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Return to Sport after Anterior Cruciate Ligament Reconstruction: A Literature Review

Kyritsis P[1]* and Witvrouw E[2]

[1]*Sports Rehabilitator, Aspetar-Qatar Orthopaedic and Sports Medicine Hospital, Qatar*
[2]*Department of Physical Therapy and Motor Rehabilitation, Belgium*

Abstract

Anterior Cruciate Ligament (ACL) injuries are very common in an athletic population. An ACL injury is a major injury, with a devastating effect on the athletes' sports participation. The goal after an ACL surgery is to return to sport, and ideally to the same level of sports participation as prior to the injury. In the literature, reports of returning to competitive sports at the same pre-injury level are rather low and differ from 33 to 63%.

General consensus exists that a successful return to sports relies heavily on the rehabilitation program. Today it is generally believed that muscle strength, neuromuscular control and fear of re-injury are critical factors for a successful return to sports and must be considered as imperative in the rehabilitation program. In this review, these parameters are described and based upon that, some criteria for a successful return to sport are provided. Indeed, research has proven that a good rehabilitation program, with demanding criteria can reduce the risk of re-injury, prepare the athlete to perform at the same pre-injury level and secure the safe transition of the player from physiotherapy to normal training. More research is needed in order to determine exact criteria for the return to sport. This evidently will lead to a higher percentage of successful return to sport.

Keywords: Anterior cruciate ligament; Athletics; Rehabilitation

Introduction

Anterior Cruciate Ligament (ACL) injuries are very common in people participating in sports even more for those participating in activities that contain pivoting and jumping movements. In the U.S, ACL injury rate is almost 1 in 3500 individuals every year [1] which is calculated to approximately 125000 to 200000 ACL reconstructions yearly. Many studies have examined the injury rate in football and they reported that from all injuries, 60% to 80% occur in lower extremities [2-4]. Most of these injuries are knee or ankle related 29% and 19% respectively [2]. From these knee injuries Anterior Cruciate Ligament (ACL), Posterior Cruciate Ligament (PCL) and Medial Collateral Ligament (MCL) are considered to be most frequent and severe [3,4].

For any individual sustaining an ACL injury there is the choice for a surgical reconstruction with rehabilitation and a conservative option with physiotherapy. The main indication for an individual to undergo ACL surgical reconstruction is the functional instability of the knee [5,6]. Many authors have proposed the Copers and Non-Copers theory presenting those who can be treated after an ACL injury without surgical reconstruction (Copers) and those who have to go through a surgical procedure (Non Copers). Hurd et al. [7], showed with their study that in the short term 72% of their potential copers returned successfully back to their preinjury activities. Frobell et al. [8] showed not only that there was no significant difference in KOOS4 (function during sport) scores between those who followed a surgical reconstruction and rehabilitation and those who followed rehabilitation and optional delayed reconstruction, but they also reported that 61% of those of the second group avoided surgery.

Whether athletes undergo an ACL surgery or not; their goal is the same: to return to sport. Return to sport is a very unclear definition [9]. The clarification of what kind of activity these individuals go back to, if their activities contain pivoting movements, if may be contact or non-contact sport, if they are planning to go back to the same pre injury level or may want to change sport or level or even retire [9-12] is critical. What return to sport means for every patient, is different and clinicians have to be very specific [13]. It also has to be defined what a successful return to sport means. Is it when the patient has a low risk of re injury on the short term [14-18] or is it crucial to take into consideration the long term consequences, before the rehabilitation is classified as successful or not. The main long term risk after ACL reconstruction is the development of osteoarthritis [14,18-22] and studies showed that 50% of ACL patients and 70% of ACL combined with meniscus injury patients are expected to develop osteoarthritis [23,24]. So, what kind of training could be included in the treatment plan in order to prevent osteoarthritis? Neuromuscular training [25-28] and strengthening training [29-31] have been found to reduce the chance of developing osteoarthritis later on, after ACL reconstruction.

The goal of rehabilitating a patient after ACL reconstruction is not only to reach a functionally good outcome, but also to protect him/her from future injuries related to the ACL injury or even re injury. Literature shows increased risk of a second ACL injury during the first year athletes return to sport [4,32-35]. More specifically the rate of re injury ranges from 6% to as high as 13% and on the contra lateral knee from 2% to 24% [4,17,29,36-39].

