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Clinical Sports Medicine Update

Health-Related Quality of Life After Anterior Cruciate Ligament Reconstruction

A Systematic Review

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Background: Anterior cruciate ligament reconstructions (ACLRs) are frequently performed on young, active patients and can result in persistent knee symptoms and activity limitations that may affect health-related quality of life (HRQoL). To date, there has been no systematic review of HRQoL outcomes after ACLR.

Purpose: The objectives of this study were to report HRQoL $\geq$5 years after ACLR, compare HRQoL outcomes with available population norms, and describe factors that may affect HRQoL in this population.

Study Design: Systematic review.

Methods: All studies reporting HRQoL $\geq$5 years after ACLR with hamstring or patellar tendon autografts were eligible for review. Common HRQoL outcomes were pooled using a random-effects meta-analysis and compared with published population norms. The Spearman rank correlation coefficient (ρ) was used to identify variables associated with HRQoL outcomes. Where insufficient data were available, outcomes were reported descriptively.

Results: Fourteen studies were eligible for review, and HRQoL was reported for 2493 patients at a mean of 9 years (range, 5-16 years) after ACLR. Pooling of knee-related quality of life outcomes (Knee injury and Osteoarthritis Outcome Score [KOOS]–QOL) found impairments after ACLR when compared with population norms. In comparison, studies using the Short Form–36 (SF-36) reported similar or better HRQoL compared with normative data. The KOOS-QOL subscores correlated strongly with KOOS-sport/recreation (ρ = .70, P = .04) and KOOS-pain (ρ = .85, P = .003) subscores. Severe radiographic osteoarthritis, meniscal injuries sustained after surgery, and revision ACLR were associated with poorer HRQoL outcomes at a minimum 5-year follow-up. The negative influence of concomitant meniscal surgery on HRQoL became apparent more than 10 years after ACLR.

Conclusion: This review found that patients assessed using a knee-specific measure (KOOS-QOL) were more likely to report poorer HRQoL values, compared with population norms, than those assessed using a generic HRQoL measure (SF-36). Revision surgeries, meniscal injuries, and severe radiographic osteoarthritis were associated with poorer HRQoL outcomes after ACLR. However, these relationships should be interpreted with caution, as they were only investigated in a small number of studies.

Clinical Relevance: These results can be used by clinicians to educate patients about potential long-term outcomes after ACLR and to develop strategies for optimizing postoperative HRQoL.

Keywords: knee injury; osteoarthritis; patient-reported outcomes; long-term follow-up

Anterior cruciate ligament (ACL) ruptures and subsequent reconstructive surgery can lead to ongoing knee symptoms with associated impairments, participation restrictions, and related psychosocial implications.[3,29] Anterior cruciate ligament reconstruction (ACLR) is a common procedure in sports medicine, with estimated surgical rates of 52 per 100,000 inhabitants in Australia,[25] 30 per 100,000 in the United States,[7] and 32 per 100,000 in Sweden.[18] The overall aim of ACLR is to restore knee biomechanics, allow the resumption of preinjury activities, and optimize health-related quality of life (HRQoL). However, a recent systematic review involving 5770 patients found that only 44% of competitive athletes returned to their preinjury level of sport at 3 years after ACLR.[4] Psychological factors, such as the fear of reinjury, can contribute to participation restrictions and have been associated with poor HRQoL outcomes 2 to 4 years after ACLR.[29,36] Other factors, such as persistent pain[32] and posttraumatic osteoarthritis (OA),[41] may be interrelated and could affect HRQoL after ACLR.

Of most concern is research showing that up to 13% of people with isolated ACL ruptures and up to 48% with

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concomitant meniscal injuries will develop knee OA as early as 10 years after ACLR, irrespective of surgical or nonsurgical management.[41] The personal effect of OA after ACLR is heightened by the age of those undergoing this procedure because the majority of ACL ruptures occur in adolescents and young adults.[18,45] Younger adults with OA can face a range of challenges not typically associated with an older OA population, including work responsibilities, parental roles, and competitive sports. Research has found that younger adults with OA experience greater psychological distress than their older counterparts.[16] Additionally, teenagers who rupture their ACL are 3 times more likely to undergo revision ACLR, and revision surgeries are associated with poorer HRQoL outcomes.[30]

