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Factors affecting return to sports after anterior cruciate ligament reconstruction with patellar tendon and hamstring graft: a prospective clinical investigation

Received: 2 February 2005
Accepted: 17 August 2005
Published online: 22 February 2006
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Abstract In athletes, anterior cruciate ligament (ACL) reconstruction is recommended after injury to restore the normal knee function and allow subsequent return to sport. Successful ACL reconstruction with patellar tendon (PT) and hamstring tendon (HT) grafts combined with a well-structured rehabilitation program could bring athletes back to their previous level of sport activities. We prospectively followed-up 100 athletes who underwent ACL reconstruction with either PT ($n=50$) or HT grafts ($n=50$). Evaluation was done pre-operatively and post-operatively (3, 6, 12, and 24 months) using International Knee Documentation Committee (IKDC), Lysholm, Noyes, and Tegner scales. Subjective assessment numeric evaluation (SANE), knee activity rating scale (Marx) and a psychological profile questionnaire (psychovitality) were also utilized. Objective evaluations included isokinetic tests and computerized knee motion analysis. Data gathered were statistically analyzed using the Mann–Whitney non-parametric U -test. Among the 100 patients who have undergone ACL reconstruction, 65% returned to the same level of sports, 24% changed sports and 11% ceased sport activities. No significant difference ($P>0.05$) in outcome between PT and HT grafts were observed. No significant differences ($P>0.05$) were noted between ath-

letes who “returned” to their previous sport and those who “did not return” to sports at the same level when using the IKDC, Lysholm, Noyes, and Tegner knee evaluation scales. However, significant difference was observed with the knee scores obtained by those who returned and those who completely ceased participation in sport activities. Computerized laxity test revealed that 90% of these patients have less than 3 mm side-to-side difference with no significant difference between HT and PT groups. Patients who “returned to sports” obtained significantly better scores with the Marx scale ($P=0.001$) and the psychovitality questionnaire ($P=0.001$) than those who did not. Conventional knee scales including IKDC, Lysholm, Noyes, and Tegner remain as reliable means of evaluating outcome of ACL reconstruction. However, the data obtained from these are not sufficient to determine which among the patients who had knee reconstruction can successfully return to sport. The use of the Marx knee activity rating scale and the evaluation of the athletes’ psychological profile are additional scales that can be useful in determining which among the patients treated have a better chance of returning to their pre-injury activity levels.

Keywords ACL · Sports · Injury · Psychological · Scales

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Introduction

The risk of anterior cruciate ligament (ACL) injury is significantly greater in individuals who participate in pivoting sports. At present, ACL reconstruction is the gold standard after ACL injury in the young athletic population [5]. The most widely used techniques for reconstruction include: patellar tendon, hamstrings or allografts [2, 6, 9, 10, 13]. The combined use of a strong graft and good fixation with an appropriate rehabilitation program should restore the knee function and normally allow the return to sport. However, there are those who even after ACL reconstruction and completion of the prescribed rehabilitation are unable to resume their pre-injury activities. This problem is most pronounced in the athletic population where expectations and demands are higher when compared to sedentary or even normal individuals [4, 5, 14, 21, 26].

Outcome assessment after ACL reconstruction has commonly used knee scoring systems like Lysholm, Noyes, International Knee Documentation Committee (IKDC), and Tegner with success usually equated with acceptable restoration of measurable parameters such as strength, stability, and functional level [12, 16, 17, 24, 28, 29, 31]. Additional evaluation schemes like the Marx scale (knee activity rating scale) can also be used; this scale enables the measurement of activity rather than health status of the patient by assessing the frequency of specific physical tasks that normally are difficult for someone who has a pathologic knee condition [19]. Furthermore, attention should be placed on the patient's psychological profile as this also can contribute to the treatment outcome [11, 20, 28].

Purpose of the study

In this prospective investigation, contributing factors that enable or prevent patients from returning to their previous sport activity levels following ACL reconstruction with patellar tendon (PT) or hamstring tendon (HT) grafts were analyzed using conventional knee scales (IKDC, Lysholm, Noyes, and Tegner), Marx scale and psychological questionnaire (psychovitality).

Materials and methods

Among a group of 134 athletes operated at our institution from January 1996 to December 2000, we included in our study 100 patients who have met the following inclusion criteria: non professional athletes playing in competitive sports at regional or national levels or participating in recreational sports at least three times per week, patients with normal contralateral knee, those who have had partial meniscectomies,

those willing to follow-up at 3, 6, 12, 24 months and those who are able to follow a standard post-operative rehabilitation program.

