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Assessing the Predictive Value of Preoperative Knee Function Tests and Self-Report Scores in Anterior Cruciate Ligament Injury Recovery

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Background: The ability to identify patients with long-term poor outcomes using clinical and functional information is limited. Identifying prognostic factors to improve long-term outcomes after anterior cruciate ligament (ACL) injury can influence and inform targeted interventions for this population.

Hypothesis: Preoperative functional tests and patient-reported outcome measures are predictive of postoperative functional recovery and satisfaction in patients undergoing first-time ACL repair, second-time ACL repair on the same knee, and bilateral ACL repair.

Study Design: Quasi-experimental prospective study.

Level of Evidence: Level 3.

Methods: A total of 88 patients with ACL reconstruction were included. Subjective knee scoring systems and functional performance tests were used for evaluation and analyzed for correlation with results.

Results: The first time ACL injury group had lower scores in the various self-report scales: Knee injury and Osteoarthritis Outcome Score (KOOS), Lysholm Rating Scale, International Knee Documentation Committee (IKDC), and Lower Extremity Functional Scale (LEFS).

Conclusion: Reduction in self-reported knee function and Y balance test performance after ACL injury are predictive factors for recovery. Estimates exceeded clinically important thresholds. Those who had already undergone surgery had clinically better thresholds, highlighting the assessing these measures when designing presurgical rehabilitation programs.

Keywords: anterior cruciate ligament; functional outcome scores; knee; patient-reported outcome measures; preoperative procedures

The preoperative phase for anterior cruciate ligament injury (ACL) reconstruction (ACLR) has been gathering more attention in the last few years as it appears to positively impact long-term outcomes.[4,12,22,33,49] Neuromuscular function is predictive of knee function and return to sport after ACLR.[22] Successful performance on flexor strength is recommended as a key goal during this phase.[13,29,35,42,46]

Thus, guidelines for rehabilitation procedures after ACLR also recommend presurgical rehabilitation programs with the aim of increasing pre- and postsurgery function.[8,27,50] Physical assessment is important to identify the signs and symptoms of injury, health condition, activity limitation, or participation restriction.[8,11,29,35]

The decision to perform ACL reconstruction should take many factors into account, including activity level, sports involvement and instability of the knee. The physical assessment is performed with assessment instruments and functional tests. The rehabilitation process begins immediately after injury to the ACL.[27,33]

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Despite function being associated with good joint stability, patients tend to value more the ability to perform activities of daily living and sports activities.[3,16,41]

Although good stability is the main success criterion for the surgery, this does not always translate into a satisfactory result for the user. From the user's perspective, symptoms and function are identified as the most important aspects for classifying a result. Although there is a consensus that preoperative intervention is crucial in obtaining good results, studies about the results obtained in reducing pain intensity and functional disability are scarce.[3,13,37,57]

Our understanding of the sequelae of ACL injury continues to improve, and rehabilitation guidelines should be adjusted to mitigate the negative impact wherever possible. Despite extensive research into ACL injuries, the rates of such injuries among professional athletes have not decreased in recent decades, in either contact or noncontact sports.[17,20,39,53] Clinical practice decisions and policies are informed by studies summarizing the effectiveness of knee injury rehabilitation interventions.[20]

Previous studies study the risk of contralateral ACL rupture or ACL graft rupture have shown conflicting evidence.[16,23,30,49] Different sports place different demands on the knee. The increased risk could be due to insufficient biologic healing (eg, graft incorporation and remodeling), incomplete rehabilitation, or both.[2,18,28]

The hypothesis of our study is that preoperative functional tests and patient-reported outcome measures (PROMs) are predictive of postoperative functional recovery and satisfaction in patients undergoing first-time ACL repair, second-time ACL repair on the same knee, and bilateral ACL repair. There is still no consensus on the characterization of functional indicators in this clinical condition, as well as their correlation with measurement instruments, establishing reference intervals.

