Comparison of Physical Impairment, Functional, and Psychosocial Measures Based on Fear of Reinjury/Lack of Confidence and Return-to-Sport Status After ACL Reconstruction

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Comparison of Physical Impairment, Functional, and Psychosocial Measures Based on Fear of Reinjury/Lack of Confidence and Return-to-Sport Status After ACL Reconstruction

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Background: Fear of reinjury and lack of confidence influence return-to-sport outcomes after anterior cruciate ligament (ACL) reconstruction. The physical, psychosocial, and functional recovery of patients reporting fear of reinjury or lack of confidence as their primary barrier to resuming sports participation is unknown.

Purpose: To compare physical impairment, functional, and psychosocial measures between subgroups based on return-to-sport status and fear of reinjury/lack of confidence in the return-to-sport stage and to determine the association of physical impairment and psychosocial measures with function for each subgroup at 6 months and 1 year after surgery.

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

Methods: Physical impairment (quadriceps index [QI], quadriceps strength/body weight [QSBW], hamstring:quadriceps strength ratio [HQ ratio], pain intensity), self-report of function (International Knee Documentation Committee [IKDC]), and psychosocial (Tampa Scale for Kinesiophobia–shortened form [TSK-11]) measures were collected at 6 months and 1 year after surgery in 73 patients with ACL reconstruction. At 1 year, subjects were divided into ''return-to-sport'' (YRTS) or ''not return-to-sport'' (NRTS) subgroups based on their self-reported return to preinjury sport status. Patients in the NRTS subgroup were subcategorized as NRTS-Fear/Confidence if fear of reinjury/lack of confidence was the primary reason for not returning to sports, and all others were categorized as NRTS-Other.

Results: A total of 46 subjects were assigned to YRTS, 13 to NRTS-Other, and 14 to NRTS-Fear/Confidence. Compared with the YRTS subgroup, the NRTS-Fear/Confidence subgroup was older and had lower QSBW, lower IKDC score, and higher TSK-11 score at 6 months and 1 year; however, they had similar pain levels. In the NRTS-Fear/Confidence subgroup, the IKDC score was associated with QSBW and pain at 6 months and QSBW, QI, pain, and TSK-11 scores at 1 year.

Conclusion: Elevated pain-related fear of movement/reinjury, quadriceps weakness, and reduced IKDC score distinguish patients who are unable to return to preinjury sports participation because of fear of reinjury/lack of confidence. Despite low average pain ratings, fear of pain may influence function in this subgroup. Assessment of fear of reinjury, quadriceps strength, and self-reported function at 6 months may help identify patients at risk for not returning to sports at 1 year and should be considered for inclusion in return-to-sport guidelines.

Keywords: anterior cruciate ligament; kinesiophobia; knee; psychological; quadriceps strength; return-to-sport

Anterior cruciate ligament (ACL) reconstruction is commonly performed to facilitate a return to unrestricted preinjury sports participation after an ACL tear.[41] However, a recent meta-analysis of return-to-sport outcomes demonstrated that while 85% of patients returned to some form of sports participation after surgery, only 64% returned to their preinjury level.[4] Furthermore, just over half (56%) were able to return to competitive sports.[4] Lynch et al[32] have defined the ability to return to preinjury level of sports participation as a consensus criterion for successful participation outcomes after ACL reconstruction. Furthermore, Kocher et al[22] found that return-to-sport participation is a significant contributor to patient

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satisfaction after ACL reconstruction. These findings suggest a need to identify and address factors that prevent the return to preinjury sports participation after surgery.[1,4,13,15,35]

Patients with ACL reconstruction may not return to preinjury levels of sports participation for a variety of reasons. Ardern et al[4] reported fear of reinjury (19%) was the most commonly cited reason for not returning to preinjury levels of sports participation, followed by reasons other than the knee (18%), knee impairments (13%), and changes in lifestyle (11%). Evidence showing that fear of reinjury negatively influences return-to-sport outcomes after ACL reconstruction has grown over the past decade.[5,24] Multiple studies suggest fear of reinjury may be responsible for poor return-to-sport rates in the absence of significant knee impairments, indicating the presence of psychologically mediated disability for some patients.[4,25,40] Poor self-efficacy, or a lack of confidence in the ability to perform a task, has also been shown to influence short-[10,26,44] and long-term recovery,[2,26,43,44] including return to sport, after ACL reconstruction. Yet despite growing awareness for the importance of fear of reinjury and lack of confidence on return-to-sport outcomes, the physical, psychological, and functional recovery of patients reporting fear of reinjury or lack of confidence as their primary barrier to sports participation is unknown.

