weak" to help interpret the quality of the study (19).

### 3. Results

Table 1 presents the scores of the reviewed articles according to the PEDro Scale. The characteristics of the included articles are shown in Table 2. Most of the studies were randomized clinical trial and three studies were cohort. The methodological quality of RCT studies was 6 to 7 out of 10, and the mean score of 6.3 of the studies showed the overall methodology quality. The scores of three Cohort Observational studies were 7 out of 12. Preoperative training varied in duration, frequency, and contents: mean preoperative training duration 4 weeks (4 to 6 weeks), average frequency 3 times per week (3 to 6 days per week), and the contents of the preoperative training were quadriceps, and hamstring strength

training, proprioception, neuromuscular, balance training and gait training. Most of the studies have examined the effect of preoperative training on knee function through questionnaires. In one of these studies to examine the relationship between the preoperative quadriceps strength and knee function after ACL injury, performing preoperative rehabilitation for 4 weeks, quadriceps strength tests after surgery, completing rehabilitation for 6 months, and the International Knee Documentation Committee 2000 subjective form (IKDC2000), Logerstedt et al. concluded that preoperative quadriceps strength was as a significant predictor of scores (IKDC2000) at 6 months after surgery. Moreover, they concluded that preoperative quadriceps defect can affect knee function after 6 months (20). Filla et al. showed that patients with Delaware-Oslo ACL Cohort (DOC) have significant improvement in International Knee Documentation Committee 2000 subjective form (IKDC) and Knee injury and osteoarthritis outcome score (KOOS) 2 years postoperatively (21). Shaarani et al. found significant differences in Cincinnati scores between the experimental and control groups 12 weeks postoperatively (8). In a study conducted by Froebel, a strategy of rehabilitation along with early ACL Reconstruction did not have superior effect comparable to the strategy of rehabilitation plus optional delayed ACL at 2 and 5 years (22, 23). Three studies examined life quality (23-25). There was documented a significant improvement from baseline to post-exercise with both groups having preoperative training in three studies. Nonetheless, no significant differences were reported between the control and experimental groups in any of the studies.

**Table 1.** Evaluation of the study according to the PEDro Scale

PEDro Scale	Frobell et al. (2010)	Shaarani et al. (2014)	Thomeé et al. (2010)	Flosadottir et al. (2018)	Frobell et al. (2013)	Aggarwal et al. (2016)	Zdunski et al. (2015)
1. Eligibility criteria were specified	+	+	+	+	+	+	+
2. Random allocation of the subjects	+	+	+	+	+	+	+
3. Allocation was concealed	+	+	+	-	+	-	-
4. Groups similar at the baseline	-	-	+	-	-	+	-
5. There was blinding of all subjects	+	+	-	+	-	-	-
6. Blinding of therapists	+	-	-	-	-	-	-
7. Blinding of assessors	-	-	-	+	-	-	-
8. >1 key outcome was obtained for more than 85% of subjects initially allocated to groups	-	+	+	+	+	+	+
9. All subjects . . . received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by 'intention to treat'	-	+	+	+	+	+	+
10. Results of between-group statistical comparisons were reported for at least one key outcome	+	+	+	+	+	+	+
Total score	6	7	7	7	6	6	5

