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Psychological factors are associated with return to pre-injury levels of sport and physical activity after ACL reconstruction

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Abstract

Purpose The impetus of anterior cruciate ligament reconstruction (ACLR) is to allow patients to return to sport and to remain engaged in physical activity. Many patients exhibit deficits in psychological domains of health-related quality of life which may impede return to sport and physical activity participation. Therefore, the purpose of this study was to examine the association of patient-based, specifically psychological, and functional outcomes with return to sport and physical activity.

Methods Forty participants, a minimum of 1-year post-ACLR, reported to the laboratory for one-testing session. Participants completed a series of patient-based and functional outcome assessments. Participants were also instructed to wear a pedometer for 1 week to monitor their daily steps.

Results Twenty-five participants (62%) did not return to sport and 29 participants (72%) did not average 10,000 steps per day. Individuals with elevated levels of self-reported kinesiophobia were 17% less likely to return to sport. Self-reported knee self-efficacy and knee-related quality of life accounted for 27.1% of the variance of average daily step counts.

Conclusions Psychological factors, specifically injury-related fear and self-efficacy, were associated more significantly than functional outcomes with return to sport and physical activity levels. Clinicians should examine psychological factors throughout rehabilitation in patients after ACLR. Future research should explore the effectiveness of psychoeducation techniques to decrease injury-related fear and enhance self-efficacy in this population.

Level of evidence III.

Keywords Physical activity · Anterior cruciate ligament reconstruction · Return to sport · Pedometer · Step counts

Introduction

The impetus of anterior cruciate ligament reconstruction (ACLR) is to allow high functioning, physically active individuals to return to desired levels of sports participation and to maintain recommended levels of physical activity [5]. However, approximately one out of three patients after ACLR fail to return to competitive levels of sports participation [2]. It has also been demonstrated that patients who have undergone ACLR spend less time in moderate-to-vigorous physical activity and have lower daily step count compared to healthy individuals [4, 15]. This is of concern as failing to engage in regular physical activity can increase the risk for several chronic diseases and associated comorbidities [25].

Currently, the majority of evidence regarding return to sport (RTS) and physical activity after ACLR has focused on the physical domain of health-related quality of life (HRQL), such as impairments, limitations, or restrictions [3, 10]. Health-related quality of life is a multidimensional patient-centred concept of health that incorporates the patient's personal, societal, spiritual beliefs, values, and preferences [9]. The domains of HRQL include: physical, social, emotional, psychological, spiritual, and economical [9]. Functional outcomes (i.e. single-leg hop) and patient-based outcomes (i.e. self-reported knee function) have been used to examine the

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different domains of HRQL in patients after ACLR to help inform the decision to RTS [3].

While the current evidence has included both functional and patient-based outcomes [3], little evidence has examined other contextual factors in the psychological domain that could affect RTS and physical activity, such as injury-related fear [10, 25]. Injury-related fear can negatively affect functional outcomes and increase the risk for subsequent reinjury in individuals post-ACLR [10, 18]. In addition, it has been suggested that the most important factor influencing RTS after ACLR is psychological readiness [3]. In a recent qualitative study, it was determined that injury-related fear was directly related to self-reported knee function and largely influenced the decision to RTS after ACLR [6]. Cumulatively, these studies suggest that psychological factors can have a significant influence on the ability to RTS following ACLR.

Currently, there is a gap in the literature that examines the impact of multiple facets of psychological readiness, including injury-related fear and self-efficacy, on RTS and physical activity levels in patients after ACLR. Furthermore, understanding the combination of factors, especially psychological factors, which limit the ability of ACLR patients to successfully RTS, restore pre-injury physical activity levels, and pursue physically active lifestyles is critical to achieve optimal patient outcomes. Therefore, the purpose of this study is to identify patient-based outcomes, including psychological factors, and functional outcomes that are associated with RTS status and physical activity levels in individuals with a history of ACLR. It was hypothesized that a combination of functional and patient-based outcomes, specifically psychological outcomes that examine injury-related fear and self-efficacy, would explain a significant amount of variance associated with RTS and physical activity levels in individuals with a history of ACLR.