Pain-related fear of movement, a psychosocial construct within the fear avoidance model, may influence recovery for patients who report fear of reinjury/lack of confidence as a barrier to return to sports.[9,10,31,47] If so, this construct may differ between subgroups of patients who do not return to sport because of fear of reinjury/lack of confidence compared with those who return to sport or do not return to sport for other reasons. However, differences between these subgroups of patients may be time dependent. Prior research indicates psychosocial constructs are differentially associated with function based on time from surgery. For instance, Chmielewski et al[9,10] demonstrated a strong association between scores on the Tampa Scale for Kinesiophobia (TSK-11) and function in the return-to-sport stage of rehabilitation (6-12 months after surgery) but not in the earlier stages (0-6 months after surgery) of postsurgical recovery. Patients are typically allowed to return to unrestricted sports participation and exposed to the highest risk for reinjury during the return-to-sport stage. Therefore, the best time to examine differences in recovery between subgroups of patients may be during the return-to-sport stage.

Comparing physical impairment, functional recovery, and psychosocial recovery between subgroups will help clinicians to better identify potentially modifiable factors that place patients at risk for poor return-to-sport outcomes because of fear of reinjury/lack of confidence.[2] Furthermore, determining the factors associated with function in the return-to-sport timeframe can provide direction for intervention strategies aimed at improving sports participation outcomes. Collectively, this information will also inform the development of evidence-based return-to-sport guidelines aimed at improving return-to-sport rates. The purpose of this study was 2-fold. First, we compared physical impairment, functional, and psychosocial measures during the return-to-sport stage after ACL reconstruction among 3 return-to-sport subgroups. These subgroups were (1) patients who return to sport, (2) those who do not because of fear of reinjury/lack of confidence, and (3) those who do not for other reasons. Second, we determined the association of the physical impairment and psychological measures with function in each subgroup. We were interested in how measures correlated with function concurrently (cross-sectional analysis) as well as whether any 6-month physical and psychological measures were associated with function at 1 year (longitudinal analysis).

METHODS

Study Overview

Data for this study were extracted from a clinical outcomes database for patients with ACL reconstruction (Microsoft Office Access 2007) at the UF Health Orthopaedics and Sports Medicine Institute, Gainesville, Florida. The electronic database includes demographic and medical history information, clinical measures, and self-report questionnaires. Measures are collected at multiple postsurgical time points including 6 months and 1 year after surgery when patients are seen for physician follow-up. Patients provide written informed consent to be included in the database, and the protocol for this study was approved by the University of Florida Institutional Review Board.

Participants

Patients meeting the following criteria were included in the study: (1) unilateral ACL reconstruction performed between September 2007 and May 2012, (2) complete 6- and 12-month data, (3) age between 15 and 50 years, (4) time from injury to surgery 12 months or less, and (5) preinjury score $\geq$5 on the Tegner activity level scale. We specified a preinjury Tegner activity level of at least 5 to target a population of patients who were, at a minimum, involved in recreational sports before injury. Potential subjects were excluded if they had (1) bilateral knee injury, (2) concomi-

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tant ligamentous injury >grade I, (3) concomitant articular cartilage or meniscal repair procedure requiring prolonged postoperative nonweightbearing (4-6 weeks), (4) not yet cleared to return to sport by their surgeon at 1 year after surgery, or (5) unable to return to sports at 1 year after surgery for social reasons. Social reasons included too little time to participate in sports, getting a job, starting a family, or other changes in priorities or lifestyle.[45] Since we were interested in the factors affecting return-to-sport participation at 1 year after surgery, we aimed to identify a cohort of patients who had the opportunity to attempt a return to sport during our study timeframe and who did not have additional injuries or surgical procedures that may significantly affect the course of rehabilitation or functional outcome.

Surgical Procedure and Rehabilitation Program

All surgical procedures were performed arthroscopically by 1 of 3 board-certified orthopaedic surgeons using autograft (bone–patellar tendon–bone or semitendinosus and gracilis tendons) or allograft (tibialis anterior, tibialis posterior, or Achilles tendon) tissue. The surgical procedure as well as graft selection process for our surgeons has been previously published.[11] Rehabilitation was not controlled in this study. However, all patients at our facility followed the same ACL reconstruction rehabilitation protocol, and patients undergoing rehabilitation at outside facilities were given a copy of the protocol. This protocol allows for immediate weightbearing with an assistive device and knee motion as tolerated. The emphasis of the first 6 weeks of rehabilitation is on decreasing knee effusion, developing quadriceps control, regaining full knee motion, and improving neuromuscular control. The next 6 weeks of rehabilitation focus on increasing lower extremity muscle strength and endurance and developing neuromuscular control for dynamic activities, such as plyometrics. Straight-ahead running is permitted at 12 weeks if (1) quadriceps strength symmetry index is >60%, (2) knee effusion is trace or less, (3) knee extension range of motion (ROM) is equal to the contralateral side, (4) knee flexion ROM is within 5° of contralateral side, and (5) average knee pain is <2 on a scale to 10. After successful completion of a 6-week straight-ahead running program, agility exercises are initiated. Patients are allowed to return to sport when the following criteria are met: (1) knee ROM equal to the contralateral side, (2) quadriceps strength >85% of the opposite knee based on isokinetic testing, (3) no knee effusion, and (4) completion of an agility and sport-specific program. Most patients meet these criteria and are cleared by their surgeon to begin unrestricted sports participation (including contact sports) around 6 months postoperatively.

