[Sports Physical Therapy]

Factors Associated With Function After Anterior Cruciate Ligament Reconstruction

Trevor A. Lentz, PT, CSCS,* Susan M. Tillman, PT, CSCS, SCS,* Peter A. Indelicato, MD,† Michael W. Moser, MD,† Steven Z. George, PhD, PT,‡ and Terese L. Chmielewski, PhD, PT, SCS‡§

Background: Many individuals do not resume unrestricted, preinjury sports participation after anterior cruciate ligament reconstruction, thus a better understanding of factors associated with function is needed. The purpose of this study was to investigate the association of knee impairment and psychological variables with function in subjects with anterior cruciate ligament reconstruction.

Hypothesis: After controlling for demographic variables, knee impairment and psychological variables contribute to function in subjects with anterior cruciate ligament reconstruction.

Study Design: Cross-sectional study; Level of evidence, 4a.

Methods: Fifty-eight subjects with a unilateral anterior cruciate ligament reconstruction completed a standardized testing battery for knee impairments (range of motion, effusion, quadriceps strength, anterior knee joint laxity, and pain intensity), kinesiophobia (shortened Tampa Scale for Kinesiophobia), and function (International Knee Documentation Committee subjective form and single-legged hop test). Separate 2-step regression analyses were conducted with International Knee Documentation Committee subjective form score and single-legged hop index as dependent variables. Demographic variables were entered into the model first, followed by knee impairment measures and Tampa Scale for Kinesiophobia score.

Results: A combination of pain intensity, quadriceps index, Tampa Scale for Kinesiophobia score, and flexion motion deficit contributed to the International Knee Documentation Committee subjective form score (adjusted $r^2 = 0.67$; $P < .001$). Only effusion contributed to the single-legged hop index (adjusted $r^2 = 0.346$; $P = .002$).

Conclusion: Knee impairment and psychological variables in this study were associated with self-report of function, not a performance test.

Clinical Relevance: The results support focusing anterior cruciate ligament reconstruction rehabilitation on pain, knee motion deficits, and quadriceps strength, as well as indicate that kinesiophobia should be addressed. Further research is needed to reveal which clinical tests are associated with performance testing.

Keywords: ACL; outcomes; practice guidelines; knee; rehabilitation

An estimated 200 000 anterior cruciate ligament (ACL) injuries occur in the United States each year, usually during sports that require cutting, jumping, or pivoting.[13] Most US orthopeadic surgeons recommend surgical reconstruction to individuals who want to continue sport activities,[20] presumably because nonoperative management does not reliably resolve knee instability, which interferes with sport participation and increases risk for secondary injury.[3] While advances in surgical techniques and rehabilitation are perceived to predictably restore knee function,[4] recent studies report that

From *Shands Rehabilitation, UF & Shands Orthopaedics and Sports Medicine Institute, the †Department of Orthopaedics & Rehabilitation, University of Florida, and the ‡Department of Physical Therapy, University of Florida, Gainesville, Florida

§Address correspondence to Terese L. Chmielewski, PhD, PT, SCS, Department of Physical Therapy, University of Florida, P.O. Box 100154, HSC, Gainesville, FL 32610 (e-mail: tchm@ufl.edu).

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between 20% to 50% of those with ACL reconstruction do not return to the same sports after surgery.[1,12,17,18,35] Moreover, 10% to 70% of those who resume preinjury sports participate at a reduced level or with significant functional impairments.[1,29] The findings of these studies were unexpected and indicate the need to improve outcomes for high-level function after ACL reconstruction.

A potential cause for an inability to return to preinjury sport activities after ACL reconstruction is discharge from physical therapy before impairments are sufficiently resolved. Unfortunately, it is difficult to determine when optimal rehabilitation status has been achieved because standardized clinical guidelines do not exist.[16] Comparison of published return-to-sport guidelines reveals little consensus on the impairments used to direct clinical decision making and significant variability in threshold values.[16] Ultimately, the creation of standardized return-to-sport guidelines depends on foundational knowledge of the impairments that deter high-level function and to what level the impairments must be resolved.

