

Psychological Readiness to Return to Sport Is Associated With Second Anterior Cruciate Ligament Injuries

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Background: Psychological responses after anterior cruciate ligament (ACL) injury and ACL reconstruction (ACLR) have been identified as predictors of return to sport but have not been investigated in relation to further injury.

Purpose/Hypothesis: To determine whether psychological readiness to return to sport is associated with second ACL injury. It was hypothesized a priori that at both preoperative and 12-month postoperative time points, patients who sustained a second ACL injury would have lower psychological readiness than patients who did not have a second injury.

Study Design: Cohort study; Level of evidence, 2.

Methods: Patients who had a primary ACLR procedure between June 2014 and June 2016 completed the ACL–Return to Sport after Injury (ACL–RSI) (short version) scale before their ACLR and repeated the scale at 12 months after surgery to assess psychological readiness to return to sport. Patients were followed for a minimum of 2 years (range, 2–4 years) after surgery to determine further injury. The primary outcome was the relationship between ACL–RSI scores and the incidence of second ACL injury.

Results: In 329 patients who returned to sport after ACLR, 52 (16%) sustained a second ACL injury. No difference in psychological readiness was observed at the preoperative time point, but patients who sustained a second injury trended toward lower psychological readiness at 12 months compared with noninjured patients (60.9 vs 67.2 points; $P = .11$). Younger (≤ 20 years) patients with injury had significantly lower psychological readiness to return to sport than young noninjured patients (60.8 vs 71.5 points; $P = .02$), but no difference was found in older patients (60.9 vs 64.6 points; $P = .58$). In younger patients, receiver operating characteristic curve analysis revealed a cutoff score of 76.7 points with 90% sensitivity to identify younger patients who sustained a second ACL injury.

Conclusion: Younger patients with lower psychological readiness are at higher risk for a second ACL injury after return to sport.

Keywords: ACL reconstruction; fear of reinjury; psychosocial factors; return to sport

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Anterior cruciate ligament (ACL) rupture is one of the most common sport-related knee injuries. A meta-analysis reported that 1 in 29 female athletes and 1 in 50 male athletes sustained an ACL injury in a window ranging from 1 season to 25 years.¹⁰ Surgical ACL reconstruction (ACLR) and rehabilitation are typically undertaken to restore joint stability and enable return to sport (RTS). Despite reporting satisfactory knee function, 35% of athletes do not return to their preinjury level of competition, and almost 20% do not return to any sport participation.^{2,15}

In addition to physical recovery and function after ACLR, psychological responses have been shown to affect a patient's recovery. Fear of reinjury is a common reason cited by athletes who do not RTS after ACLR.⁷ Longitudinal studies have also shown that athletes' psychological response can be predictive of whether they return to their preinjury level of sport.^{2,8} Specifically, improved psychological readiness, assessed preoperatively and during early rehabilitation, was shown to increase the odds of return to preinjury activity after ACLR.² Therefore, it is important to consider a whole-person approach to recovery. The

Anterior Cruciate Ligament–Return to Sport after Injury (ACL-RSI) scale was developed to assess psychological readiness in relation to RTS and has identified psychological aspects for which patients may need counseling, concomitant with their physical rehabilitation, to improve their chances of successful RTS.¹⁷ Factors that are known to be associated with psychological readiness to RTS include self-reported symptoms and knee function.¹⁹ In addition, male sex, younger age, and a higher frequency of sports participation have a positive effect on psychological readiness when assessed 12 months after ACLR.¹⁹

Although psychological interventions can reduce postoperative pain and improve function after ACLR, it is unknown how psychological readiness influences the risk of second ACL injury.⁹ Of the young, active athletes who return to their previous level of activity, 1 in 3 to 1 in 4 sustains a second ACL injury.^{13,14,18,21} A recent small pilot study reported that patients with greater self-reported fear at the time of RTS clearance were less active, demonstrated increased biomechanical asymmetries, and had an increased risk of experiencing a second ACL injury in the 24 months after RTS.¹² Psychological readiness has been suggested for inclusion in RTS test batteries, but empirical evidence to confirm the validity of this parameter is lacking.^{1,6} Therefore, the purpose of this study was to investigate whether psychological readiness associated with RTS is related to subsequent injury after RTS in a 2-year follow-up period, particularly in young patients who are at the highest risk for second ACL injury. The hypothesis tested was that patients who went on to sustain a second ACL injury would have lower presurgery and 12-month post-ACLR scores on the ACL-RSI than patients who did not have a subsequent second ACL injury.