Return to Sport and Fear of Reinjury/Lack of Confidence Status

At 1 year after surgery, subjects were asked, "Have you returned to the same level of sports as before your injury?" Those who indicated that they had returned to the same level of preinjury sports participation (ie, a "yes" response) were designated YRTS, and those who reported that they had not returned to the same level (ie, a "no" response) were designated NRTS. Fear of reinjury/lack of confidence status was assessed for patients assigned to the NRTS subgroup. Those in the NRTS subgroup selected the primary reason for not returning to their preinjury level of sports participation from a list that included pain, swelling, fear of injury or lack of confidence, knee instability, muscle weakness, not yet cleared from doctor to return to sports, and other. Those who reported fear of reinjury or lack of confidence were assigned to the NRTS-Fear/Confidence subgroup. Those who selected a different option were assigned to the NRTS-Other subgroup.

Demographic Information

Demographic information included age, sex, weight, time from injury to surgery, graft type (autograft or allograft), concomitant knee injuries, and time from surgery to follow-up. Concomitant injuries were diagnosed during the preoperative physician evaluation or during surgery and included meniscal injuries, chondral lesions, and collateral ligament injuries.

Physical Impairment Measures

Muscle Strength. Quadriceps and hamstring strength were assessed with an isokinetic dynamometer (Biodex System3). Before testing, subjects were given a 5-minute warm-up on a stationary bicycle. They were then seated and stabilized with a lap and thigh belt. The dynamometer arm was set to move through a range of 90° to 0° of knee motion at a speed of 60 deg/s. Testing was conducted on the nonsurgical side first. Subjects performed 2 practice trials followed by 5 maximal effort trials. Testing was then repeated on the surgical side. The peak knee extensor and flexor torque of 5 trials was recorded for each side. Three separate measures of strength were calculated. First, a quadriceps symmetry index (QI) was calculated by dividing the peak knee extensor torque on the surgical side by the nonsurgical side and multiplying by 100. Second, knee extensor torque on the surgical side (ft-lbs) was normalized to the subject's body weight (lbs) (QSBW). Third, a hamstring:quadriceps strength ratio (HQ ratio) was calculated by dividing peak knee flexor torque on the involved side by peak knee extensor torque on the involved side. Isokinetic strength testing has been shown to be a reliable method of muscle strength testing (intraclass correlation coefficient [ICC] = 0.81 to 0.97)[8] and sensitive to strength changes in the first 2 years after ACL reconstruction.[39]

Knee Pain Intensity. Knee pain intensity was assessed with an 11-point visual numeric rating scale (NRS). Pain intensity ratings range from 0 (no pain) to 10 (worst imaginable pain). Subjects were asked to rate their worst and best pain levels over the past week. They were also asked to rate their current level of pain. All 3 pain ratings were averaged to get a composite knee pain intensity score. The NRS has been shown to be a reliable method of pain intensity assessment (ICC = 0.74-0.76).[12,36]

Functional Measures

Tegner Activity Rating Scale. The Tegner activity rating scale is an 11-point self-reported grading scale for work and sports activities.[42] The scale rates activity level from 0 (sick leave or disability pension because of knee problems) to 10 (competitive sports such as soccer, football, or rugby at the national or elite level). Level 5 indicates participation in sport-related activities at the lowest recreational level. The Tegner scale is a valid and reliable (ICC = 0.80) measure of function after ACL reconstruction.[6] At the time of follow-up testing, subjects were asked to rate their current level of sports participation as well as to recall their preinjury level of sports participation.

International Knee Documentation Committee Subjective Form. The International Knee Documentation Committee (IKDC) subjective form contains 10 items related to knee symptoms and physical function.[20] Scores range from 0 to 100, with higher scores indicating less disability. An ICC value of 0.94 and a standardized response mean of 0.94 have been reported for the form across a broad range of knee conditions including ACL injury and ACL reconstruction.[20,21]

Psychological Measure

Tampa Scale for Kinesiophobia. Pain-related fear of movement/reinjury was measured with the shortened version of the Tampa Scale for Kinesiophobia (TSK-11).[49] Response items are related to somatic sensations (eg, "Pain always means I have injured my body") and activity avoidance (eg, "I'm afraid that I might injure myself if I exercise"). Scores on the TSK-11 range from 11 to 44 points, and higher scores indicate greater pain-related fear of movement/reinjury. Good test-retest reliability (ICC = 0.81 and 0.93) has been reported for the TSK-11 in patients with chronic low back pain.[18,49] The TSK-11 is a valid measure of fear of movement/reinjury in the later stages of rehabilitation after ACL reconstruction.[17]