Exclusion criteria were: previous open knee surgery, injury on the contralateral knee, grade III–IV chondral damage and significant associated ligament injury requiring reconstruction.

Through simple random sampling technique, the 100 athletes [67 males:33 females, mean age of 28 years (17–50 years)] included were assigned the specific type of reconstruction to be used [PT reconstruction (50) and HT reconstruction (50)]. Odd-numbered patients in the list had knee reconstruction using PT while even-numbered patients were reconstructed using HT. All the athletes reported ACL injury during participation in various sports activities (Table 1). Mean interval from injury to knee reconstruction was 8.9 months. Eight patients had minor previous surgery on the involved knee consisting of diagnostic arthroscopy with partial meniscectomy.

All surgeries were performed by the senior author while rehabilitation was conducted for 6 months in the same rehabilitation center.

Evaluation

To document the progression of the patients' recovery, clinical evaluations were conducted by the surgeon and a physical therapist pre-operatively and then at 3, 6, and 12 months following the knee reconstruction. Final follow-up was performed at a minimum of 24 months by an independent examiner (orthopedic surgeon). Subjective and objective assessment were conducted using the IKDC evaluation scales. Further evaluations were carried out using the Lysholm, Noyes, and Tegner scales. In addition, single assessment numeric evaluation (SANE) was also used to subjectively assess their knee function and symptoms [19].

Table 1 Sports activities among patients who had PT and HT ACL reconstruction

Sport activity (PT group)	No. of patients	Sport activity (HT group)	No. of patients
Soccer	16	Skiing	21
Running	1	Motocross	6
Volleyball	4	Trekking	2
Motocross	8	Tennis	2
Skiing	9	Soccer	14
Tennis	2	Volleyball	1
Horseback riding	1	Karate	1
Cycling	3	Swimming	1
Basketball	5	Aerobics	1
Gymnastics	1	Basketball	1
	50		50

PT Patellar tendon, *HT* hamstring tendon

Computerized analysis of anterior knee laxity was performed using the OSI CA 4000 arthrometer (Orthopaedic System Inc., Hayward, CA, USA) pre-operatively and then at 6 and 12 months [5, 22].

Isokinetic testing for analysis of muscle strength was performed with Biodex multijoint system (Biodex, Shirley, NY, USA) at 3, 6, and 12 months after surgery. The maximum peak torque in flexion and extension were determined at speeds of 60, 180, and 300°/s and total work and hamstring/quadriceps ratio were calculated.

A knee activity rating scale (Marx scale) was also used pre-operatively and at final follow-up to measure the patients' activities and the frequency by which they are able to perform specific physical tasks that would be difficult for someone who has a pathologic knee condition. The scores range from 0 to 16; a higher score indicates a better functional capacity on the part of the patient to resume pre-injury activity levels.

To determine the patients' psychological profile, a specific questionnaire (psychovitality) was administered prior to surgery. (Table 2) The series of questions included satisfied the recommended guidelines on item generation, item reduction, reliability and validity testing. In this questionnaire, psychological factors including patients' expectation related to treatment outcome and motivation to resume pre-injury activity levels were analyzed. Scores can range from 3 to 18 points; a higher score would indicate better motivation on the part of the patient.

Data obtained pre-operatively and at subsequent follow-up were also analyzed to determine existing trends and correlations with results obtained from conventional knee evaluation scales such as Lysholm, Noyes, and Tegner scales.

Statistical analysis of data obtained was performed using non-parametric technique with the Mann-Whit-

ney *U*-test (Wilcoxon rank-sum test) due to the different variables measured between the two groups.

Results

Knee scores

Objective IKDC knee scores of normal or nearly normal obtained among the 100 patients treated demonstrated significant improvement ($P < 0.05$) from pre-operative value of 33–97% at final follow-up.

Further analysis in terms of the type of graft used revealed that 88% with PT and 90% with HT reconstructed knees attained normal or nearly normal knees (IKDC A or B) on final evaluation following ACL reconstruction. This slight difference was not statistically significant ($P < 0.05$).

