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Psychological Responses Matter in Returning to Preinjury Level of Sport After Anterior Cruciate Ligament Reconstruction Surgery

Clare L. Ardern,*† PT, Nicholas F. Taylor,† PT, PhD, Julian A. Feller,‡§ MD, FRACS, Timothy S. Whitehead,‡ MD, FRACS, and Kate E. Webster,§ PhD
Investigation performed at La Trobe University, Melbourne, Victoria, Australia

Background: Up to two-thirds of athletes may not return to their preinjury level of sport by 12 months after anterior cruciate ligament (ACL) reconstruction surgery, despite being physically recovered. This has led to questions about what other factors may influence return to sport.

Purpose: To determine whether psychological factors predicted return to preinjury level of sport by 12 months after ACL reconstruction surgery.

Study Design: Case control study; Level of evidence, 3.

Methods: Recreational and competitive-level athletes seen at a private orthopaedic clinic with an ACL injury were consecutively recruited. The primary outcome was return to the preinjury level of sports participation. The psychological factors evaluated were psychological readiness to return to sport, fear of reinjury, mood, emotions, sport locus of control, and recovery expectations. Participants were followed up preoperatively and at 4 and 12 months postoperatively.

Results: In total, 187 athletes participated. At 12 months, 56 athletes (31%) had returned to their preinjury level of sports participation. Significant independent contributions to returning to the preinjury level by 12 months after surgery were made by psychological readiness to return to sport, fear of reinjury, sport locus of control, and the athlete's estimate of the number of months it would take to return to sport, as measured preoperatively ($\chi^2_2 = 18.3$, $P < .001$, classification accuracy = 70%) and at 4 months postoperatively ($\chi^2_4 = 38.7$, $P < .001$, classification accuracy = 86%).

Conclusion: Psychological responses before surgery and in early recovery were associated with returning to preinjury level of sport at 12 months, suggesting that attention to psychological recovery in addition to physical recovery after ACL injury and reconstruction surgery may be warranted. Clinical screening for maladaptive psychological responses in athletes before and soon after surgery may help clinicians identify athletes at risk of not returning to their preinjury level of sport by 12 months.

Keywords: sport; orthopaedic; return to sport; participation; psychology; anterior cruciate ligament

Anterior cruciate ligament (ACL) injuries are particularly common in sports that involve cutting, jumping, and pivoting movements[19] because of high impulsive axial and valgus forces acting at the knee.[13] An ACL rupture is often treated with ACL reconstruction surgery to restore knee stability and, subsequently, to restore function sufficient to enable the athlete to return to the preinjury level of sports participation. Athletes are expected to resume sport by 12 months after surgery.[38] However, few studies have specifically evaluated the rate of return to sport at 12 months postoperatively, and their results are variable. The rates of return to preinjury sport reported in these studies range from 33% to 92%,[7,29,39,45] suggesting as many as two-thirds of patients may not have returned to their preinjury level of sport by 12 months after surgery.

The lower than expected rates for return to sport after ACL reconstruction surgery, despite satisfactory surgical and functional outcomes, has led to questions of what other factors may influence return to sport. It has been hypothesized that athletes' psychological responses to the initial injury, to surgery, and to recovery and rehabilitation might be an important additional determinant of returning to

*Address correspondence to Clare L. Ardern, PT, School of Allied Health, La Trobe University, Health Science 3 Building, Bundoora, VI 3086, Australia (e-mail: c.ardern@latrobe.edu.au).
†Department of Physiotherapy, School of Allied Health, La Trobe University, Melbourne, Victoria, Australia.
‡OrthoSport Victoria, Epworth Richmond, Melbourne, Victoria, Australia.
§School of Allied Health, La Trobe University, Melbourne, Victoria, Australia.

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sport after surgery.[5,6,28,29,51] In cross-sectional studies comparing athletes who did and did not return to their preinjury level of sport after ACL reconstruction, there is evidence that low fear of reinjury, motivation to return, and psychological readiness to return to sport are associated with returning to the preinjury level of sport.[18,29,30,51] However, it cannot be determined from these studies whether participants did not return to sport because of their psychological response or whether their negative psychological response arose secondary to not having returned. No prognostic study of patients' psychological responses after ACL reconstruction could be identified. However, Johnson,[25] in a previous study that evaluated the psychological responses of 12 athletes after knee or foot/ankle injuries and their relationship to returning to sport, found that athletes with a negative perception of the influence of their injury on their current life situation were 3.5 times less likely to return to their preinjury level. In addition, female sex, lack of rehabilitation goals, a negative outlook regarding injury, a negative outlook toward rehabilitation, and lower hedonic tone (the ability to experience pleasure) were predictive of an athlete who was unlikely to return to sport.[25] Therefore, relatively little is known about whether positive psychological responses are predictive of returning to sport after injury generally and returning after ACL reconstruction specifically. Because psychological responses are modifiable, if these responses are found to predict returning to sport, it may suggest that the development and trial of psychological screening programs and interventions aimed at addressing maladaptive psychological responses may be warranted.

