

## PAPER DETAILS

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PAGES: 305-309

ORIGINAL PDF URL: <https://dergipark.org.tr/tr/download/article-file/1460484>

## Original investigation

# The Relationship Between Joint Awareness and Muscle Strength, Return to Sports and Quality of Life After ACL-R Surgery in Recreational Athletes: A Cross-Sectional Study

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Received: 25.04.2020; Accepted: 18.08.2020; Available Online Date: 15.10.2020

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**Cite this article as:** Akinci I, Ozturk F, Ozcadirci A, Atay OA, Kinikli GI. The Relationship Between Joint Awareness and Muscle Strength, Return to Sports and Quality of Life After ACL-R Surgery in Recreational Athletes: A Cross-Sectional Study J Basic Clin Health Sci 2020; 4:305-309.

## ABSTRACT

**Objectives:**The aim of this study was to investigate the relationship between joint awareness, muscle strength, return to sports and quality of life in patients with anterior cruciate ligament reconstruction (ACL-R) with hamstring tendon autografts.

**Patients and Methods:**Aged between 18-40 years 23 patients with ACL-R at least one year after the surgery participated in the present study. Muscle strength was measured with ISOMED 2000 isokinetic dynamometer. Joint awareness, quality of life and return to sport were evaluated respectively by using Forgotten Joint Score (FJS), Anterior Cruciate Ligament-Quality of Life Questionnaire (ACL-QoL) and Anterior Cruciate Ligament-Return to sport after Injury (ACL-RSI).

**Results:**There was a moderate correlation between FJS-12 with ACL-RSI ( $r=0.441$ ;  $p=0.035$ ), and ACL-QoL scores ( $r=0.505$ ;  $p=0.014$ ). A strong positive correlation was found between ACL-RSI and ACL-QoL scores ( $r=0.827$ ;  $p<0.001$ ). There was no correlation between muscle strength and FJS-12, ACL-RSI, and ACL-QoL scores in the patients with ACL-R ( $p>0.05$ ).

**Conclusion:**This current study showed that joint awareness was related to return to sports and quality of life in the long term following ACL-R. In conclusion, we recommend minimizing joint awareness for a better quality of life and returning to sports.

**Keywords:** awareness, muscle strength, anterior cruciate ligament, return to sports, quality of life.

## INTRODUCTION

Anterior cruciate ligament (ACL) injuries are one of the most common knee injuries in sports. In the United States of America (USA), approximately 200,000 ACL injuries occur annually; 70% of them occur during sports such as football, volleyball, basketball, gymnastics and skiing (1). ACL injuries are treated conservatively or reconstructively. ACL reconstruction (ACL-R) is the process of reconstruction of the injured ligament by fixing the grafts to fix the normal function of the injured ligament and fixing them with tunnels opening to the femur and tibia (2). While tendon allografts are used in 40% of ACL-R performed in the USA, autografts from hamstring, patellar tendon or quadriceps femoris (QF) tendon are used in 60% (2). The primary goal of ACL-R is to minimize the risk of re-injury, provide to return daily living activity by restoring muscle strength as soon as possible.

Restoring muscle strength after ACL surgery is considered one of the criteria for returning to recreational sports activities (3, 4). In addition, it is reported that after reconstruction, there is a deterioration in the quality of life in the long term due to the persistent symptoms of the individuals and they are reflected in the activities of daily living (ADL). Filbay et al. (5) stated that poor quality of life is associated with surgery in 32 patients with ACL-R even at least 5 years after surgery.

After surgery, the sense of joint position may be lessened due to the decreasing of proprioceptive inputs inside the joint and patients may not feel their joints as normal. Thus, this feeling may cause increased joint awareness due to high concentration on that joint. (6). This sense of awareness may decrease patient's quality

of life and delay the return to recreational sports. Therefore, joint awareness may be an issue that 'should be considered by the patient after ACL reconstruction. Frequently evaluated parameters such as pain, function and muscle strength may be lacking in what we need to know about the patient. In a study conducted in 2012, a questionnaire focusing on patient's joint awareness in their daily lives have also supported this argument (7).