METHODS

A prospective longitudinal study design was used to evaluate the relationship between psychological readiness and second ACL injury. The project procedures were approved by institutional ethics committees. Participants who underwent an arthroscopic ACLR procedure by 1 of 3 orthopaedic surgeons at a private orthopaedic clinic were recruited for this study. Of these patients, 95% had a hamstring autograft, 3% a patellar tendon autograft, and 2% another graft type (ie, synthetic graft, quadriceps tendon autograft). Immediate in-hospital postoperative physical therapy was supervised by the same physical therapy practice for all patients. After discharge, rehabilitation was supervised by a patient-selected physical therapist approved by the treating surgeon. Treating physical therapists were given the same rehabilitation protocol guidelines. The rehabilitation protocol focused on early recovery of full active knee extension and quadriceps function. Weightbearing was permitted as tolerated from the first postoperative day. Minimum requirements for RTS clearance from the surgeon were no effusion, full range of motion, good quadriceps strength and neuromuscular control of a single-legged squat, observation of normal running and landing mechanics, and at least 4 weeks of

unrestricted sports training. These minimum requirements were not assessed as part of a formal RTS test battery. Patients were eligible for the study if their ACLR procedure was between June 2014 and June 2016. Patients were included if the injury occurred during sport and was a primary ACL injury. Exclusion criteria included (1) patients with previous knee injuries, (2) patients who declared their activity level as nonsporting, and (3) patients who, before their ACLR procedure, intended to give up sport after surgery.

Patients completed the ACL-RSI (short version) scale on average 2 weeks before their ACLR procedure (the preoperative time point) and at their routine 12-month postoperative clinical appointment (the 12-month time point) before seeing their treating surgeon.¹⁶ The scale measures psychological readiness to RTS after an ACL injury in 3 main categories: emotions, confidence, and risk appraisal.¹⁷ Scores for each category are summed and averaged for a total score between 0 and 100 points. A higher total score indicates greater psychological readiness for RTS.

Demographic information was recorded from medical records, including sex, age, and anthropometric measurements (height, weight) at surgery. Patients completed follow-up surveys at a minimum of 2 years (range, 2-4 years) after their ACLR procedure to report number and type of injuries since the ACLR. In addition, patients were asked to report whether they had returned to sport and at what level in comparison with preinjury (ie, same, higher, lower, or training only). The questionnaire was constructed and administered by use of a web-based software program (LimeSurvey). The survey was sent via email, and a reminder was sent to patients who did not respond. Patients who did not complete the 2-year follow-up survey online were contacted by a member of the research team to determine their RTS status and document any injuries since the primary ACLR. For all patients who reported ACL graft rupture or contralateral ACL injury, the medical record was additionally checked to confirm the diagnosis. The primary outcome of interest was the relationship between ACL-RSI scores (preoperative and 12-month time points) and incidence of second ACL injury after RTS.

Data Analysis

All analyses were performed for patients who indicated they had returned to sport after their ACLR, ranging from training only to the same or higher level of competition than before injury. Exact athletic exposure was not systematically tracked for each patient. For analysis, patients were classified into 1 of 2 groups: injured or noninjured. The injured group consisted of patients who reported a second ACL injury (ACL graft rupture or contralateral ACL injury) after RTS from their primary ACLR. The noninjured group consisted of patients who had returned to sport and at follow-up did not report a second ACL injury. Descriptive statistics were calculated for demographics of all patients. Additional descriptive statistics were calculated for younger patients (≤ 20 years old) and older patients (> 20 years old). Statistical analyses

were performed in JMP 13.0 (SAS Institute). Three separate *t* tests (whole cohort, ≤ 20 years, and >20 years) were used to determine differences between the 2 groups (injured vs noninjured) for ACL-RSI scores at each time point (preoperative, 12-month). Additional analyses were performed to explore differences between sexes for any significant differences between injured and noninjured groups. Statistical significance was set a priori at $P < .05$. The predictive validity of the scale was assessed by use of receiver operating characteristic (ROC) curve statistics. The maximum Youden *J* statistic was calculated to determine the optimum cutoff point of the ACL-RSI score to predict second ACL injury.⁵

