CRITERIA FOR THE RETURN TO SPORT AFTER RECONSTRUCTION OF THE ANTERIOR CRUCIATE LIGAMENT (RACL)

Heba Alaeddine, PT, DPT Student
Samar Delbani, PT
Hassane Kheir Eddine, PT, MS, DPT
Khodor Haidar Hassan, MD, PhD
Hassan Karaki, PT, MS, PhD
Department of Physical Therapy, Faculty of Public Health,
Lebanese University, Hadath, Lebanon

Abstract

Background: One of the objectives of the reconstruction of the anterior cruciate ligament (RACL) is the return of athletes to existing activity before the injury. Thus, it is essential to understand the variables that influence the return. Associations between the return to sport and the variables representing the strength of the quadriceps, instability and symmetry of the members, and the psychological state have not been studied in athletes following the RACL.

Purpose: The purpose of this study is to summarize the literature relating to the proposed variables to be associated with the return to sport following a reconstruction of the anterior cruciate ligament.

Method: During this study, we searched electronic databases, PubMed, Medline, Embase, and Cochrane Database to find the most recent articles about returning to the sport after the RACL criteria.

Therefore, the articles included in this review meets these criteria: 1) patients who underwent a RACL; 2) reported at least one measurement of quadriceps strength, symmetry between members, and the psychological state; 3) the return to the sport identified by subjective measures or action to identify the level of sports participation of patients; and 4) any relationship analysis between the measures and the return to sport**.**

Conclusion: Despite the fact that there are a number of important criteria influencing the return to sport, some have remained critical which have been considered and supported.

By analyzing the items, the following results were obtained as described below:

A quadriceps strength [IQ = 90%] and a motivating psychological state are the two criteria that ensures sport participation and reduction of the rate of re-injury or injury to the contralateral side. However, other criteria should not be neglected, with a view of their interaction with quadriceps strength and psychological status influence on the overall condition of the athlete wishing to return to the sport.

Keywords: Knee, Measures, rehabilitation, kinesiophobia, self-Reported Measures, leg spring stiffness, sledge apparent strength.

Introduction

Methodology of the Research

The Ruptures of the anterior cruciate ligament (RACL) is the most common sports injuries of the knee. Thus, this type of injury requires medical intervention for its reconstruction. Basically, the costs of surgery is significant, and it can also result to various complications. When we talk about athletes, we talk about people whose individual wish is to acquire the same sport played before the break and at the same level. Consequently, since the future of these people depends on sporting activities, their main concern is to return as quickly as possible to the sport and to continue their activities in full.

Despite many positive results following the RACL reports, recent reports have suggested that the rate of return to sport cannot match the success of the type of surgery. Nevertheless, this is due to other factors [5,6,7,8,9,10,11,12,13], where this discrepancy raises many questions. The criterion used to be a good excessive and accelerated rehabilitative program followed by a professional therapist. However, there are criteria used for measuring outcomes of treatment other than the recovery time of sport. Indeed, determining the criteria till date remains a real challenge, either for the athletes or the therapists themselves.

Hence, what is the return to sport? This remains one of the most fundamental questions that have been asked.

Furthermore, numerous authors have studied, analyzed, and focused on certain criteria. Others were associated with multiple variables influencing the return to the field such as the strength of the quadriceps and hamstrings [14,15,16,17,18], the difference in symmetry between the members [19], the association measures of the knee (ROM, quadriceps strength, and functional performance tests), and the patient's psychological state[20]. It is also important to clarify whether the return to training or competition will be with the same degree of competition before injury. In this study, we tried to summarize the criteria for a return to the field in full security. Thus, this is to a level equal to the one existing before the break.

Subsequently, this is based on the fact that this return requires the interaction of several variables and no variable cannot be overlooked.

Search Strategy

The Electronic Databases through which we started our research include PubMed, Medline, Embase, and Cochrane Database. These databases were searched in order to find the most recent articles criteria for return to sport after ACL reconstruction.