Health-related quality of life fundamentally refers to the influence of a person's health status on their perceived wellbeing and life quality. It is a multifaceted construct that encompasses physical, social, emotional, and psychological components and considers one's goals, values, and priorities in life.[11,17,46] The effect of ACLR on HRQoL could be exacerbated by limitations in participating in high-functioning activities such as competitive sports and through difficulty in meeting occupational demands. Patient-reported outcomes are commonly used to assess HRQoL. The Short Form–36 (SF-36) is a generic health status measure designed for use in any population,[53] while the Knee injury and Osteoarthritis Outcome Score (KOOS) measures knee-related quality of life (KOOS-QOL).[48] Both measures have been shown to be valid and reliable in patients with ACL ruptures and OA.[28,47,50] Despite the high prevalence of ACLRs internationally and the potential longer term implications for young, active populations, no systematic reviews have focused on HRQoL after ACLR. The aims of this systematic review were (1) to report HRQoL in patients $\geq$5 years after ACLR, (2) to compare HRQoL outcomes with available population norms, and (3) to explore the relationship between HRQoL and participant factors (follow-up duration, sex, graft type).

MATERIALS AND METHODS

This systematic review followed the PRISMA guidelines for reporting systematic reviews and meta-analyses.[37]

Eligibility Criteria

To be eligible for inclusion, studies were required to report generic or knee-specific HRQoL outcomes after arthroscopic ACLR with hamstring or patellar tendon autografts at a minimum 5-year follow-up. Studies were excluded from the review if (1) all ACLRs were performed with a polyester ligament scaffold or synthetic ligament graft or reinforced with a Ligament Augmentation Reconstruction System (LARS) artificial ligament (LARS, Surgical Implants and Devices, Arc-sur-Tille, France), (2) all ACLRs were performed using an open surgical or robot-assisted operative technique, (3) all surgeries involved primary repair of the ACL, (4) all ACLRs were revision surgeries, (5) all ACLRs were performed using an operative technique with allografts, (6) all patients had meniscal or concomitant ligament repairs in addition to ACLR, or (7) the article was published in a language other than English.

Studies involving patients who underwent ACLR using an eligible autograft technique and patients whose surgeries utilized techniques mentioned in our exclusion criteria (allografts, open procedures, primary repairs, etc) were eligible for inclusion in the review only if they reported (or the authors provided on request) separate HRQoL data for the eligible patients. Where articles utilized an outcome measure with a HRQoL component (such as the KOOS) but did not report data for the HRQoL subscale, these data were requested from the authors. If these data were not provided within 4 weeks, the article was deemed to be ineligible for the purposes of this review. Where multiple publications reported outcomes at various time points for the same study population, only the most recent publication was included in the review. We defined a HRQoL instrument as any patient-reported outcome measure (generic or knee specific) that primarily assesses HRQoL or features a HRQoL component or subscale.

Search Strategy

A systematic search was undertaken in June 2012 to identify all relevant articles using the following 5 databases: Medline, CINAHL, Web of Knowledge, Scopus, and Sports Discus. The search strategy involved screening titles, abstracts, and keywords for the terms "anterior cruciate ligament" or "ACL" AND "quality of life" or "QOL" or a range of relevant outcome measures such as the KOOS (see Appendix 1 for the full search strategy, available at http://ajsm.sagepub.com/supplemental). The search was performed independently by 2 of the authors (S.R.F., K.M.C.). We reviewed all titles and abstracts and excluded clearly ineligible publications from further screening (Figure 1). Any disagreements regarding eligibility were resolved by an independent arbitrator (T.G.R.). The full text versions of identified studies were reviewed for final eligibility screening. Reference lists of key articles were cross-checked to ensure that all relevant studies were included in the final yield. Finally, the search was repeated in October 2012 before data analysis to ensure that all eligible publications had been included.

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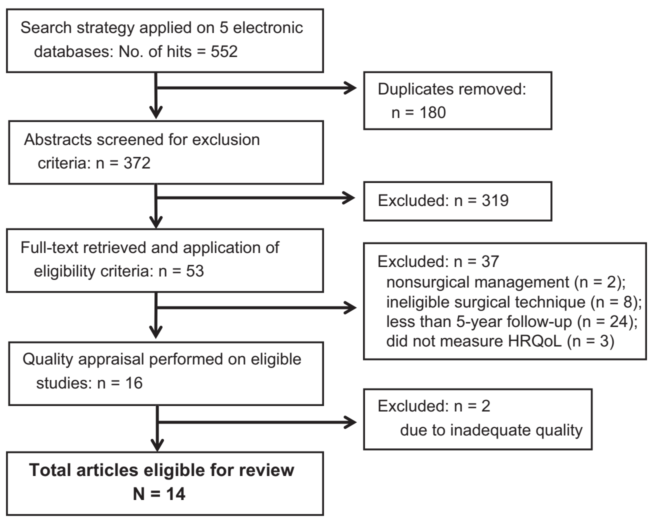


Figure 1. Search strategy.