Additional factors may influence psychological responses and returning to sport after surgery. Two previous cross-sectional investigations examined differences in psychological responses between competitive and recreational-level athletes[36] and between people who undergo surgery within 3 months from injury and those who delay surgery.[4] Competitive athletes have been shown to have greater mood disturbance at the time they receive medical clearance to return to sport compared with recreational athletes.[36] In a group who had all returned to sport after surgery, athletes who waited longer than 3 months to have surgery were found to have significantly higher fear of reinjury compared with people who had early surgery.[4] To our knowledge, these studies are the only reports evaluating whether factors related to sports participation or surgery influence psychological responses. Competitive athletes may also invest more time in sport than do recreational athletes, which may result in greater motivation to return to sport after surgery. To our knowledge there are no published studies that account for potential differences in the rate of return to preinjury sport between competitive and recreational athletes.

The aim of this study was to investigate whether the psychological responses of injured athletes, measured at critical, clinically relevant times, predicted successful return to sport. The influence of factors related to sports participation and surgery on the psychological responses and return-to-sport rate of these athletes were also considered. Specifically, there were 2 research questions:

1. Are preoperative psychological responses associated with returning to the preinjury level of sports participation at 12 months after ACL reconstruction?
2. Are psychological responses measured at 4 months after surgery associated with returning to the preinjury level of sports participation by 12 months after ACL reconstruction?

MATERIALS AND METHODS

Design

A prospective design was used to evaluate a consecutive series of patients preoperatively and then follow them for 12 months after ACL reconstruction surgery. This study received ethical approval from the university faculty ethics committee. All patients provided written, informed consent to be contacted and to participate in this study. Completion of the online questionnaire used in this study was accepted as implied consent to participate.

Participants

Inclusion criteria were ACL rupture (diagnosed via clinical assessment and subsequently confirmed via arthroscopy) treated with ACL reconstruction surgery, active participation in recreational (n = 54) or competitive level (n = 133) sport at least twice weekly before injury, and ability to complete a written survey in English. Patients were recruited between April 2010 and April 2011 from the practices of 2 experienced orthopaedic surgeons in a private orthopaedic clinic.

Single-incision, arthroscopically assisted ACL reconstructions were performed on all patients. Weightbearing on the operated limb was permitted from the first postoperative day. No braces or splints were used. Patients were provided with guidelines regarding their progression, the rate of which was governed primarily by the presence or absence of pain and effusion, and were free to attend supervised postoperative rehabilitation. Completion of supervised rehabilitation was not mandatory for inclusion in this study. Straight-line running was permitted from 12 weeks and sport-specific exercises from 16 weeks. The criteria for clearance to return to sport were successful completion of sport-specific exercises, symmetrical knee range of motion, adequate knee stability, functional quadriceps control, and absence of knee effusion. Return to sport was permitted for all patients from 9 months after surgery, and all patients received surgical clearance to return to sport.

Procedures

An online questionnaire was used for data collection. The questionnaire was constructed and administered using a web-based software program (SurveyManager, Australian Research Group, Melbourne, Australia). Participants received the questionnaire via e-mail. Participants who had not responded received e-mail reminders, and if they did not respond to these reminders they were sent paper

copies of the questionnaire. Participants without an e-mail address were sent paper copies of the questionnaire. Participants completed the online questionnaire preoperatively (in the week before surgery) and at 4 months after surgery. They also had an in-person clinical examination at 12 months after surgery, which was conducted by a physical therapist blinded to the preoperative and 4-month questionnaire responses.

Outcome Measures

The primary outcome variable was return to the preinjury level of sports participation at 12 months. Participants were asked to indicate the main sport they played before injury and were instructed to use this sport as the reference when answering all questions regarding sports participation. Return-to-sport status was determined by interview at the time of completion of the 12-month clinical examination. Participants who did not attend the 12-month examination were contacted by a member of the research team to determine their status. The return-to-sport rate was calculated from the athletes' response (yes or no) to the question "Have you attempted to play sport at the same level that you played before your knee injury?"

Predictor Variables: Psychological Factors. The Anterior Cruciate Ligament-Return to Sport after Injury scale (ACL-RSI)[51] was used to measure psychological readiness to return to sports participation. Each of the 12 items on the measure was rated on an 11-point scale that ranged from *extremely* to *not at all*. Questions included "Are you fearful of reinjuring your knee by playing sport?" and "Are you confident you can perform at your previous level of sports participation?" The Tampa Scale of Kinesiophobia (TSK)[26,50] was used to measure fear of reinjury. We used the version of the TSK that was adapted by Kvist et al[28] for use in populations with ACL injury. Items were scored on a 4-point ordinal scale that ranged from *strongly agree* to *strongly disagree*, and they included statements such as "My injury has put my knee at risk for the rest of my life" and "No one should have to exercise when he/she is injured." The Incredibly Short Profile of Mood States (ISP) (Dean JE, Whelan JP, Meyers AW. An incredibly quick way to assess mood states: the incredibly short POMS. Paper presented at the meeting of the Association for the Advancement of Applied Sport Psychology; 1990; San Antonio, Texas), an adaptation of the Profile of Mood States,[34] was used to measure mood. This scale asked respondents to rate their current levels of anxiety, sadness/depression, confusion, anger, energy, and fatigue on a 5-point ordinal scale that ranged from *nothing* to *extreme*. The Emotional Responses of Athletes to Injury Questionnaire (ERAIQ)[36] was used to evaluate emotions. The relevance of emotions such as anger, optimism, and helplessness to the respondent's current emotional state was ranked on a 0- to 12-point scale. The Sport Rehabilitation Locus of Control (SRLC) scale[37] was used to evaluate whether athletes had a predominantly internal or predominantly external locus of control regarding their recovery from injury. Participants responded to statements including "I'm in control of my rehabilitation and return to sport" and "If it's meant to be, I'll get back to sport" on a 5-point ordinal scale that ranged from *strongly agree* to *strongly disagree*. Athletes' expectations for recovery were assessed using a series of questions adapted from Cole and colleagues'[16] evaluation of recovery expectations for returning to work after soft tissue injury sustained at work. The responses analyzed were as follows: whether the athlete thought he or she would return to the preinjury level of sports participation (yes/no), and the athlete's estimation of the number of months it would take to return to any form of sport and return to his or her preinjury level.

