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Controversies in Knee Rehabilitation: Anterior Cruciate Ligament Injury

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Abstract

Controversy in management of athletes exists after anterior cruciate ligament injury and reconstruction. Consensus criteria for evaluating successful outcomes following ACL injury include no re-injury or recurrent giving way, no joint effusion, quadriceps strength symmetry, restored activity level and function, and returning to pre-injury sports. Using these criterions, we will review the success rates of current management strategies after ACL injury and provide recommendations for the counseling of athletes after ACL injury.

Keywords

Anterior Cruciate Ligament; Knee; ACLR; ACL; Physical Therapy; Athletes; Sports Physical Therapy

Introduction

More than 250,000 anterior cruciate ligament (ACL) injuries occur yearly in the United States¹, with 125,000–175,000 undergoing ACL reconstruction (ACLR)^{2,3}. While standard of practice in the United States is early reconstruction for active individuals with the promise of returning to pre-activity injury levels^{4,5}, evidence suggests athletes are counseled that reconstruction is not required to return to high level activity after a program of intensive neuromuscular training⁶. Others advocate counseling for a delayed reconstruction approach⁷, however no differences in outcomes exist between delayed and early ACL reconstruction⁶. Furthermore, athletes in the United States are commonly counseled to undergo early ACLR⁵ with the promise of restoring static joint stability, minimizing further damage to the menisci and articular cartilage^{8,4}, and preserving knee joint health⁵, however, not all athletes are able to return to sport or exhibit normal knee function following

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reconstruction⁹. Several factors, such as impaired functional performance, knee instability and pain, reduced range of motion, quadriceps strength deficits, neuromuscular dysfunction, and biomechanical maladaptations, may account for highly variable degree of success.

In order to identify the minimum set of outcomes that identify success after ACL injury or ACLR, Lynch et al established consensus criteria from 1779 sports medicine professionals concerning successful outcomes after ACL injury and reconstruction¹⁰. The consensus of successful outcomes were identified as no re-injury or recurrent giving way, no joint effusion, quadriceps strength symmetry, restored activity level and function, and returning to pre-injury sports¹⁰ Figure 1. Using these criteria we will review the success rates of current management after ACL injury and provide recommendations for the counseling of athletes after ACL injury.

Impairment Resolution

Following ACL injury or reconstruction, athletes undergo an extensive period of vigorous rehabilitation targeting functional impairments. These targeted rehabilitation protocols strive for full symmetrical range of motion, adequate quadriceps strength, walking and running without frank aberrant movement, and a quiet knee: little to no joint effusion or pain¹⁰. Despite targeted post-operative rehabilitation, athletes commonly experience quadriceps strength deficits^{11,12,13}, lower self-reported knee function¹⁴, and movement asymmetry^{15,16} up to two years after reconstruction. The importance of quadriceps strength as a dynamic knee stabilizer has been established, as deficits have been linked to lower functional outcomes^{12,17}. In a systematic review of quadriceps strength after ACLR, quadriceps strength deficits can exceed 20% 6 months after reconstruction, with deficits having the potential to persist for 2 years after reconstruction¹³. Otzel et al reported a 6–9% quadriceps deficit 3 years after reconstruction, concluding that long-term deficits after surgery were the results of lower neural drive as quadriceps atrophy measured by thigh circumference was not significantly different between limbs¹⁸. Grindem et al reported at two-year follow up 23% of non-operatively managed athletes had greater than 10% strength deficits compared to 1/3 of athletes who underwent reconstruction.¹⁹ Another study comparing operatively and non-operatively managed patients 2–5 years after ACL injury found no differences in quadriceps strength between groups concluding reconstructive surgery is not a prerequisite for restoring muscle function²⁰. Regardless of operative or non-operative management, quadriceps strength deficits are ubiquitous after ACL injury, and can persist for the long term. The current evidence does not support ACLR as a means of improved quadriceps strength outcomes over non-operative management after ACL injury.