RESULTS

After inclusion and exclusion criteria were applied, 567 patients with preoperative ACL-RSI scores were determined to be eligible for this study (Figure 1). Full data were available for 429 patients, which required further injury status at a minimum of 2 years after ACLR unless a further ACL injury had already been recorded (mean, 3.0 years; range, 2-4 years) and confirmation of RTS status, resulting in a 76% follow-up rate. In this cohort, 52 second ACL injuries were recorded (34 graft ruptures, 18 contralateral tears). For patients who sustained a second injury before the 12-month review ($n = 5$), their preoperative ACL-RSI score was used for the preoperative analysis but they were not included in the analysis for the 12-month time point. Next, 329 patients indicated they had returned to some level of sport, which included all 52 (16%) second ACL injuries; 100 patients had not returned to any level of sport and were not included in the current analyses. The analyses included 118 females and 211 males, with a mean \pm SD age of 25.3 ± 8.7 years at the time of surgery (Table 1). The mean RTS time after ACLR was 411.2 ± 174.5 days.

The mean \pm SD preoperative ACL-RSI score for the full cohort who returned to sport ($n = 329$) was 49.5 ± 21.8 points, and this score was not significantly different between the injured and noninjured groups ($P = .16$) (Table 2). The mean 12-month ACL-RSI score ($n = 282$) was 66.4 ± 22.4 points, and no significant difference was noted between the injured and noninjured groups ($P = .11$). No significant difference was found in RTS time between the injured and noninjured groups (427.5 ± 121.0 vs 409.0 ± 180.8 days, respectively; $P = .61$).

For younger patients (≤ 20 years old), no significant difference was found in preoperative ACL-RSI scores between the injured ($n = 29$) and noninjured group ($n = 103$), but a significant difference was noted in 12-month ACL-RSI scores ($P = .02$). The injured group ($n = 21$) scored significantly lower than the noninjured group ($n = 94$), 60.8 vs 71.5 points, respectively. Further analysis showed that injured males trended toward lower scores than noninjured males (61.6 vs 71.1 points; $P = .11$). Similarly, injured females trended toward lower scores than noninjured females (59.6 vs 71.9 points; $P = .11$).

For older patients (>20 years old), no significant difference was found in psychological readiness between the

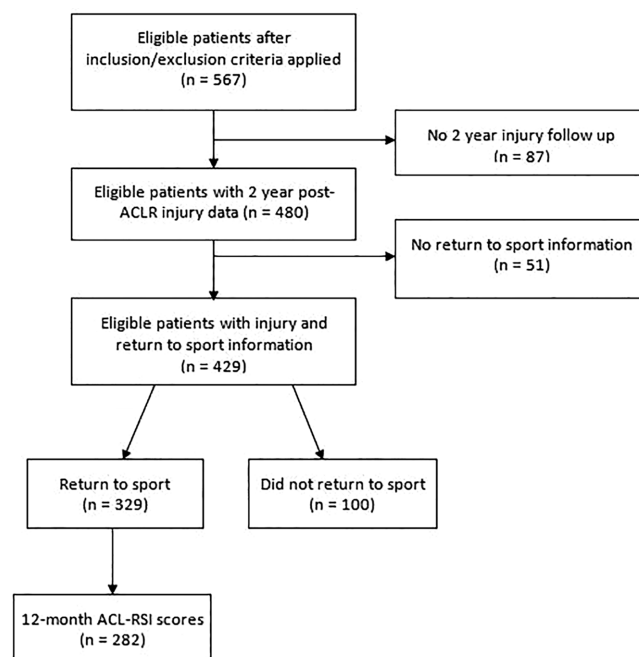


Figure 1. Flow diagram of patient inclusion. ACLR, anterior cruciate ligament reconstruction; ACL-RSI, Anterior Cruciate Ligament–Return to Sport after Injury.