Previous studies provide insight into knee impairments that might influence function in patients with ACL reconstruction. Wilk et al[36] found significant correlations between scores on a modified version of the Cincinnati knee rating scale and the timed hop test score, and also between the single-legged, crossover hop score, the knee extensor peak torque at 180°/s and 300°/s, the knee extension acceleration at 180°/s and 300°/s, and the number of months from surgery. Significant correlations were also found between single-legged hop test scores and knee extension isokinetic testing results (the only knee impairment studied). Risberg et al[26] used stepwise regression analysis to examine which variables contributed to the Cincinnati knee score at various time points after ACL reconstruction. Total extension work from isokinetic testing and pain intensity were consistent variables contributing to Cincinnati knee score at 6 months, 1 year, and 2 years after surgery. In addition, total extension work, pain intensity, knee flexion motion, and anterior knee laxity contributed to triple-hop test results.[26] Ross et al[28] studied the contribution of demographic, impairment, and performance-based activity variables to scores on the Knee Outcome Survey, a self-report of function questionnaire. Stepwise regression analysis revealed that the number of injured knee structures, time from surgery, and hop test scores contributed to the variance in the Knee Outcome Survey scores, and that quadriceps strength and anterior knee laxity were not contributing factors. The results of these studies highlight knee impairments that potentially influence function, but the results are not consistent between studies. Without controlling for the effect of demographic variables, the unique contribution of knee impairments to function cannot be determined. Additionally, not all studies differentiate knee impairments that contribute to self-report of function and performance-based assessment of function. It is important to differentiate between these 2 assessment methods because both are used to evaluate function after ACL reconstruction and can result in different conclusions regarding an individual's preparedness to return to high-level activities.[21,23]

Kinesiophobia, or fear of movement/reinjury, is a psychological variable with potential to impede a return to sport activities after ACL reconstruction.[17,18] Kvist et al[17] used the Tampa Scale for Kinesiophobia (TSK) to examine fear of movement/reinjury levels in patients 4 years post-ACL reconstruction. Higher TSK scores were found in subjects with reduced activity level compared to those that resumed preinjury sports participation. Moreover, higher TSK scores were correlated with lower self-report of function scores. Fear of movement/reinjury thus warrants further investigation as a factor that influences function after ACL reconstruction.

The purpose of this study was to investigate the association of knee impairment and psychological variables with function in subjects with ACL reconstruction. We hypothesized that, after controlling for demographic variables, knee impairment and psychological variables would contribute to function in subjects with ACL reconstruction. The knee impairment variables chosen for this study were based on findings in previous research and published clinical guidelines. Function was assessed with both self-report and performance-based testing methods. By accounting for demographic variables, the intention of this study was to identify potentially modifiable variables that may be the target of future evidence-based rehabilitation and return-to-sport guidelines.

MATERIALS AND METHODS

Subjects

Patients with ACL reconstruction who were seen for routine physician follow-up at 6 or 12 months postsurgery were eligible to participate in this study. At our facility, patients typically receive medical clearance to return to unrestricted sports participation at 6 months following ACL reconstruction. Thus, this study was conducted in a timeframe in which patients were participating in sports activity. Rehabilitation was not controlled in this study; however, a rehabilitation protocol was followed and given to individuals not undergoing rehabilitation in our facility. Briefly, the protocol allowed for immediate weightbearing with no knee motion restrictions. The emphasis of the first 6 weeks was on developing quadriceps control and regaining full knee motion. Patients were allowed to perform open-chain quadriceps strengthening through full range at 10 weeks postoperation, followed by the initiation of a running program at 12 weeks and an agility and jump-training program at 18 weeks.

