Knee Surg Sports Traumatol Arthrosc (2015) 23:2367–2375
DOI 10.1007/s00167-014-3404-8

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Turkish version of the Anterior Cruciate Ligament Quality of Life questionnaire

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Received: 8 May 2014 / Accepted: 22 October 2014 / Published online: 8 November 2014

Abstract
Purpose To test the measurement properties of Turkish version of the Anterior Cruciate Ligament Quality of Life (ACL-QOL) questionnaire.
Methods One hundred and nineteen patients with ACL reconstruction (ACL-R) completed internal consistency, agreement, construct validity, floor and ceiling effect analyses. Eighty out of 119 patients with ACL-R completed Turkish version of the ACL-QOL questionnaire twice for the test–retest reliability. A subgroup of thirty-nine patients undergoing physiotherapy were also asked to answer the ACL-QOL questionnaire, the Lysholm Knee Scale (LKS), Knee Outcome Survey—Activities of Daily Living Scale (KOS–ADLS) and the short form 36 (SF-36) at pre-operative, 16th week and 2 years post-operatively to assess responsiveness.
Results The questionnaire had high internal consistency (Cronbach's $\alpha = 0.95$). The paired t test showed no significant difference between the test–retest means. The intraclass correlation was excellent for reliability and agreement in five domains and overall score (ICC 0.95, 0.95, 0.97, 0.95, 0.96 and 0.95; $p < 0.001$). The standard error of measurement and the minimum detectable change (MDC_{95}) were found to be 3.1 points and 8.7 points, respectively. The questionnaire showed a fair correlation ($r = 0.23$) with LKS and a poor correlation ($r = 0.14$) with KOS-ADLS; good and very good construct validity ($r = 0.51$, $r = 0.62$) with SF-36 physical component score and mental component score, respectively. No ceiling and floor effects were observed except the subdomain of 'work-related concerns' (22.9 %). A dramatic effect size was demonstrated at the 16th week (2.1) and 2 years (1.1) of follow-up.
Conclusion Turkish version of the ACL-QOL questionnaire is a reproducible and responsive instrument that can be used in clinical studies.
Level of evidence Diagnostic study, Level I.

Keywords The Anterior Cruciate Ligament Quality of Life (ACL-QOL) questionnaire · Knee · Validity · Reliability · Turkish version

Introduction

Assessing patients' perception about their quality of life and improvements in clinical and functional status is becoming more routine in scientific and clinical areas [8, 13]. 'Quality of life' is described as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity according to the World Health Organization [30]. There are many subjective and objective scales used to measure the amount of abnormal translation in pre- and post-treatment evaluation of patients

Electronic supplementary material The online version of this article (doi:10.1007/s00167-014-3404-8) contains supplementary material, which is available to authorized users.

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with ACL injury. Among these are radiographic findings, functional tests, proprioception, return to activity and pain and strength measures. However, there is not yet a measure of subjective, patient-based quality of life assessment for these patients. The use of health-related quality of life (HRQOL) questionnaires allows clinical professionals to explore many areas of interest, including the patient's understanding of his/her condition and satisfaction [4].

The International Knee Documentation Committee (IKDC) subjective knee form [10], the Tegner Activity Scale [26], Knee Injury and Osteoarthritis Outcome Score [23] (KOOS), Lysholm Knee Scale (LKS) [19], Knee Outcome Survey—Activities of Daily Living Scale [11] (KOS-ADLS) are frequently used questionnaires in ACL literature. Only a small number of questionnaires to assess knee function have been translated into Turkish and validated, including the KOOS [24], the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) [29], the Lysholm Knee Scale [3], the KOS-ADLS [6]. The KOOS is a new instrument developed for assessing posttraumatic or primary osteoarthritis, which is a more detailed version of the WOMAC index. The KOS-ADLS combines questions on symptoms and functional limitations for patients with various painful knee conditions. Although these joint-specific questionnaires are useful to provide information that is more focused on the affected joint, some of them measure similar features. In addition, these scores are based mainly on clinical findings, subjective complaints of the patients or a combination of these factors, but none of these instruments assesses the disease-specific HRQOL adequately. However, the ACL-QOL questionnaire represents a purely subjective, patient-based evaluative instrument and measures symptoms and physical complaints, work-related concerns, recreational activities and sports participation, lifestyle and social and emotional health status relating to the knee and ACL deficiency [22]. Furthermore, it is recommended that the ACL-QOL questionnaire be used in conjunction with currently available objective and functional outcome measures during the pre-operative, conservative and post-surgery treatment of patients with chronic ACL deficiency.