The keywords used for each search engine were: knee, ACL reconstruction, return to sport, functional performance testing, knee function, knee injuries, hop testing, outcomes Measures, rehabilitation, kinesiophobia, self-Reported Measures, leg spring stiffness, and sledge apparent strength. In this research, we chose 10 items, of which nine of them was published the last five years (from 2010 to 2015). Through working on the items, we found the opinion of several authors that attracted us to have an idea about the products which they have taken. We have cited the information that interest us specifying the reference sites of each of them (the author's).

Criteria for Selection

The inclusion criteria's for the selected articles were: (1) Patients undergoing primary unilateral ACL reconstruction; (2) patients injury surgery time of at least 12 months; (3) people involved in sports activities related to the RACL; (4) patient in a sport before the accident; (5) complete patient rehabilitation program and those allowed to return to top-level sport; 6) patients who reported at least one measurement of quadriceps strength, symmetry of the members, and the psychological state; 7) The return to sport was identified by subjective measures or action to identify the level of sports participation of patients; and 8) any relationship analysis between the measures and the return to sport.

On the other hand, the exclusion criteria include: (1) Bilateral injury; (2) relapse history on the knee after RACL; (3) concurrent ligament injuries; (4) symptomatic meniscal lesions; (5) damage or repairs cartilage concomitant joint with RACL; (5) fractures; (6) injury or previous surgery of the hip and knee; and (7) inability to support the significant weight or lameness.

Table of Results

Author's Name	Level of Evidence	Protocol	Measurement Scales	Results
Sylvia Czuppon	Systematic review	Analyse and summarize 16 Articles of literature by presenting the various disorders of the knee associated with return to sport after RLCA.	• LSI of quadriceps • Single leg hop test • Marx activity score • IKDC • Lysholm score • Tampa scale of kinesiophobia • Psychovitality questionnaire • Knee self efficacy scale • Shortened profile of mood states • Pain catastrophizing scale • Emotional responses of athlete to injury questionnaire.	There is only weak evidence to support the association between disorders of the knee, functional variables, and psychological as well as return to sports.
Stéphanie Di Stazi	Systematic review	Contribution evidence regarding the factors related to the second ACL injury and their link with previous neuromuscular deficiencies, with the proposed intervention method.	• Drop jump landing, Drop vertical jump, Trunk repositioning, kneeling sudden force release, and Sport related jumping task. • Single leg hop and timed 6-meter hop tests • IKD 2000 • Crossover test	Targeted interventions against the deficiencies of movements associated with effective rehabilitation programs (long term), reduce the risk of relapse, restore performance and improve the ability to maintain ADL (daily life activities) without symptoms disabling the knee.
	Randomized clinical trial	• 40 randomly distributed. Noncopers were divided into two groups at 10 rehabilitation sessions before surgery. The first group achieved progressive strength exercises of the quadriceps, while the second group had training related to disturbances strength exercises. • The same		

Erin H. Hartigan		rehabilitation was made post-operatively for the 2 groups. • Given a quadriceps strength of 4 hop index score, the two self administered questionnaires were administered preoperatively. Also, it was administered postoperatively at 3, 6, and 12 months.	• Mann Whitney • 1RM Testing • KinCom	It must need further rehabilitation in Noncopers to pass back to sport criteria.
A. Kobaya-chi	Transversal study	Study of the isokinetic quadriceps strength in 36 athletes during the concentric contraction (60 and 180 degrees for 12 to 24 months).	• Biodex dynamometer • 8 Peak torque	The quadriceps strength is restored over time (88% to 180 degrees for 12 months, and 91% at 24 months). However, its performance is favorably cured after returning to the sport.
David Logerstedt	Cohort study	• Study conducted on 120 patients undergoing RACL. • Tests performed preoperatively and in six months after RACL. • Regression analysis to identify the self reported knee function in normal amplitudes.	• IKDC 2000 • 4 single legged hop test	The legged hop singles postoperative tests can predict the success or failure of the results and the knee function, but cannot predict the preoperative function.
Trevor A. Lentz	Transversal study	Study was performed on 84 patients who underwent RACL. They were divided into two groups: ♣ Yes: return to the sport, ♣ No: return to sports. Depending on their response, they were asked if they have returned to the same level existing prior to the wound.	• Knee Effusion • Knee ROM • KT 1000 • Isokinetic dynamomètre (biodex) • Self report questionnaire	The most associated factors with the return to the sport are episodes of instability, effusion of the knee, and self reported function of the latter.