Outcomes

Individuals do not respond uniformly to an acute ACL injury and outcomes can vary. Most individuals decrease their activity level after ACL injury^{21,20,22–25}. While a large majority of individuals rate their knee function below normal ranges after an ACL injury, which is a common finding early after an injury^{26–30}, some individuals exhibit higher perceived knee function than others early after ACL injury^{28–30}. This highlights the variability in outcomes seen after ACL injury.

Knee outcome scores are lowest early after surgery and improve up to 6 years post surgery^{29,31,32}. Using the Cincinnati Knee Rating System, scores improved from 60.5/100 at 12 weeks post reconstruction to 85.9/100 at 1 year follow-up³². By six months after surgery almost half of individuals score greater than 90% on the Knee Outcomes Survey- Activities of Daily Living Scale (KOS-ADLS) and Global Rating Scale of Perceived Function (GRS) and 78% have achieved these scores by 12 months¹⁴. Using the GRS, scores improved from 63.1/100 taken at week 12 to 83.3/100 at week 52³². Moksness and Risberg reported similar post-surgical GRS results of 86.0/100 at 1 year follow-up²⁹. Poor self-report on outcome measures after ACLR are associated with chondral injury, previous surgery, return to sport, and poor radiological grade in ipsilateral medial compartment³³. ACLR revision and extension deficits at 3 months are also predictors of poor long term outcomes^{34,35}

Patient reported outcomes from multiple large surgical registries are available concerning patients after ACLR. A study from the MOON consortium of 446 patients reported International Knee Documentation Committee Subjective Knee Form 2000 (IKDC) for patients 2 and 6 years after reconstruction³⁶. The median IKDC score was 45 at baseline, rose to 75 at 2 year follow up, and reached 77 at 6 years after reconstruction³⁶. Grindem et al compared IKDC scores between athletes managed non-operatively or with reconstruction at baseline and 2 years¹⁹. The non-operative group improved from a score of 73 at baseline to 89 2 years after injury¹⁹. The reconstructed group improved from 69 at baseline to 89 2 years after surgery¹⁹. There were no significant differences between groups at baseline or at 2 year follow-up¹⁹. Using the Knee Injury and Osteoarthritis Outcome Score (KOOS), Frobell et al compared patient reported outcomes at 5 years after ACL injury and found no significant differences in change score from baseline to 5 years in those managed with early reconstruction versus those managed non-operatively or with delayed reconstruction³⁷. Outcomes after ACL injury, whether managed non-operatively or with ACLR, have similar patient reported outcomes scores at up to 5 years after injury.

Long-Term Joint Health

Preventing further intra-articular injury and preserving joint surfaces for long-term knee health is a purposed reason to surgically stabilize an unstable knee⁵. Patients who had increased knee laxity after an ACL injury are more likely to have late meniscal surgery³³ and time from ACL injury is associated with the number of chondral injuries and severity of chondral lesions³⁸. Injury to menisci or articular cartilage places the knee at increased risk for the development of osteoarthritis³⁹. Barenius et al found a 3 fold increase in knee osteoarthritis prevalence in surgically reconstructed knees 14 years after surgery³⁹. They concluded that while ACLR did not prevent secondary osteoarthritis, initial meniscal resection was a risk factor for osteoarthritis with no differences in osteoarthritis prevalence seen between graft types³⁹. A recent systematic review compared operatively and non-operatively treated patients at a mean of 14 years after ACL injury⁴⁰ and found no significant differences between groups in radiographic osteoarthritis⁴⁰. The operative group had less subsequent surgery and meniscal tears, as well as increased Tegner change scores however there were no differences in Lysholm or IKDC scores between groups⁴⁰. The current evidence does not support the use of ACLR to reduce secondary knee osteoarthritis after ACL injury.

