Open Kinetic Chain Versus Closed Kinetic Chain Exercise After ACL Injury

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Source

REHABILITATION techniques following anterior cruciate ligament (ACL) injury or reconstructive surgery remains an important clinical topic for health care professionals who manage sports-related injuries. ACL rehabilitation continues to evolve on the basis of clinical experience and research reports, but optimal techniques have not been established. An often debated topic is the use of open kinetic chain (OKC) and closed kinetic chain (CKC) exercises for the restoration of quadriceps strength following injury and surgery. The purpose of this report is to review evidence pertaining to the use of OKC exercise for quadriceps strengthening of patients with ACL injury and its effect on tibial translation in comparison to CKC exercise.

Summary of Methods
Isolated ACL rupture that was confirmed by arthroscopy or magnetic resonance imaging and a maximum of 14 weeks elapsed since the traumatic event were inclusion criteria. Participants included 24 males and 18 females who had a mean age of 26 years. All subjects received a standard rehabilitation program and were randomly assigned to either a supplemental OKC exercise group (n = 22) or a supplemental CKC exercise group (n = 20). With the exception of the supplemental exercises, the rehabilitation program was identical for all subjects. The primary exercise for the CKC exercise group was the one-leg squat, whereas the primary

Key Points
- OKC exercise is more effective in restoring quadriceps strength than CKC exercise in ACL-deficient patients.
- OKC knee extension exercise did not increase static or dynamic tibial translation.
- OKC exercise should be included in a comprehensive rehabilitation program following ACL injury.

Study Purpose
This purpose of the referenced study was to compare the effects of a comprehensive rehabilitation program that was supplemented with either OKC or CKC exercise on the quadriceps strength of patients with ACL deficiency. In addition, the researchers examined the effects of OKC and CKC exercise on static and dynamic tibial translation, knee function, and other common outcome measures. The researchers hypothesized that OKC exercises would improve quadriceps strength and improve knee function without increasing tibial translation as compared with the same comprehensive rehabilitation program supplemented with CKC exercises.
exercise for the OKC exercise group was seated knee extension. Exercises were progressed using widely-accepted clinical guidelines and were performed three times per week for duration of four months. All subjects were assessed before and after rehabilitation for the clinical measurements summarized in Table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measurement Tool/Technique</th>
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<tbody>
<tr>
<td>Knee swelling</td>
<td>Tape measurement</td>
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<tr>
<td>Passive knee range of motion</td>
<td>Plastic goniometry</td>
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<td>Anterior tibial translation</td>
<td>Electrogoniometer</td>
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<td>Muscle strength</td>
<td>Isokinetic dynamometer</td>
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<td>Muscle strength</td>
<td>Single-leg squat</td>
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<td>Knee function</td>
<td>Lysholm score, Knee injury osteoarthritis outcome score</td>
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<td>Muscle activation</td>
<td>Surface electromyography</td>
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Study Findings

The primary findings of the study were a significantly greater increase in isokinetic quadriceps strength in OKC exercise group and similar tibial translation for both groups. No other differences in outcomes were reported. The authors concluded that OKC exercise improved quadriceps strength to a greater extent than did CKC, without increasing static or dynamic tibial translation.

Restoration of muscular strength is a primary goal of rehabilitation following ACL injury or ACL reconstructive surgery, particularly that of the quadriceps. Over the years, clinicians have debated the relative merits of different types of exercise to promote optimal restoration of strength, without compromising secondary restraints or the integrity of the graft used to surgically reconstruct the ACL. Historically, OKC exercise was the primary method for strengthening the quadriceps following ACL injury or surgery. Concern for the biomechanical stresses placed on the knee structures during resisted OKC knee extension led to reluctance to utilize such exercise, however. The primary concern was the development of anterior tibial translation shear forces as the knee approaches full extension, which could result in elongation of the ACL graft in a surgically reconstructed knee or impose potentially injurious loading of secondary restraints.¹ Consequently, clinicians began to rely more on CKC exercises to restore quadriceps strength, with the belief that they produced lesser anterior shear forces and provided other benefits not derived from OKC exercises, such as improved postural balance. CKC exercises have become an integral component of lower extremity joint rehabilitation, but some clinicians are skeptical about their suitability for generating the strength gains that are needed for full recovery of functional capabilities, especially among athletes who are returning to high-demand sport activities.

The difference in isokinetic strength between the OKC and CKC groups was statistically significant; the authors reported a *P* value of 0.009. Knee extension strength was determined by isokinetic testing at 60 degrees per second and expressed as a percentage of the uninjured extremity. The CKC group had a ratio of 84 ± 15%, and the OKC group had a ratio of 96 ± 14%. In addition to the statistical difference between the OKC and CKC groups, a meaningful clinical effect was reported. Effect size provides an indication of the clinical importance of an observed difference.² One simple method for determination of effect size involves division of the difference between the means of the two groups by a pooled standard deviation for both groups. The calculated effect size for this study was 0.80 (96–84/14.5). An effect size is generally classified as small (0.20), medium (0.50), or large (0.80). The statistically significant and clinically meaningful increase in quadriceps strength produced by OKC exercise is important, because weakness of the quadriceps is common in patients who report poor function following ACL injury and/or reconstruction.³ Such patients may need more aggressive quadriceps strengthening.⁴

Many clinicians may not find it surprising that OKC exercise produced an increase in quadriceps strength when it was quantified by an isokinetic dynamometer during OKC knee extension; however, the finding that OKC exercise did not increase static or dynamic tibial translation is contrary to the expectation of many ATs. In addition to the static Lachman test, this study quantified anterior tibial translation during normal walking gait, during performance of a single-leg squat, and during isokinetic knee extension. The authors noted that a limitation of other studies has been a lack of dynamic translation assessment, which reflects

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Both OKC and CKC exercises produce tibial translation, but there does not appear to be a difference between the exercise modes. Interestingly, one of the reports cited by the authors suggested that patients with increased tibial translation demonstrated better knee function during gait than those with less tibial translation.

The reviewed study was a well-controlled randomized clinical trial, which provides useful clinical information about the relative effects of different modes of strength restoration following ACL injury. An important characteristic of this study is that subjects were ACL-deficient and had not undergone surgical reconstruction of the ACL. Most physically active patients with a history of ACL rupture have received reconstructive surgery. Thus, generalization of the results to the rehabilitation of surgically reconstructed patients should be done cautiously. The results of this study do not discount the possibility that OKC exercise could have an adverse effect on an ACL graft. The clinical recommendation that can be derived from the results of this study is that OKC quadriceps strengthening exercises should be included in a rehabilitation program for an ACL-deficient patient to achieve an optimal level of quadriceps strength. OKC exercise does not appear to have an adverse effect on knee joint stability in ACL-deficient patients.

References

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