Inclusion criteria for this study were: unilateral ACL reconstruction, age between 15 and 45 years, time from injury to surgery ≤12 months, and preinjury ≥5 on the Tegner activity level scale.[33] We specified a preinjury Tegner activity level of at least 5 to target a population of subjects that were, at a minimum, involved in recreational sports.

Potential subjects were excluded if they had: bilateral knee injury, prior knee ligament injury and/or surgery,

concomitant other ligamentous injury higher than grade I, or cartilage repair procedure performed in conjunction with ACL reconstruction. These exclusion criteria were chosen because they represent additional injuries that may affect functional outcome.[28]

All surgical procedures were performed by a board-certified orthopedic surgeon (P. A. I. or M. W. M.). Subjects provided written informed consent on a form approved by the University of Florida Institutional Review Board.

Testing Overview

Testing was performed at Shands Rehabilitation at the UF & Shands Orthopaedics and Sports Medicine Institute. Demographic information was collected and included age, gender, height, weight, time from injury to surgery, time from surgery to follow-up, concomitant orthopedic surgeries or injuries, graft type, and accompanying surgical procedures. Standardized testing consisting of clinical tests and measures for knee impairments, self-report questionnaires for knee pain intensity, kinesiophobia, and knee function, and a single-legged hop test was administered by 1 of 4 physical therapists who specialize in sports rehabilitation at the clinic. Sample specific intra- and inter-rater reliability of these tests and measures was not assessed, but these therapists regularly participated in a biannual training session to standardize techniques.

Knee Effusion and Range of Motion

Knee effusion was assessed with the sweep test and graded on a 5-point scale (none, trace, 1+, 2+, 3+).[2] Inter-rater reliability using this method of assessing effusion produces kappa values in the substantial agreement range.[31] Knee flexion and extension passive range of motion were measured on the surgical and nonsurgical side using a standard clinical goniometer. Side-to-side knee extension and flexion motion deficits were calculated. Intra- and inter-rater reliability of extension and flexion measurements using a universal goniometer have been reported to be high (r = 0.83-0.997).[7]

Knee Ligament Laxity Testing

In order to assess integrity of the ACL graft, anterior displacement at the tibiofemoral joint was measured with a knee ligament arthrometer (KT-1000, MedMetric, San Diego, California). Measurements were taken with 15, 20, and 30 pounds of force and with a manual maximum force. Two trials were recorded in millimeters for each knee and averaged. The difference in values between the surgical and nonsurgical sides was calculated for the manual maximum force and recorded as the KT difference. The KT-1000 test has been shown to be a valid[24] and reliable[27] measure of anterior knee joint laxity.

Quadriceps Strength Testing

Quadriceps strength was assessed with an isokinetic dynamometer (Biodex System3, Chattanooga, Tennessee). Prior to testing, subjects were given a 5-minute warm-up on a stationary bicycle. Subjects were then positioned and stabilized on the isokinetic dynamometer with the hip in 90° of flexion. The dynamometer arm was set to move through a range of 90° to 0° of knee motion at a speed of 60°/s. Testing was conducted on the nonsurgical side first. Subjects performed 2 practice contractions followed by 5 maximal effort contractions. Testing was then repeated on the surgical side. A quadriceps index was calculated by normalizing the peak torque on the surgical side to the nonsurgical side and multiplying by 100.

Self-Report Questionnaires

Medical Outcomes Survey-Short Form 8

Knee pain intensity was assessed from item 4 of the Short Form 8 (SF-8), a general quality of life survey that has domains for physical and mental health.[34] Item 4 asks, "How much bodily pain have you had during the past 4 weeks?" Six responses are possible, ranging from "none" to "very severe." Numerical values were assigned to each response corresponding to magnitude of pain intensity (eg, none = 0, very severe = 5). While knee pain is more commonly measured with visual analog or numerical rating scales, the SF-8 is a part of the standardized testing battery in our facility. Bost et al[6] found that the SF-8 bodily pain question was equally responsive and gave comparable results as a 10-point numerical rating in the first 4 days after ACL reconstruction.