Statistical Analysis

Statistical analyses were performed with SPSS version 13.0 (IBM Corp). Demographic variables were compared between subgroups with 1-way analysis of variance (ANOVA) or chi-square analysis. For our first aim, group × time differences in physical impairment, functional, and psychological measures were examined with 2-way repeated-measures ANOVA with post hoc testing using Bonferroni adjustments. Pairwise comparisons determined group or time differences when interactions were not statistically significant.

For our second aim, we determined the association of the physical impairment and psychological measures with IKDC score in each subgroup using Pearson product coefficients. We were interested in how measures correlated with IKDC score concurrently at 6 months and 1 year (cross-sectional analyses) as well as whether any 6-month physical and psychological measures were associated with IKDC score at 1 year (longitudinal analysis).

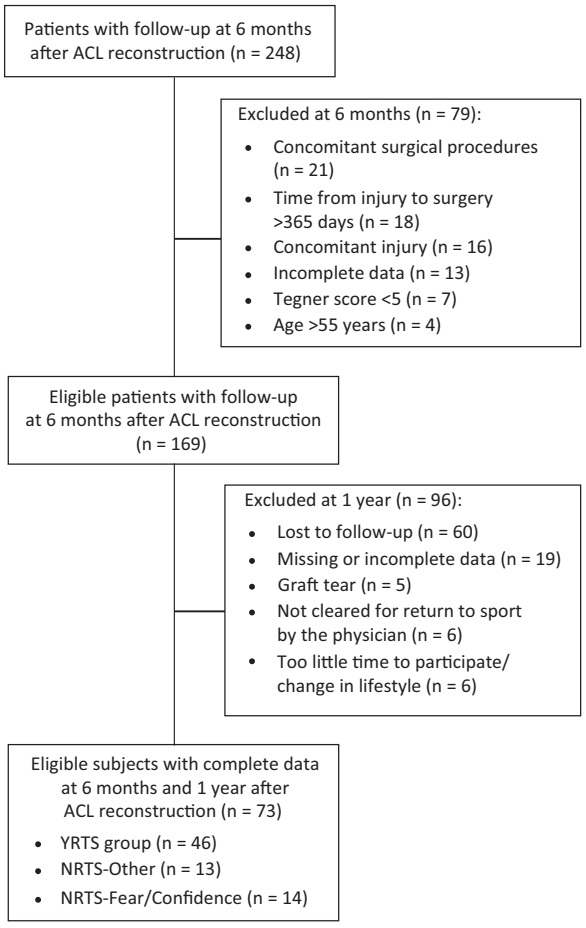

Figure 1. Flow diagram of the study cohort.

RESULTS

A flow diagram of study cohort is presented in Figure 1. A total of 248 patients were seen for follow-up at 6 months after ACL reconstruction. Of these, 79 potential subjects were excluded based on predetermined eligibility criteria. Of the remaining 169 subjects, complete 1-year follow-up data were not available for 84 subjects for the following reasons: loss to follow-up (n = 60), missing or incomplete data (n = 19), and patient suffered graft tear (n = 5). Eighty-five subjects had complete follow-up data at both 6 months and 1 year after surgery. Of those subjects, 12 (14%) were excluded due to either lack of clearance for return-to-sport (n = 6) or too little time to participate/ change in lifestyle (n = 6). The remaining 73 patients were included in the final analyses. Based on classification at 1 year after surgery, 46 patients (63%) were assigned to YRTS, 13 (18%) were assigned to NRTS-Other, and 14 (19%) were assigned to NRTS-Fear/Confidence. Demographic information is listed in Table 1. Subjects in the NRTS-Fear/Confidence subgroup were older than subjects in the YRTS subgroup (29.7 years vs 21.0 years, respectively; $P = .004$), however no other significant differences were observed between subgroups for demographic information. Subgroup means for physical impairment,

TABLE 1
Demographic Variables for Return-to-Sport Status Subgroups[a]

Measure	YRTS (n = 46)	NRTS-Other (n = 13)	NRTS-Fear/Confidence (n = 14)	Total (N = 73)	*P* Value[b]
Age, y	21.0 ± 8.7	25.1 ± 9.0	28.8 ± 11.6	23.2 ± 9.7	.021
Preinjury Tegner score	8.6 ± 1.6	8.2 ± 1.3	8.4 ± 2.0	8.5 ± 1.6	.634
Time from injury to surgery, d	65.0 ± 56.5	101.2 ± 101.5	90.1 ± 85.1	76.2 ± 72.5	.207
Sex, n					.634
Male	28	7	10	45	
Female	18	6	4	28	
Graft type, n					.067
Allograft	20	6	11	37	
Autograft	26	7	3	36	

[a]Data are presented as mean ± SD unless otherwise indicated. NRTS-Fear/Confidence, patients who had not returned to preinjury levels of sports participation because of fear of reinjury; NRTS-Other, patients who had not returned to preinjury levels of sports participation for reasons other than fear of reinjury; YRTS, patients who had returned to preinjury levels of sports participation.
[b]Significant difference between YRTS, NRTS-Other, and NRTS-Fear/Confidence subgroups.