There are plenty of questionnaires in the area of the anterior cruciate ligament injuries though many studies have shown that all the patients do not return to their previous activity level or sport in spite of good knee function. This may suggest that other factors such as disease-specific health-related quality of life may influence return to sport outcomes, and thus, demonstrate the importance of examining such factors. Clearly, reliable, valid and responsive instruments are required in order to enable accurate and complementary examination of the quality-of-life factors relevant to returning to sport following ACL injury and surgery. There are currently no studies that evaluate the HRQOL in the Turkish-speaking population who have experienced ACL reconstruction (ACL-R). A valid and reliable instrument for this purpose is needed. Therefore, the purpose of this study was to translate and cross-culturally adapt the ACL-QOL questionnaire to Turkish and to assess the measurement properties of the translated version.

The first hypothesis of the study was that it would be possible to translate and culturally adapt the ACL-QOL questionnaire to Turkish so that it would be understandable and applicable for Turkish-speaking societies. It was expected that the Turkish version of the ACL-QOL questionnaire would provide high internal consistency, test–retest reliability, agreement and responsiveness.

Materials and methods

The study was approved by Hacettepe University Ethics Committee (LUT 09/166-21). All patients were provided with written informed consent forms prior to participation, were assured of their right to refuse to participate and were told that the information they gave would be de-identified, that no names would be stored and that their identity would be kept confidential.

Translation and cultural adaptation procedure

The internationally accepted forward back-translation technique was used [2]. First, the original questionnaire was translated from English into Turkish independently by two Turkish individuals. The informed translator was a physical therapist and the uninformed translator was an engineer. The native language of both translators was Turkish, and they were fluent in English. Both translations were compared and reviewed by a bilingual person who highlighted any conceptual errors or inconsistencies in the translations in order to establish the first Turkish translation. Once the first Turkish translation was established, two native English speakers with a good command of Turkish separately translated the final Turkish translation back into English. Both translators were unaware of the purpose of the study and had no access to the original questionnaire. The Turkish-to-English back-translation was then compared with the English version of the ACL-QOL questionnaire and discussed to achieve 100 % agreement period. Some differences in meaning were seen confirming semantic equivalence and confirming the conceptual meaning, clarity and terminology by the specialist committee consisting of a methodologist, a language professional and the four translators. After discussing the discrepancies, the committee approved the final Turkish version of the ACL-QOL questionnaire.

Pre-testing

Pre-testing was conducted on 20 patients with ACL-R who fulfilled the eligibility criteria of the study to determine their comprehension of the translated version. The patients were questioned about their difficulties in understanding the questions immediately after completing the form. The questions that were difficult to understand were noted, and the patients were asked for their recommendations for revising the questions.

Design

One hundred and nineteen patients (out of 138) with ACL-R were recruited. The inclusion criteria were age of 15–51 years and unilateral ACL injuries, including patients who had meniscus tears, osteochondral defects or both. Exclusion criteria included multiple injuries around the knee or any existent knee pathology or previous surgery with more than grade 3 osteochondral defect. All patients were examined by the same doctor (O.A.A) who made a confirmed diagnosis by clinical examination with positive Lachman and pivot shift testing and with complementary examination using MRI. Demographics of the patients are summarized in Table 1. Eighty patients (group A) with ACL-R completed the Turkish-adapted version of the ACL-QOL questionnaire twice for reliability assessment. To assess the test–retest reliability, the questionnaire was sent on seventh day prior to first assessment and the participants were asked to complete the second assessment in 1 week. Thirty-nine patients (group B) who were on the waiting list for ACL-R surgery completed the Turkish-adapted version of the ACL-QOL questionnaire with the LKS, the KOS-ADLS and the SF-36 pre-operatively, the 16th week post-operative and after 2-year follow-up for validity assessment. Patients with associated grade 3 collateral ligament injuries, posterior cruciate ligament injuries and bilateral ACL injuries were excluded. Patients who met the eligibility criteria were informed of the purpose of the research and invited to take part as volunteers by the researchers (Fig. 1).