Materials and methods

A modified cross-sectional design was used for this study. All participants reported to the laboratory for one testing session. This study consisted of a single group of individuals with a history of ACLR. The predictor variables included scores on patient-based and functional outcomes, and the dependent variables were RTS status (yes/no) and average daily step counts (steps/day). Informed consent was obtained prior to the start of the study and the study was approved by Old Dominion University (16-213) and the University of Kentucky Institutional Review Boards (43341).

Participants

Forty participants (24 female, mean age = 24.3 ± 4.1 years) were recruited from a physical therapy clinic and from a general student population between 2017 and 2018. No participants were lost to follow-up. Participants were a median of 5 (7) years from index ACLR (Table 1). Participants were eligible if they had a history of unilateral ACLR with or without concomitant meniscal pathology, were between the ages of 18 and 35, and self-reported clearance by a physician to RTS. Participants were excluded from the study if they were currently injured, reported concomitant collateral ligament or posterior cruciate ligament injury at the time of their index ACL injury, or had a history of concussion in past

Table 1 Participants' demographics

	RTS ($n = 15$) Mean (SD) Frequency (%) Median [IQR]	NRTS ($n = 25$) Mean (SD) Frequency (%) Median [IQR]	Total ($n = 40$) Mean (SD) Frequency (%) Median [IQR]	*p* value
Height (cm)	170.8 (8.6)	169.4 (9.6)	169.9 (9.1)	n.s.*
Weight (kg)	75.3 (17.2)	71.9 (13.8)	73.2 (15.1)	n.s.*
Age (years)	23.3 (4.4)	25.1 (4.4)	24.28 (4.2)	n.s.#
Sex				n.s.^
Females	11 (73.3%)	18 (72%)	25 (62.5%)	
Males	4 (26.7%)	7 (28%)	15 (37.5%)	
Time from Index ACLR (years)	4 [4]	7 [7]	5 [7]	n.s.#
Average daily step counts	7754.3 (2399.4)	9198.9 (2385.3)	8657.2 (2467.2)	n.s.*
Tegner Score (before injury)	8 [2]	9 [2]	9 [2]	n.s.#
Tegner Score (current level)	7.7 (1.5)	6.0 (1.2)	6.6 (1.5)	0.00*

RTS return to pre-injury sports participation, *NRTS* no return to pre-injury sports participation, *Tegner* Tegner Physical Activity Assessment, *n.s.* non-significant

*Independent *t* test

#Mann–Whitney *U* test

^Fishers exact

3 months. Participants were dichotomized into a RTS and no RTS (NRTS) group using the Tegner Physical Activity Assessment [22]. Participants were considered to have RTS if they scored within one of their pre-injury physical activity level status. This method was used to account for maturation as a limitation associated with the scale.

Procedures

After informed consent, participants completed a demographic questionnaire which assessed self-reported physical activity history, previous orthopaedic history, and anthropomorphic measurements such as age, weight, sex, and ethnicity. Additional questions regarding the ACL surgery, graft type, and rehabilitation were assessed. Additionally, participants completed the following patient-reported outcome measures (PROs): Fear-Avoidance Belief Questionnaire [26], Knee Injury and Osteoarthritis Outcome Score [20], Knee Self-Efficacy Scale [23], the Modified Disablement in the Physically Active Scale [12], Pain Catastrophizing Scale [21], Tampa Scale of Kinesiophobia-11 [27], and the Tegner Physical Activity Assessment [22]. Once the PROs were completed, the participants completed a series of functional tests which included: single leg hop for distance, triple hop for distance, crossover hop for distance, landing error scoring system-real time, and peak torque concentric isokinetic quadriceps and hamstring strength testing. After testing, participants were given a pedometer to wear for 1 week and encouraged to follow their normal routine. After 1 week, the participants followed up with the investigators to return the pedometer and step log. Completion of clinical outcome measures and use of the pedometer were counterbalanced to control for order effect. All data were collected by the primary author (S.E.B), who is a certified athletic trainer, and was not involved in the treatment or rehabilitation of any participant.