TABLE 2
Physical Impairment Measures at 6 Months and 1 Year After ACL Reconstruction[a]

Measure	Time	YRTS (n = 46)	NRTS-Other (n = 13)	NRTS-Fear/Confidence (n = 14)
QI[b]	6 mo	0.83 (0.78-0.87)	0.67 (0.58-0.76)	0.72 (0.64-0.81)
	1 y	0.92 (0.88-0.97)	0.84 (0.75-0.92)	0.82 (0.73-0.90)
QSBW[c]	6 mo	0.74 (0.68-0.80)	0.57 (0.45-0.69)	0.56 (0.45-0.67)
	1 y	0.79 (0.73-0.85)	0.71 (0.60-0.81)	0.62 (0.51-0.72)
HQ ratio[d]	6 mo	0.59 (0.54-0.64)	0.74 (0.65-0.84)	0.67 (0.58-0.76)
	1 y	0.56 (0.51-0.61)	0.57 (0.48-0.65)	0.63 (0.55 -0.72)
Pain[e]	6 mo	0.62 (0.17-1.10)	1.62 (0.77-2.50)	1.41 (0.87-2.85)
	1 y	0.40 (0.03-0.78)	1.97 (1.30-2.70)	1.02 (0.35-1.70)

[a]Data are presented as mean (95% CI). ACL, anterior cruciate ligament; HQ ratio, hamstrings:quadriceps strength ratio; NRTS-Fear/Confidence, patients who had not returned to preinjury levels of sports participation because of fear of reinjury; NRTS-Other, patients who had not returned to preinjury levels of sports participation for reasons other than fear of reinjury; QI, quadriceps index; QSBW, quadriceps strength/body weight; YRTS, patients who had returned to preinjury levels of sports participation.
[b]QI increased in all subgroups over time ($P \leq .01$), with mean QI scores significantly higher in the YRTS subgroup than the NRTS-Other subgroup ($P = .009$) at 6 months.
[c]QSBW values in YRTS and NRTS-Other increased over time. QSBW values were higher in YRTS compared with NRTS-Other at 6 months ($P = .04$). Compared with NRTS-Fear/Confidence, QSBW values for YRTS were higher at 6 months ($P = .02$) and 1 year ($P = .02$).
[d]Mean values were significantly higher in the NRTS-Other group compared with the YRTS group at 6 months and decreased significantly between 6 months and 1 year.
[e]Higher mean pain intensity scores in NRTS-Other than in YRTS ($P = .001$) at 1 year.

functional, and psychosocial measures at 6 months and 1 year after ACL reconstruction are listed in Tables 2 and 3.

Impairment Measures

The group × time interaction for QI was not significant, $F(2, 70) = 1.4$, $P = .266$; however, significant main effects for time, $F(1, 70) = 39.2$, $P < .001$, and group, $F(2, 70) = 5.6$, $P = .006$, were found (Table 2). Pairwise comparisons showed QI increased in all subgroups over time ($P \leq .01$), with mean QI scores significantly higher in the YRTS subgroup than the NRTS-Other subgroup ($P = .009$) at 6 months.

The group × time interaction for QSBW was not significant, $F(2, 70) = 2.1$, $P = .134$; however, significant main effects for time, $F(1, 70) = 21.7$, $P < .001$, and group, $F(2, 70) = 5.5$, $P = .006$, were found. Pairwise comparisons showed QSBW in the YRTS and NRTS-Other subgroups increased over time ($P < .01$). The QSBW values were significantly higher in the YRTS subgroup compared with the NRTS-Other subgroup at 6 months ($P = .04$); the QSBW values in the NRTS-Fear/Confidence subgroup were lower at 6 months ($P = .02$) and 1 year ($P = .02$) compared with the YRTS subgroup (Table 2).

The group × time interaction for HQ ratio was significant, $F(2, 70) = 5.0$, $P = .010$. Mean values for HQ ratio were significantly higher in the NRTS-Other subgroup compared with the YRTS subgroup at 6 months and decreased significantly between 6 months and 1 year. The HQ ratio values for the YRTS and NRTS-Fear/Confidence subgroup were similar and did not change between 6 months and 1 year after surgery.