Table 1 Patient demographics

Variable	$N = 80$ (group A)	$N = 39$ (group B)
Gender		
Female	8 (10 %)	2 (5.12 %)
Male	72 (90 %)	37 (94.87 %)
Education		
High school	7 (8.75 %)	1 (2.56 %)
University degree	73 (91.25 %)	38 (97.43 %)
Combined injuries		
Meniscus tear	41 (51.25 %)	18 (46.15 %)
Osteochondral defect	23 (28.75 %)	9 (23.07 %)
Both	13 (16.25 %)	5 (12.82 %)
Mean age (years)	31.2 ± 8.7	33.9 ± 8.5
BMI (kg/m^2)	25.0 ± 3.5	25.5 ± 7.2
Duration from injury (years)	2.8 ± 4.5	2.6 ± 6.5

R right, *L* left, *BMI* body mass index, *group A* patients with anterior cruciate ligament reconstruction (ACL-R), *group B* patients with ACL-R undergoing physiotherapy

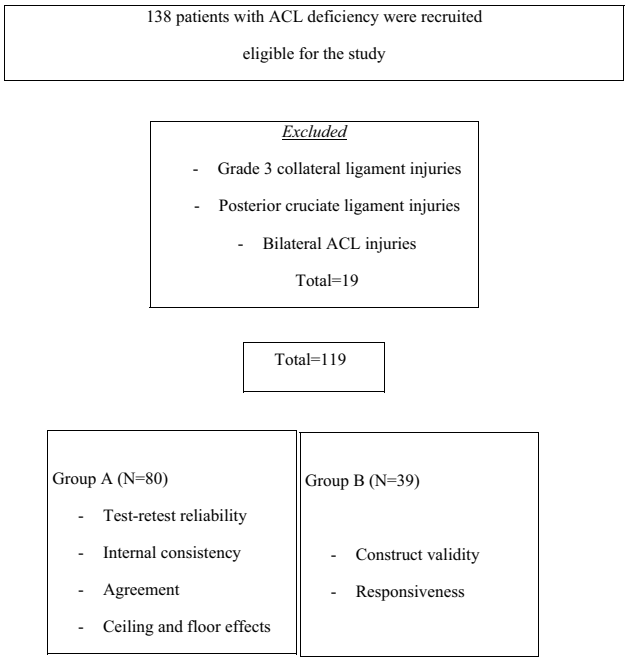

Fig. 1 Flow of patients in the study. (group A: patients with anterior cruciate ligament reconstruction (ACL-R) and group B: patients with ACL-R undergoing physiotherapy)

Surgery

Autogenous quadrupled semitendinosus and gracilis grafts were used for ACL reconstruction. An oblique incision two fingerbreadths below the medial joint line over the pes anserinus tendons was used to harvest the tendons. Tendons were harvested with a tendon stripper and all muscle remnants were removed bluntly with scissors. Tibial and femoral tunnels were created. Suspension type fixation was used on the femoral side and intratunnel fixation with bioabsorbable interference screws plus supplemental staples were used on the tibial side.

Outcome measures

The ACL-QOL questionnaire

The ACL-QOL questionnaire represents a subjective, patient-based and disease-specific questionnaire. It includes

32 separate items in 31 questions and uses a 100-mm visual analogue scale (VAS) response format. There are five separate items retained in the domain of symptoms and physical complaints: 4 representing work-related concerns, 12 in the recreational activity and sport participation or competition domain, 6 questions related to lifestyle and 5 in the social and emotional domains. The mean score of the five domains and of the entire scale is calculated with higher scores indicating a higher quality of life [22].

The Knee Outcome Survey—Activities of Daily Living Scale (KOS-ADLS)

The KOS-ADLS is a self-administered questionnaire designed to determine the symptoms and functional limitations in usual daily activities experienced within the last few days [12]. It contains six questions concerning symptoms: pain, stiffness, swelling, giving way, weakness and limping. The responses are given in a Likert-type format and graded on a scale from 0 to 5, with 5 being no symptoms and 0 being the highest limitation caused by the symptoms. The symptom score and function score added together make the total score; lower total scores indicate lower levels of function and/or greater limitation. In a previous study, the Turkish version of the KOS-ADLS met the criteria of reliability and validity in measuring symptoms and functional limitations in patients with knee pain [7].