Our group's research has been focused on understanding preoperative clinical outcomes correlate with postoperative results, which included ACL for the first time and in cases of recurrence. In the present paper, we explore these themes further by studying potential relationships among stiffness, pain, symptoms, activities of daily life, quality of life (QOL), and functional asymmetries variables in the functional test of 3 different group participants.

METHODS

Design and Sample

A quasi-experimental prospective study was carried out. A sample of 88 young participants were recruited from a hospital setting and divided into 2 groups.

The first group included both sexes (15 female and 29 male; 25.8 ± 9.1 years old) and corresponds to the group of people who had an ACL injury for the first time. The second group includes those of both sexes (9 female and 16 male; 27.1 ± 7.5 years old) who have reinjured the ACL in the same knee, and includes people of both sexes (5 female and 14 male; 30.4 ± 6.8 years old) who had ACL injury bilaterally.

Selection took place after informed consent and involved the specific predefined inclusion/noninclusion criteria described below. Participants were nonsmokers, exercised regularly, were monitored by a coach/teacher, and did not take any dietary supplements or medications.

Inclusion criteria: patients must have started physiotherapy before surgery and continued with rehabilitation for up to 2 weeks postsurgery; patients must be capable of accurately completing assessment instruments and providing informed consent.

Exclusion criteria: concomitant bilateral injury/history of surgery or contralateral dysfunction; meniscal suture; cartilaginous injury; injury to the medial collateral ligament, lateral collateral ligament, and posterior cruciate ligament; concomitant intra and extra-articular plastic surgery; complex injury from any accident; complex tibial condyle fracture; rheumatoid arthritis; nonacute ACL injury, people with recent heart disease, intermittent claudication, neuropathies, and cognitive alterations.

Sample Size Calculation

Proper sample size calculation and power analysis are important issues in research and analysis. The G*Power software (latest Version 3.1.9.7; Heinrich-Heine-Universität Düsseldorf) was used to support sample size and power calculation for various statistical methods.[51] The sample size calculations indicated that 88 participants would be needed.

Ethical Considerations

The project received approval by the local Bioethics Committee of the Grupo de Saúde da Clínica São João de Deus in Lisbon, Portugal and was registered prospectively at https://clinicaltrials.gov (NCT06050005). All voluntary participants gave written informed consent before beginning the investigation protocol. All procedures complied with the principles of good clinical practice adopted for human research in accordance with the Declaration of Helsinki and subsequent amendments.

Procedure

Participants were all athletes reporting regularly high physical activity and absence of any metabolic disease (diabetes, dyslipidemia, obesity). Body mass index was always registered (22.6 ± 1.8 kg/m^2). Baseline measurement included a general health questionnaire. The study-specific questionnaire included information on occupation, family history of ACL injuries, and the type of activity and activity level before their first ACL injury and after the first and second ACLR, age at surgery, and time interval between injury and surgery were recorded from medical records. The patients were also asked about their current activity level and whether they were satisfied with this.

Once the criteria were met to perform the evaluation before the surgical procedure, a single investigator evaluated and recorded the values.

Variables

Measures of Knee Function. The Knee injury and Osteoarthritis Outcome Score (KOOS), which is self-completed by the patient, was developed in the 1990s as an instrument to measure and assess the disability caused by knee problems. It covers health conditions such as knee osteoarthritis, knee arthroplasty, and other problems that may subsequently result in post-traumatic osteoarthritis, ACL injury, meniscal injury, and chondral injury.[14,32,42]

The dimensions are divided into 5 items (Symptoms, Pain, Activities of Daily Living, Sports and Leisure Activities, and Quality of Life) on a positive orientation scale from 0 (extreme knee problems) to 100 (no knee problems). A user's guide, scoring file, and questionnaires in different languages can be downloaded from http://www.koos.nu.[14]