Mean Tegner activity score from 100 patients reviewed demonstrated no statistically significant difference ($P > 0.05$) from 7.6 points pre-injury to 6 points on final follow-up. Mean Noyes and Lysholm scores, on the other hand improved from 45 and 50 pre-operatively to 88 and 90 on final follow-up (Fig. 1). These improvements in the Noyes and Lysholm scales were noted to be statistically significant ($P < 0.05$).

Mean subjective knee score of 47 points pre-operatively improved to 85 points at final follow-up among the 100 patients treated using the IKDC evaluation form which compared the investigated knee to the patient's uninjured contralateral knee. Analyzing the scores obtained in terms of the type of graft used revealed no significant difference ($P < 0.05$).

Comparing the scores obtained by those who "returned to sport" against those who "did not return at the same level of sport activity" revealed no significant differences. In the same way, patients who completely

Table 2 Psychological data questionnaire

	Not important	Slightly important	Very important
1. How important is it for you to be involved in competitive sports?	1	2	3
2. How fast do you expect to return to your sport after surgery?	1 year 1	6 months 2	3 months 3
3. How much time are you willing to spend for rehabilitation after surgery?	1x/week 1	3x/week 2	Everyday 3
4. Do you have any doubts in your ability to return to your previous sports?	Yes 0	No 3	
5. Would you be content if after your surgery you can only manage to go back to an activity level that is less than your pre-injury sporting level?	0	3	
6. After your surgery, would you be willing to settle for a less strenuous sporting activity than your were previously engage in?	0	3	

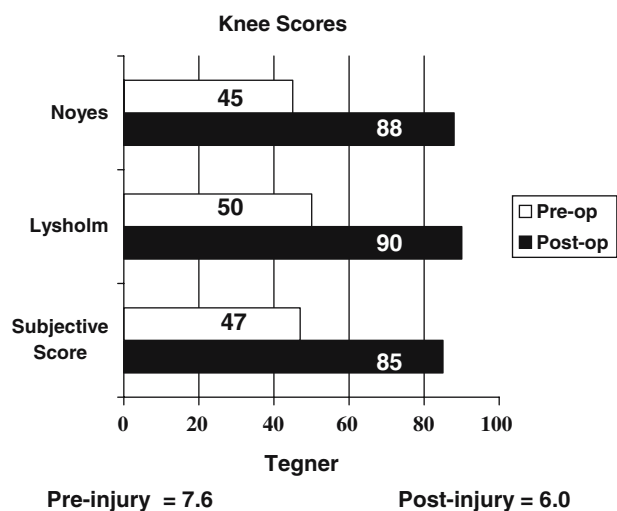


Fig. 1 Knee scores. Pre-injury = 7.6 and post-injury = 6.0

ceased participation in sport activity demonstrated no statistically significant difference with those who “returned to sport at a lower level” [Objective IKDC ($P=0.38$); Subjective IKDC ($P=0.22$); Lysholm ($P=0.38$); Noyes ($P=0.053$); and Tegner ($P=0.94$)].

Isokinetic tests and computed analysis

Isokinetic tests conducted at 60°/s 3 months following surgery demonstrated decreased quadriceps strength in the PT group (23% deficit in total extensor work versus 7.3% deficit in total flexor work) and decreased hamstring strength in the HT group (21.3% deficit in total extensor work versus 22.4% deficit in total flexor work). Tests conducted at 60, 180, and 300°/s in extension 1 year post-operatively demonstrated no statistically significant difference between the PT and HT groups. One year evaluation in flexion revealed significant difference ($P=0.0164$) in HT group at 60 and 180°/s, while at 300°/s no difference was detected.

Anterior laxity tests performed with computed analysis (OSI) carried out at 3 months, 1 and 2 years from knee reconstruction demonstrated 90% of the 100 patients treated to have less than 3 mm side-to-side difference; 8% with 3–5 mm difference; and 2% to have more than 5 mm difference; no statistically significant difference was noted among the two grafts (Fig. 2).