The Lysholm Knee Scale (LKS)

The LKS consists of eight questions on the subjective perception of pain and instability. The score ranges from 0 (worst) to 100 (best), and a score of 95 indicates no knee problem (excellent), 84–94 indicates problems during sports (good), 83–65 indicates knee problems in sports and sometimes in daily life (fair), and <65 indicates problems in daily life (poor) [19]. The Turkish version of the Lysholm Knee Scale is quickly administered, valid and reliable and can be used for patients with various knee disorders [3].

The short-form health survey (SF-36)

The SF-36 survey was used to establish a health profile that consists of eight scaled scores, where each scale was directly transformed into a scale from 0 to 100 in order to identify the patient's physical and mental state. These eight sections include physical functioning (PF), role limitations due to physical function (RP), bodily pain (BP), general health perceptions (GH), vitality (VH), social function (SF), emotional function (RE) and mental health (MH) [21]. The Turkish version of the SF-36 has been shown to be valid and reliable [14].

Statistical analysis

All statistical analyses were performed using PASW version 18.0 (SPSS Inc, Chicago, IL), with a level of significance of 5 %. The measurement properties analysed in this study for the instruments included internal consistency, test–retest reliability, agreement, criterion validity, ceiling and floor effects and responsiveness.

Reliability

Reliability can be defined as the instrument's ability to distinguish variation in measurements between testing occasions under stable conditions [20]. The test–retest reliability was assessed using intraclass correlation coefficients (ICC). The minimum value recommended for this measurement property is 0.70 [25, 27]. For all variables, test–retest reliability was calculated by the intraclass correlation coefficient (ICC) using a two-way mixed model with under consistency. The mean and standard deviation of the first and second administrations of the questionnaire are given in Table 2.

Internal consistency

Eighty patients (group A) (8 females and 72 males; mean ± SD age 31.2 ± 8.76 years) who had undergone ACL-R at least 1 year previously were used to establish internal consistency. This was assessed using Cronbach's coefficient alpha. This test indicates the homogeneity of the distinguishing factors between the items within a questionnaire or subdomains of the questionnaire. 'Cronbach's alpha' is also to determine the interrelatedness among the items of a questionnaire. An inter-item correlation matrix was used to indicate if one of the items does not correlate positively with the other items. An α value ranging from 0.70 to 0.95 was considered to be adequate [27].

Test–retest reliability

Group A was also used to estimate the test–retest reliability. Since measuring and scoring the questionnaire requires time and effort, using an 10-point check-box scale alleviated these problems and allowed direct data input and analysis [18]. Hence, the questionnaire is formulated into an online web link via (http://freeonlinesurveys.com/s.asp?sid=bcgnjuor16kus60238418). In addition, a check-box scale format is less time-consuming to score and anecdotally, patients seem to find this format easier to use. All participants returned the questionnaire by e-mail within the 7- to 15-day interval, and the average time taken for the second mail of the questionnaire was 9.93 ± 0.86 days. Participants who returned an incomplete data form were contacted

Table 2 Test–retest reliability of the components of the ACL-QOL questionnaire

ACL-QOL	$N = 80$ (group A) Mean (SD)		Reliability [95 % CI]	
	t_1	t_2	Test–Retest	Cronbach's α
Symptoms and physical complaints	75.9 ± 17.9	75.4 ± 18.3	0.97 [0.96–0.98]	0.80 [0.72–0.87]
Work-related concerns	72.5 ± 23.7	71.1 ± 23.5	0.95 [0.96–0.98]	0.77 [0.66–0.85]
The recreational activity and sport participation/competition	49.8 ± 25.7	49.2 ± 26.1	0.98 [0.97–0.99]	0.92 [0.89–0.95]
Lifestyle issues	71.6 ± 21.9	70.4 ± 21.7	0.98 [0.97–0.99]	0.82 [0.74–0.88]
Social and emotional concerns	60.6 ± 22.3	60.1 ± 23.4	0.98 [0.97–0.98]	0.80 [0.77–0.87]
Overall ACL-QOL	66.1 ± 18.6	65.2 ± 19.3	0.98 [0.98–0.99]	0.95 [0.93–0.97]

$p < 0.001$

ACL-QOL Anterior Cruciate Ligament Quality of Life questionnaire, *group A* Patients with anterior cruciate ligament reconstruction (ACL-R), t_1 seventh day prior to first assessment, t_2 the second assessment in 1 week, *SD* standard deviation, *CI* confidential interval

by phone to retrieve the missing answers. Therefore, 100 % return rate of both assessments were provided for the test–retest reliability for all 80 participants.