The Lysholm Rating Scale was initially designed for physician administration and was validated in patients with ACL injuries and meniscal injuries.[14] The Lysholm scale does measure the domains of symptoms and complaints and does measure functioning in daily activities slightly but does not measure the domain of functioning in sports and recreational activities. This scale consists of 8 items. It is scored on a scale of 0 to 100, with higher scores indicating fewer symptoms and higher levels of functioning.[14,15,28]

International Knee Documentation Committee (IKDC)-Subjective Knee Evaluation Form was developed in 1991, undergoing several changes, with the aim of evaluating the improvement or deterioration of the function and symptomatology of injuries that affect the knee joint, with good levels of discrimination.[14,31]

Since 2001, the form has not undergone changes and maintains 7 questions about patient symptoms; 1 question about sporting activity; 9 topics about activities of daily living, where the patient grades (in 5 levels) from "no difficulty" to "not achievable"; and a final topic on the assessment of knee function (before and after injury). It should always be performed in the presence of the examiner, preferably by the patient, using simple language and quick response. Obtaining the final score obeys a calculation formula that can be used even in situations where there are still answers to be obtained, with a range between 0 and 100, with the maximum value meaning no limitation in sports activities and daily life and no symptomatology.[14,26,47]

The Anterior Cruciate Ligament-Return to Sport after Injury (ACL-RSI) Scale was developed as a tool to evaluate psychological readiness to return to sport after ACL injury and is currently the only scale specific to ACL injury. It is a specific 12-item questionnaire assessing the psychological impact (emotions, confidence in performance, and evaluation of risk) of returning to sport after ACL reconstruction. Scores range from 0 to 100, and high scores were related to a positive psychological response.[15,45]

The Lower Extremity Functional Scale (LEFS) is a measurement instrument for the limb bottom that evaluates the level of difficulty in carrying out activities of daily life. This measurement instrument consists of 20 items, each of which is scored on a 5-point scale, from 0 to 4.[21] The total LEFS score, with a minimum value of zero (low functional level) and maximum of 80 (high functional level), which can be exposed in percentage terms, can be used as a measure users' initial functionality, continuous progression, and measurement of results, as well as to define functional goals.[1,21,38,52]

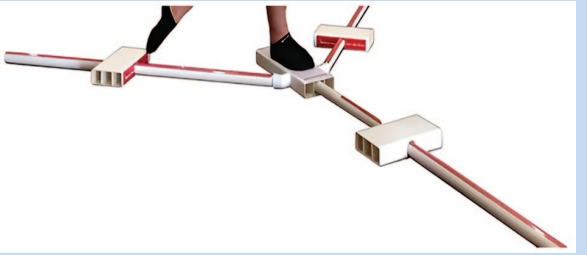

Figure 1. Demonstration of the YBT. YBT, Y balance test.

Functional Performance Test. The Y balance test (YBT) is a tool used to test a person's risk for injury or after injury to check for asymmetries between right and left side. The YBT protocol is based on research done in the Star Excursion Balance Test. As such, most of the supportive research for the YBT is based on the investigations conducted on the Star Excursion Balance Test. Nevertheless, the YBT has not only proven itself to have a high level of test-retest reliability but also to be a sensitive indicator of injury risk amongst athletes.[6,47]

The YBT was performed using the Y-Balance Test Kit (Functional Movement Systems) (Figure 1).

The YBT requires the athlete to balance on one leg while simultaneously reaching as far as possible with the other leg in 3 separate directions: anterior, posterolateral, and posteromedial. Therefore, this test measures the athlete's strength, stability, and balance in various directions. The YBT composite score is calculated by summing the 3 reach directions, and normalizing the results to the lower limb length, whereas asymmetry is the difference between right and left limb reach. With the test complete and all performances recorded, the test administrator can then calculate the athlete's YBT performance scores using any of, or all of, the following 3 equations[2,15,34,55]:

$$\text{Absolute reach distance (cm)} = (\text{Reach 1} + \text{Reach 2} + \text{Reach 3}) / 3$$

$$\text{Relative (normalized) reach distance (\%)} = \text{Absolute reach distance} / \text{limb length} \times 100$$

$$\text{Composite reach distance (\%)} = \text{Sum of the 3 reach directions} / 3 \text{ times the limb length} \times 100$$