TABLE 1
Demographic Data for the Combined Cohort
and for Each Age Group^a

Variable	All (N = 329)	≤ 20 Years Old (n = 132)	>20 Years Old (n = 197)
Sex, male/female, n	211/118	76/56	135/62
Age at surgery, y	25.3 ± 8.7	17.7 ± 2.0	30.4 ± 7.7
Height, cm	176.5 ± 9.6	175.6 ± 10.2	177.2 ± 9.1
Weight, kg	77.0 ± 13.7	72.3 ± 13.7	80.1 ± 12.7
Return to sport, d	411.2 ± 174.5	407.5 ± 147.2	413.5 ± 190.0

^aValues are expressed as mean \pm SD except for sex.

injured and noninjured groups for either preoperative or 12-month ACL-RSI scores ($P > .05$).

The area under the ROC curve was 0.57 for 12-month ACL-RSI scores in the full cohort (Figure 2A). A Youden index of 0.16 was observed at 76.7 points, which corresponded to 78% sensitivity and 39% specificity for second ACL injury. For the younger patients, the area under the ROC curve was 0.66 (Figure 2B), and a Youden index of 0.37 was observed at 76.7 points, which corresponded to 90% sensitivity and 47% specificity for second ACL injury.

DISCUSSION

This study sought to identify whether psychological readiness to RTS after a primary ACL injury and reconstruction

TABLE 2
Anterior Cruciate Ligament–Return to Sport after Injury (ACL-RSI) Scores for Combined Group, Younger Patients (≤ 20 years), and Older Patients (>20 years), Between Injured and Noninjured Patients^a

Variable		All	Injured	Noninjured
Preoperative score	Combined group	49.5 \pm 21.8	53.4 \pm 24.5	48.8 \pm 21.2
	≤ 20 y	51.9 \pm 21.2	54.6 \pm 24.7	51.2 \pm 20.1
	>20 y	47.9 \pm 22.1	51.9 \pm 24.6	47.4 \pm 21.7
12-month score	Combined group	66.4 \pm 22.4	60.9 \pm 23.4	67.2 \pm 22.2
	≤ 20 y	68.7 \pm 20.5	60.8 \pm 19.1	71.5 \pm 19.3 ^b
	>20 y	64.1 \pm 23.9	60.9 \pm 29.1	64.6 \pm 23.4

^aValues are expressed as mean \pm SD.

^bSignificant difference between injured and noninjured patients ($P < 0.05$).

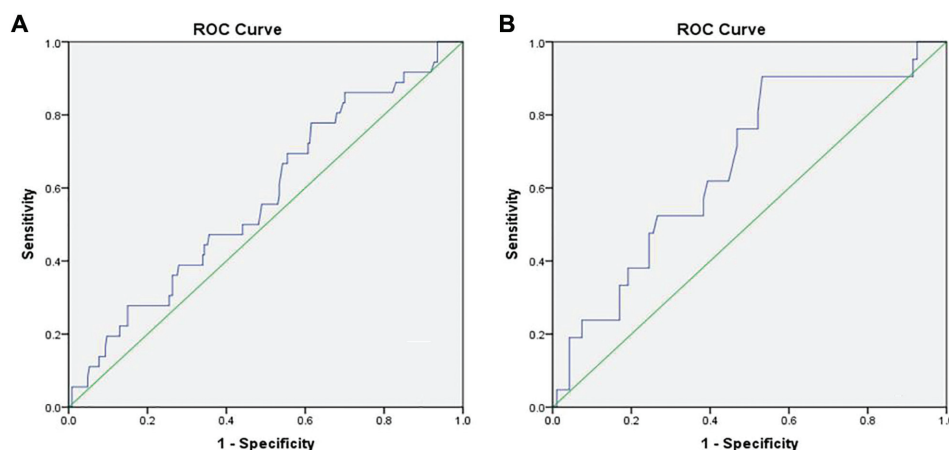


Figure 2. Receiver operating characteristic (ROC) curve for 12-month Anterior Cruciate Ligament–Return to Sport after Injury (ACL-RSI) score predicting second ACL injury in (A) the full cohort and (B) younger patients.

surgery was associated with second ACL injury in a large cohort of patients who had returned to sport. In confirmation of the a priori hypothesis, second ACL injury was associated with lower 12-month psychological readiness to RTS in younger patients, as measured by the ACL-RSI scale. However, no difference was found between groups for older patients (>20 years). This distinction between age groups is of particular importance since the probability of second injury increases 3 to 6 times when the athlete is younger than 20 years.¹⁸

In the current study, a cutoff of 76.7 points was found to have maximum sensitivity to distinguish between injured and noninjured patients in both the full cohort and the younger group. Specifically in the younger group, this score corresponded to 90% sensitivity to distinguish between injured and noninjured patients. In the full cohort, sensitivity for identification of injured patients was relatively lower but remained high (78%). Psychological readiness measured at 12 months in the cohort of younger patients had good predictive capability for identification of those who had a second ACL injury. Although some patients scored below the cutoff point and did not sustain a second ACL injury, this score could identify with 90% certainty those who did have a second ACL

injury. This finding indicates that a score of about 77 points is an appropriate cutoff to use in order to minimize the risk of second ACL injury on the basis of psychological readiness to RTS.