Instrumentation

Patient-reported outcome measures (PROs)

The Fear-Avoidance Belief Questionnaire (FABQ) is a 15-item questionnaire designed to evaluate fear-avoidance beliefs in patients with low back pain [26]. We utilized the amended version for use in patients with knee pathology, where “back” was changed to “knee” throughout the questionnaire and the FABQ-W was modified to the FABQ-Sport (FABQ-S) [19]. Higher scores represent elevated levels of fear-avoidance beliefs [26]. The Knee Injury and Osteoarthritis Outcome Score (KOOS) is a 42-item questionnaire that evaluates knee-related disability for individuals with a variety of knee conditions [20]. The KOOS has five domains: symptoms (KOOS-Sy), pain (KOOS-P), activities of daily living (KOOS-ADL), function in sport and recreation (KOOS-Sport), and quality of life (KOOS-QOL) [20]. A score of 100 on each subscale represents no disability [20]. The Knee Self-Efficacy Scale (KSES) is a 22-item questionnaire that measures self-efficacy following ACL injury [23]. The four subscales are scored separately, with higher scores representing increased self-efficacy [23]. The Modified Disablement in the Physically Active Scale (mDPA) is a 16-item generic questionnaire that measures HRQL [12]. The two domains: physical summary component (mDPA-PSC) and mental summary component (mDPA-MSC) are scored separately, with higher scores representing better HRQL [12]. The Pain Catastrophizing Scale (PCS) is a 13-item questionnaire that examines a patient’s frequency in engaging in pain catastrophizing behaviours, higher scores represent increased pain catastrophizing [21]. The Tampa Scale of Kinesiophobia-11 (TSK-11) is a valid and reliable 11-item questionnaire that evaluates fear of movement and re-injury in patients, with higher scores representing increased kinesiophobia [27]. The Tegner Physical Activity Assessment (Tegner) is a questionnaire that is used to evaluate an individual’s current physical activity level and physical activity level prior to injury [22].

Functional testing

Participants completed a series of functional tests suggested as a battery for return to sport decision making for post-ACLR patients [11]. Participants began with a 5-min stationary bike warm up. The uninvolved limb was tested first and participants received a 3-min rest period between tests.

The landing error scoring system-real time (LESS-RT) is a valid and reliable clinical assessment that is used to identify individuals at risk of lower extremity injury [17]. The participants were instructed to perform the task and were assessed using the defined criteria by Padua et al. [17]. The single-leg (SL) hop for distance, triple (TL) hop for distance, and crossover (CO) hop for distance measured limb power. All hops were completed as previously described [11]. The participant completed one practice trial followed by three test trials, with 30s for recovery between each trial. The total distance hopped was recorded at the mark closed to the toe (cm), and the average of the trials for each limb was used to calculate the limb symmetry index (LSI). The Biodex isokinetic dynamometer (Biodex System 4 Pro; Biodex Medical Systems, Inc., Shirley, NY) was used to assess concentric isokinetic quadriceps and hamstring strength at 60°/s, 180°/s, and 300°/s (Nm/kg) [11] with 1-min rest between each speed. Peak torque LSI was measured at each speed with 100% representing full symmetry and 0% representing full asymmetry. The LSI for each assessment was averaged and measured to the nearest tenth.

Pedometers

A pedometer (Digi-Walker SW-200; New Lifestyles Inc., Lees Summit, MO) was used to measure physical activity, similar to previous literature [14]. The participants were instructed to put the pedometer on in the morning near the hip joint, and to wear the pedometer at all times during the week except when showering, swimming, or sleeping [14]. They were instructed to log their steps each night on the step log. Throughout the 1-week period, the participants received a daily reminder to log their steps each night, and to reset the pedometer before going to sleep [14]. Average steps over the 1-week period were used for analysis.