Limb Symmetry Index. The patients made a single-leg forward hop to calculate the distance. They were instructed to

Table 1. Participant demographics after ACLR

		Unilateral ACLR (n = 44)	Reinjury ACLR (n = 44)	
			Primary	Contralateral
Age, y	25.8 ± 9.1	27.1 ± 7.5	30.4 ± 6.9	
Gender	Male	29	16	14
	Female	15	9	5
Occupation	Athlete	22	12	9
	Student	10	6	4
	Worker, mainly physical	6	5	4
	Worker, mainly sedentary	3	2	1
	Unemployed	3	-	1
Family history of ACL injury		4	2	-
Graft type	Hamstring tendon graft	44	23	15
	Bone-patellar-bone graft	-	2	3
	Allograft	-	-	1

Data presented as mean ± SD or *n*. ACL, anterior cruciate ligament; ACLR, ACL reconstruction.

jump as far as possible and control the reception to the ground. A previous jump was allowed, considered as a familiarization test. Two successful trials of both limbs were recorded and averaged to calculate a limb symmetry index (LSI). The limb without recent injury was tested first, followed by the limb with indication for surgery. For data analysis, the means of the 2 jumps were used and the volunteer functions inventory (VFI) values were calculated (LSI = involved/not involved × 100).

Statistical Analysis

Statistical analysis was performed with Prism software (GraphPad Software Inc Version 10.2.0) normal distribution was confirmed using Anderson-Darling (A2*); D'Agostino-Pearson omnibus (K2); Shapiro-Wilk (W), and Kolmogorov-Smirnov (distance) tests; we used at paired *t*-test for comparative analysis. The test for 2 related specimens studies the healthy leg with the injured leg (for the primary ACLR group).

In the reinjury group, it was necessary to distinguish whether the injury is primary (ACL injury repeated in the same leg) and it was also possible to compare it with the primary injury. On the other hand, if contralateral, the injured one leg was compared with the recovered leg.

The correlation between variables was performed using Pearson's test, with reported outcomes: KOOS-pain, KOOS-symptoms, KOOS-daily living, KOOS-sport/recreational, KOOS-QOL, Lysholm score, IKDC score, ACL-RSI, LEFS, and preoperative YBT scores.

The independent variables are shown as mean, ranges of minimum to maximum and standard deviation values for the descriptive data analysis. Categorical variables are presented as percentages and absolute values.

The analysis of outcomes was performed with the IBM SPSS Statistics Version 27.0.01.0 package for windows. For all analyses, significance was established at $P < 0.05$ with a 95% CI.

RESULTS

Patients

A total of 88 patients who matched the inclusion criteria were identified. All patients included in the study answered live. The mean time between the primary and the contralateral ACLR was 4.5 ± 2.8 years. The mean time from the second (same knee) ACLR was 6.6 ± 3.8 years. A total of 88 patients responded and gave their informed consent.

The characteristics of patients in the study groups are shown in Table 1.

Prognostic Factors Through PROM

Fair/poor Lysholm score (compared with excellent/good) will a prognostic factor for an uneventful initial recovery. Patients in the reinjury ACLR group had a higher Lysholm rating score, IKDC, and LEFS score before the first ACLR surgery. The only scale reported with a lower value was the ACL-RSI. However, the current study—the first to do this—investigated the

