

Rehabilitation and Return to Sport Testing After Anterior Cruciate Ligament Reconstruction: Where Are We in 2022?



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Abstract: Athletes who sustain an anterior cruciate ligament (ACL) injury often opt for an ACL reconstruction (ACLR) with the goal and expectation to return to sports at the preinjury level. The proportion of athletes who successfully return to preinjury-level sport is low and disappointing, whereas the rate of second ACL injury in athletes under the age of 20 has been reported to be as high as 40% after return to sport (RTS). Although in recent years, new insights pertaining to RTS have been published, the lack of validity of RTS criteria after ACLR remain. The purpose of this clinical commentary is to present a critical overview of the current literature on RTS testing after ACLR.

An injury of the anterior cruciate ligament (ACL) is a common injury in athletes participating in landing- and pivoting-type sports. An ACL reconstruction (ACLR) is considered by many the clinical standard to restore mechanical stability of the joint as a prerequisite for return to sports (RTS).¹ Webster and Feller² recently determined that patients who were about to undergo a primary ACLR had high expectations for return to their preinjury level of sport, with 88% expecting to achieve this outcome. In reality, only 65% of patients after ACLR return to their preinjury level of sport.³ Unfortunately, the active, young athlete (<20 years) who resumes activity after ACLR has a greater risk for a second ACL injury. Injury rates in this young

cohort have been reported to be up to 23% to 29% in the literature.⁴⁻⁶ In men's Australian football, second ACL injury rates of 40% after RTS have recently been reported.⁷

There has consequently been a growth in studies that propose RTS criteria with the aim to reduce the risk of a second ACL injury. Despite the development of RTS guidelines over recent years, there is a lack of a scientific consensus on the RTS criteria used to release a patient to unrestricted sport activity after ACLR.⁸ A proportional meta-analysis showed that only 23% of patients after ACLR passed RTS test batteries before RTS.⁹ These findings highlight that many patients may have returned to sport without acceptable knee function. Although passing RTS criteria reduce the risk of subsequent graft rupture by 60%, it increases the risk of a contralateral ACL rupture by 235%.⁹ In support of this meta-analysis, a recent study found that RTS tests including strength, hop tests, and patient-reported outcomes fail to identify patients who are at risk for a second ACL injury.¹⁰

Overall, the validity of current RTS tests is questionable. These equivocal findings in terms of validity of RTS tests after ACLR leaves clinicians with high level of uncertainty in clinical decision-making. The purpose of this clinical commentary is to present a critical overview of the current literature on RTS testing after ACLR.

Definition of RTS tests

Although the specific content of reported RTS test batteries has varied, overall they are designed to incorporate several domains of risk factors. An RTS test

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battery should at least include strength tests, hop tests, and measures of quality of movement.¹¹ More recently, the importance of athletes' psychological responses to the initial injury, to surgery, and to recovery during rehabilitation are important additional determinants of RTS.¹² In the following sections we will discuss the various components that compromise the current recommended RTS test battery.

Muscle Strength

In the United States, 56% of therapists use manual muscle testing as their only method of strength evaluation.¹³ This is an area of concern because manual muscle tests using the Medical Research Council scale has several limitations, including poorly defined limits between grades "4" and "5."¹⁴ For research purposes, isokinetic dynamometry is often used for strength assessment of the quadriceps and hamstrings.¹⁵ However, isokinetic devices lack practicality in clinical settings because of high cost, lack of portability, and space requirements. A more clinically viable alternative is hand-held dynamometry¹⁶ or the use of, for example, a leg press or leg extension machine.¹⁷

Commonly a limb symmetry index (LSI) is used, defined as the ratio of the involved limb score and the uninvolved limb score expressed in percent ((involved/uninvolved) · 100). An LSI > 90% is usually used as a cutoff score.¹⁸ For recreational and non-pivoting sports an LSI of >90% may be acceptable, whereas a >100% LSI for knee extensor and knee flexor muscle strength for the pivoting/contact/competitive athlete has been recommended.¹⁹ A few major issues arise when using these criteria: 1) only 14% of all patients achieved a LSI of 100% for strength tests at 2 years after ACLR²⁰ questioning whether this is feasible in daily practice; 2) the LSI is based on the assumption that the uninjured leg can be used as a reference for strength. Larsen et al.²¹ showed that, not only do patients after ACLR exhibit side to side deficits, but the uninvolved limb of ACLR is also significantly weaker to a matched limb of a control group. This implies that the LSI may underestimate strength deficits and argues for an implementation of absolute strength evaluation and not only limb symmetry.²¹ Current evidence summarized in a meta-analysis revealed persistent quadriceps and hamstring strength deficits in both the short (<6 months) and long term (>2 years) after ACL injury.²² In that meta-analysis, studies comparing the strength on the involved side with the uninvolved side were excluded because there was evidence of bilateral neuromuscular changes after unilateral injury.²²