Shortened Version of the Tampa Scale for Kinesiophobia

Kinesiophobia, or fear of movement/reinjury, was measured with the shortened version of the Tampa Scale of Kinesiophobia (TSK-11).[37] The TSK-11 eliminates psychometrically poor items from the original version of the TSK to create a shorter questionnaire with comparable internal consistency (TSK: α = .76; TSK-11: α = .79), test-retest reliability (TSK: intraclass correlation coefficient [ICC] = 0.82, standard error of measurement [SEM] = 3.16; TSK-11: ICC = 0.81, SEM = 2.54), responsiveness (TSK: standardized response mean [SRM] = –1.19; TSK-11: SRM = –1.11), concurrent validity and predictive validity.[37] 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.

International Knee Documentation Committee Subjective Form

Self-report of knee function was measured with the International Knee Documentation Committee (IKDC) Subjective Form. The IKDC is a 10-item questionnaire with items related to knee symptoms and physical function.[14] Scores range from 0 to 100, with higher scores indicating less disability. The IKDC subjective form has been shown to be responsive and reliable across a broad range of knee pathologies, including ACL injury and ACL reconstruction.[14,15]

Table 1. Descriptive statistics for demographic and knee impairment variables, self-report questionnaire scores, and single-legged hop testing results.[a]

	6 Months Postoperative (n = 32)	12 Months Postoperative (n = 26)	All (n = 58)
Gender, female/male	8/24	12/14	20/38
Age	25.1 (15-43)	21.6 (15-45)	23.5 (15-45)
Time from surgery, weeks	25.7 ± 3.3	48.4 ± 4.6	35.9 ± 12.0
Graft, allograft/autograft	25/7 16 Achilles allograft 7 hamstring autograft 6 patellar tendon allograft 3 tibialis anterior allograft	15/11 9 Achilles allograft 11 hamstring autograft 6 patellar tendon allograft	40/18
Concommitant surgical procedures	10 lateral menisectomy 6 medial meniscectomy 2 chondroplasty	10 lateral menisectomy 7 medial meniscectomy 4 chondroplasty	
Pain intensity	2.28 ± 2.29	2.54 ± 2.4	2.4 ± 2.3
Laxity, mm	1.77 ± 1.08	2.6 ± 1.26	2.13 ± 1.22
TSK-11 (score)	17.75 ± 5.54	18.23 ± 4.33	18.0 ± 5.0
Extension deficit	0.72 ± 1.14	0.81 ± 1.7	0.76 ± 1.4
Flexion deficit	3.25 ± 4.15	2.3 ± 4.05	2.83 ± 4.1
Quadriceps index, %	83.6 ± 21.8	88.9 ± 15.6	86.0 ± 19.3
Tegner score, preinjury/follow-up	8.65 ± 1.6/5.87 ± 1.54	8.4 ± 1.35/7.55 ± 1.79	8.53 ± 1.49/6.65 ± 1.85
Single-legged hop index	98.4 ± 9.3	95.7 ± 8.0	97.0 ± 8.6
IKDC score	79.4 ± 15.8	87.2 ± 11.6	82.9 ± 14.5

[a]TSK-11, shortened version of the Tampa Scale of Kinesiophobia; IKDC, International Knee Document Committee.

Single-Legged Hop Testing

Single-legged forward hop testing was used as a performance-based measure of function because it is commonly used in return-to-sport testing.[16] All subjects that were 12 months postsurgery participated in single-legged hop testing. Subjects that were 6 months postsurgery only participated in single-legged hop testing if they met the following criteria: (1) full knee extension and active knee flexion within 5° of the contralateral side, (2) pain rating <2/10 with hopping on the injured side, (3) quadriceps index at least 80%, and (4) KT-1000 results ≤5 mm with side-to-side comparison of manual maximum force.