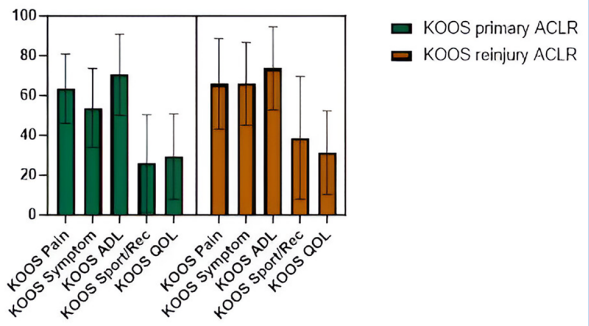

Figure 2. Differences regarding the KOOS subscales between the 2 groups. ACLR, anterior cruciate ligament reconstruction; ADL, activities of daily living; KOOS, Knee injury and Osteoarthritis Outcome Score; QOL, quality of life; Sports/Rec, sport/recreational.

responsiveness of the ACL-RSI scale before surgery. The scale was shown to be moderately responsive over a 6-month average timeframe, which began when patients had just commenced sport-specific training, but most had not yet attempted to play, through to when most had returned to some form of sport participation. Due to the increasing tendency to initiate conservative treatment in ACL recovery, it may also be a good functional indicator to use this scale at an early stage.

There were significant differences between the groups regarding the KOOS-pain, KOOS-symptoms, KOOS-daily living, KOOS-sport/recreational, and KOOS-QOL subscales between the 2 groups (Figure 2). The mean and mode averages for each of the clinical outcome measures (continuous and categorical variables respectively) are displayed in Table 2. In the second ACLR group, there were no significant differences regarding knee function between the first ACL-reconstructed knee.

Table 3 presents the results of analysis between each of the preoperative YBT scores. In a subgroup analysis of each direction, Lysholm score, IKDC score, ACL-RSI, and LEFS were correlated significantly with performance in the anterior reach before ACLR.

It has been reported frequently that balance and lower-extremity muscle strength/power are associated with sports-related and everyday activities. Knowledge about the relationship between balance, strength, and power are important for the identification of at-risk people because deficits in these neuromuscular components are associated with an increased risk of sustaining injuries. In addition, this knowledge is of high relevance for the development of specifically tailored health and presurgical care. Table 4 presents results of the 1-legged jump test.

DISCUSSION

Benchmarks for rehabilitation progression can also be established through presurgery reference values. Patients who achieve greater symmetry in the preoperative period tend to have more favorable clinical outcomes after surgery.[1,24,27]

The group that had ACL injury for the first time showed lower values in all self-reported scales, except for the ACL-RSI. This is a curious fact, and one that can be explained by the unpredictability they expect from the recovery. Education will be fundamental throughout the process. The fact that the ACL-RSI questionnaire was designed to measure the psychological impact of the athlete after ACLR may explain this difference, being a component of increasing relevance in the current scientific evidence.[25,27,53] The use of PROMs has become a cornerstone for researchers to understand the patient's perspective of the impact of ACL injury and treatment.[7,10,44]

Although YBT could evaluate the overall function of the lower leg, few studies have been conducted to correlate YBT with ACL injury or ACLR.[40,48,54] A prospective study revealed that lower limb injury could be predicted with differences of 4 cm from normal values in the anterior, posteromedial, and posterolateral directions in women, and 4 cm in the anterior direction in men. In this study, in group I, there are differences of up to 12 cm in the anterior distance, which reveals the dynamic instability in this functional movement.[6,47]

The constructs assessed in the Lysholm score may be more meaningful to patients than objective measures of knee function, including knee strength and a flexion or extension deficit. Measures of knee laxity assessed clinically are poorly correlated with patient-reported knee instability.[19,31,56]

The minimal clinically important difference (MCID) for the KOOS is 8 to 10 points. A recent study suggested different MCIDs for the KOOS subscale scores for patients undergoing ACLR. The authors suggested that only the sport/recreation and QOL subscales should be considered as primary outcomes after ACLR, and that the MCIDs for those subscales would be 12.1 and 18.3, respectively.

A potential strength is that the patient group was relatively homogeneous and included only patients who had undergone a first primary ACLR and were active in sport before ACL injury, either recreationally or professionally. This was, however, a deliberate decision so that experience of ACL injury and/or surgery would not influence patient responses and the concept of readiness to return to sport would be relevant. To our knowledge, studies thoroughly comparing patients with bilateral ACLR with matched patients with unilateral ACLR, regarding ACL recovery and knee function are lacking. It is not known whether the administration of scales preoperatively will relate to patient postoperative outcomes after ACLR.