Eamonn P. Flanagan	Transversal study	• Study conducted on 20 subjects rehabilitated. • Evaluation of the symmetry between members. • Study of the production capacity and strength reactivity.	• IKDC • Single leg hop for distance • Sledge machine • Six meter timed hop	Subjects with symmetry between the members after ACL restored production capacity and strength reactivity.
Gregory D. Myer	Case-control study	•2 groups composed of 33 patients who underwent RACL and 67 healthy subjects. • Analysis of difference in symmetry between the members by: ♣ Measure of production and force absorption for each member. ♣Measurement of anteroposterior movement of the tibia relative to the femur.	• Single legged vertical hop • Maximum vertical ground reaction • Complete knee arthrometre	A unilateral deficit on the development and absorption strength persists after RLCA. Thus, it causes an asymmetry between the members, which consequently affects their performance.
Laura C. Schmitt	Transversal study	• 2 groups: 55 patients who underwent RACL, and a control group of 35 subjects. • Patients in the RACL group were divided into: ♣ QI Group> 90% ♣ Group IQ <85% • Measure the function of each group.	• Biodex Medical • Systems IKDC • 6m Timed Hop • KOOS • Single hop for distance • Triple hop for distance • Triple cross over hop for distance	The indices of symmetry with a force of less than 10% quadriceps showed a similar functional performance than those not injured.
Doo Hwan Kong	Transversal study	• 60 topics were divided into 2 groups: 30 who underwent RACL and 30 which is healthy and similar in terms of age and activity level. • Taking subjective/objective measures, • Realization of functional tests on the two (2) groups • Retest performed after 2 weeks.	• Lyshlom score • Tegner activity • Score KT 2000 • Arthrometre isosinetic • Strength test • One leg hop test • Co-contraction test • Shuttle run test • Carioca test.	The performance of functional tests (Co-contraction carioca test, shuttle run test) showed a correlation with the established methods for determining the return to sport after RACL. Therefore, it had high test-retest reliability.

Discussion

The aim of the reconstruction of the anterior cross ligament (RACL) according to **Sylvia Czuppon** cannot be completed without the recovery of muscle strength. Even if the knee has good stability and sufficient range of motion[21], the strength of the quadriceps and hamstrings are considered the most objective criteria used to determine the possibility of return to sport [14,15,16,17,18]. Consequently, other authors have integrated quadriceps strengthening exercises preoperatively. Among them, **Erin H. Hartigan** has shown that it takes an additional rehabilitation in non-coopers to pass the criteria of return to sport which also affects the business results. Therefore, this was until he found that intensive inclusion in the preoperative and postoperative exercise in progressive quadriceps strengthening protocol gives favorable results. Likewise, the University of Delaware followed clinical milestones which indicates that a walking program/jogging dependent quadriceps strength, pain, and effusion should begin two months after the RACL[22].

However, the weakness of the quadriceps is still better than years of surgery, after RLCA performance improved over time [23,24]. This was stated by **A. Kobayashi** which showed that quadriceps strength is restored over time (88% at 12 months and 91% at 24 months) and its performance is favorably cured after returning to the sport[25].

Laura C. Schmitt agrees with the importance of the influence of the symmetry of the quadriceps on performance and therefore the return to sport. Based on single leg hop tests (the single hop for distance, the triple hop for distance, the triple crossover hop for distance, and the six meter timed hop), it showed that patients with a higher IQ or equal to 90% (less than 10% deficit) and an LSI quadriceps equivalent to 80-90% compared to the opposite side has a similar performance as the non-injured patients[26]. According to **Stephanie DI Stasi**, athletes who were recovering from RACL should not be considered to be wholly and purely rehabilitated in the absence of symmetry. The persistence of asymmetry present a risk for the occurrence of a second ACL injury. As against its restoration, it not only leads to maximizing its functional performance, but also mitigate the risk of a new injury[2]. Then, it is commonly suggested that such asymmetries should be resolved prior to initiation sports [27,28,29].