Return to sport

On final follow-up, 65% of the 100 patients were able to return to their pre-injury sport at the same level; 24% shifted to a lower activity level while the remaining 11% were unable to return to their previous

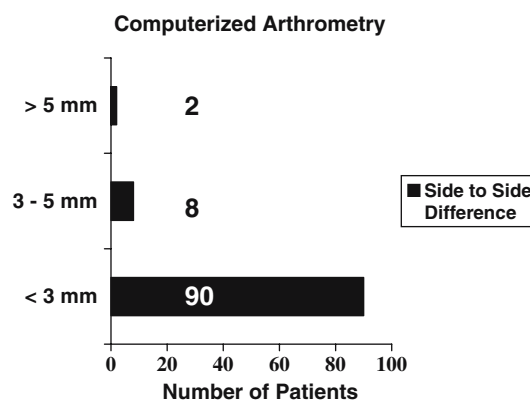


Fig. 2 Computerized arthrometry

sport activities (Fig. 3). Among the six patients with PT reconstruction who were unable to return to sports, two feared re-injury to their reconstructed knee, another two had pain related to chondropathy, one had extension deficit while another cited personal reasons for not resuming pre-injury activity levels. On the other hand, patients with HT reconstruction cited strength deficits (2), pain related to chondropathy (1), pain at tibial fixation site (1), and personal reasons (1) as factors which prevented them from resuming pre-injury activity levels (Table 3).

Knee activity rating scale (Marx scale)

Among the 100 patients reviewed, 52 were available for final follow-up and determination of their knee activity score. Scores obtained from 26 of the 35 patients who “did not return to sport” had a mean of 7.5 points (0–16) with only 17.1% obtaining a score ≥ 15 points. This group of patients reported some difficulty in resuming running, cutting, decelerating and pivoting activities.

On the other hand, a mean score of 15 points (9–16) was documented among 26 of the 65 patients who “returned to sport”. In this group, 53.3% scored ≥ 15 points as they did not encounter any difficulty doing the same activities. Statistical analysis carried out using the Mann–Whitney U -test demonstrated a significant difference ($P < 0.001$) between patients who “returned” and those who “did not return” to their previous sport (Fig. 4a, b).

Psychovitality questionnaire

Data from the psychological questionnaire administered before surgery demonstrated that 28.6% of the athletes

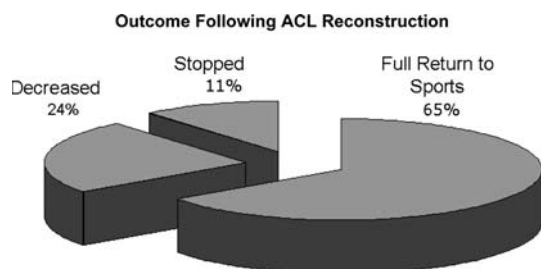


Fig. 3 Outcome following ACL reconstruction

that “did not return to sport” scored ≥ 15 points. On the other hand, 67% of the athletes that “returned to sport”, scored ≥ 15 points. Statistical analysis using the Mann–Whitney *U*-test revealed a significant difference ($P < 0.001$) between these two groups (Fig. 5a, b). Athletes who were able to return to previous sport had a mean score of 16.5 while those who changed or completely stopped any sport activity had an average score of 9 points.

Subsequent surgeries

Two patients presented with persistent clicking and catching during the first year post-ACL reconstruction. On second-look arthroscopy, a medial meniscal tear was demonstrated in one case (HT graft) while the other case (PT graft) had a grade II chondral pathology at the area of the medial femoral condyle. Partial meniscectomy and chondroplasty were done, respectively. At final follow-up, both patients were able to return to their previous sport.

In another case (HT graft), re-injury to the operated knee was documented. Second-look arthroscopy demonstrated a grade IV chondropathy at the trochlear area for which autologous chondrocyte implantation was carried out. At final follow-up, the patient has not returned to his previous activities secondary to restrictions imposed following graft implantation.

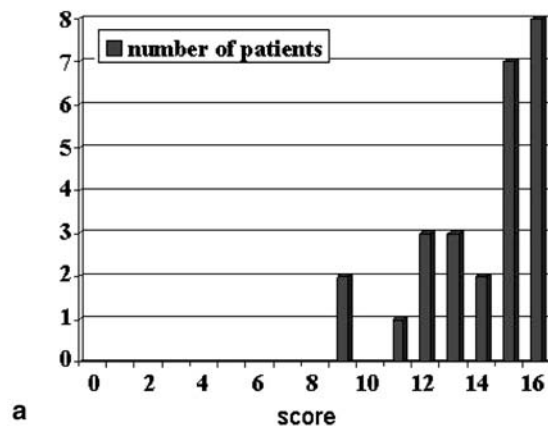
Table 3 Factors related to patient’s inability to return to sport according to type of graft used for reconstruction