For single-legged hop testing, the subject stood on 1 leg, jumped forward horizontally as far as possible, and landed on the same leg. Subjects were permitted to let their arms hang free and were not required to hold their position upon landing. Three practice trials were given followed by 2 maximal effort hops. The nonsurgical side was measured first, followed by the surgical side. Results were recorded in centimeters and averaged. A single-legged hop index was computed by normalizing the hop distance on the surgical side by the hop distance on the nonsurgical side and multiplying by 100. This test has been shown to be a reliable and valid test of physical performance following ACL reconstruction.[5,25]

Statistical Analysis

Statistical analyses were conducted with SPSS for Windows, Version 13.0 (SPSS Inc, Chicago, Illinois). Descriptive statistics were generated for demographic and knee impairment variables, self-report questionnaire scores, and single-legged hop testing results. It was our intention to examine factors that contribute to function after accounting for demographic variables. Thus, separate multiple regression analyses were conducted using our measures of function (IKDC score and single-legged hop index) as dependent variables. Demographic variables (age, gender, time from injury to surgery, and time from surgery to follow-up) were first entered in the regression model, then knee impairment measures (effusion, extension motion deficit, flexion motion deficit, quadriceps index, KT difference, pain intensity) and TSK-11 scores were entered in the regression model in a stepwise fashion. Stepwise regression was selected for the second part of the model because it has been used in other studies for developing clinical prediction rules,[8,10] we did not have a priori hypotheses regarding the specific variables that would be related to function, and we wanted to create a parsimonious model. Gender was coded as male = 1 and female = 0. Effusion was coded as 0 and trace values = 0 and values > trace = 1. Statistical significance was set at .05.

RESULTS

A total of 92 patients (33 women, 59 men) with ACL reconstruction were identified as potential subjects for the study. Twenty-four patients were excluded from participation because they did not meet the inclusion criteria. Five patients had a history of contralateral or revision ACL reconstruction, 5 had concomitant ipsilateral cartilage repair, 3 had ACL reconstruction greater than 1 year following injury, and 11 had a Tegner activity level <5. This left a total of 68 subjects eligible to participate in the study. Of the 68 subjects, 10 were evaluated at both 6 and 12 months postsurgery. For these subjects, results of one test session were selected for analysis using a random number generator. Thus, 58 subjects

Table 2. Regression analysis model summary with IKDC score as the dependent variable.

Model	R^2	Adjusted R^2	F	*P* Value
1[a]	.321	.269	6.139	<.001
2[b]	.566	.524	13.314	<.001
3[c]	.662	.622	16.330	<.001
4[d]	.693	.649	15.777	<.001
5[e]	.717	.670	15.221	<.001

[a]IKDC, International Knee Documentation Committee; TSK, Tampa Scale of Kinesiophobia.
[b]Predictors: (constant), time from surgery, injury to surgery, age, gender.
[c]Predictors: (constant), time from surgery, injury to surgery, age, gender, pain.
[d]Predictors: (constant), time from surgery, injury to surgery, age, gender, pain, quad index.
[e]Predictors: (constant), time from surgery, injury to surgery, age, gender, pain, quad index, TSK.
[f]Predictors: (constant), time from surgery, injury to surgery, age, gender, pain, quad index, TSK, flexion motion deficit.

Table 3. Parsimonious final regression model with IKDC score as the dependent variable.[a]

Variables	Standardized β	*t*	*P* Value
Gender	.224	2.571	.013
Time from surgery	.189	.189	.027
Pain intensity	–.396	–4.282	<.001
Quadriceps index	.291	3.348	.002
TSK-11 score	–.219	–2.517	.015
Flexion deficit	–.164	–2.043	.047

[a]IKDC, International Knee Documentation Committee, TSK-11, shortened version of the Tampa Scale of Kinesiophobia. $R^2 = 0.717$; Adjusted $R^2 = 0.670$; F = 15.221; $P < .001$.

participated in the study. Demographic information for the subjects in this study is summarized in Table 1.