Return to Pre-Injury Sports

Returning to sports is often cited as the goals of athletes and health care professionals after ACL injury or ACLR. When asked, 90% of NFL head team physicians believed that 90–100% of NFL players returned to play after ACLR⁴¹. Shah et al found that regardless of position 63% of NFL athletes seen at their facility returned to play⁴². A recent systematic review reported 81% of athletes return to any sports at all, but only 65% return to their pre-injury level and an even smaller percentage, 55%, return to competitive sports⁴³ Figure 2. This review found that younger athletes, men, and elite athletes were more likely to return to sports⁴³. Similar reports within this range are common when examining amateur athletes by sport. McCullough et al. report that 63% of high school and 69% of college football players return to sport⁴⁴. Shelbourne found that 97% of high school basketball players return to play, 93% of high school women and 80% of high school male soccer players returned⁴⁵. Brophy et al. found a slightly different trend in soccer players; 72% returned to play, where 61% returned to the same level of competition but when broken down by sex more men (75%) returned than women (67%)⁴⁶. These studies highlight the fact that while there may be a link between sport and return to sport, due to a lack of high quality research, current literature was unable to come to any conclusion⁴⁷.

Reduced return to sport rates can be attributed to many factors, including age, sex, pre-injury activity level, fear and psychological readiness. Age and sex are two variables which have been identified in multiple studies^{43,46}, with men and younger athletes being more likely to return to sport. Age, may be a proxy measure for changing priorities (i.e. family), commitments (i.e. employment), and/or opportunities to play at the same level (i.e. no longer have the competitive structure of high school, college, or club sports)⁴³. Further, it has been hypothesized that “For those athletes whose life and social networks are inherently structure around participating in sport, a stronger sense of athletic identity may be a positive motivator for return to sport”⁴³. While this hypothesis remains to be tested, this could explain the higher rates of return to sport in younger and elite/professional level athletes. Dunn et al found that higher level of activity at prior to injury and a lower BMI were predictive of higher activity levels at two years following ACLR⁴⁸. Ardern et al found that elite athletes were more likely to return to sport than lower level athletes⁴³. Professional and elite level athletes may have access to more resources, particularly related to rehabilitation services, but motivation to return to that high level of play and athletic identity may also drive such return to sport⁴³. Interestingly, Shah et al. found that in NFL players return to play was predicted by draft round. Athletes drafted in the first four rounds of the NFL draft were 12.2 times more likely to return to sport than those athletes drafted later or as free agents⁴². This could represent the perceived talent of the player as well as the investment of the organization in that player⁴².

Despite common misconceptions, non-operatively managed athletes can return to sport without the need for reconstruction²⁶. Fitzgerald et al reported a decision making scheme for returning ACL deficient athletes to sport in the near-term, without furthering of meniscal or articular cartilage injury²⁶. There is a paucity, however, of long-term evidence on non-operatively managed athletes returning to high level sports. Grindem et al compared return to sport in operatively and non-operatively managed athletes after ACL injury. They found

no significant differences between groups in level I sports participation, and higher level II sports participation in the non-operative group in the first year after injury¹⁹. This is the only study to our knowledge comparing return to sport rates in the longer term. Further research is needed on long-term non-operatively managed athletes after ACL injury.

Re-Injury

Second injury, whether it is an insult to the ipsilateral graft or the contralateral ACL, is a growing problem after ACLR as rates appear to be higher than once thought. Risk factors for second injury include younger athletes⁴⁹ who return to high level sporting activities early^{50,51}, with women having a higher risk of contralateral injury^{52,53}, and men having a higher risk of ipsilateral injury^{54,55}. While second injury rates in the general population 5 years after reconstruction are reported to be 6%⁵⁶, rates in young athletes are considerably higher.⁵¹ Paterno et al followed 78 athletes after ACLR and 47 controls over a 24 month period. They found an overall second injury rate of 29.5% which was an incidence rate nearly 4 times that of the controls (8%)⁵¹. Over 50% of these injuries occurred within the first 72 athletic exposures, while in the control group only 25% were injured within the same time frame⁵¹. The MOON cohort reported a 20% second injury rate in women and a 5.5% rate in men of 100 soccer players returning to sport after ACLR⁴⁶. Shelbourne et al⁵⁵ and Leys et al⁵⁷ both reported 17% second injury rates in younger athletes. Besides missing more athletic time, increasing healthcare costs, and increased psychological distress, re-injury and subsequent revision surgery has significantly worse outcomes compared to those after initial reconstruction³⁴. FIGURE 3