Statistical analysis

All statistical analyses were conducted with SPSS software (v23.0, SPSS, Inc., Chicago, IL, USA). Independent *t* tests and Chi square analyses were used to determine between-group differences in demographics. Mean values for the SL hop series and peak torque for the uninvolved and involved limbs were used to calculate LSI for each participant, and were calculated by: involved limb/uninvolved limb × 100. For linear regression analyses, it has been suggested a minimum of ten participants should be included per predictor variable [7, 8]. As a result, it was decided a priori that no more than 4 predictor variables would be included in the final regression models. A binary logistic regression was used to determine patient-based and functional outcomes associated with RTS (yes or no). To reduce the number of potential explanatory variables, bivariate analyses were completed between the predictor variables and each dependent variable to identify factors to include into the initial model. A significance level of ≤ 0.10 was used to determine which predictor variables entered the initial model. The predictor variables in the initial model were assessed for multicollinearity using a Variance Inflation Factor based on linear regression methods. The remaining variables which had the strongest bivariate correlation to RTS and exhibit acceptable levels of collinearity were entered into a backwards stepwise model with a significance level of ≤ 0.05.

Separate stepwise multiple linear regression analysis was conducted with PRO scores and functional outcome scores as predictor variables and average daily steps count serving as the dependent variable. A series of correlation analyses between each functional variable and average daily steps count were performed to reduce the number of predictor variables. All predictor variables with $r > 0.20$ were eligible for inclusion in the model. Predictor variables were assessed for collinearity and if strongly correlated ($r > 0.70$), only the variable with the strongest correlation to average daily steps count moved forward. Next, at each step a predictor variable was removed if it did not significantly contribute to the predictive value of the model (R^2). The overall percent of the explained variance (R^2) for the regression analysis was identified. The regression coefficient (β), the constant, the *p* values, confidence intervals, and the individual predictive power of each variable were calculated. Significance was set a priori at $p < 0.05$. All data were collected and managed in REDCap (Research Electronic Data Capture), an electronic data capture tool.

Results

Twenty-five participants (62%) did not RTS and 29 participants (72%) did not average 10,000 steps per day. There was a significant difference between the RTS and NRTS groups for current level of activity on the Tegner ($p = 0.00$), but there were no significant differences in pre-injury Tegner Scores between the RTS and NRTS groups. There were no significant differences in anthropometric measures and time since index ACLR between the RTS and NRTS groups (Table 1).

Predictors of self-reported return to pre-injury sport

Bivariate analyses determined that the TSK-11 (18.2 ± 5.3), KOOS-Symptoms (81.5 ± 13.2), and KSES-Future (5.7 ± 2.6), with time from index ACLR included as a covariate, were associated with RTS and met inclusion criteria for the model (Table 2). KOOS-Symptoms were removed after the backwards regression, and the final model included the TSK-11, KSES-Future, and time from index ACLR (Table 2). Holding future knee self-efficacy and time from index ACLR constant, for every point increase on the TSK-11, individuals were 17% less likely to RTS (no RTS = 19.7 ± 5.3, RTS = 15.7 ± 4.4).

Predictors of average daily step count

Univariate analysis demonstrated LESS-RT, CO hop for distance, peak torque concentric hamstring strength at 180°/s and 300°/s, KOOS-Sport, KOOS-QOL, KSES-ADL, KSES-Total, FABQ-S, FABQ-Total, PCS, and RTS were associated with average daily step counts (Table 3). The LESS-RT, KOOS-QOL, KSES-ADL and RTS were selected for the model (Table 4), and explanation can be found in Table 3. The average LESS-RT score was 6.1 ± 3.2, average KOOS-QOL score was 74.2 ± 17.6, average KSES-ADL was 8.9 ± 2.2, and 37.5% of the sample RTS. In the stepwise multiple linear regression model, the KSES-ADL and KOOS-QOL accounted for 27.1% of the variance of average daily step counts in individuals with a history of ACLR (Table 4).