Secondary Outcome Variables: Knee Symptoms and Function. The International Knee Documentation Committee (IKDC) subjective knee evaluation form[24] was used to evaluate knee symptoms and subjective function. Objective knee function was assessed with a clinical evaluation consisting of the Noyes hop tests,[40] instrumented knee laxity, and the IKDC knee evaluation. For all hop tests, the results were presented for the operated limb as a percentage of the nonoperated limb. Satisfactory knee function in this study was defined as having an overall classification of normal (category A) or nearly normal (category B) on the IKDC knee evaluation and an overall hop test limb symmetry index of 85% or greater.[9,15] See Appendix 1 (available online at http://ajsm.sagepub.com/supplemental) for a description of the scoring method and measurement properties for all primary and secondary outcome measures.

Statistical Analysis

Data were analyzed with SPSS 20.0 (IBM Corp, Armonk, New York). The required sample size was determined a priori using the rule $N \geq 50 + 8 \times m$ (where m = number of independent variables).[47] The minimum sample size required for this study was calculated to be 130 participants [$N = 50 + (8 \times 10)$]. Descriptive statistics were calculated for all demographic, subjective, and clinical outcome data. Mann-Whitney U tests and chi-square analyses were used as appropriate to determine whether there were differences in subjective and clinical data between athletes who did and did not return to their preinjury sports participation level.

Preoperative and 4-month data were used to analyze between-group differences in psychological responses between those who did and did not return to sport; the analysis was conducted with independent-samples t tests or nonparametric tests as appropriate. Alpha corrections were made with Benjamini and Hochberg's[11] false discovery rate approach. Unadjusted and adjusted significance values were calculated and presented to provide an indication of the likelihood of both type I and type II error rates, as it has been previously advised that in exploratory research, minimization of the likelihood of type II error is preferable.[20,41] Binary regression analysis was used to determine whether psychological responses predicted returning to the preinjury level of sports participation at 12 months after surgery. Two overall regression models were analyzed. The first model was used to examine for associations between preoperative psychological responses and returning to sport. The second model was used to examine for associations between psychological responses

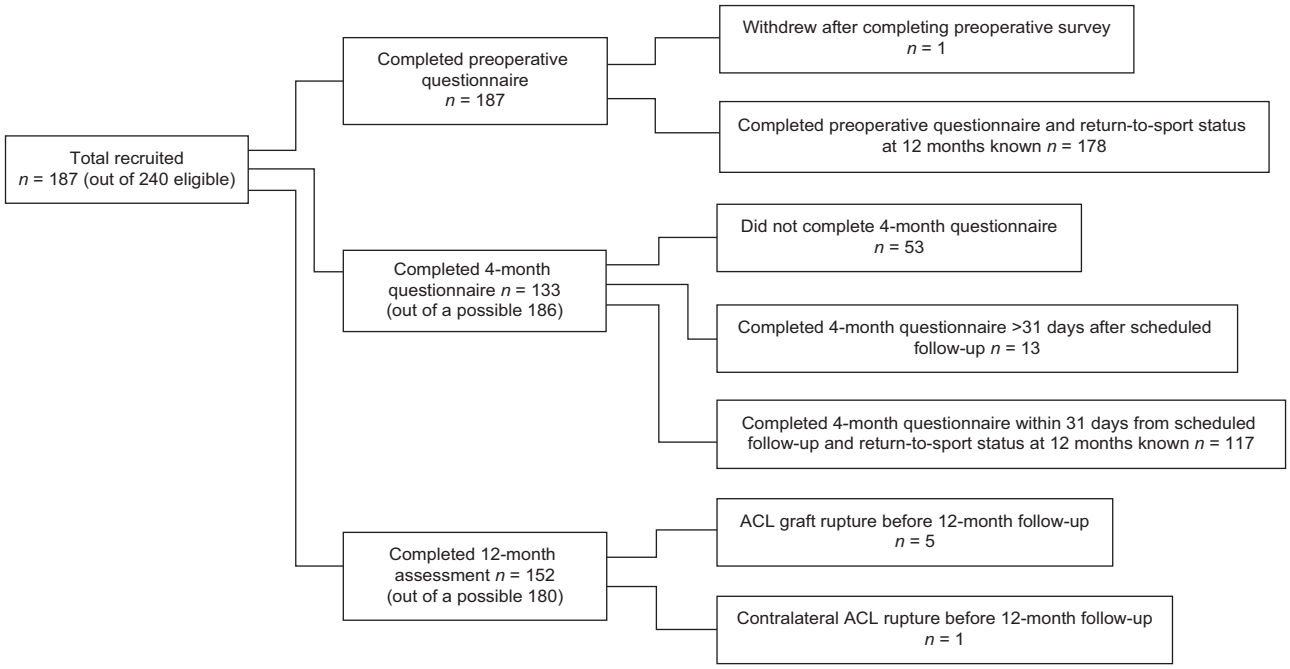

Figure 1. Flow of participants through the study.