Prior studies have identified a low RTS rate in patients despite achieving functional recovery and passing clinical criteria for RTS clearance.^{2,4} Previous research indicated that patients with a greater fear of reinjury had lower RTS activity.⁷ Psychological recovery concomitant with physical recovery after ACLR has been recognized as an important factor for prediction of successful RTS.³ In a previous study, a higher ACL-RSI score was associated with greater return to preinjury level of sport at 12 months and was a significant predictor of RTS with high sensitivity (97%) as early as 6 months after ACLR.^{2,11} Patients in the current study who experienced a second ACL injury had lower psychological readiness than noninjured patients at 12 months but no significant difference in RTS times (427.5 vs 409.0 days). This study provides evidence that psychological counseling may be needed in parallel with physical recovery to improve chances of successful RTS as well as reduce the risk of second ACL injury. Review studies and consensus statements have suggested that assessment of psychological readiness should

be part of RTS test batteries, without empirical evidence for the validity of this parameter.^{1,6} While psychological readiness is unlikely to be the sole contributor to second ACL injury, the current study confirms the importance of psychological factors in the recovery and RTS process.

This study is not without limitations. The cohort in the current study was recruited from a single, private, high-volume metropolitan clinic, and the results may not be generalizable to a more heterogeneous population. Although all patients included in the analysis had indicated returning to sport at some level, exposure to twisting and pivoting movements was not explicitly tracked. The rate of second ACL injury in the current study (16%) was lower than previously reported.^{13,14,18,21} Young patients treated at this clinic have been advised by the surgeons to delay RTS after a higher risk of second injury was reported in this age group.¹⁸ This change of practice may have biased the rate of second ACL injuries in the current cohort. Alpha corrections were not used in the current analysis given our interest in determining the independent effect of each time point and preserving a balance between type I and type II error so as to not miss potentially relevant findings. However, if adjustments for 2 comparisons had been made (alpha adjusted to $P < .025$), the finding in younger patients would still have achieved statistical significance ($P = .02$). Furthermore, 6-month postoperative ACL-RSI scores might help identify at-risk groups in earlier phases of rehabilitation, but these scores were not available for the current cohort. A prospective study showed a significantly higher mean ACL-RSI score at 9 months after ACLR compared with 6 months after ACLR (72.6 vs 59.7, respectively).²⁰ This finding indicates that there may be a smaller window of time that can capture significant changes in psychological readiness compared with preoperative and 12-month time points. Given the findings of the current study, which support the role of psychological variables in reinjury prediction models, future studies should investigate how changes in psychological readiness throughout rehabilitation affect the risk of second injury. Future studies that investigate specific aspects of psychological readiness and their association with second ACL injury may further delineate areas on which clinicians should focus during rehabilitation and counseling.

Findings from the current study will help inform clinicians with regard to incorporating psychological components into a rehabilitation treatment program before RTS. In addition, measures of psychological readiness at 12 months after ACLR will be useful for clinicians since this is approximately the time many athletes receive medical clearance for RTS from the surgeon. The present study demonstrates that lower psychological readiness at 12 months is associated with second ACL injury in younger patients. A recent study identified ACL-RSI score as a significant predictor of passing all components of the RTS test criteria at 6 and 9 months postoperatively.²⁰ Thus, in addition to assessing physical and functional abilities, clinicians should consider incorporating psychological readiness in their RTS criteria and injury prediction models.

CONCLUSION

Young patients who experienced a second ACL injury had lower psychological readiness measured at 12 months after ACLR. A score of less than 77 points on the ACL-RSI scale indicates that a young (≤ 20 years old) patient is at higher risk of a second ACL injury and may benefit from additional psychological counseling before clearance for RTS.

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