Most studies report assessment of maximal strength; however, this may only present the tip of the iceberg of strength deficits after ACLR. Deficits in rate of force development, power, and reactive strength have been reported as well, which may have important relationships

with athletic performance and second ACL injury prevention rather than maximal strength alone.²³

Hop Tests

Commonly used hop tests are the single hop for distance, triple hop for distance, triple cross-over hop, and the 6-m timed hop.²⁴ LSI criteria >90% could be used as cutoff scores to determine readiness for RTS in recreational or nonpivoting-type sports, whereas an LSI of 100% is recommended for pivoting/contact sports.¹⁹ As with the LSI for strength, there are some concerns regarding the use of the uninvolved limb as a reference for the involved limb. Athletes who have undergone an ACLR demonstrate bilateral deficits on hop tests in comparison to age- and sex-matched normative data of healthy controls.²⁵ Of interest, all athletes in that study had a mean LSI of 95.4% for the 3 hop tests, being well over the clinical cutoff of 90% symmetry frequently used for RTS criteria.²⁵ Despite achieving an LSI >90%, patients demonstrated significant and clinically relevant deficits in performance for both limbs when compared to normative data from healthy athletes. Findings from a recent meta-analysis suggest that symmetry in hop distance may not mean knee function is also symmetrical.²⁶ Moreover, the LSI should not be used in isolation to evaluate functional performance changes after ACLR, because it may overestimate functional improvement, as a result of worsening contralateral limb function.²⁷ Using the LSI for hop tests may underestimate performance deficits and should therefore be used with caution as a criterion for RTS after ACLR.^{25,28,29} On a final note, a limitation of the current hop test battery is that these tests predominantly consist of straight movements in the forward direction. Medial and rotational hop tests are more likely to show limb asymmetries in athletes after ACLR participants compared to forward hop tests.³⁰

Movement Quality Assessment

Although patients after ACLR may achieve normalization in single leg hop test distance, kinematic and kinetic deficits may persist.²⁹ Welling et al.³¹ found that 60% of patients after ACLR had abnormal landing kinematics in the injured leg compared to their non-injured leg, although 72.3% of them passed the LSI >90% criteria for hop tests. Between-limb deficits in eccentric and concentric loading parameters persist >9 months after ACLR, indicating a compensatory off-loading strategy to protect the involved limb during an athletic performance task.³² In addition, graft-specific loading asymmetries have been identified for double leg jump-landing tasks.³³ Greater asymmetry of trunk-side flexion, distance from center of mass to the knee and ankle in the frontal plane, pelvic tilt, and pelvic drop during unplanned change of direction was found for those athletes who sustained second ACL injuries

compared to this who did not.³⁴ Therefore the integration of a biomechanical evaluation should supplement the decision-making regarding RTS.

Psychological factors

An ACL injury not only leads to physical impairments but also has a psychological impact. Hence, in addition to the physical readiness, monitoring patient-reported outcome measures and psychological readiness are important to determine successful RTS. Significantly lower scores on self-reported knee function questionnaires were found in patients who did not RTS compared to patients who RTS.³⁵ Psychological readiness is a predictor for returning to preinjury levels of sport in patients after ACLR.³⁶

A systematic review revealed that 65% of patients cited a psychological reason for not returning to sport, with fear of reinjury as the most common reason.³⁷ In other words, patients with higher scores on questionnaires regarding psychological readiness for RTS had increased chances to return to the preinjury level of sport.