Discussion

ACLR continues to be the gold standard treatment of ACL injuries in the young athletic population. A survey of American Academy of Orthopedic Surgeons reported 98% of surgeons would recommend surgery if a patient wishes to return to sport, with 79% believing ACL deficient patients are unable to return to all recreational sporting activities without reconstruction⁵. Revisiting the successful outcomes criterion after ACL injury, a successful outcome is considered no re-injury or recurrent giving way, no joint effusion, quadriceps strength symmetry, restored activity level and function, and returning to pre-injury sports¹⁰. After reviewing the current literature looking at these criteria, counseling athletes to undergo early reconstruction after ACL injury may not be in the athlete's best interests. Undergoing reconstruction does not guarantee athletes return to their pre-injury sport, and return to the pre-injury competitive level of sport is unlikely. The risk of a second injury is high in young athletes returning to sport, especially in the near-term. Risk of secondary injury increases for the contralateral limb in females, or the ipsilateral limb in males. The risk for developing osteoarthritis is high in the long-term regardless of surgical intervention, and even higher if a revision procedure is required⁵⁸. A Cochrane Review found that there was insufficient evidence to recommend ACLR compared to nonoperative treatment, and recent randomized control trials have found no difference between those who had ACLR and those treated nonoperatively with regards to knee function, health status, and return to pre-injury activity level/sport after two and five years in young, active individuals^{19,37,59}. With no differences in outcomes between early reconstruction, delayed

reconstruction, and no surgery at all, counseling should start by considering non-operative management. Eitzen et al⁶⁰ found a 5 week progressive exercise program after ACL injury led to significantly improved knee function before deciding to undergo reconstruction or remain non-operatively managed Figure 4. The authors reported good compliance with few adverse events during training. Non-operative management is a viable evidence based option after ACL injury, allowing some athletes to return to sport despite being ACL deficient, with equivalent functional outcomes to those after ACLR. Given there is no evidence in outcomes to undergo early ACLR, non-operative management should be a first line of treatment choice in athletes after ACL injury. Figure 5

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Key Points

- Undergoing ACL reconstruction does not guarantee athletes will return to their pre-injury sport, and return to the pre-injury competitive level of sport is unlikely.
- The risk of a second ACL injury is high in young athletes returning to sport, especially in the near-term.
- The risk for developing osteoarthritis after ACL injury is high in the long-term regardless of surgical intervention, and even higher if a revision procedure is required.
- Despite common misconceptions, non-operatively managed athletes can return to sport without the need for reconstruction
- Without differences in outcomes between early reconstruction, delayed reconstruction, and nonoperative management, counseling should start by considering non-operative management.

Successful Outcomes After ACL Injury

Criterion	2 Years After Operative Management	2 Years After Non-Operative Management
	(Consensus %)	(Consensus %)
Absence of Giving Way	96.4	96.5
Return To Sports	92.4	92.7
Quadriceps Strength Symmetry	90.3	90.7
Absence of Joint Effusion	84.1	85.0
Patient-reported Outcomes	83.2	83.5

Adapted from Lynch AD, et al. Br J Sports Med 2013;0:1–9. doi:10.1136/bjsports-2013-092299

Figure 1.

Consensus criteria on successful outcomes after anterior cruciate ligament injury and reconstruction from 1779 sports medicine professionals.