Table 2 Logistic regression model to determine predictors of RTS

Model	Independent variables	β	SE	Wald statistic	p value	OR (95% CI)
1	TSK-11	−0.20	0.10	4.2	0.04	0.82 (0.68–0.99)*
	Time from Index Surgery	−0.30	0.13	5.6	0.02	0.74 (0.57–0.95)*
	KOOS-Symptoms	0.03	0.05	0.5	n.s.	1.03 (0.94–1.14)
	KSES-Future	0.19	0.28	0.5	n.s.	1.21 (0.70–2.14)
2	TSK-11	−0.19	0.09	4.1	0.04	0.83 (0.69–0.99)*
	Time from Index Surgery	−0.31	0.13	6.3	0.01	0.73 (0.57–0.94)*
	KSES-Future	0.33	0.21	2.6	n.s.	1.39 (0.93–2.09)

TSK-11 Tampa Scale of Kinesiophobia-11, *KOOS* Knee Injury and Osteoarthritis Outcome Score, *KSES* Knee Self-Efficacy Scale, *n.s.* non-significant

*Statistically significant

Table 3 Selection of eligible predictor variables for stepwise regression model

Predictor variable	Correlation coefficient	Included	Reason for inclusion/exclusion
LESS-RT	−0.4	Yes	Strongest functional outcomes associated with physical activity in this sample
Crossover hop for distance LSI	−0.2	No	Ceiling effect with LSI present in this sample
Peak torque hamstring 180°/s LSI	0.4	No	Ceiling effect with LSI present in this sample
Peak torque hamstring 300°/s LSI	0.2	No	Ceiling effect with LSI present in this sample
KOOS-Sport	−0.3	No	Eliminated due to collinearity with KOOS-Quality of Life
KOOS-Quality of Life	−0.4	Yes	Changes in quality of life have been associated with physical activity modification
KSES-ADL	0.4	Yes	Strongest patient-oriented outcome associated with physical activity in this sample
KSES-Total	0.2	No	Eliminated due to collinearity with KSES-ADL
FABQ-S	0.3	No	Eliminated due to collinearity with KOOS-Quality of Life
FABQ-Total	0.3	No	Eliminated due to collinearity with KOOS-Quality of Life
PCS	0.3	No	Eliminated due to floor effect of the instrument observed in this sample
RTS	−0.3	Yes	Tegner Physical Activity Assessment is responsive to physical activity change in ACLR patients

LESS-RT Landing Error Scoring System–Real Time, *LSI* Limb Symmetry Index, *KOOS* Knee Injury and Osteoarthritis Outcome Score, *KSES* Knee Self-Efficacy Scale, *ADL* activities of daily living, *FABQ-S* Fear-Avoidance Belief Questionnaire Sports Subscale, *PCS* Pain Catastrophizing Scale, *RTS* return to pre-injury sports participation

Table 4 Independent variables identified as significant predictors for PA after ACLR

Model	Independent variables	β (95% CI)	R^2	Adjusted R^2	Constant	F	p value
1	KSES-ADL	477.3 (144.9–809.5)	0.18	0.16	4387.8	8.45	0.006*
2	KSES-ADL	476.9 (167.0–786.7)	0.31	0.27	8087.1	8.26	0.004*
	KOOS-QOL	−49.8 (−88.6 to −11.0)					0.013*
3	KSES-ADL	433.6 (129.8–737.4)	0.37	0.32	8773.4	7.04	0.006*
	KOOS-QOL	−38.8 (−78.2 to 0.7)					n.s
	LESS-RT	−184.1 (−383.8 to 15.6)					n.s
4	KSES-ADL	415.7 (132.1–699.2)	0.47	0.41	9049.6	7.72	0.005*
	KOOS-QOL	−25.7 (−63.9 to 12.5)					n.s
	LESS-RT	−258.4 (−453.6 to −63.1)					0.011*
	RTS	−1689.7 (−3032.6 to −346.7)					0.015*

PA physical activity, *LESS-RT* Landing Error Scoring System–Real Time, *RTS* return to pre-injury sports participation, *FABQ* Fear-Avoidance Belief Questionnaire, *n.s.* non-significant

*Statistically significant

Discussion

The most important findings of the present study are as follows: (1) injury-related fear was associated with RTS, even after controlling for future knee self-efficacy and time since index ACLR, and (2) knee self-efficacy and knee-related quality of life were associated with step counts in patients after ACLR. Additionally, it was observed that this cohort of individuals with a history of ACLR averaged approximately 8657 daily steps.