With regard to the development and absorption force, **Gregory D. Myer** also found a significant relationship between the latter and the symmetry. As asymmetry affects the development and absorption of force, it also affects its performance [19]. This difference in symmetry between members, was perceived as the Single vertical legged hop test which was performed on a member of unilateral deficit. What was stated by **Eamonn Flanagan P** after testing the symmetry between the members using the single

leg hop for distance, six meter timed hop, and the subjective IKDC form (Sledge capacity measured by the device), obtained high scores. However, he confirmed that participants who had a symmetry between the members after RACL, restored production capacity and strength reactivity. He also concluded that the symmetry of functional performance between the members after RACL is necessary to have a production capacity and strength of responsiveness[30].

Previous studies have reported conflicting results regarding the influence of the performance of the quadriceps on functional outcomes. This inconsistency appears to be closely linked to the method by which the performance of the quadriceps was measured. Therefore, this may be related to the study results [31,32,33,34]. In addition, it can also be influenced by the variability of the rehabilitation programs.

Trevor A. Lentz reported that the maximum torque of the quadriceps, the surgical side, normalized to body weight status differs between groups that are returning to the sport. However, the Symmetry Index of the quadriceps does not differ between these groups. The results of this study indicate that, despite the fact that the strength of the quadriceps is normalized, the body weight may be an important consideration in determining the ability of returning to sports. The asymmetry of quadriceps strength did not constitute a discriminating factor. However, the importance of symmetry of the quadriceps and the risk of relapse should not be overlooked.

With regard to the measurement methods of symmetry, the tests were varied. **David Logerstedt** found that singles legged hop tests identify asymmetry members after RACL. He also found that they are predictive of the self-report of the function of the knee measured by postoperative IKDC 2000. Furthermore, they also predict the success or failure of the results, but cannot predict the preoperative based[35]. Some studies seeking to determine whether the functional tests designed to identify the symmetry of the lower limbs are reliable, have found that unilateral hopping tasks (Broad jump and Vertical jump, double Modified limb performance testing, the crossover hop for distance, Triple hop test for distance, and Six meter timed hop) can identify non-obvious unilateral performance deficits during bipodal performance[3].

Doo Hwan Kong has clear advantage on the effectiveness of performance testing. To validate these tests, he used the one leg hop test, the test Co-contraction, the shuttle run test and the Carioca test, to evaluate the performance necessary to return to the sport after RACL. Thus, he conducted an evaluation of the test-retest reliability of these tests in a healthy group and a group that undergoes RACL. The results showed a correlation with the established methods for determining the return to sport after RACL with a

high test-retest reliability. Furthermore, he concluded that they can be used to assess knee function to return to the field[4]. But some authors came to upset what has been mentioned above; and they considered the relationship between the functional test of performance of the athlete to be badly established[36].

By cons, **Trevor A. Lentz** has shown that episodes of instability, effusion of the knee, and postponed auto function are the factors that differs between groups of individuals returning to the sport. Therefore, more than half of the patients through which the study was conducted, were respondents to self-report questionnaires. Also, attorneys have to return to the same level of sport that existed before the injury. This is accompainied by less effusion, fewer episodes of instability quadriceps, less pain, and a lower level of kinesiophobia [22,32,37,38,39,40,41]. However, all these factors are potentially modifiable and should be considered when developing guidelines back to the sport and the participation criteria following ACL reconstruction [22].

Finally, studies have shown that the function of the knee is associated with the fear of movement re-injury [6,42,43,44,45,46]. Some patients without disorders ROM or strength or other knee disorders can choose not to return to the existing level of activity before the injury. This is due to reasons unrelated to the function of the knee such as the change of their lifestyle. Unlike other patients, they have knee disorders after RACL return to the competitive sport[47]. However, the psychological variables may partly explain the lack of association between physical function and return to sports [46,47,48].