Graft type	Reason for inability to return to sports	Number of patients
PT	Fear of new injury	2
	Pain related to chondropathy	2
	Extension deficit	1
HT	Reasons unrelated to surgery	1
	Strength deficit	2
	Pain related to chondropathy	1
	Pain at tibial fixation site	1
	Reasons unrelated to surgery	1

PT Patellar tendon, HT hamstring tendon

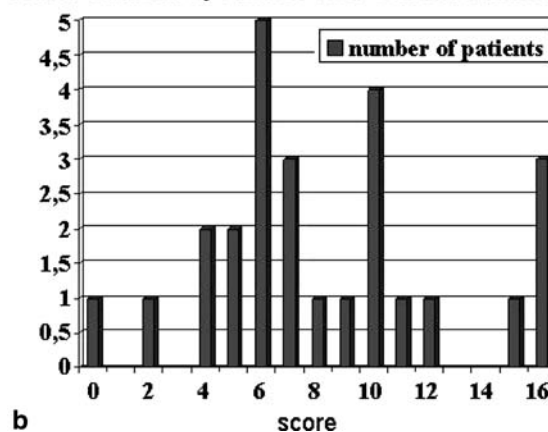
Knee Activity Rating Scale (Marx)

Scores Obtained by Patients Who “Returned to Sports”



a

Scores Obtained by Patients Who “Did Not Return to Sports”



b

Fig. 4 Knee activity rating scale (Marx). Scores obtained by patients who “returned to sports” (a) and “did not return to sports” (b)

Discussion

Anterior cruciate ligament reconstruction in athletes is carried out to achieve a stable knee that can enable them to return to their desired activities. For athletes with ACL tear, the outcome of reconstruction becomes more important as expectations of returning to pre-injury activity levels are usually higher.

Unfortunately, even with the present techniques in knee reconstruction successful return to sport cannot be guaranteed. Restoration of mechanical restraints is the initial step in achieving knee functional recovery but factors including the patient’s motivation and willingness to complete the prescribed rehabilitation program may also play a role in influencing outcome.

Results of this investigation using the IKDC (objective and subjective), Noyes, and Lysholm demonstrated

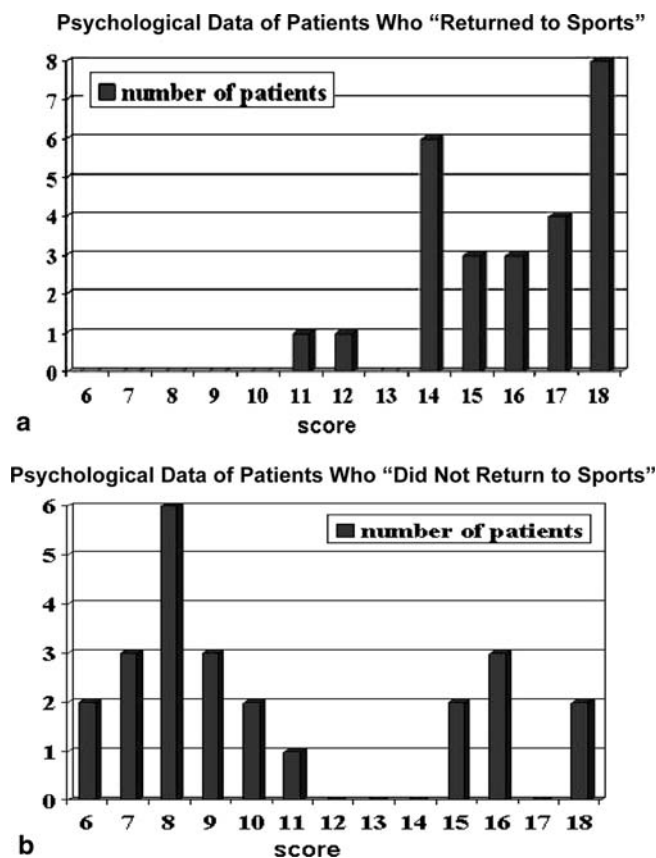


Fig. 5 Psychological data of patients who "returned to sports" (a) and "did not return to sports" (b)

significant overall improvement in all the patients reviewed. No significant differences were observed when we compared outcomes of the PT and HT groups. However, with the use of the Tegner scale, a slight decrease in score between pre-injury and post-treatment was documented. This difference was not statistically significant. Commonly utilized knee evaluation scales remain as good indicators in evaluating the results of ACL reconstructions. However, in certain cases return to the same level of previous sport after ACL reconstruction is not achieved [23, 24, 28, 29]. To identify the possible factors responsible for preventing successful return to previous sport, two additional scales were utilized for this study: the knee activity rating scale (Marx scale) and the psychovitality questionnaire.