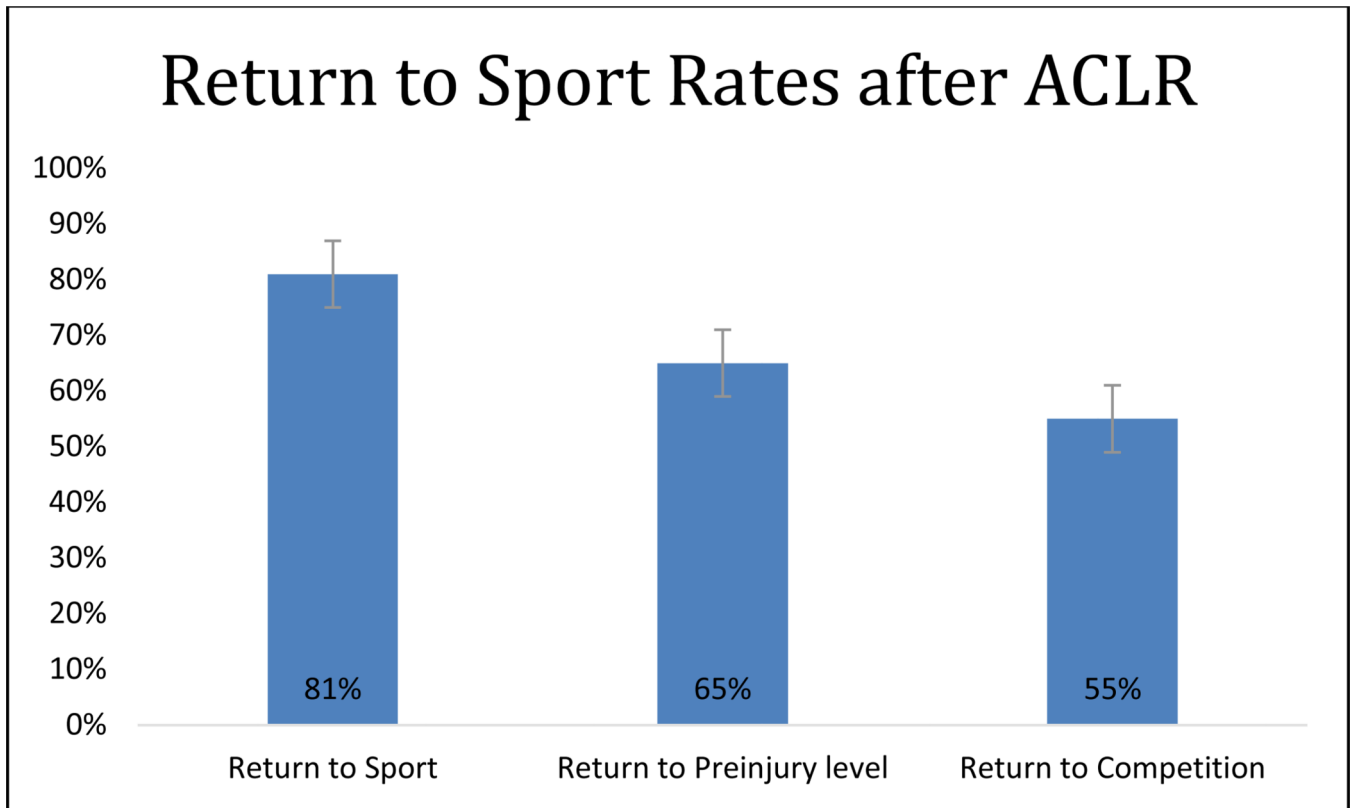


Figure 2.

Meta-analysis pooled return to sport rates⁴³

Reported return to sport rates after ACLR from Arden et al 2014 systematic review and meta-analysis