measured at 4 months postoperatively and returning to sport. Checks for multicollinearity were performed with the linear regression technique[47] for scale variables and bivariate correlations for categorical variables. A variance inflation factor > 5 and Pearson $r \geq 0.8$ were used to denote significant multicollinearity. Goodness of fit was assessed using the Hosmer-Lemeshow test.[10,21] The Cook's distance and leverage statistics were examined to provide an estimate of the influence of outliers on the full model. Standardized residuals were examined for outliers, with the cutoff of 2.58 used to denote outliers.[47] Outliers were removed from the regression analysis. Classification accuracy for each regression model was calculated using the receiver operating characteristic (ROC) curve method.[21] For the 4-month psychological factors model, cases were removed from the analysis if there were more than 31 days between the scheduled 4-month follow-up for the study and the actual time the participant completed the survey, because of the potential for psychological responses to be skewed by differences in follow-up time. Interaction terms were examined in both the preoperative and 4-month models to account for potential confounding of the psychological response data by the following variables: level of preinjury sports participation (recreational or competitive), time between injury and surgery (early surgery defined as <3 months from injury; late surgery defined as ≥3 months after injury), and previous ACL reconstruction (yes or no). A sensitivity regression analysis was performed with psychological response data from participants who had undergone primary ACL reconstruction surgery (ie, psychological response data from participants with revision surgery removed).

To determine the predictive capabilities of individual psychological variables, secondary analyses using backward-elimination stepwise logistic regression were performed. The psychological variables that made significant independent contributions to the logistic regression full model were entered into reduced models. Sensitivity, specificity, positive and negative predictive values, and conventional positive and negative likelihood ratios were also determined. Psychological variables that made significant independent contributions in the logistic regression full model were compared by use of ROC curves to determine the individual psychological variable with the best discriminative capabilities. The psychological variable with the largest area under the ROC curve was interpreted as possessing the greatest discriminative power.[3,46] The Youden index[52] was calculated for the psychological variable with the greatest discriminative power (based on the ROC curve comparison) and used to determine the cut point that optimized the psychological variable's ability to discriminate between returning and not returning to sport when equal weight was given to sensitivity and specificity.[44]

RESULTS

Demographic Factors

A total of 187 patients were recruited (Figure 1), and 182 (97%) were injured while playing sport. Participants were most commonly injured while playing Australian football (n = 67; 36%), netball (n = 29; 16%), soccer (n = 27; 14%), or basketball (n = 21; 11%). There were 122 (65%) men and 176 (94%) primary single-bundle ACL reconstructions. The predominant graft type was a doubled semitendinosus–doubled gracilis tendon autograft (91% of patients). Fifty percent of the patients had meniscal treatment (resection or repair) at the time of the ACL

TABLE 1
Demographic Data for People Who Did and Did Not Return to Preinjury Sport[a]

Variable	Returned to Preinjury Sport[b] Yes (n = 56)	No (n = 122)	P
Sex			.40
Male	39	76	
Female	17	46	
Procedure type			.74
Primary	52	115	
Revision	4	7	
Graft type			.58
STG autograft	50	112	
Other	6	10	
Meniscal treatment			.15
Yes	23	66	
No	33	56	
History of contralateral ACL reconstruction surgery			.20
Yes	9	11	
No	47	111	
Level of preinjury sport competition			.02
Competitive	46	80[c]	
Recreational	10	42[c]	
Age at surgery, mean (SD), y	25.6 (9.4)	28.3 (8.5)[c]	.06
Time between injury and surgery, mean (SD), wk	22.9 (44.2)[d]	32.1 (73.5)[e]	.85

[a]Values for Return to Preinjury Sport are number of participants, unless noted. ACL, anterior cruciate ligament; SD, standard deviation; STG, doubled semitendinosus–doubled gracilis.
[b]Return-to-sport status unknown for 8 participants.
[c]$P < .05$ level.
[d]Data missing from 10 participants.
[e]Data missing from 16 participants.

reconstruction. The rate of meniscal treatment was similar for patients who had revision surgery compared with those who had primary surgery. Twenty-one patients (11%) had a history of contralateral ACL reconstruction before the index surgery in this study. In the first 12 months postoperatively, 5 patients (3%) ruptured their ACL graft and 1 patient (0.5%) sustained a contralateral ACL injury. The mean age at surgery was 27.3 years (standard deviation [SD], 8.7 years; range, 15.1-60.1 years). The median time from injury to surgery was 12.4 weeks (mean ± SD, 29.4 ± 65.9 weeks; range, 1 week-10.6 years). Return-to-sport data were available for 178 of 186 participants (96%). At 12 months, 56 of 178 (31%) had returned to their preinjury level of sports participation.