The Marx scale demonstrated a significant difference ($P < 0.001$) between athletes who were able to return to previous sport and those who "did not return to any sport." In this scale, patients were asked about the components of physical function common to different sporting activities, putting more focus in measuring activity rather than health status. However, it should be emphasized that among the 100 athletes who underwent

knee reconstruction, only 52 were available on final follow-up for evaluation of their activities. As a consequence, this transfer bias partially limits the accuracy of the data obtained.

The psychological questionnaire, on the other hand, focused on factors which included the patient's commitment, willingness, and interest in resuming pre-injury activity levels. Valuable information extracted from these additional scales can provide the data necessary to go beyond the objective measures available with standard knee scales. The importance of using these two questionnaires cannot be undermined especially in cases where good results with IKDC, Lysholm, Tegner, and Noyes scales are obtained and yet the athlete remains unable to resume previous activity levels.

This investigation demonstrated that only 65% of athletes were able to resume the same sport activity at the same level following ACL reconstruction while the remaining 35% for various reasons decreased their level of activity (24%) or completely ceased sport participation (11%). Further evaluation revealed that 4/11 (36.4%) had persistent pain related to chondropathy or at the area of tibial fixation while factors like fear for new injury, strength deficit and factors unrelated to surgery each had an incidence of 2/11 (18.2%). Only 1/11 (9%) cited extension deficit as the reason for not resuming pre-injury activity levels (Table 3).

A previous study conducted by Aglietti et al. [2], demonstrated similar results comparable to our findings. Jarvinen et al. [13] and Condello et al. (unpublished data, 2002) found in their studies that 53 and 40%, respectively "returned to sport" following knee reconstruction. On the other hand, Nakayama et al. [21] reported a 92% incidence of return to sports among 50 young athletes reviewed. However, in all these studies mentioned, the main focus was on the technique utilized for reconstruction (PT vs. HT) followed by analysis of outcome using standard knee rating scales. In cases where less satisfactory results were obtained, possible contributory factors were enumerated but not thoroughly discussed.

Our investigation indicates that restoration of ligament stability is just one of several factors required to facilitate return of athletes to sport. Patient selection, type of sport and factors which include pain, patellofemoral dysfunction, change in life-style, rehabilitation as well as concomitant injuries to the joint may lead to a less than desired result in an ACL reconstructed knee [6, 17, 18, 23]. Some studies emphasized the importance of early recovery of knee function as a significant determinant of the long-term outcome of reconstructed knees [23, 24, 28]. Furthermore, other factors such as proprioception and neuromuscular control have also been cited to influence the outcome [1, 9, 25, 30, 32, 33]. In general, a progressive neuromuscular control rehabilitation program should be

made to minimize the risk of injury and to promote a greater chance of successful return to competition [3, 7, 8, 11, 15, 18, 27].

This study also demonstrated that factors rarely mentioned including the psychological profile of patients have been found to exert a certain degree of influence in the final outcome of treatment. Morrey et al. [20] demonstrated that significant mood changes throughout rehabilitation may be a contributing factor to poor psychological and physical outcomes. Furthermore, Pantano et al. [26] emphasized that a variety of psychosocial factors including motivation, influence the level of activity following surgical procedures.

The recognition of the variety of factors influencing outcome following ACL reconstruction is important especially when developing a sport specific post-operative rehabilitation program focused in facilitating the full return of athletes to previous levels of activity.

Although certain weaknesses are evident in this investigation including the relatively low number of patients included per group and the medium term follow-up achieved, the data obtained can be very important in analyzing the rationale behind some athletes inability to return to sport following ACL reconstruction.

Conclusion

Standard knee scales like IKDC, Lysholm, Noyes, and Tegner remain a valuable tool for evaluating the progression of knee recovery following ACL reconstruction. However, we believe that the additional use of the Marx knee activity rating scale and the psychovitality evaluation can provide additional data on the patient's functional capabilities and psychological profile which could be useful in determining the capacity of athletes to resume pre-injury activity levels.

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