The group × time interaction, $F(2, 70) = 0.94$, $P = .396$, and main effect for time, $F(1, 70) = 0.15$, $P = .703$, were not

TABLE 3
Knee Function and Pain-Related Fear of Movement/Reinjury at 6 Months and 1 Year After ACL Reconstruction[a]

Measure	Time	YRTS (n = 46)	NRTS-Other (n = 13)	NRTS-Fear/Confidence (n = 14)
IKDC[b]	6 mo	86.36 (82.45-90.26)	76.04 (68.70-83.37)	75.53 (68.46-82.61)
	1 y	94.18 (90.32-98.03)	78.60 (71.36-85.85)	73.73 (67.40-81.37)
TSK-11[c]	6 mo	17.09 (15.63-18.55)	18.46 (15.68-21.24)	21.86 (19.18-24.54)
	1 y	15.34 (13.83-16.87)	17.23 (14.44-20.02)	21.50 (18.82-24.19)

[a]Data are presented as mean (95% CI). ACL, anterior cruciate ligament; IKDC, International Knee Documentation Committee subjective form; NRTS-Fear/Confidence, patients who had not returned to preinjury levels of sports participation because of fear of reinjury; NRTS-Other, patients who had not returned to preinjury levels of sports participation for reasons other than fear of reinjury; TSK-11, Tampa Scale for Kinesiophobia–shortened form; YRTS, patients who had returned to preinjury levels of sports participation.
[b]Mean IKDC scores were significantly higher in the YRTS subgroup at 6 months and 1 year compared with the NRTS-Other and NRTS-Fear/Confidence subgroups.
[c]Scores in NRTS-Fear/Confidence were higher compared with YRTS at 6 months ($P = .008$) and 1 year ($P < .001$).

TABLE 4
Correlations of Physical and Psychosocial Impairment Measures With IKDC Scores at 6 Months and 1 Year After ACL Reconstruction[a]

		IKDC Score					
		6 Months			1 Year		
Measure		YRTS	NRTS-Other	NRTS-Fear/Confidence	YRTS	NRTS-Other	NRTS-Fear/Confidence
6 months	QI	0.575**	0.701*	0.521	0.482**	0.459	0.383
	QSBW	0.486**	0.586*	0.779**	0.307*	0.368	0.586*
	HQ ratio	−0.414*	−0.490	0.188	−0.217	−0.118	−0.013
	Pain intensity	−0.607**	−0.885*	−0.545*	−0.416*	−0.585*	−0.203
	TSK-11	−0.405*	−0.458	−0.365	−0.318*	−0.642*	0.379
1 year	QI				0.438*	0.498	0.669*
	QSBW				0.390*	0.534	0.610*
	HQ ratio				−0.355*	0.075	0.036
	Pain intensity				−0.748**	−0.447	−0.585*
	TSK-11				−0.498**	0.182	−0.808**

[a]ACL, anterior cruciate ligament; HQ ratio, hamstrings:quadriceps strength ratio; IKDC, International Knee Documentation Committee subjective form; NRTS-Fear/Confidence, patients who had not returned to preinjury levels of sports participation because of fear of reinjury; NRTS-Other, patients who had not returned to preinjury levels of sports participation for reasons other than fear of reinjury; QI, quadriceps index; QSBW, quadriceps strength/body weight; TSK-11, Tampa Scale for Kinesiophobia–shortened form; YRTS, patients who had returned to preinjury levels of sports participation.
*$P < .05$. **$P < .001$.

significant for pain intensity; however, a significant group effect was found, $F(2, 70) = 6.7$, $P = .002$. Pairwise comparisons showed higher mean pain intensity scores in the NRTS-Other subgroup compared with the YRTS subgroup ($P = .001$). This difference was most evident at 1 year (Table 2).

Functional Measure

The group × time interaction, $F(2, 70) = 2.74$, $P = .071$, and main effect for time, $F(1, 70) = 2.84$, $P = .097$, were not significant for the IKDC score; however, a significant effect for group was found, $F(2, 70) = 13.33$, $P < .001$. The mean IKDC scores were significantly higher in the YRTS subgroup compared with the NRTS-Other and NRTS-Fear/Confidence subgroups ($P < .05$) (Table 3).

Psychosocial Measure

For TSK-11 scores, the group × time interaction, $F(2, 70) = .39$, $P = .679$, and main effect for time, $F(1, 70) = 2.43$, $P = .124$, were not significant. There was a significant main effect for group, $F(2, 70) = 8.63$, $P < .001$ (Table 3), with higher mean scores in the NRTS-Fear/Confidence subgroup compared with the YRTS subgroup at 6 months ($P = .008$) and 1 year ($P < .001$).