We acknowledge a number of study limitations. We could have used a comprehensive assessment of the psychological and psychosocial impact on ACLR, since factors such as psychological readiness, locus of control, self-confidence, optimism, self-motivation, stress, social support, and self-identification influence clinical outcomes after ACLR.[5,9,36] Muscle strength was not assessed and could have been another component for the study. This was an ideal sample for studying a high-risk population,[43] it is not representative of all patients

Table 2. PROM of knee function measures

	Unilateral ACLR	Reinjury ACLR	*P* Value
Lysholm Rating Scale	56.0 ± 19.9	67.1 ± 17.5	**0.01**
IKDC	53.1 ± 15.2	62.9 ± 14.1	**0.02**
LEFS	57.0 ± 13.1	63.1 ± 15.9	0.27
ACL-RSI	63.2 ± 14.2	49.2 ± 14.3	**0.01**

Data are presented as mean ± 95% CI (scores on a range from 0 to 100). Bold *P* values indicate a statistically significant difference between groups ($P < 0.05$). ACLR, anterior cruciate ligament reconstruction; ACL-RSI, Anterior Cruciate Ligament-Return to Sport after Injury; IKDC, International Knee Documentation Committee; LEFS, Lower Extremity Functional Scale; PROM, patient-reported outcome measure.

Table 3. Y balance test

	Injured Leg	Leg Without Acute Injury	*P* Value
Group I—first ACL injury, n = 44			
Anterior, cm	55.1 ± 7.3	67.1 ± 5.2	0.12
Posteromedial, cm	98.1 ± 12.3	99.4 ± 12.8	0.90
Posterolateral, cm	94.1 ± 14.5	95.3 ± 11.7	0.94
Composite score, cm	84.1 ± 6.5	95.1 ± 4.2	0.22
Group II—recurrent ACL injury, n = 25			
Anterior, cm	53.8 ± 11.9	64.0 ± 8.3	0.04
Posteromedial, cm	96.5 ± 15.1	103.4 ± 13.4	0.70
Posterolateral, cm	93.2 ± 12.3	96.1 ± 10.3	0.81
Composite score, cm	82.8 ± 8.8	94.7 ± 3.7	0.18
ACL injury other leg, n = 19			
Anterior, cm	52.1 ± 8.1	60.1 ± 8.8	0.31
Posteromedial, cm	90.2 ± 10.4	94.7 ± 6.3	0.70
Posterolateral, cm	87.1 ± 14.5	93.2 ± 10.0	0.31
Composite score, cm	81.7 ± 9.3	90.8 ± 8.2	0.08

Values are mean ± SD. Composite score is the average of the 3 reach distances in centimeters (ANT, PM, PL) divided by 3 times the leg length and multiplied by 100. Statistically significant difference at the 0.05 level. ACL, anterior cruciate ligament.

Table 4. One-legged jump test

1-Legged Jump Test	Unilateral ACLR (n = 44)	Reinjury ACLR (n = 44)	*P* Value
Ipsilateral, cm	114.5 ± 29.9	108.3 ± 33.1	**0.02**
Contralateral, cm	128.9 ± 12.8	121.1 ± 9.5	0.30

Values are mean ± SD. Bold *P* value indicates a statistically significant difference between groups ($P < 0.05$). ACLR, anterior cruciate ligament reconstruction.

who undergo ACLR. As a result, this population has low generalizability to other demographics, including older patients and those who do not return to sport.

CONCLUSION

Reduction in self-reported knee function and YBT performance after ACL injury are predictive factors for recovery. Estimates exceeded clinically important thresholds and it is interesting to note that those who had already undergone surgery had clinically better thresholds, highlighting the importance of evaluating these constructs in presurgical program management.

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