Agreement

Agreement was assessed by a standard error measurement (SEM) and the minimal detectable change (MDC). The ICC was used to calculate the SEM, which is an index of measurement precision. The SEM is calculated as SD × $\sqrt{(1 - \text{ICC})}$. The MDC refers to the minimal amount of change that is within measurement error. The SEM was used to determine the minimum detectable change at the 95 % limits of confidence ($MDC_{95\%}$) and was calculated using the formula 1.96 × $\sqrt{2}$ × SEM. The ICC was used to calculate the SEM, which is an index of measurement precision [5, 27].

Criterion validity

Criterion validity refers to the extent to which scores on a particular questionnaire relate to measured gold standard [27]. Criterion validity was evaluated by testing two predefined hypotheses that were developed by the authors. The hypotheses, ordered in level of importance, were as follows: patients who scored high on the physical component summary (PCS) and mental component summary (MCS) subdomains of the SF-36 would be moderately correlated with the ACL-QOL questionnaire. Patients who were not satisfied with their functional knee status (LKS) and activities of daily living (KOS-ADLS) would also score lower on the ACL-QOL questionnaire. A subgroup of 39 patients (group B) (2 females and 37 males; mean ± SD age 33.97 ± 8.55 years) was used for testing the criterion validity of the ACL-QOL questionnaire. The criterion validity was assessed by correlating the first assessment of the ACL-QOL, the LKS, the KOS-ADLS and the SF-36. The validity was analysed using the Pearson correlation. The qualitative indicators for the relative ranges of correlation values were considered as follows: $r \geq 0.81$–1.0 was excellent, 0.61–0.80 was very good, 0.41–0.60 was good, 0.21–0.40 was fair, and 0.00–0.20 was poor [15, 17].

The ceiling and floor effects

Ceiling and floor effects refer to content validity, and their presence indicates that extreme items are missing in the scale. The percentages of responders who scored the lowest (i.e. scored 0) or highest (i.e. scored 10) in each subdomain on the ACL-QOL questionnaire were documented. Descriptive statistics (mean values, standard deviations and quartiles) were calculated in order to determine distribution and ceiling/floor effects. These were considered to be relevant if more than 15 % of the subjects experienced them [30].

Responsiveness

This measurement determines whether the instrument can detect clinical changes, however slight, over time. Subjects followed the same post-operative rehabilitation programme and all measurements were taken at pre-operative, 16th week and 2 years after surgery. Pre-operative responses (group B) were compared with post-operative responses at the 16th week and 2 years after treatment for ACL-R. Effect sizes were determined by calculating the differences in the means of baseline and follow-up data, divided by the standard deviation at baseline [9]. A value of 0.20 or less represents a change of approximately 20 % of the baseline standard deviation and is considered a small effect size. A value of 0.50 is considered moderate, whereas a value of 0.80 or greater is viewed as a large effect size [9]. Values between 0.20 and 0.50 were considered to be small effects; those between 0.51 and 0.80, moderate effects; and those of >0.80, large effects [12].

Results

Translation and cultural adaptation

The translators had difficulty translating the words of 'recreation' and 'go full out'. The committee decided to translate 'recreation' as a 'hobby' in the third domain headings, since the term is not used often among the Turkish population and a lack of understanding of the term could affect scores on the questionnaire. In addition, the committee also decided to translate 'go full out' into 'maximum effort' during recreational/hobby activities in the question 17. Since its perception in its original form might be influenced by cultural differences, the question has been changed to 'How difficult is it for you to do your activity/hobby?' For a precise understanding, see supplementary material.

Reliability

Internal consistency

The Cronbach's α for internal consistency was analysed for the overall and the subdomains of the ACL-QOL. The results were between 0.77 and 0.95 for the first administration of both subdomains of the ACL-QOL questionnaire.

Test–retest reliability

The ICC was excellent overall instrument and for all five domains (ICC value = 0.94–0.98 $p < 0.001$). The paired t test did not demonstrate any statistically significant difference between the test–retest means (p = n.s.).

Agreement

The SEM and MDC_{95} were found to be 3.1 points and 8.7 points, respectively.