Significantly more competitive level athletes had returned to sport by 12 months after surgery compared with recreational athletes ($\chi^2_1 = 5.10$, $P = .02$) (Table 1). No other differences in demographic factors between people who did and did not return to sport were found. Fifty-three participants (38 men; mean age ± SD, 24.9 ± 7.5 years) did not complete the 4-month psychological questionnaire. Athletes in this group were significantly younger (mean difference, –3.5 years, 95% confidence interval [CI], –6.2 to –0.7 years) than the athletes who completed the 4-month questionnaire. The group who did not respond at 4 months also had significantly less anterior tibial translation as measured by KT-1000 arthrometer (mean difference, –0.67 mm; 95% CI, −1.2 to −0.15 mm) than did the group who completed the 4-month questionnaire. There were no other between-group differences in demographic or clinical factors. There was also no difference in rate of return to preinjury level sport between people who did and did not complete the questionnaire ($\chi^2_1 = 2.75$, $P = .10$). Thirty-four participants (21 men; mean age ± SD, 27.3 ± 9.3 years) did not complete the 12-month clinical evaluation. Demographic and psychological factors were similar compared with the group who completed the 12-month clinical evaluation.

Postoperative Knee Function

Data regarding subjective and objective knee function were available for 152 participants (82%) at 12-month follow-up (Table 2). Five participants declined to complete the hop tests (3 from the group who did not return to sport, 2 from the group who returned to sport). Overall, satisfactory knee function (IKDC category A or B and overall hop test limb symmetry index ≥85%) was achieved for 91% of participants. There were 107 participants with knee function classified as normal (IKDC category A) and 36 classified as nearly normal (IKDC category B); the rate of return to preinjury level sport was similar between those in category A (30% returned to preinjury level) and B (25% returned to preinjury level) ($\chi^2_1 = 0.064$, $P = .81$). Participants who returned to sport had a significantly higher subjective rating of knee function (IKDC subjective knee evaluation) than those who had not returned to sport (mean difference, 5.3 of 100 units; 95% CI, 1.2-9.3 units) and a significantly higher single-limb hop test limb symmetry index (mean difference, 3.4%; 95% CI, 1.0%-7.9%). No other between-group differences for function were observed (Table 2). The objective knee function (hop tests, knee laxity, IKDC knee evaluation) of participants who had revision ACL reconstruction was no different than that of participants who had primary surgery.

Between-Group Differences in Psychological Factors

Participants who returned to their preinjury level of sport at 12 months scored significantly higher on the ACL-RSI preoperatively (mean difference = 7.9 of 100 units; 95% CI, 1.6-14.1 units) and at 4 months postoperatively (mean difference, 17.0 units; 95% CI, 9.7-24.4 units) (Table 3) compared with participants who did not return to sport. Participants who returned to sport also estimated preoperatively that they would return to their preinjury level significantly faster compared with those who did not return (mean difference = −2.1 months, 95% CI −3.7 to −0.43 months). When alpha corrections were made, the only difference between the groups was in 4-month ACL-RSI score (Table 3). There were no between-group differences in expectation for return to the preinjury level (yes/no) preoperatively ($\chi^2_1 = 1.46$, $P = .23$) or at 4 months ($\chi^2_1 = 3.23$, $P = .07$).

TABLE 2
Postoperative Knee Function[a]

Outcome	No.	Group Mean (SD)	Returned to Sport, Mean (SD) (n = 45)	Did Not Return, Mean (SD) (n = 107)	Mean Difference (95% CI)	*P*
IKDC subjective assessment[b]	151	83.9 (11.8)	87.6 (8.1)	82.3 (12.8)[c]	5.3 (1.2 to 9.3)	.03
Single-limb hop LSI[d]	147	94.4 (12.6)	96.8 (11.8)	93.4 (12.8)[c]	3.4 (1.0 to 7.9)	.04
Triple-hop LSI[d]	147	98.9 (12.1)	98.9 (9.9)	98.9 (13.0)	0.01 (4.3 to −4.3)	.94
Overall hop test LSI[d]	147	96.7 (10.7)	97.9 (9.9)	96.2 (11.0)	1.7 (2.1 to 5.5)	.20
KT-1000 SSD[e]	151	0.74 (1.9)	0.89 (2.3)	0.67 (1.7)	0.22 (0.46 to 0.89)	.98
IKDC objective assessment[f]	152					
Category A	107		n = 32	n = 75	$\chi^2_2 = 3.21$[g]	.20
Category B	36		n = 9	n = 27		
Category C	9		n = 4	n = 5		
Category D	0					

[a]CI, confidence interval; IKDC, International Knee Documentation Committee; LSI, limb symmetry index; SD, standard deviation; SSD, side-to-side difference.
[b]Mean (SD) values for Group and Returned/Did Not Return to Sport and mean (95% CI) for Difference are expressed as units out of 100.
[c]$P < .05$.
[d]Mean (SD) values for Group and Returned/Did Not Return to Sport and mean (95% CI) for Difference are expressed as percentages.
[e]Mean (SD) values for Group and Returned/Did Not Return to Sport and mean (95% CI) for Difference are expressed as millimeters.
[f]Values for Returned/Did Not Return to Sport are expressed as number of subjects.
[g]$\chi^2_{(df)}$ statistic for between-group comparison.