Rehabilitative Approach

RTS tests should be seen in the context of factors such as content, specificity, intensity, frequency, and duration of rehabilitation given the need for optimization of current rehabilitation programs. Several conceptual frameworks on how rehabilitation can be optimized have been published but require scientific validation.^{8,38,39} In a retrospective study of 676 patients after ACLR, an individualized RTS rehabilitation program supervised by strength and conditioning coaches over a period of 3 months in addition to the standard rehabilitation program was the most important factor to positively influence an RTS test battery.⁴⁰ This study is in agreement with previous studies.^{41,42} Patients who completed 6 months of rehabilitation incorporating jumping and agility tasks were almost 8 times more likely to RTS compared with those who did not.⁴¹ Della Villa et al.⁴² evaluated the association between compliance in postoperative rehabilitation and RTS rate in patients after ACLR revision. As much as 86% of fully compliant patients were able to return to the preinjury level, versus 50% and 45% of the patients defined as minimally compliant and noncompliant, respectively.⁴²

Timing of RTS testing?

It has been suggested to delay RTS until 9 months after ACLR surgery.⁴³ However, the claimed 84% reduction of risk was a nonsignificant finding because of low statistical power.⁴³ Between 9 months and 2 years after surgery, there was no significant reduction in the risk for second knee injuries. Over that time period, 19.4% of these patients sustained second knee reinjuries.⁴³

In a recent study no clear association between age and second ACL injury was suggested.⁴⁴ This is in conflict with other studies. Webster et al.⁵ reviewed 561 patients at a mean follow-up of approximately 5 years and reported odds for sustaining a contralateral ACL rupture increased threefold for patients younger than 20 years. Kaeding et al.⁴⁵ reviewed 2683 patients from the Multicenter Orthopaedic Outcomes Network cohort and reported that younger age and higher activity level (and allograft type) were predictors of increased odds of ipsilateral graft failure. It may be questioned whether young age is indeed a risk factor or a proxy for higher exposure to high-risk activities such as return to soccer or other landing and pivoting sports.

Future studies should clearly point out whether tests were conducted at a certain fixed time point (for example 9 months after surgery) or at the time of return to sport. If the second option would be the case, it should be clear which criteria were used to decide whether it's safe to return to sport.

How Many Tests Need to Be Included?

Another problem with these test batteries is the "penalty" of multiple tests. With a test battery, multiple tests across several domains are required to be passed at a required pass rate, which was most often set at 90%. If athletes meet the pass rate for one test and a second test with a 90% pass requirement is added, the percentage of athletes who pass will almost certainly drop.⁴⁶ For example, even if 80% of athletes pass each test of a test battery, the overall pass rate for the test battery will be dependent on the total number of tests such that the pass rate for the first test will be 80%, but then only 64% (0.8×0.8) for 2 tests, 51% (0.64×0.8) for 3, 40% (0.5×0.8) for 4, and so on.⁴⁷ Furthermore, the relative importance of each of these tests is unknown and can vary between sports and individuals.

What Are the Consequences of the RTS Testing?

The consequence of not passing tests, is often not explicitly stated in studies. In the study of Grindem et al.,⁴³ of the 74 patients who returned to level 1 sports, those 51 patients who did not sustain a second knee injury had a mean quadriceps LSI of 84.4%, which was below the recommended LSI of >90%. In the review of Webster and Hewett,⁹ 77% of patients who did not pass RTS test after ACLR, participated in sports. On the one hand, the above findings highlight the need for a stricter definition of what the consequences of the tests are. On the other hand, the very low proportion of athletes passing the traditional RTS tests also indicate that in general, a criterion-based rehabilitation is not adopted in clinical practice.^{13,48,49}

The problem within the current literature is that we hardly know what happened after the RTS tests. The exposure to high-risk activities is an essential point

when evaluating the validity of RTS tests. Indeed, a player failing RTS tests but returning to sports with very low exposure to high-risk activities might still be at a relatively lower injury risk compared to another player passing RTS tests with very high exposure to high-risk activities. However, this exposure is not reported in current studies. The use of the term RTS must be accompanied by a detailed description of the individual characteristics of the athletes being studied; the intensity, duration, and frequency of each exposure; duration of sport participation after ACLR; the type and level of activity; and the use of protective equipment.⁸ Truly successful RTS allows the athlete to return to their prior level of sport while also at a reduced (or reasonable) risk for a second ACL (or any) injury.⁹

Conclusion

After ACLR, ligament (ACL), the proportion of athletes who successfully return to pre-injury level sport is low and disappointing, while the rate of second ACL injury in athletes under the age of 20 has been reported to be as high as 40% after RTS. Although in recent years, new insights pertaining RTS have been published, the lack of validity of RTS criteria after ACLR remains.

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