Criterion validity

All correlation coefficients for the comparisons described, including the comparison between the ACL-QOL and the KOS-ADLS, as well as the Lysholm Knee Scale and the subscores of the SF-36 are displayed in Table 3. The relationships between the ACL-QOL and the KOS-ADLS ($r = 0.14$), and the Lysholm Knee Scale ($r = 0.23$) score were low. Good correlations were found between the ACL-QOL and the subscores of the SF-36 (VT, *r:* 0.42; SF, *r:* 0.58; RE, *r:* 0.54; MH, *r:* 0.41). Physical role subscore of the SF-36 had very good correlation with the ACL-QOL ($r = 0.71$). PCS and MCS score of the SF-36 had good and very good correlations with the ACL-QOL ($r = 0.51$ and $r = 0.62$, respectively) (Table 3).

Table 3 Correlation between ACL-QOL with the other outcome measurements

Outcome measurements	$N = 39$ Mean (SD)	r [95 % CI]	p
KOS-ADLS—symptoms	20.1 ± 4.9	0.03 [0.00–0.34]	n.s.
KOS-ADLS—function	23.4 ± 7.2	0.18 [0.00–0.46]	n.s.
KOS-ADLS—total	43.1 ± 10.6	0.14 [0.00–0.43]	n.s.
Lysholm Scale	59.0 ± 11.6	0.23 [0.00–0.50]	n.s.
SF-36 (PF)	69.2 ± 19.5	0.33 [0.03–0.58]	0.03
SF-36 (RP)	26.1 ± 38.0	0.72 [0.54–0.84]	0.001
SF-36 (BP)	67.0 ± 26.0	0.34 [0.03–0.59]	0.001
SF-36 (GH)	69.8 ± 13.5	0.29 [0.00–0.55]	0.07
SF-36 (VT)	61.7 ± 14.9	0.42 [0.12–0.65]	0.007
SF-36 (SF)	70.6 ± 25.9	0.58 [0.32–0.76]	0.001
SF-36 (RE)	43.6 ± 41.2	0.54 [0.28–0.73]	0.001
SF-36 (MH)	63.0 ± 17.0	0.41 [0.11–0.64]	0.009
SF-36 (PCS)	44.9 ± 13.0	0.51 [0.23–0.71]	0.001
SF-36 (MCS)	44.9 ± 9.4	0.62 [0.37–0.78]	0.001

$p < 0.001$

n.s. non-significant p values, *KOS-ADLS* knee outcome survey activities of daily living, *SF-36* short form 36, *PF* physical functioning, *RP* role physical, *BP* bodily pain, *GH* general health, *VT* vitality, *SF* social functioning, *RE* role emotional, *MH* mental health, *PCS* physical component score, *MCS* mental component score, *SD* standard deviation, *CI* confidential interval

The ceiling and floor effects

The ceiling and floor effects of the four subdomains and the overall score were acceptable. Only ceiling effect (22.9 %) was found for the 'work-related concerns' subdomain of the ACL-QOL questionnaire which is more than the 15 % threshold typically used to indicate floor and ceiling effects (Table 4) [27].

Responsiveness

Table 5 presents the 16-week and 2-year follow-up data on the effect size of the group B patients. Overall, the Turkish version of the ACL-QOL questionnaire demonstrated a large effect size (ES: 2.12) at 16th week of follow-up. Effect size was still large (ES 0.97) at 2 years post-operative, but lower than at the 16th week of post-operative assessment.

Discussion

The most important finding of the present study was that the Turkish translation of the ACL-QOL questionnaire was shown to have high reliability, appropriate criterion validity and acceptable responsiveness in patients with ACL-R.

Table 4 Ceiling and floor effect of the components of the ACL-QOL questionnaire

ACL-QOL ($N = 80$)	Floor effect	Ceiling effect
Symptoms and physical complaints	1 (1.25 %)	4 (8.3 %)
Work-related concerns	1 (1.25 %)	11 (22.9 %)
The recreational activity and sport participation/competition	1 (1.25 %)	3 (6.2 %)
Lifestyle issues	1 (1.25 %)	3 (6.2 %)
Social and emotional concerns	1 (1.25 %)	4 (8.3 %)
Overall Score	0 (0 %)	3 (6.2 %)