TABLE 3
Preoperative and 4-Month Psychological Responses of Participants Who Did and Did Not Return to Preinjury Sport[a]

	Preoperative Psychological Responses[b]					4-Month Psychological Responses[c]				
Psychological Variable	Returned to Sport, Mean (SD) (n = 56)	Did Not Return, Mean (SD) (n = 122)	Mean Difference (95% CI)	*P*	FDR-Adjusted Significance Value, *q*	Returned to Sport, Mean (SD) (n = 34)	Did Not Return, Mean (SD) (n = 83)	Mean Difference (95% CI)	*P*	FDR-Adjusted Significance Value, *q*
ACL-RSI score (0-100)[d]	45.2 (21.6)	37.4 (18.4)[e]	7.9 (1.6 to 14.1)	.02	0.09	57.3 (20.3)	40.4 (17.1)[e]	17.0 (9.66 to 24.4)	<.001	0.008
TSK score (17-68)[d]	36.6 (4.4)	36.2 (4.4)	0.46 (–0.95 to 1.9)	.34	0.72	35.6 (6.0)	37.0 (5.3)	–1.4 (–3.6 to 0.83)	.21	0.32
ISP score (0-20)[d]	8.9 (4.9)	8.1 (4.3)	0.74 (0.69 to 2.2)	.40	0.72	5.8 (4.5)	6.9 (4.7)	–1.0 (–2.9 to 0.82)	.21	0.32
ERAIQ score (0-120)[d]	54.2 (24.7)	56.0 (22.8)	–1.8 (–9.3 to 5.7)	.83	0.87	38.0 (30.4)	43.7 (25.2)	–5.7 (–16.5 to 531)	.12	0.32
SRLC_internal (0-15)[d]	4.3 (1.7)	4.6 (1.7)	–0.27 (–0.82 to 0.27)	.22	0.66	4.3 (1.6)	4.8 (2.1)	–0.51 (–1.3 to 0.29)	.19	0.32
SRLC_powerfulothers (0-15)[d]	8.8 (2.1)	8.8 (2.2)	0.01 (–0.68 to 0.69)	.87	0.87	9.4 (2.2)	9.4 (2.2)	0.03 (–0.86 to 0.92)	.52	0.52
SRLC_chance (0-15)[d]	11.9 (2.0)	11.6 (2.4)	0.31 (–0.42 to 1.0)	.66	0.87	12.8 (1.8)	11.8 (2.0)[e]	0.98 (0.19 to 1.8)	.02	0.09
How long RTS_any[f]	8.3 (2.8)	8.3 (3.0)	–0.04 (–0.97 to 0.89)	.83	0.87	5.4 (3.0)	5.3 (3.9)	0.12 (–1.6 to 1.4)	.39	0.44
How long RTS_preinjury[f]	11.4 (3.0)	13.5 (5.6)[e]	–2.1 (−3.7 to −0.43)	.01	0.09	8.9 (4.1)	10.2 (5.0)	–1.24 (–3.3 to 0.78)	.34	0.44

[a]ACL-RSI, Anterior Cruciate Ligament-Return to Sport after Injury scale; ERAIQ, Emotional Responses of Athletes to Injury Questionnaire; FDR, false discovery rate; ISP, Incredibly Short Profile of mood states; How long RTS_any, estimate of number of months before return to any form of sport; How long RTS_preinjury, estimate of number of months before return to preinjury level sport; SRLC, Sport Rehabilitation Locus of Control scale; TSK, Tampa Scale for Kinesiophobia.
[b]Return-to-sport status unknown for 8 athletes.
[c]Completed 4-month survey within 31 days of scheduled follow-up and return-to-sport status known (n = 117).
[d]Mean (SD) values for Group and Returned/Did Not Return to Sport and mean (95% CI) for Difference are expressed as scores for the respective scales.
[e]$P < .05$.
[f]Mean (SD) values for Group and Returned/Did Not Return to Sport and mean (95% CI) for Difference are expressed as months.

Psychological factors measured preoperatively were compared between those who did and did not complete the 4-month questionnaire. People who did not complete the questionnaire scored significantly higher on the SRLC Internal subscale (mean difference = 1.1 of 15 units; 95% CI, 0.37-1.8 units), ERAIQ (mean difference = 12.6 of 120 units; 95% CI, 5.3-19.9 units), and ISP (mean difference = 2.2 of 20 units; 95% CI, 0.75-3.6 units) measures compared with those who completed the 4-month questionnaire.

Prospective Association Between Psychological Factors and Return to Sport

Preoperative psychological responses predicted returning to the preinjury level by 12 months ($\chi^2_{11} = 28.1$, $P = .002$; goodness of fit, $\chi^2_8 = 5.71$, $P = .68$, classification accuracy = 0.75; 95% CI, 0.67-0.83). Appendix 2 (available online) shows the regression coefficients and odds ratios (ORs) for each independent variable in the full model. A higher ACL-RSI score predicted returning to the preinjury level

of sport (OR, 1.03; 95% CI, 1.01-1.06), and the greater the number of months estimated before a return to preinjury level, the lower the chances of actually returning to sport at 12 months (OR, 0.78; 95% CI, 0.66-0.92). The psychological responses in the reduced model also predicted returning to the preinjury level at 12 months ($\chi^2_2 = 18.3$, $P < .001$; classification accuracy = 0.70; 95% CI, 0.61-0.79) (Appendix 3, available online). There were no interaction effects from level of sport participation, time between injury and surgery, and history of ACL reconstruction surgery on psychological responses. This indicated that whether participants played competitive or recreational level sport before injury, whether they had undergone surgery within 3 months from injury or waited longer for surgery, and whether they had undergone ACL reconstruction surgery in the past did not significantly influence the psychological responses.