Return to sport after an ACL reconstruction has by itself an increased risk of a second ACL injury [40,41]. There are many factors that may affect the injury or re injury rates. Such factors can be the type of activity football, basketball [42], handball [37] which is associated to higher injury rates, or the age of the patients. Patients younger than 18 years old [42,43] or younger than 21 years old [29,44] have higher

***Corresponding author:** Kyritsis P, Sports Rehabilitator, Aspetar-Qatar Orthopaedic and Sports Medicine Hospital, Qatar, Tel: +(974) 4413 2000; E-mail: polyvios.kyritsis@aspetar.com

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possibilities to get reinjured than patients of an older age. Athletes having deficits on their strength and proprioception, have limited abilities to regain their sports skills and that can lead to an increased risk of re injury [32,33,45,46]. Although, authors have shown that the graft type is not a risk factor for return to sport [42,47] and a recent study after comparing bone patella tendon bone graft (BPTB) with hamstring autograft showed no difference between the two grafts on return to sport [48-50], Bochers et al. [51] showed that the use of allograft is a high risk factor for ACL graft failure when these patients attempted to return to high level sports activities.

Taking into consideration all the above described risk factors and examining the rates of return to sports activities, literature presents many different outcomes. Some studies show rates of return to some kind of sport participation as high as 75% while others present the rate of return to competitive sports after ACL reconstruction as 64% [52,53]. Later studies by giving a more specific definition of returning to sport, reported only 33% rate of returning to competitive sports at same pre injury level [9]. A recent review has shown that generally 82% of their patients returned to some kind of activity, 63% took part in their pre injury activity and only 44% participated in competitive sports [54]. All the above rates look to decrease even more with time. Brophy et al. [3] reported that 72% of their athletes resumed to play after ACL reconstruction and at 7 years follow up only 36% of those athletes were still playing soccer. Another study examining an even longer follow-up showed that the rate of participation in competitive pivoting sports went down from 65% at 2 years after ACL surgery to only 19% at 13.5 years follow-up [55]. What comes up by reviewing the literature is that return to sport after an ACL injury at the same preinjury level is much less common than it should be expected and that short term success does not really guarantee the long term participation in the same competitive level [56]. Dunn and Spindler [57] suggested that when an athlete has a high pre injury activity level then it is more likely that this individual will return to sport at least at 2 years post ACL reconstruction.

What are the other factors that can make a rehabilitation program successful and reassure a successful return of the patients to the activities that they are willing to practice? Clinicians should keep in their mind that successful return to sport is multi factorial and influenced by many different factors. Today it is generally believed that muscle strength [52] neuromuscular control [58,59], fear of re injury [9,52] and perceived level of knee function [60-62] are probably the most important factors affecting a successful return to sport after ACL reconstruction.

Muscle Strength

It is well supported in the literature that quadriceps strength is highly correlated with good outcome post ACL reconstruction [63-66] and deficits in quadriceps strength are associated with low self-reported function and performance measures [67]. Deficits on quadriceps strength have been shown to predict performance based functions better than other factors, like graft type, knee pain or asymptomatic knee [67]. The same authors concluded that quadriceps strength deficits of more than 15% are negatively correlated with function and performance after ACL reconstruction. Although hamstrings are considered very important for the stability of the knee, there is no impact of hamstrings strength deficit on the performance of functional tests [68]. Yet, hamstrings are very important not only for flexing the knee but also for reducing the ACL strain [69-71] and their strengthening should be of high importance.

The acceptable deficit on muscle strength before returning to sport as described by different authors varies from study to study but rates between 10% to 35% [41,68,72-75]. Ekstrand [71] suggested that the athlete before return to team training should have regained at least 90% of the muscle strength. Hartigan et al. [76] required 90% or more of quadriceps strength before return to sport. Van Grinsven et al. [77] accepted a deficit on hamstrings to quadriceps ratio of 15% or less for their patients before allowing them to return to sports activities. Literature reports that these deficits continue to exist even after individuals return to sports [67,78-80] and it is even more prolonged for those individuals who had a BPTB graft for their reconstruction since the deficits in quadriceps strength is higher compared to those who had a hamstring graft [81].