ACL-QOL Anterior Cruciate Ligament Quality of Life questionnaire

Table 5 Responsiveness of the components of the ACL-QOL questionnaire

$N = 39$ (group B)	Mean (SD)			16-week	2-year
ACL-QOL	Pre-operative	16-week	2-year	ES [95 % CI]	ES [95 % CI]
Symptoms and physical complaints	46.6 ± 14.9	69.2 ± 7.0	77.7 ± 14.8	1.5 [1.1–1.8]	2.0 [1.6–2.5]
Work-related concerns	60.8 ± 18.1	86.6 ± 10.4	76.6 ± 23.6	1.4 [0.9–1.8]	0.7 [0.1–1.1]
The recreational activity and sport participation/competition	39.1 ± 22.7	83.2 ± 7.6	55.3 ± 25.6	1.9 [1.5–2.3]	0.6 [0.1–1.1]
Lifestyle issues	49.0 ± 20.9	87.5 ± 9.8	75.2 ± 19.0	1.8 [1.4–2.2]	0.6 [0.7–1.6]
Social and emotional concerns	59.0 ± 23.8	93.1 ± 9.3	62.1 ± 21.5	1.4 [1.1–1.7]	0.0 [0.3–0.5]
Overall ACL-QOL	50.9 ± 15.5	83.9 ± 6.2	69.4 ± 17.2	2.1 [1.7–2.5]	1.1 [0.5–1.6]

ACL-QOL Anterior Cruciate Ligament Quality of Life questionnaire, *ES* effect size, *CI* confidential interval

The internal consistency analysis using Cronbach's alpha showed the ACL-QOL questionnaire to be within the recommended range of values (0.70–0.95) [27]. Interestingly, the original version of the ACL-QOL questionnaire was not assessed in terms of internal consistency. Unfortunately, there is no validation study in the literature of the ACL-QOL questionnaire in other languages to which to compare Cronbach's alpha.

Test–retest reliability involves only looking at the data provided by group A. The ICC was found to be excellent for all five domains of the Turkish version of the ACL-QOL questionnaire (ICC 0.94–0.98). The original version of the ACL-QOL questionnaire did not include this analysis [24]. However, a previous study pointed out that the level of reliability is linked to the test–retest interval [30]. Reliability was higher when a short time interval was used (8 days or less), whereas short test–retest intervals carry the risk of patients becoming familiar with the questions and simply answering based on memory of the first assessment. However, the risk is higher if the questionnaire is short. Since the ACL-QOL questionnaire consists of 32 questions, the highest test–retest reliability was expected with an interval of 7–15 days in our study.

The level of agreement for the Turkish version of the ACL-QOL questionnaire may be considered excellent, with a SEM value of 3.1 points. Accordingly, the MDC_{95} was 8.7 points, which means that a change of at least 8.7 points is needed, on a scale of 100 points, to be confident that this change is not due to random measurement error. In other words, when a patient is measured two or more times with the Turkish version of the ACL-QOL questionnaire, a change of less than 8.7 points from one time to the next should be considered to reflect measurement error rather than a true change in the patient's condition. In comparisons with earlier studies with respect to the SEM and MDC are not possible because, to our knowledge, they have not been reported before.

The criterion validity was also tested by correlating the scores on the Turkish version of the ACL-QOL with the scores on the KOS-ADLS, the LKS and the SF-36. These questionnaires assess subjective perceptions of symptoms and functional limitations in daily activities (KOD-ADLS) and pain and instability (Lysholm Knee Scale) with similar, but not identical, constructs compared to the ACL-QOL questionnaire; accordingly, a poor correlation was expected ($r \leq 0.20$). In addition, the patients in group B who were not satisfied with their functional knee status (LKS) and activities of daily living (KOS-ADLS) also demonstrated lower pre-operative scores on the ACL-QOL questionnaire. According to Terwee et al. [27], the recommended level of agreement between questionnaires should be greater than 0.70 when they are of the same construct, but lower levels of agreement are allowed for questionnaires with similar, but different constructs. Therefore, considering that the LKS and the KOS-ADLS were developed as a region-specific questionnaire to assess symptoms and function for different knee conditions and the ACL-QOL was developed as a condition-specific questionnaire to assess

quality of life concerns related to anterior cruciate ligament deficiency, the moderate level of correlation between these three instruments is expected. This provides evidence for the need for further evaluation of the criterion validity of the ACL-QOL questionnaire.