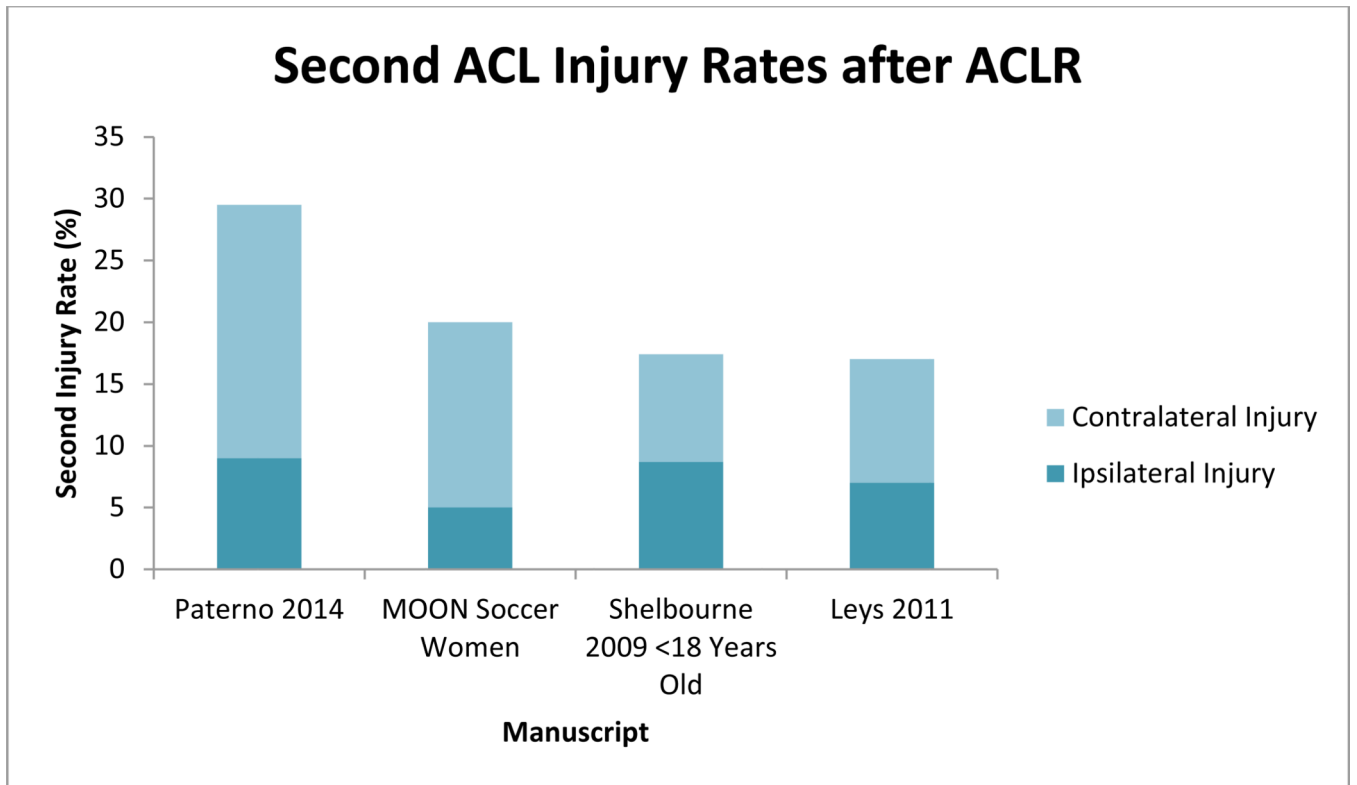


Figure 3.



Figure 4.
Perturbation Training
Unilateral rollerboard portion of perturbation training. The athlete attempts to maintain balance in slight knee flexion while the therapist performs manual perturbations. Progression includes adding sport specific tasks while maintaining balance.

Test

Criteria

Global Rating of Perceived Knee Function
KOS-ADLs
Episodes of Giving Way
Timed hop limb symmetry index

≥60%

≥80%

≤1

≥80%

Figure 5.

Decision-making scheme for ACL deficient athletes²⁶

Global Rating of Perceived Knee Function (GRS) is a scale from 0 to 100 asking the athlete to rate their current knee function with 100 being back to all pre-injury activity and function. Knee Outcome Survey Activities of Daily Living Questionnaire (KOS-ADLs) is a patient reported outcome measure evaluating knee function within daily activity. Episodes of giving way are true moments of instability in which a shifting occurs in the tibio-femoral joint resulting in an increase in knee pain and joint effusion. The timed hop is one component of hop testing in which the athlete unilaterally hops down a 6 meter line as fast as possible. Symmetry index is calculated by dividing the uninvolved limb time by the involved limb time and multiplying by 100.