Relationship of Function With Physical and Psychosocial Measures at 6 Months and 1 Year After Surgery

Cross-sectional Analysis. Correlations of physical and psychosocial measures with function for each subgroup at 6 months and 1 year are listed in Table 4. For the YRTS

subgroup, all measures were correlated with IKDC score at both 6 months and 1 year. For the NRTS-Other subgroup, pain intensity, QI, and QSBW were correlated with IKDC score at 6 months, whereas no measures were correlated with IKDC score at 1 year. For the NRTS-Fear/Confidence subgroup, QSBW and pain intensity were correlated with IKDC score at 6 months, whereas QI, QSBW, pain intensity, and TSK-11 scores were correlated with IKDC score at 1 year.

Longitudinal Analysis. In the YRTS subgroup, all measures except HQ ratio at 6 months were correlated with IKDC score at 1 year. In the NRTS-Other subgroup, 6 month TSK-11 scores and pain intensity were correlated with IKDC scores at 1 year. In the NRTS-Fear/Confidence subgroup, only QSBW at 6 months was correlated with IKDC score at 1 year.

DISCUSSION

Patients who do not return to preinjury levels of sports participation after ACL reconstruction because of fear of reinjury/lack of confidence have elevated pain-related fear of movement/reinjury, quadriceps weakness, and reduced IKDC score but similar levels of pain intensity compared with patients who return to sport. These patients are also older than patients who return to sport, supporting prior studies linking age with the reduced likelihood of returning to sport after ACL reconstruction.[1,7,15] Collectively, these measures may be useful for identifying patients at risk for poor sports participation outcomes after ACL reconstruction. Interestingly, physical impairment and psychosocial measures were associated with IKDC score in correlational analyses for subjects in the YRTS subgroup, suggesting these factors contribute to function even for patients who return to sport after ACL reconstruction.

While graft type distribution was not significantly different between the 3 subgroups, we observed a trend toward a higher proportion of subjects with allografts in the NRTS-Fear/Confidence subgroup. This trend is likely related to the older age of the NRTS-Fear/Confidence subgroup. In our sample, subjects with allograft reconstructions were significantly older, on average, than those with autograft reconstructions (26.8 $\pm$ 12.1 vs 19.5 $\pm$ 4.0 years; $P = .001$). Thus, age is likely a mediating factor explaining the trend toward a higher proportion of subjects with allograft reconstructions in the NRTS-Fear/Confidence subgroup. This explanation is supported by limited evidence to demonstrate poorer return-to-sport rates based on graft type.[19,33,34,37]

Our findings suggest 2 potential mechanisms for reduced function as a result of elevated psychosocial factors in the NRTS-Fear/Confidence subgroup. First, consistent associations between QSBW and function may be partially mediated by elevated fear of movement/reinjury. For example, patients may fear participating in advanced functional activities, such as running or jumping, because of a sense of weakness around the surgically reconstructed knee. Yet despite improvements in some measures of quadriceps strength from 6 months to 1 year, functional limitations persisted. This would be an unexpected finding if quadriceps strength deficits alone were responsible for functional limitations in these patients. Instead, the strong association between TSK-11 scores and function at 1 year in the NRTS-Fear/Confidence subgroup suggests a progression toward psychologically mediated functional limitations. Consistent with fear avoidance models,[28,46,47] our results indicate physical impairments may contribute to initial functional deficits, whereas psychological factors may contribute to longer term functional deficits in patients who report fear of reinjury or lack of confidence as a barrier to sports participation.

A second potential mechanism for reduced function as a result of elevated psychosocial factors is related to avoidance behavior. Unexpectedly, subjects who tended to report the highest pain ratings were not the subjects who reported fear of reinjury or lack of confidence as their primary barrier to sports participation. A potential explanation is that patients who report fear of reinjury or lack of confidence may choose to reduce their exposure to potentially painful activities, thus minimizing their average pain intensity. The consistent relationship between pain intensity and IKDC score despite low pain ratings in the NRTS-Fear/Confidence subgroup helps to support this explanation. The pain avoidance mechanism for reduced pain in the presence of elevated psychosocial factors is also consistent with fear avoidance models,[28,46,47] as fear of pain produces lower levels of function and pain through reduced exposure to potentially painful activities.