One of the ultimate goals of surgery is to prevent joint awareness. The surgeon wants to achieve a normal knee with the same feeling and stability as before the surgery. Also, for optimal effectiveness of the treatment, it is desirable to complete objective measurements of the clinicians with subjective assessment of the patient (6). Therefore, it would be clinically relevant to investigate the relationship between patient-reported outcomes and clinical measurements in patients with ACL-R. Therefore, the aim of this study was to investigate the relationship between joint awareness, muscle strength, return to sport and quality of life in patients with ACL-R with hamstring tendon autografts.

## METHODS

### Participants

This study was carried out on aged 18–40 years 23 male patients who had ACL-R with autogenous hamstring tendon autograft (HTG) and performed recreational sports activities at least 1 to 3 times weekly. Patients who have undergone lower extremity surgery other than ACL-R and signs of infection were excluded from the study. Patients who could not tolerate isokinetic test measurements were also excluded. The ethics committee approval required for the study was approved by Hacettepe University Non-Interventional Clinical Research Ethics Committee with the decision number GO 18/103-29.

### Joint Awareness

The Forgotten Joint Score (FJS-12), which is considered valid and reliable in individuals with ACL injury was used (8). The FJS-12 consists of 12 questions evaluating the joint awareness of the individual during daily living activity (ADL) with a 5-point Likert system (None: 0, Almost none: 1, Rarely: 2, Sometimes: 3, Always: 4). In scoring, all answers are summed and divided by the total number of questions answered. The average value is multiplied by 25 and subtracted from 100 to make the total score between 0–100. High scores indicate how much (%) the patient can forget the operative side or adapt to ADL.

### Isokinetic Muscle Strength

Patients were placed on the seat of the isokinetic dynamometer with the trunk vertical and the hip 90° flexed and the knee motion angle adjusted to 0° and 90° flexion (0° knee extension). The bands of the isokinetic system were passed over both shoulder and abdomen of the participants to prevent compensatory movements during the test. The center of motion of the dynamometer was adjusted to be at the level of the lateral femoral condyle. The force arm of the dynamometer, which makes the knee flexion and extension movement, was fixed to the distal end of the tibia



**Figure 1.** Isokinetic muscle strength analysis.

with Velcro tape and during the test, the participants were held by the arms on both sides of the bed. Firstly, the test was applied to the non-operated extremity followed by the operated extremity. Before starting the test, the test procedure was explained to the participants in detail and the tests were practiced once (Figure 1).

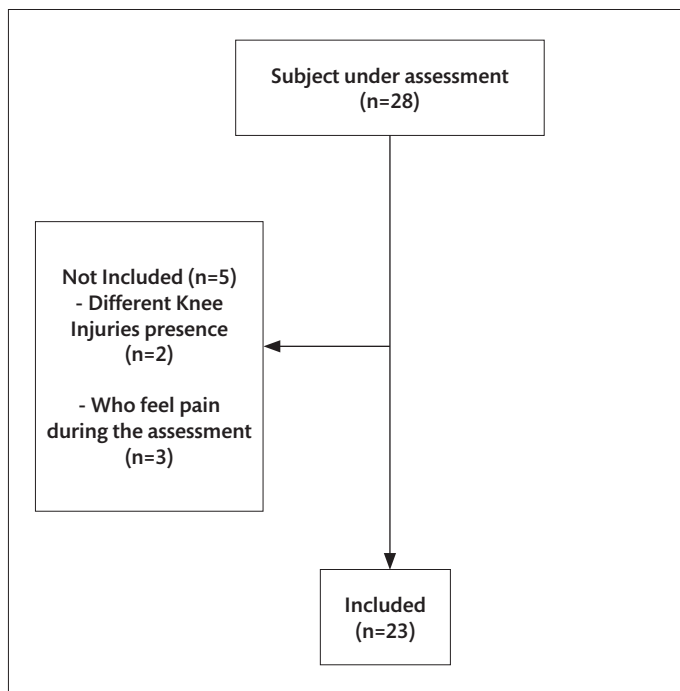
The test measurement protocol included 5 repeats at a rate of 60°/sec for both QF and hamstring as a concentric-concentric contraction; then 10 repetitions at a rate of 180°/sec (9, 10). Peak torque was recorded as Newton meter/kilogram (Nm/kg). In the isokinetic test, the concentric Quadriceps Index and Hamstring Index at angular speeds of 60°/sec and 180°/sec [Index (%)=(Operated side Peak Torque/Unoperated side Peak Torque) x100 were calculated and recorded.