Four-month psychological responses predicted returning to the preinjury level at 12 months ($\chi^2_{10} = 49.0$, $P < .001$; goodness of fit, $\chi^2_8 = 2.08$, $P = .98$, classification accuracy = 0.90; 95% CI, 0.84-0.96). Appendix 4 (available online) shows the regression coefficients and odds ratios for each independent variable. A higher ACL-RSI score (OR, 1.10; 95% CI, 1.06-1.20), TSK score (OR, 1.21; 95% CI, 1.01-1.44), and SRLC Chance subscale score (OR, 1.89; 95% CI, 1.15-3.09) and a greater number of months estimated before a return to any form of sport (OR, 1.42; 95% CI, 1.04-1.93) were predictive of returning to the preinjury level of sport. When these 4 variables were entered in the reduced model, ACL-RSI score, TSK score, and SRLC Chance subscale score predicted returning to the preinjury level at 12 months ($\chi^2_4 = 38.7$, $P < .001$; classification accuracy = 0.86; 95% CI, 0.78-0.93) (Appendix 5, available online). There were no interaction effects from participation, time between injury and surgery, and history of ACL reconstruction surgery on psychological responses.

Sensitivity analysis demonstrated that the same psychological variables (at both the preoperative and the 4-month assessments) were predictive of returning to sport regardless of whether the patient had revision or primary reconstruction surgery.

The optimal combination of variables for clinical prediction of returning to sport at 12 months, based on psychological responses, was the full 4-month model (sensitivity = 59%; 95% CI, 39%-77%; specificity = 92%; 95% CI, 82%-97%; positive likelihood ratio = 7.1; 95% CI, 3.1-16.3; negative likelihood ratio = 0.4; 95% CI, 0.3-0.7). The psychological variable with the best discriminative capabilities was the 4-month ACL-RSI assessment (area under ROC curve = 0.8; 95% CI, 0.7-0.9). The highest Youden index (0.41) for the ACL-RSI was observed at a score of 56 points, corresponding to a sensitivity of 58% and specificity of 83%.

DISCUSSION

The results of this study provide evidence of a temporal relationship between psychological factors and returning to the preinjury level sport after ACL reconstruction surgery. Psychological readiness to return to sport, the participant's estimate of the number of months it would take to return to sport, and locus of control predicted returning to sport by 12 months after surgery. The common link between the psychological factors that were found to be associated with returning to sport is that they involved the participant making a prospective appraisal of his or her ability to return to sport. Even before the participants underwent surgery, their psychological responses were associated with their chances of returning to the preinjury level 12 months later.

The finding that psychological factors accounted for part of the variance in returning to sport suggests that these factors may also be clinically important. Much of the previous research evaluating returning to sport after ACL reconstruction focused on measuring important factors associated with surgery (eg, ACL tunnel position[22] and graft type[18]) and physical recovery from surgery[6,27] (eg, knee range of motion) or focused on physical rehabilitation techniques.[12,17] No relationship has been identified between physical knee function measured with the IKDC knee evaluation and returning to sport in athletes who were cleared to return to sport after ACL reconstruction surgery.[7] Taken together, the results of the current study and of previous research suggest that other aspects of recovery, such as psychological factors, are also important for returning to sport and may have been underrecognized.[14,32]

This study found that factors influencing athletes' prospective judgment of their ability to return to sport predicted returning to the preinjury level. This judgment involved the athlete taking into account his or her psychological readiness to return, his or her perception of control over the return, and a timeline for return, which supports the notion that individuals are more likely to engage in an activity when they perceive greater competence and therefore have higher self-efficacy in the particular activity.[2,8] In our study, the prospective judgment athletes made about their own ability to return to sport required them to consider factors that may have included their own experience and attitudes, the experiences and attitudes of significant others, the advice of health care professionals, and other individually relevant factors. This suggests that factors that inform the individual's appraisal of how long it will take to return to sport and how he or she will perform upon returning to sport may exert the strongest influence on the behavior of returning to sport.

Factors such as locus of control, emotions, mood, pain, and patient commitment have been suggested to contribute to self-efficacy after ACL reconstruction surgery.[14] Consistent with our findings, self-efficacy of future knee function (how the patient thinks his or her knee will function after surgery), measured before surgery, has been shown to predict subjective and objective knee function and return to physical activity by 12 months after ACL reconstruction surgery.[48] Similarly, patients' responses to surgery and early physical recovery (pain control, recovery of physical capacity in functional tasks) may also influence their psychological responses and return to sport

outcomes. For example, a patient who perceives surgery as a painful experience and takes longer to resume functional tasks such as walking without crutches may perceive that not returning to sport is the best way to avoid having to go through surgery again.