Hamstring to Quadriceps ratio is also an important parameter discussed frequently in literature. There are two types of suggested ratios. Conventional and functional ratios [82]. Conventional ratio (concentric hamstring peak torque/concentric quadriceps peak torque) has been criticized for lacking in functional relation. For this reason the functional ratio (eccentric hamstring peak torque/concentric quadriceps peak torque) [82] has been suggested. A functional ratio of less than 0.6 has been connected with increased risk of hamstring injuries [83], a 1:1 ratio is accepted as the reference value [84] and any value between 0.7 to 1 is accepted since it presents enough dynamic stability [85,86].

Neuromuscular Control/Functional Readiness

Good neuromuscular control is also considered as imperative following ACL reconstruction and can determine a successful return to sporting activities [58,59]. Neuromuscular control shows an individual's ability to coordinate in such a way that full symmetry can be obtained at any given task. Neuromuscular training can start with basic core stability exercises from the very beginning of rehabilitation after surgery and progressively become more and more advance. Correction of walking and running are crucial in order to make sure that the patient is able to load both limbs equally [87]. Neuromuscular training such as proprioception and perturbation exercises improve the ability of nervous system to start a fast muscle contraction, optimize coordination and balance, limits limbs asymmetries [88] and finally improve the ability to relearn movement patterns and skills [89]. Great emphasis has to be given in single limb power production and control and all movements have to be performed equally good in both sides [87].

A well-structured neuromuscular training program can eliminate uncoordinated movements which are predictive for another injury [32,90-92]. During rehabilitating the ACL patient it is therefore very important to measure qualitatively and quantitatively the function and neuromuscular control. The most commonly used tests known for their reliability are the 4 available hop tests (single hop, triple hop, crossover hop and timed hop test) [9,93-96]. All these tests can assess the functional performance and the neuromuscular control of an individual by imitating the high demands of the knee during high level activities [65,94,97,98]. Taking the results of these 4 hop tests Limb Symmetry Index (LSI) is calculated for each test separately.

LSI for single hop, triple hop and triple crossover hop tests can be calculated by taking the performed result of the injured leg, divide it with the performed result of the uninvolved leg and multiply the result by 100. For the LSI value of the timed hop test the performed result of the uninvolved leg is divided by the result of the injured leg and then the result is multiplied by 100.

LSI is one of the most frequently used criteria and an LSI greater than 85% is an acceptable value before a patient can return to sports activities [9,77,99,100]. The results of the hop tests are not only a good way to examine the readiness of an athlete before returning to sport, but it has been shown to be a good predictor of osteoarthritis development at 1 year post surgery [29].

Psychological Readiness

The psychological status of an athlete experiencing an ACL injury is of great importance in order to manage a successful return to his preinjury level. Langford et al. [52] suggested that the fear of getting injured again was a significant factor for not returning to their preinjury level of activity. Ardern et al. [54] reported that individuals who manage to go back to their preinjury level sport had a much lower fear of reinjury compared to those who did not manage to go back to this level. There are also other psychological factors that can affect the decision of an athlete to return or not, like concerns about the inability to perform at the same level, feeling of isolation from the team mates, lack of athletic identity and may be lack of social or family support [77]. From all the above factors, fear of reinjury has been stated to be the most common reason for retiring from sports, choosing another sport or going back to a lower level of participation [54]. Clinicians should take their patients through every stage of rehabilitation on a very progressive way. Progression from one phase to the other or from a simple set of exercises to more advances should take place only if patients are fully confident and psychologically prepared [101].

Different psychological questionnaires focusing on knee injuries and even more specific to ACL injuries can be a great tool to every clinician. Questionnaires can evaluate the psychological status of the patients and if needed, further assistance can be provided to the patients. There are many questionnaires available, but the two most commonly used are KOOS and ACL-RSI. KOOS (knee injury and osteoarthritis outcome score) examines the subjective knee function by using 5 different subscales (symptoms, pain, function in daily life, function during sport or recreational activities and knee related quality of life) and a score from 0 to 100 comes out from each subscale where 100 means that the knee is fully functional [102]. Another questionnaire that is frequently used is the ACL-Return to sport after injury scale (ACL-RSI) which evaluates patients' emotions, confidence and risk perception in relation to return to sport and it is scored with a 0 to 10 scale where 0 is the best result [103].