### Return to Sports

Anterior Cruciate Ligament-Return to Sport after Injury Scale (ACL-RSI) was used to evaluate return to sports after the ACL injury. There are 12 questions on the scale consisting of emotions, self-confidence in performance and risk assessment. Each of the questions is scored between 0–10 according to Visual Analog Scale (VAS). High scores indicate the subjective perception of the patient about returning to sports (11).

### Quality of Life

Anterior Cruciate Ligament-Quality of Life questionnaire (ACL-QoL) was used to evaluate the quality of life. ACL-QoL



**Figure 2.** Patient flow diagram.

is a specific scale for anterior cruciate ligament injury, which examines a total of 32 main questions, including symptoms and physical complaints, work-related concerns, hobbies, sports or competition participation, lifestyle, and social-emotional issues. The questions were answered on a 100 mm VAS. The total score of each topic was divided by 5 and multiplied by 100. High scores indicate a high quality of life (12).

### Statistical Analysis

G\*Power program was used in power analysis while determining the number of samples. When the hamstring index at 60°/sec angular velocity in the isokinetic system is considered as the main outcome measure, it is envisaged to include at least 23 individuals with a  $p < 0.05$  significance level with 90% power ratio. Data were analyzed using IBM SPSS 22.0 (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0, Armonk, NY: IBM Corp.). The suitability of the variables to normal distribution was examined by visual (histogram and probability graphs) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). While performing descriptive analyzes, mean and standard deviation are given for numerical variables showing normal distribution; for variables that do not show normal distribution, median, minimum-maximum and 25th-75th percentiles values were given. Correlations coefficients and statistical significance were determined using the Spearman test since the data were not normally distributed. Correlation coefficients were low or insignificant for values between 0.05 and 0.30; low-medium degree for the values between 0.30-0.40; medium level for the values between 0.40-0.60; good level for values between 0.60-0.70; perfect correlation for values 0.70-1.0. A 5% type-1 error level was used to infer statistical significance.

## RESULTS

Twenty-eight patients were included in the study, but 2 patients were excluded from the study because it was found that they have undergone a different knee surgery and 3 people felt pain during the isokinetic muscle strength test. The flow diagram for the study is shown in Figure 2. The demographic characteristics of the 23 patients were shown in Table 1.

**Table 1.** Sociodemographic characteristics of patient with ACL-R

	Mean (SD, Minimum-Maximum)
Age	28.52 (6.88, 19-40)
Height (cm)	180.60 (6.30, 166-190)
Weight (kg)	86.47 (15.93, 57-119)
Body mass index (kg/m <sup>2</sup> )	26.34 (4.17, 20.68-32.96)
Injury mechanism n (%)	
Contact injury	6 (26.08%)
Contactless injury	17 (73.91%)
Sport injury n (%)	
Football	7 (30.43%)
Basketball	5 (21.73%)
Volleyball	1 (4.34%)
Handball	2 (8.68%)
Motocross	1 (4.34%)
Wrestle	3 (13.04%)
Judo	3 (13.04%)
Ski	1 (4.34%)
Patient-reported outcomes	
FJS-12	77.25 (43.75-100, 62.50-98.00)
ACL-RSI	57.25 (26.66-91.66, 47.91-74.75)
ACL-QoL	37.44 (19.04-59.64, 28.28-49.40)

ACL-RSI: Anterior Cruciate Ligament-Return to Sport after Injury; ACL-QoL: Anterior Cruciate Ligament-Quality of Life questionnaires; FJS-12: Forgotten Joint Score.