Our results suggest that when rehabilitating injured athletes who wish to return to sport, clinicians could consider addressing the athlete's psychological readiness to return to sport, not just his or her physical readiness, as a way of maximizing the chances that the athlete will return to his or her preinjury level. This is relevant because returning to sport is of primary importance to most athletes.[7,35,43] Preoperative psychological screening of injured athletes has been suggested to complement the usual physical and functional testing completed throughout rehabilitation.[14] The ACL-RSI was the measure with the best discriminative capabilities with regard to returning to sport, which provides preliminary evidence that the scale may be a relevant screening tool to identify athletes who may be at risk of not returning to their preinjury level of sport by 12 months after surgery. The results of this study suggested that a score of less than 56 points on the ACL-RSI may indicate an increased risk of not returning to the preinjury level and may help clinicians to identify at-risk athletes. Our findings could also suggest that an appropriate line for future investigation may be to examine interventions aimed at addressing psychological factors that may increase the risk of an athlete not returning to sport, to test the hypothesis that positively changing psychological factors could improve rates of return to sport. Such investigation may provide evidence about whether these interventions can change psychological factors and influence return to sport. For example, health coaching is an example of an intervention that has been used effectively to increase physical activity in people with chronic disease[33,49] and in people with musculoskeletal injury[23] via encouraging behavior change. With this technique, a rehabilitation professional helps a patient become actively involved in managing his or her injury and in behavior change by addressing the psychological aspects most relevant to the patient's recovery from injury.[31] Motivational interviewing techniques, goal setting, and cognitive-behavioral strategies are examples of approaches used in health coaching.[31]

A strength of this study is that it prospectively evaluated the psychological factors associated with returning to sport, in a large and clearly defined population, using valid population-specific outcome measures with established psychometric properties. This is important as it addresses some of the bias present in previous cross-sectional research that has compared the psychological responses of injured athletes who did and did not return to sport.[5] Sample sizes used in previous studies of the psychological factors associated with returning to sport after injury generally numbered 100 athletes at most, and only one study of athletes returning to sport after ACL reconstruction[51] followed a larger population (N = 220) than the current study.

Although our study has considered a number of psychological variables, and the choice of these variables was based on previous literature, there will be other psychological factors that influence return to sport that we have not evaluated. We also acknowledge that other nonpsychological factors such as environmental, physical, and social factors, which were not measured, may be important influences on return to sport. For example, people who play seasonal sports may wait until the beginning of a new season to return to sport, and this may not coincide with a 12-month follow-up. However, it has been shown that people who played seasonal sports were more likely to have returned to their preinjury level of competitive sport by 12 months.[7] Another potential influence on the rate of return to sport might occur if sports participation is linked to education institutions, as graduation from these institutions would preclude an athlete from returning to his or her preinjury level. However, in Australia, where this study was conducted, sports participation is not typically linked to educational institutions. That is, the opportunity to participate in sport extends beyond the completion of undergraduate study, and athletes who are older than school or college age also readily compete in competitive sport.

Given that up to two-thirds of athletes may not have returned to their preinjury level of sport by 12 months, we cannot determine from these results whether psychological factors are also predictive of longer term outcomes after ACL reconstruction surgery. Seemingly counterintuitively, at 4 months athletes who did return to their preinjury level estimated that it would take them longer to return to sport compared with athletes who did not return to their preinjury level by 12 months. This may suggest that asking athletes to estimate when they will return to any type of sport is not as meaningful as asking them to estimate when they will return to their preinjury level (the primary outcome).

Thirty-four participants (of 186, 18%) did not attend the 12-month clinical assessment. Therefore, we were unable to collect clinical data for these participants. Return-to-sport status could not be determined for 8 participants (of 186, 4%). It is possible that some of the participants had not returned to sport and were subsequently unhappy with their knee function and therefore chose not to attend their clinical assessment. Equally, they may not have returned for their assessment because they had returned to sport and considered their knee function to be satisfactory so did not perceive the need to attend. At the 4-month follow up, approximately 30% of participants did not complete the psychological factors questionnaire, raising the possibility of response bias. However, the people who did not complete the questionnaire were just as likely to have returned to sport at 12 months as those who did complete the questionnaire. This group's participants were also significantly younger than the people who did complete the questionnaire, and their preoperative psychological responses demonstrated a greater mood disturbance and a more external locus of control prior to surgery. However, they exhibited a more positive emotional response before

surgery than the people who did complete the 4-month questionnaire. This may suggest that the noncompleters had a greater psychological investment in playing sport and more strongly identified with an athletic identity.[42] Therefore, it is possible that this group may have exhibited similar psychological disturbance at 4 months.

Although our findings showed that psychological factors predicted return to sport, they do not explain what informed individual participants' psychological responses. Future research could explore what informs negative psychological responses (eg, previous experience, knowledge of the experiences of family and friends, perceptions of knee function). For example, patients' perceptions of their knee function may exert an important influence on psychological response. This may be mediated via patients' appraisal of their recovery, which subsequently may influence their prospective judgment of their ability to return to sport. It will also be important to test the validity of the psychological factors that this study has identified in an independent sample, to determine whether these factors remain reliable.[1] Another focus for future research must be to investigate the prospective association of psychological factors with longer term return to sport rates (beyond 12 months postoperatively). A trial of interventions aimed at addressing negative psychological responses may also be warranted to test the hypothesis that changing psychological factors can affect return to sport after ACL reconstruction surgery.

CONCLUSION

The effect of psychological factors on returning to sport after ACL reconstruction surgery has been underrecognized in the literature, with most previous research focusing on physical and surgical factors. The purpose of this study was to determine whether psychological factors predicted return to sport. Positive psychological responses measured before the athlete had surgery and early in the postoperative recovery phase were associated with returning to sport at 12 months. Postoperative clinical screening of athletes' psychological responses in addition to routine evaluation of physical recovery may assist clinicians to identify athletes at risk of not returning to sport.

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