This study contributes to the growing body of literature that demonstrates the impact of psychosocial impairments on RTS in patients after ACLR. While most of the current literature examines psychosocial impairments in an acute ACLR population [1, 2, 16], this study examined these factors in individuals ranging from 1 to 14 years post-index ACLR. These results indicated injury-related fear, as measured by the TSK-11, and time from index ACLR was associated with RTS. In a recent qualitative study, Burland et al. [6] interviewed a cohort of individuals with a history of ACLR who were at least 1 year post-operative to determine what factors were associated with their decision to RTS. It was discovered that the decision to RTS was based primarily on psychosocial factors, including injury-related fear and self-efficacy [6]. In conjunction with Burland et al. [6], this study quantitatively highlights that psychosocial impairments are present years after ACLR and affect the patient's ability to RTS. The present study also suggests that psychosocial impairments may affect physical activity engagement in this population.

The included participants took 1350 daily steps less than the recommended daily step count of 10,000 steps per day by [25]. This phenomenon has also been previously demonstrated in a post-ACLR population [4, 15]. Although the impetus of ACLR is to allow individuals to return to a physically active lifestyle, it appears that patients after ACLR are consistently failing to engage in the recommended levels of daily steps suggested for maintenance of long-term health. This is concerning as failure to engage in regular physical activity can increase the risk for the development of chronic disease and comorbidities [25]. While the included participants did not meet the goal of 10,000 steps per day [25], we identified the KSES-ADL and KOOS-QOL were predictive of average daily step counts. Interestingly, previous research has demonstrated that preoperative knee self-efficacy predicted return to previous levels of physical activity, symptoms, and muscle function at 1-year post-reconstruction [24]. This is in agreement with our findings which suggest that knee self-efficacy plays an important role throughout the ACLR rehabilitation and post-recovery process.

Interestingly, lower KOOS-QOL scores were associated with increased daily step counts. This may be due to the time since index ACLR. This sample was a median of 5 years post-index ACLR, and it may be that those individuals who did not average 10,000 steps per day may have modified their activity preferences after ACLR which could have led to an increase in knee-related quality of life. These individuals may have recalibrated their knee-related quality of life because of the lack of engagement in activities that make them aware of their knee. This phenomenon is called response shift, where changes in self-evaluation and appraisals affect perceived HRQL [13]. In this particular sample, patients who were no longer engaging in physical activity may have undergone response shift, reconceptualizing how they view their knee, and thus improving perceived quality of life. Therefore, individuals who RTS may experience decreased knee-related quality of life as a result of increased exposure to situations that make them aware of the discomfort in their knee.

This study is not without limitations. First, all step counts were self-reported by each participant. The authors assumed that all participants used the pedometer and accurately reported their step counts on the log. Second, the authors have used the Tegner to determine RTS. While not statistically significant, those individuals who were dichotomized into the NRTS were further out from their index ACLR compared to those in the RTS group. Individuals may not have RTS because of transitions from high school to college or beyond. Third, the authors did not document occupation status of all participants which could have influenced daily step counts. Lastly, some scores on the PROs may not accurately represent the participant's perspective as participants may have experienced burdened as a result of completion of many PROs simultaneously.

Conclusion

Psychological factors, specifically injury-related fear and self-efficacy, were associated more significantly than functional outcomes with return to sport and physical activity levels. Future research should explore the effectiveness of psychoeducation techniques to decrease injury-related fear and enhance self-efficacy in this population.

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Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to disclose.

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