Fear of movement and new break (kinesiophobia) is one of the reasons patients do not return to the sport. Although kinesiophobia decreases during rehabilitation, it remains present in more than 20-24% of patients[11,49]. Despite these reports, psychological measures are not typically used in the criteria to return to the sport after RACL. After examining other opinions and studies, we considered the strength of the quadriceps as the main criterion for the return to sport [14,15,16,17,18,19,20]. Furthermore, it is known as the most sought muscle during sports activities. It undergoes extensive alteration during surgery. For this reason, he needs significant time to recover his strength [14,15,16,17,18,19,20]. Hence, completing an LSI quadriceps equivalent to 90% compared to the opposite side is a sufficient evidence to allow athletes to return to sport with security[14,15,16,17,50]. Thus, this is against other deficits which are recovered generally after returning to the sport [25]. Although muscle strength is considered as the main criterion to return to the sport, other variables are not neglected due to their influence on athletes and their return to sport.

After a good read of the articles which is present at our disposal, we found that the symmetry between members is also a very important criterion for the return to the field after RACL. However, it view his influence on functional performance, and the necessity to have a capacity of productive and reactive force [19,30,51]. Indeed, an IQ equal to 90% ensures symmetry, and the athlete will therefore be able to return to his activities [51]. As regards the measure of symmetry, the use of functional tests to assess the performance is paramount, and the hop test proves to be effective [35]. The singles legged hop tests can predict the success or failure of the results, while unilateral hopping unilateral tasks can identify the performance gaps which is not obvious during the performance bipodales [3]. The ideal would be to use one leg hop test, the test Co-contraction, the shuttle run test, and the test after which carioca Re-test shows good reliability[4].

In addition, we also talked about kinesiophobia which is defined as the fear of movement. It scares the athlete to return to his sport activity for fear of the occurrence of re-injury and in re-experiencing the pain he had once experienced. Hence, it is important to treat kinesiophobia because it can hinder and avoid a return to the sport, even after recovering the strength of the knee and solving all of its problems[47].

Other than the symmetry and kinesiophobia, there is effusion, pain, and the instability of the knee. The effusion and knee pain which are part of the immediate complications of surgery, are treated by the first week's icings, punctures, which is associated with drug treatments. For that, they must not be regarded as a criteria of return to sport since it requires at least 9 months.

Through cons stability, it is important to ensure a safe return and avoid further injury[1]. Indeed, the quadriceps is one of the main causes of knee stability, which brings us back to the original idea on the importance of the recovery of quadriceps: "Completing the requested quadriceps strength leads to complete knee instability".

Conclusion

The return to sport is a concern accompanying the athlete from the moment he agrees to undergo the reconstruction of the anterior cruciate ligament (RACL). This occurs especially when it comes to high-level athletes. This concern is related to social reasons, especially the celebrity who may be affected and altered during the period of absence of the athlete of the land. However, this influences its future as an athlete. Indeed, the decision to return to the sport depends primarily on the state that the quadriceps have lost his strength following the surgery. The quadriceps is the key of the relationship between instability, and the symmetry between the members and performance. Therefore, it is a basic element. So when the

force required of the quadriceps is reached, the knee stability which is the symmetry between the members and its performance are reached too at the same time. Thus, this result in the return to sport. An IQ equal to 90%, and consequently an LSI equal to 90% equivalent to the opposite side, is considered to be the criterion which enables the above relation based on the required performance. In order to assert the latter, multiple functional performance tests were used. Among them, four have shown good reliability which include: One leg hop test, the test Co-contraction, the shuttle run test, and the Carioca test.

Although the functional status of the athlete is important to return to the sport, the psychological status must not be overlooked. Hence, kinesiophobia, in other words the fear of movement, is considered a criterion for influencing the return to the field. It must be taken into consideration and should be supported by all members of the team. This should begin from the doctor to the therapist's coach, and then the family and anyone who can be able to influence them.

Finally, a patient with the right quadriceps strength [IQ = 90%] and a motivating psychological status, is considered as the criteria for ensuring participation in sport and enabling a reduction in the rate of re-injury or injury on the side which is contralateral.

Recommendation

During our work, we have seen that the majority of articles have talked about the various functional tests and the ways of their realization. However, none of them did talk about the physiological effects that resulted at that time. We also noticed that there are no strict studies that consider kinesiophobia as a criterion even though it does not lack importance to the other criteria mentioned. Subsequently, we hereby recommend:

• To prepare studies identifying the physiological effect of functional tests realized.

• To consider the advantage of kinesiophobia that should not be underestimated in athletes who undergoes RACL.

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