The patients with ACL-R were evaluated on average  $33.26 \pm 17.12$  months after surgery. The mean body mass index (BMI) of the patients with ACL-R was  $26.34 \pm 4.17$  kg/m<sup>2</sup>. Min-max and percentiles (25th and 75th) values of data that do not show normal distribution (FJS-12, ACL-RSI, and ACL-QoL) are shown in Table 1.

There was no correlation between FJS-12 and isokinetic knee muscle strength (both HI and QI at angular velocity of 60°/s and 180°/s) (Table 2).

**Table 2.** Correlation between isokinetic muscle strength and patient-reported outcomes

	ACL-RSI		ACL-QoL		FJS-12	
	r*	p	r*	p	r*	p
QI (60°/s)	-0.269	0.215	-0.034	0.879	-0.333	0.121
QI (180°/s)	-0.277	0.201	-0.235	0.280	-0.244	0.263
HI (60°/s)	-0.231	0.288	0.024	0.914	-0.083	0.706
HI (180°/s)	0.271	0.211	0.259	0.233	0.179	0.414

QI: quadriceps index; HI: hamstring index; ACL-RSI: anterior cruciate ligament-return to sport after injury; ACL-QoL: anterior cruciate ligament-quality of life questionnaires; FJS-12: forgotten joint score.

\* Spearman correlation coefficient

There was a moderately positive correlation between FJS-12 and ACL-RSI ( $r=0.441$ ;  $p=0.035$ ); ACL-QoL scores ( $r=0.505$ ;  $p=0.014$ ); while the ACL-RSI and ACL-QoL scores had highly ( $r=0.827$ ;  $p<0.001$ ) statistically significant correlation (Table 3).

**Table 3.** Correlation between patient-reported outcomes

	ACL-RSI		ACL-QoL		FJS-12	
	$r^*$	$p$	$r^*$	$p$	$r^*$	$p$
ACL-RSI			0.872	0.000	0.441	0.035
ACL-QoL	0.872	0.000			0.505	0.014
FJS-12	0.441	0.035	0.505	0.014		

ACL-RSI: anterior cruciate ligament-return to sport after injury; ACL-QoL: anterior cruciate ligament-quality of life questionnaire; FJS-12: forgotten joint score.

\*Spearman correlation coefficient.

## DISCUSSION

The results of the current study showed that joint awareness is related to return to sports and quality of life in the long-term following ACL-R whereas it is not correlated with the isokinetic muscle strength. In addition, return to sports was associated with quality of life.

Patients who underwent ACL-R reported that knee pain and instability were not usually present at 6 months after surgery, but that their knees were not 'the same as before reconstruction' (6). In general, individuals with healthy and functional joints are not aware of their joints in daily life, so their joints can be considered "forgotten". However, after any injury around the joint, the attention of the patients is directed to the injured joint and joint awareness can be developed in this area. Joint awareness can be defined as the involuntary perception of any joint. The term "joint awareness", a new approach that was first described after arthroplasty surgery, may also be relevant to the evaluation results of ACL-R. However, there are limited studies in the literature examining joint awareness after ACL-R surgery (6, 13). In the first study about joint awareness in patients with ACL-R, Behrend et al. (13) found FJS-12 to be valid after ACL-R. In another study, Behrend et al. (6) concluded that joint awareness is appropriate in assessment of medium and long-term outcomes of patients after ACL-R. The authors stated that the FJS-12 questionnaire had 71 points in these patients. The FJS-12 score was 77 in the current study. The high and similar scores of the two studies may indicate that there is little awareness in the mid-term after ACL-R and that these individuals may have a better quality of life when returning to sports.

It is known that the insufficiency in muscle strength of individuals with ACL-R makes it difficult to adapt both sportive activities and daily living activities while adversely affect their return to sports and quality of life. However, restoration of muscle strength and knee joint function cannot be considered separately from joint awareness. Considering the importance of components of muscle strength and joint awareness, it is noteworthy that there was no study investigating the correlation between the FJS-12 scores and muscle strength in the current literature. Therefore, we

investigated the relationship between joint awareness, isokinetic muscle strength, return to sports and quality of life scores. While joint awareness is not correlated with isokinetic muscle strength; it was correlated with quality of life and return to sports. According to these findings, decreased awareness of the joints can facilitate the return to sports and improve the quality of life.