**Table 2.** Display of research papers in preoperative training on outcomes anterior cruciate ligament reconstruction

Study	Participants	Outcome measures	Intervention /control	Patient assessment/ follow up	Findings
Frobell et al. 2010	121 young, active adults with acute ACL injury. 18 to 35 years	Primary outcome: four subscales of the Knee Injury and Osteoarthritis Outcome Score (KOOS). Secondary outcomes: Five KOOS subscales. 36-Item Short-Form Health Survey, And the score on the Tegner Activity Scale	RCT 1- Con: structured rehabilitation Plus early ACL Reconstruction. 2-Exp: structured rehabilitation with the option of later ACL reconstruction 24 weeks Frequency and duration of sessions not reported	Baseline 3 months 6 months 12 months 24 months	Early reconstruction as compared with the option of delayed reconstruction did not result in a significant improvement in the primary outcome the change in the KOOS score between baseline and 2 years or in any of the secondary outcomes.  (PEDro score: 7/10; High quality)
Logerstedt et al. 2012	Fifty-five male and female in a group 26.8 ±11.2 age	IKDC2000	Longitudinal observational clinical study. Preoperative program: Strength (high intensity, low repetition) + perturbation training and post-operative rehabilitation 10 preoperative sessions and 6 month post-operative exercise	IKDC2000 six months after ACL reconstruction	IKDC2000 scores after surgery were significantly higher than IKDC2000 scores before surgery.
Shaarani et al. 2014	Twenty men between the ages of 18 and 45 years with an isolated ACL tear (n=10 each group)	Modified Cincinnati Knee Rating System score	RCT 1-Exp = gym- and home-based preoperative exercise program and post-operative exercise 2-Con= No preoperative exercise and 12 weeks post-operative exercise	Baseline Preoperative 12 weeks postoperative	The mean modified Cincinnati score was better in the exercise-injured limb compared with baseline (85 vs 78, p= 0.004). (PEDro score: 7/10; High quality).
Failla et al. 2016	150 patients from the University of Delaware in the United States and 150 patients from the Norwegian Research Center 10 and 85 years	International Knee Documentation Committee (IKDC) and Knee injury and Osteoarthritis Outcome Score (KOOS)	For 6-week preoperative, 12 week post-operative Cohort study 1- Oslo ACL Cohort [DOC] = preoperative rehab (neuromuscular training+ Strength) and Postoperative rehab 2- Multicenter Orthopaedic outcomes Network (MOON) cohort = no preoperative rehab and postoperative Protocol  4week preoperative exercise and 6month post-operative	Baseline 2 years after ACLR	The DOC patients showed significant and clinically meaningful differences in IKDC and KOOS scores 2 years after ACLR. There was a significantly higher percentage of DOC patients returning to preinjury sports (72%) compared with those in the MOON cohort (63%).
Thomeé et al. 2010	40 patients with ACL injuries. receiving exercises administered by self-efficacy trained physiotherapists. 16 to 55 years	The International Knee Documentation Committee 2000 subjective form), the Tegner Activity Scale, the Physical Activity Scale, the Knee Injury and Osteoarthritis Outcome	RCT Control and experimental groups received the same Exercises (strengthening, Range of motion,	Baseline 4 months 6 months 12 months	Current knee-function self-efficacy, knee symptoms in sports, and knee quality of life improved significantly (P = .05) in both groups during rehabilitation. Both groups had a significantly (P

Flosadotfir et al. 2018	89 young, active adults with acute ACL injury. 18 to 35 years	Score, and the Multidimensional Health Locus of Control  knee-related self-efficacy score (k-SES)	coordination, balance exercises) with the intervention group receiving exercises administered by self-efficacy trained physiotherapists. 24 weeks, one hour exercise twice a week RCT Exercise therapy alone (ACL-D, n = 20), exercise therapy plus early reconstruction (ACL-R n = 46), and exercise therapy plus delayed reconstruction (ACL-X n = 23).	At the end of exercise therapy 5 years follow up 6 years follow up	= .05) lower physical activity level at 12 mo than pre injury. No significant differences were found between groups. (PEDro score: 5/10; Moderate quality)  There were no differences between the three treatment groups in K-SES (knee –self efficiency score) 6 years after injury. (PEDro score: 5/10; Moderate quality)
Frobell et al. 2013	121 young, active adults with acute ACL 18 to 35 years	Score (KOOS), 36-Item Short-Form Health Survey, score on the Tegner	RCT 1- structured rehabilitation Plus early ACL Reconstruction. 2- structured rehabilitation with the option of later ACL reconstruction 24 weeks Frequency and duration of sessions not reported	Baseline 5 years follow up	The mean change in KOOS score from baseline to five years was 42.9 points for those assigned to rehabilitation plus early ACL reconstruction and 44.9 for those assigned to rehabilitation plus optional delayed reconstruction. At five years, no significant differences between group differences were seen in KOOS (P=0.45), any of the KOOS subscales (P≥0.12), SF-36 (P≥0.34), Tegner activity scale (P=0.74), (PEDro score: 6/10; Moderate quality)
Aggarwal et al. 2016	20 Male patients with unilateral Acl tear. 20 to 45 years (n=10 each group)	Cincinnati knee rating system  Lysholm scoring scale	Randomized Controlled Trial (RCT). 1- Experimental: Isokinetic strength training: 3 sets of 10 repetitions at velocity 60 and 120 sec 2-control: conventional training  4 week 6 days a week only preoperative exercise	Before and after preoperative exercise	No significant differences were found with use of functional scales (p>0/05). (PEDro score: 6/10; moderate quality)
Zedunski et al. 2015	Isolated ACL Rupture awaiting reconstruction; n = 30; 40 ± 8 years, 56.7% male	Self-reported knee function assessed by the Lysholm-Gillquist scale	Preoperative physiotherapy	Baseline Post training (pre reconstruction)	Significant differences from baseline to presurgery assessment within and between groups (PEDro score: 5/10; Moderate quality)
Grindem et al. (2015)	Primarily unilateral ACL-R awaiting reconstruction; n = 2,774; 25,1 ± 7,5 years; 48,5% male	self-reported knee function (KOOS–subscales: Pain, symptoms, ADLs, sports/ recreation, QoL)	Neuromuscular training, strength training and plyometric 5-week preoperative rehabilitation program	no baseline pre reconstruction • 2 years post reconstruction	Comparison of KOOS in the two cohorts preoperatively and 2 years postoperatively stratification of preoperative KOOS subscale scores (Low/high scores were defined as scores below/above the median preoperative scores)