Regression analysis using IKDC score as the dependent variable showed that a combination of demographic, knee impairment, and psychological variables accounted for 67% of the variance in IKDC score (adjusted $r^2 = 0.670$; $P < .001$). After accounting for demographic variables, knee impairment and psychological variables accounted for 40% of the variance in IKDC score (Table 2). In the final regression model, pain intensity had the strongest association with IKDC score, followed by quadriceps index, TSK-11 score, and flexion motion deficit, while gender and time from surgery to follow-up were the only significant demographic variables (Table 3).

Of the 58 subjects included in the study, only 39 met the criteria to participate in single-legged hop testing. This included the 17 subjects tested at 6 months post-ACL reconstruction and all 26 subjects tested at 12 months post-ACL reconstruction. The overall regression model predicted 35% (adjusted $r^2 = .346$; $P = .002$) of the variance in the single-legged hop index (Table 4), and effusion was the only knee impairment variable to contribute (Table 5).

DISCUSSION

The purpose of this study was to investigate the association of knee impairment and psychological variables with function after ACL reconstruction. As hypothesized, after controlling for demographic variables, we found several knee impairment variables and a psychological variable to be significant contributors to IKDC score, a self-report of function. Importantly, these factors explained an additional 40% of the variance in IKDC score beyond demographic variables. On the other hand, only 1 impairment variable, knee effusion, contributed to the single-legged hop index. Our results thus provide direction on knee impairment variables that can be used in future research aimed at improving self-report of function after ACL reconstruction.

Differential findings for self-report and performance-based assessment of function are not surprising. Research in several patient populations indicate that these 2 forms of assessing function can produce different conclusions.[19,21,30] However, it was unexpected that only knee effusion was associated with the single-legged hop index. Furthermore, the model accounted for only a small amount of variance in the single-legged hop index. It is possible that knee impairment variables other than those in this study are more important to performance test results. For example, Wilk et al[36] found that peak knee extension torque when tested at 180°/s was correlated with single-legged hop distance ($r = 0.62$; $P = .003$). Unlike the study by Wilk et al,[36] the authors used the quadriceps index, a measure of symmetry in quadriceps strength, not the peak torque variable. It is also possible that a larger patient sample is needed to obtain a true indication of whether the variables included in this study contribute to single-legged hop index. Only 39 of the 58 subjects were able to perform the single-legged hop test. A reason for the relatively small single-legged hop test sample size was the stringent criteria set for subjects who were 6 months postoperative in order to protect them from potential injury. Subjects who did not meet the criteria were not allowed to participate in single-legged hop testing. Mean single-legged hop index at 6 months was 98.4% ± 9.3% compared to 95.7% ± 8.0% at 12 months. The single-legged hop index scores at 6 months postoperative are unusually high due to the selection of patients who demonstrated relatively small quadriceps deficit and a stable knee.

The results of the regression for the single-legged hop index should be interpreted with caution. The positive relationship

Table 4. Regression analysis model summary with single-legged hop index as the dependent variable.

Model	R^2	Adjusted R^2	F	*P* Value
1[a]	.078	–.033	.703	<.001
2[b]	.434	.346	4.910	.002

[a] Predictors: (constant), time from surgery, injury to surgery, age, and gender.
[b] Predictors: (constant), time from surgery, injury to surgery, age, gender, and effusion.

Table 5. Parsimonious final regression model with single-legged hop index as the dependent variable.[a]

Variables	Standardized β	*t*	*P* Value
Effusion	.617	4.485	<.001

[a] $R^2 = 0.434$; Adjusted $R^2 = 0.346$; F = 4.910.

between effusion and single-legged hop index indicates that single-legged hop index improves as effusion becomes greater. This is not logical clinically. Upon further examination of the data, we found that only 1 subject had effusion rates greater than trace, and this subject had a high single-legged hop index. Thus, the results of this study may not clearly define the relationship between effusion and the single-legged hop index. Further research is needed to clarify factors associated with functional performance.