Criteria to Return to Sport

Many studies have been performed, looking for the ideal rehabilitation protocol after ACL reconstruction. Each study sets different criteria before allowing an athlete to return back to sports activities. For some studies the amount of time from ACL reconstruction is the only criterion, for some others the time together with subjective criteria are important and very few authors set objective criteria, such as muscle strength, hop tests, clinical assessment tests and related questionnaires [65]. There is no one or two tests that have to be performed. There is a battery of different tests that have to be used in order to have a more complete image of the athlete. These tests must be as demanding as possible [104] and it is preferred if they can be performed under fatigue [105]. The most common outcome measures examined in the literature are, quadriceps- hamstrings strength deficit, LSI deficits, anterior-posterior tibial displacement, pain, effusion, swelling, patellar mobility and range of motion [9-11,104,106].

Conclusion

By reviewing the literature authors come across many different factors that can affect the return to sports rate after ACL reconstruction and keeping all these factors in mind while rehabilitating an individual is crucial. Age, gender, past injuries, level, type of sport and whether the sport is seasonal or all year round [13,29,42-44,99] are just a few factors that may affect the results of ACL rehabilitation. Before start rehabilitating an individual, goals must be set. What are the specific expectations of this individual patient after completing his/her rehabilitation? It has to be defined very precisely, what return to sports mean for this specific individual [13,99,107]. Consequently, patients have to go through each phase of ACL rehabilitation, and move from one phase to the other by setting specific criteria and not by time. A well designed late phase rehabilitation and return to sports training program can reduce the risk of reinjury, prepare the athlete to perform at the same preinjury level [6,41,75,108,109] and secure the safe transition of the player from physiotherapy to normal training [104]. On-field rehabilitation programs must be based on measurable outcomes and in that way the complete functional recovery of the individual can be reassured [71,110].

Since literature shows a great discrepancy between clinical outcomes and the actual rate of return to sports, [9] it is preferred to suggest more demanding criteria before return to the same pre-injury level of activity and through this paper authors take the opportunity to share the criteria used in their clinic. Pain and swelling should not be accepted at the time of return to sport and at the same time normal patellar mobility is of great importance. An isokinetic evaluation gives very interesting and objective information about the muscle strength at different velocities. Bilateral differences of 10% or less are accepted before return to sport, combined with hamstrings to quadriceps ratio between 70 to 90% during a ecc/conc measurement at 60°/sec. Functional and neuromuscular control are tested by using T-test which is a timed run which consists of front running, side steps and backwards running at maximum speed and all 4 hop tests from where LSI scores are calculated and deficits should not exceed 10% for all 4 tests. In order to reassure the self- reported readiness of the athletes, KOOS questionnaire is very frequently chosen and have been shown to be reliable and valid measure of knee function for ACL patients [102,111-114]. Another very important factor is the psychological status of the patients at the stage just before return to sport. A patient specific functional scale [115] is used at the very beginning of the last rehabilitation phase. Patients are asked to report different activities that they are unable or have difficulty to perform and score them from 0 to 10. A score of 0 means that they are unable to perform this specific activity, whereas 10 means that they can perform at the same level like before injury. At the end of rehabilitation any activities score less than 9 cannot be accepted (Table 1).

Before returning to sport, the athletes should be able to perform all the exercises with good comfort, a good coordination in near maximum intensity [116] and reach all the above described criteria.

Criteria	Requirements
Pain	No
Swelling	No or stable for 1 month
Isokinetic test at 60, 180, 300°/sec	Quadriceps and Hamstrings deficit less that 10%
Isokinetic test at 60°/sec	Hams/Quads ratio 0.7-0.9
T-test	Men<10sec. Women<11sec.
LSI	Greater than 90%
KOOS	Score from each subscale greater than 90
Patient Specific Functional Scale	Score of 9 or 10 for each reported activity
On-field Sports Specific Rehabilitation	Fully Completed

Table 1: Criteria needed before return to sport.

Only then they are allowed to return back to their sporting activities, suspecting they are well prepared for this and the chances for re-injury or secondary injury will be minimal.

There is no one specific criterion that can reassure a safe return to sport, but a holistic approach is suggested. All different factors affecting recovery after an ACL injury must be taken into consideration and lead the athlete to a safe return to the same pre injury level of participation.

This field is open to future studies, to develop an ideal rehabilitation protocol which will allow athletes to return to sport on the best possible way.

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