\*DOC = Delaware-Oslo ACL Cohort; Moon= Multicenter Orthopedic Outcomes Network; KOOS = Knee injury and Osteoarthritis Outcome Score; IKDC= International Knee Documentation Committee; K-SES= knee-related self-efficacy score; ADL = Activities of daily living; QoL = Quality of life; EXP= Experimental; Con= Control

#### 4. Discussion

In spite of the many preoperative approaches that were examined in this review paper, it was found that preoperative rehabilitation is effective in enhancing postoperative outcomes. Moreover, the variety of approaches used in this review paper showed the nature of preoperative exercises in the patient population and it strengthens the clinical validity of the results. The results indicated that the group receiving preoperative training program experienced significant enhancement in postoperative physical function relative to the control group (24). It has been suggested that preoperative training (strength + neuromuscular) and obtaining a normal range of motion, quadriceps activation, pain reduction, and swelling lead to significant enhancement after two years of ACL surgery (24). Furthermore, preoperative rehabilitation including range of motion, strength, balance and proprioception exercises significantly minimize deficit of knee extensor strength at velocity of 60° and 180 ° sec (26). Postoperative knee extensor defect is a common problem as reported in previous studies (27,28). The quick reduction in quadriceps function, mostly occurring in the early postoperative period, is due to arthrogenic muscle inhibition, caused by pain, inflammation, swelling, and impaired arthritis. This neural mechanism for quadriceps weakness may persist for a long time after ACL injury or surgery (29,32). The four papers in both the control and experimental groups used a preoperative training program, and these studies showed improvement in performance in both groups after a rehabilitation program prior to surgery (22-25). Several studies have shown that muscle function maximization and range of motion deficit minimization

preoperative are connected to improved postoperative outcomes (25-27). Moreover, this is consistent with previous results that preoperative outcome scores significantly predict postoperative outcomes (33).

Just in a study, active adults with an acute ACL tear, a strategy of structured rehabilitation plus early ACL reconstruction did not result in better patient-reported outcomes at 5 years than a strategy of rehabilitation plus optional delayed ACL reconstruction in those with symptomatic instability. Also, the results did not differ between knees surgically reconstructed early or late and those treated with rehabilitation alone (22). Generally, these results should encourage clinicians and young active adult patients to consider rehabilitation as a primary treatment option after an acute ACL tear. Eitzen and Moksnes found that a 5-week program before surgery could improve post-ACLR functional outcomes (33). Our results were found to be in line with those of Eitzen et al. (33) and Grindem et al. (34) in that, progressive preoperative rehabilitation is a significant element in maximizing postoperative results. Furthermore, patients with total ACL rupture attending a preoperative training program led by a physiotherapist (experimental group) achieved greater improvement in functional status compared with the control group (35). Hence, a proper and adequate preoperative training program can have a significant role in enhancing postoperative muscle strength. The results indicated that preoperative training not only deters quadriceps weakness but also accelerates muscle strength improvement and patient-reported outcome, assisting the patients to adapt quickly to the rehabilitation environment. Moreover, it is predicted that with better strength and performance,



preoperative training can prevent re-injury. While preoperative rehabilitation exercises seem to be a useful and effective program for improving postoperative outcomes, further studies are recommended to examine the effects of preoperative protocols on the kinematic and kinetic variables.

## 5. Conclusion

Moderate quality evidence indicates that preoperative rehabilitation exercises based on neuromuscular exercises with strength training could enhance self-reported function. Additionally, maximizing quadriceps strength with progressive preoperative exercises should be a purpose for specialists in enhancing functional outcomes after ACL reconstruction.

## Conflicts of Interest

The authors declared no conflicts of interests.

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