The results demonstrated the significant correlations between the ACL-QOL questionnaire and the SF-36 (physical component summary and mental component summary) that have been widely evaluated in patients following ACL injury. Criterion validity was moderately correlated with the ACL-QOL questionnaire regarding the physical component summary (PCS) and mental component summary (MCS) scores of the SF-36. Shapiro et al. suggested that the use of SF-36 should be encouraged in conjunction with knee-specific instruments for studies of ACL-injured patients [25]. The fact that SF-36 correlations were significant appears to suggest that SF-36 does evaluate aspects thought to be important in determining disease-specific quality of life. Similarly, satisfactory correlations were found between the ACL-QOL and SF-36 subscores in our study. Overall, the difference in focus of these questionnaires may explain the difference in the strength of the associations.

In the assessment of the presence of ceiling and floor effects, we found that the number of the patients who scored maximum or minimum values on the questionnaire was below 15 % threshold. However, slightly high ceiling effects related to the 'work-related concerns' domain in the questionnaire were more heavily weighted in our study. The relative weighting and aggregation of the questions remain an issue for this questionnaire. Intuitively, one would expect that sport and recreational issues should be more heavily weighted in this population. However, if a patient has a job requiring intense physical activity, the work-related domain may take on a greater significance in the questionnaire [24]. Similarly, the patients who had previously undergone reconstructive surgery in our study were not professional, but recreational athletes, and their sports participation was as considered hobby throughout their life. Therefore, these patients might have had high scores in 'work-related concerns', in spite of their ACL deficiency.

The analysis of responsiveness, as generated by completion of the Turkish version of the ACL-QOL questionnaire before and after the 16th week post-operative and 2-year follow-up showed a high effect size indicating that this instrument is responsive. The original study does not include the evaluation of patients pre- and post-operatively to address the change in quality of life scores over time [24]. However, unpublished data which have examined this issue before and after ACL-R reported that the ACL-QOL questionnaire scores were dramatic in all domains, in accordance with our study results.

ES is still large (ES: 1.10), at 2 years post-operative, but lower than at the 16th week (ES: 2.12) of assessment. Most patients (85–90 %) reported a good knee function after ACL reconstruction, but less than half were able to return to their pre-injury competitive sport [1]. In addition, many athletes do not return to their pre-injury level of sports even though they are physically rehabilitated [7, 17, 19] and despite the fact that the goal of reconstruction and rehabilitation was to return to the pre-injury level [31]. Similarly, the reason for the decline in the ES in our study may be due to the patient not returning to a previous activity level or sport in spite of good knee function at 2 years post-operatively. Studies have also shown that the reason for the low rate of return to sport may be that the patient is not prepared psychologically for a return. Fear of new injury and negative psychological response has been reported to be associated with not returning to the pre-injury level of sport [16, 18, 28]. In our study, ES might be affected by other factors, such as a psychological response relevant to returning to a sport following ACL-R, which might influence quality-of-life outcomes.

There are some limitations of our study. The findings of the study might not be representative for a typical patient cohort with ACL injury since the patient demographics included mainly male patients with university degree education. In addition, we only included the patients with ACL injury which is unaccompanied by grade 3 collateral ligament injury, posterior cruciate ligament injury or bilateral ACL injury. Future studies should focus on the validity of ACL-QOL in those with additional ligament injuries. Due to a lack of adaptation studies, comparison of the present results is somewhat limited. Further studies are required to test for the generalizability of the ACL-QOL questionnaire in other patients with ACL deficiency.

As a consequence, this study provides the first cross-cultural evidence for the usefulness of the ACL-QOL questionnaire in another country with a different cultural background. The information obtained by the Turkish version of the ACL-QOL questionnaire will help health professionals who challenge with ACL injuries and rehabilitation. This is also an important advance, because health-related quality of life of patients with ACL-R plays a central role in developing the effectiveness of ACL rehabilitation programmes in the physiotherapy and rehabilitation fields.

Conclusion

Based on the results of this study, it can be concluded that there is enough evidence of acceptable reliability and validity to use the Turkish version of the ACL-QOL questionnaire in patients with ACL-R in Turkish-speaking societies.

Acknowledgments The authors would like to thank physiotherapist Dilber Coskunsu for her outstanding work in patient recruitment and data management.

Conflict of interest The authors declare that they have no conflict of interest.

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