Factors found to contribute to self-report of function in this study have similarities with previous research. Risberg et al[26] also found quadriceps strength to be associated with self-report of function in subjects with ACL reconstruction, and both Risberg et al[26] and Ross et al[28] found anterior knee joint laxity to have no association. Although Ross et al[28] did not find an association between quadriceps strength and self-report of function, they did not use a 2-step regression model as in our study, thus demographic and impairment variables were considered together. In our study, pain intensity was the single largest contributor to self-report of function (standardized $\beta = -0.396$), as in the study by Risberg et al.[26] These findings indicate that pain may be a critical factor to address following ACL reconstruction. The results of our study provide evidence to support the consideration of these impairments in designing rehabilitation interventions and return-to-sport guidelines for patients with ACL reconstruction.

Fear of movement/reinjury levels, as assessed by the TSK-11 questionnaire, also contributed significantly to self-report of function. Few studies have examined the role of fear of movement/reinjury in relation to sports performance and function following ACL reconstruction. While the influence of pain-related fear on the transition of acute to chronic pain has been well-documented in the spine literature,[11] the impact of fear on self-report of function and performance following ACL reconstruction is less clear. The findings of this study lend further support to the theoretical application of the fear-avoidance model in knee rehabilitation and identify fear of movement/reinjury as a potential target for ACL reconstruction rehabilitation guidelines.

It was not a purpose of this study to identify demographic variables associated with function because they are not factors modifiable through rehabilitation. However, it is important to note that gender and time from surgery were also significant contributors to self-report of function. Based on the direction of association, men tended to have higher scores on the IKDC subjective form than women. Previous studies of patients at least 2 years after ACL reconstruction have shown no gender differences in self-report of function[9] or lower scores for females.[22] In addition, IKDC scores improved as time from surgery increased. The finding is clinically observed and in agreement with other studies.[28,36]

The design of this study has strengths that include limiting subjects to patients who had been participating in moderate to high-level activities prior to surgery, the use of a 2-step, regression analysis, and the inclusion of a psychological variable. Considering the subject sample, the results have direct implications for the future development of return-to-sport guidelines. Our statistical methods were unique and allowed us to examine the individual contributions of a variety of impairment measures as they relate to 2 separate measures of function. Finally, while fear of movement/reinjury has been noted to be a concern of patients,[32] the influence of this psychological variable on self-report of function has only been reported in univariate analysis[17] prior to our study.

There are limitations to this study that require consideration. First, the study is a cross-sectional design, which prohibits comparison of longitudinal outcomes. Second, the criteria to perform the single-legged hop test were stringent, such that individuals with large quadriceps deficits, significant anterior knee joint laxity, and knee pain were not permitted to participate. Therefore, selection bias may be present in determining the association of knee impairments and single-legged hop performance because of the exclusion of individuals with poor measures in these areas, specifically at the 6-month evaluation time point. An additional limitation is the inclusion of 2 separate groups at 6 months and 12 months post-ACL reconstruction. This prohibited examination of a homogenous group of individuals. A final limitation is that this study included measurements taken by multiple testers. While inter-rater reliability for these measures was enhanced by biannual training sessions, this limitation should be considered when interpreting the results of the study.

The findings of this study identify important knee impairment and psychological factors that contribute to self-report of function. Future longitudinal studies are needed to examine the ability of the impairments identified in this study to predict participation restrictions. Other physical impairment

measures and self-report questionnaires have the potential to provide a better assessment of function in this population and should be examined in future studies. Ultimately, this information may be used in the development of rehabilitation criteria and return-to-sport guidelines aimed at maximizing performance and function following ACL reconstruction.

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