Sadeqi et al. (14) examined the progression of sports-back progression of ACL-R patients and stated that professional athletes who scored 60 points in the post-operative 6th month were more likely to return to the performance level before ACL-R at 2 years after surgery. Previous studies showed that 56 points are low, and 75 points are high for ACL-RSI for returning to sports (15–18). In the present study, the ACL-RSI score was lower than the average scores in the literature. Decreased return to sports scores of the patients who underwent ACL-R in our study suggests that they are still not ready to achieve their previous performances after the surgery. In addition, there was no correlation between knee extensor and flexor muscle strength and ACL-RSI in our study. Although muscle strength reached a certain level, the fact that the muscle strength was not associated with ACL-RSI may be due to the recreational level of sports of ACL-R patients. Furthermore, existing literature suggest that return to sports should not be merely a decision taken at the end of the recovery and rehabilitation process; instead, it is a consensus that return to sports should be considered as a continuation of the recovery and rehabilitation process (19). Physiotherapists who will manage a successful rehabilitation process should benefit from biopsychosocial models for individual factors that may affect the return to sports. Because fear of re-injury, low self-efficacy and lack of motivation affect return to sports in patients with ACL-R (19).

It is well known that adequate muscle strength is a necessary component for returning to sports. However, deciding on return to sports based solely on muscle strength cannot indicate whether individuals are truly psychologically prepared for a successful return to sports. The lower ACL-RSI scores compared to the literature suggest that it may be beneficial to use sports-specific approaches that increase return to sports and reduce performance anxiety in the rehabilitation process rather than focusing solely on muscle strength.

Lafave et al. (20) reported that the mean ACL-QoL score was 77.5 24 months after anterior cruciate ligament reconstruction, while Leiter et al. showed that the ACL-QoL score was 67.4 points (21). In our study, the mean ACL-QoL score of patients with ACL-R was found to be  $37.57 \pm 11.61$ , and this score was lower when compared with the existing literature. These low scores indicate that the individuals evaluated in our study had a low quality of life. The application of approaches aimed at increasing the quality of life of individuals may be beneficial in terms of supporting the development of other factors such as return the sport related to the quality of life. In our study, no correlation was found between QF, hamstring muscle strength and ACL-QoL scores. Considering the functions of the knee joint in daily life, muscle strength is expected to affect the quality of life. Unsurprisingly, only muscle strength is not sufficient to have a functional knee joint during



daily life.

The most important limitation of this study is that joint awareness was not made with proprioceptive measurement. Also, another limitation of our study was the lack of data on preoperative isokinetic knee muscle strength, quality of life, return to sports, and activities of daily living in individuals with ACL-R. It is important to evaluate kinesiophobia in the long-term after surgery in patients with ACL-R. In this respect, the lack of evaluation of the fear of movement in this study is another limitation.

In considering the long-term joint awareness, muscle strength, return to sports, and quality of life results of individuals after ACL-R, joint awareness should be on the agenda of physiotherapists during the rehabilitation process. Patients should also be encouraged to decrease joint awareness for a successful readiness to sports accompanying with a better quality of life.

**Informed Consent:** Consent was taken from all participants

**Compliance with Ethical Standards:** Hacettepe University Non-Interventional Clinical Research Ethics Committee GO 18/103-29

**Peer-review:** Externally peer-reviewed.

**Author Contributions:** Concept - GIK; Design - IA, GIK; Supervision - OAA, GIK; Fundings - OAA, GIK; Materials - IA; Data Collection and/or Processing - IA, FO, AO; Analysis and/or Interpretation - FO, AO; Literature Search - IA, GIK; Writing Manuscript - IA, FO, AO; Critical Review - OAA, GIK

**Conflict of Interest:** No conflict of interest was declared by the authors.

**Financial Disclosure:** The authors declared that this study has received no financial support.

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