In contrast to a psychologically influenced pathway to reduced function after ACL reconstruction, elevated pain intensity with low levels of psychosocial factors may also contribute to poor function for some patients. Similar to previous studies, we found relatively low average pain intensity ratings in the return-to-sport stage across all subgroups.[27,29,45,48] However, for subjects in the NRTS-Other subgroup, elevated pain intensity was associated with IKDC score at 6 months and in our longitudinal analysis. Consistent with prior research, these findings demonstrate pain can remain a significant hindrance to sports participation for some patients in the return-to-sport stage and may be an important predictor of function after ACL reconstruction.[14,16,23,30,45]

Our findings have important implications for treatment after ACL reconstruction. First, psychologically informed interventions may be indicated for patients with elevated fear of reinjury/lack of confidence. Future intervention studies should confirm the effectiveness of this approach for reducing fear of reinjury/lack of confidence and improving return-to-sport outcomes. Second, early resolution of quadriceps strength deficits may be important for improving confidence and knee-related function. Interestingly, QSBW had a stronger association with function compared with QI in the NRTS-Fear/Confidence subgroup at 6 months. Side-to-side quadriceps strength symmetry is often used clinically to measure quadriceps muscle strength after ACL reconstruction, presumably because of the higher risk of knee reinjury as the result of large strength asymmetries.[38] However, maximizing quadriceps muscle strength relative to body weight may be more important for establishing confidence in the surgical knee. HQ ratio was not significant in the correlational analyses for either NRTS subgroup and may not be as useful compared with other measures of muscle strength

for predicting reduced function. However, HQ ratio was not evaluated based on graft type in this study and may be a more important predictor of function for patients with hamstring autografts.[3]

These findings also provide direction for the development of evidence-based return-to-sport guidelines. Specifically, the combined use of physical impairment and fear of reinjury measures may provide a more thorough evaluation of return-to-sport readiness. Our results suggest that physical impairment measures should include QSBW, as this measure had a stronger relationship with function compared with QI for some subjects. Our results also indicate that pain-related fear of reinjury should be included in assessing return-to-sport readiness. This is noteworthy because most return-to-sport guidelines reported in the literature do not include assessment of psychosocial factors. As a result, clinicians may neglect relevant factors that contribute to an inability to return to sport. Overall, our study supports a growing body of evidence highlighting the importance of measuring and addressing pain-related fear of reinjury, in addition to physical impairments, in return-to-sport decision making.[1,2,4,24,26,27,30]

This study is limited by a small sample size with a large proportion of subjects excluded a priori or lost to follow-up at 1 year. Approximately 35% of our eligible sample was lost to follow-up. This may be due, in part, to the transient nature of the population we treat as a regional academic medical center. Through an exploratory analysis, we analyzed key demographic, physical impairment, functional, and psychological measures included in this study and found no differences at 6 months between subjects who did and did not follow up at 1 year. We performed a similar exploratory analysis between patients with missing or incomplete 1-year data and those with complete 1-year data and also found no significant differences. Therefore, we do not expect systematic selection bias in this study.

Our exclusion criteria were established to identify a cohort of patients who had the opportunity to attempt a return to sport during our study time frame in accordance with our study aims. Because we were interested in factors that are potentially modifiable through rehabilitation, we excluded patients who did not return to sport for social reasons. This exclusion criterion has been used in prior ACL reconstruction outcomes studies.[27,30] However, it is plausible these patients may have had underlying physical or psychosocial reasons that led them to avoid sports and change their lifestyle. In addition, while no specific graft types were excluded in our study, we only had 2 subjects with patellar tendon autografts. Anterior knee pain is common with patellar tendon autograft reconstructions,[23,37] and the influence of pain on function may be more significant in this cohort. Therefore, readers are cautioned against generalizing these findings to patients whose profiles were not represented in our study.

Prospective studies are required to confirm the predictive ability of these and other measures for identifying those at risk for poor return-to-sport outcomes. Additional psychosocial constructs (eg, pain catastrophizing, negative affect, self-efficacy, or depression), as well as other modifiable, impairment-based, or functional measures (eg, rate of force development of the quadriceps, dynamic stability/balance, or single-leg hop testing), may differ between return-to-sport status subgroups and represent additional, potentially important, rehabilitation targets. Future studies should also examine subgroup characteristics in earlier stages of rehabilitation. Recovery patterns in the first 6 months for patients who ultimately report psychosocial barriers to return-to-sport are unknown. As a result, we do not have a clear understanding of whether these patients may be identified in earlier stages of rehabilitation. Because subgroup differences already exist for key measures at 6 months, understanding the progression of these measures in the early stages of rehabilitation may provide important information on the ideal timing and approach for psychologically informed or impairment-based interventions.

CONCLUSION

Elevated pain-related fear of movement/reinjury, quadriceps weakness, and reduced function in the return-to-sport stage distinguish patients who are unable to return due to fear of reinjury/lack of confidence. Despite low overall pain ratings, consistent relationships between pain intensity and function in patients who do not return to sport due to fear of reinjury/lack of confidence suggest fear of pain may underlie activity restrictions in this subgroup. Future studies should assess the predictive ability of these measures for identifying those at risk for poor return-to-sport outcomes as well as determine the effectiveness of psychologically informed practice approaches for improving function in these patients after ACL reconstruction.

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