Quality Appraisal

The methodological quality of the included studies was appraised using a 21-item checklist adapted from the Downs and Black criteria.[10] The Downs and Black measure has been identified as a useful tool for assessing both randomized and nonrandomized studies.[9] Some items in the tool were deemed not applicable to the study aims and designs of articles included in this review. As the intervention was interpreted as ACLR surgery, items such as "blinding of participants to intervention" and "compliance with intervention" were excluded from the checklist (a total of 6 items were excluded) (see Appendix 2, available online). Additionally, some items were slightly modified to capture all areas relevant to this review. We modified the last item on the scale to a dichotomous score of 0 or 1, where 0 was allocated to studies with no sample size calculation or reporting of insufficient power, and a score of 1 was given for sample size calculations and sufficient power to detect a clinically significant difference in the primary outcome(s). All modifications and explanations for each item are listed in Appendix 2. Items were scored 1 point for satisfaction of the criterion and 0 points for not satisfying the criterion or if it was unable to be determined. The maximum quality score was 21, with higher scores indicating greater methodological quality. The quality of all articles was evaluated by 2 independent assessors (S.R.F., E.M.M.); where agreement was not achieved, an independent arbitrator (K.M.C.) was used to reach a consensus.

Data Management

All data were extracted and collated by 2 independent reviewers (S.R.F., E.M.M.), including patient demographics (eg, age, sex, and time from injury to surgery), surgical details (graft type, concomitant injuries), outcome measures, and adverse events (reruptures, additional injuries, subsequent surgeries, rates of OA). Means and standard deviations (SDs) were extracted for each patient-reported outcome measure. Where only means and P values were reported, SDs and standard errors were estimated by using the mean difference between groups and converting P values to t scores.[19] Where HRQoL data were reported in graph form only, mean values were estimated from the graph (Table 1) when such data could be clearly ascertained (eg, full scale visible). Additionally, if a study characteristic was reported for 2 separate eligible subgroups (eg, age at follow-up reported separately for male and female patients), the subgroups were combined using a formula from *The Cochrane Handbook for Systematic Reviews of Interventions*[19] to obtain mean and SD estimates for the combined cohort. If sufficient data were not reported, the corresponding author was contacted to request further data.

Statistical Analysis

The mean difference and associated 95% confidence interval (CI) were calculated for KOOS-QOL data. With use of a random-effects meta-analysis,[1] studies were weighted according to variance within and between studies. The random-effects model accounts for heterogeneity in covariates between studies, which may influence HRQoL. Combining SF-36 data for the meta-analysis was deemed inappropriate because of the small number of studies reporting this outcome. To provide a context for interpreting HRQoL outcomes after ACLR, HRQoL scores were compared with previously published population norms from similar age groups where possible. The 2-tailed Spearman rank correlation coefficient (ρ) was used to explore correlations between potential predictive variables (graft choice [% patellar tendon], sex [% female], follow-up duration) and HRQoL outcomes. Additionally, this test was used to identify relationships between outcome measure subscales.

RESULTS

Search Strategy

The systematic search strategy initially yielded 552 studies. After the removal of 180 duplicate articles and the exclusion of 319 ineligible studies, we obtained and reviewed the full text of 53 articles (Figure 1). Of these, 37 articles did not meet the inclusion criteria. Because of heterogeneity in data-reporting methods or insufficient descriptions of surgical techniques, we requested additional data or surgical details from 11 authors (for 13 studies). Of these, 7 authors (for 8 studies) replied and provided data for 6 studies.[5,15,34,35,40,49] Six studies were subsequently excluded for not providing details or data necessary for inclusion or confirming ineligibility by correspondence. This resulted in the quality appraisal of 16 articles.

Methodological Appraisal

Quality appraisal scores ranged from 4 to 18. Two studies did not satisfy more than 10 items of the criteria and were therefore excluded from the review.[2,12] The mean modified Downs and Black score for the included studies was 14 ± 2. When

TABLE 1
Study Characteristics[a]

Study	Quality	Sample Size, N	Eligible,[b] n	Follow-up, y	HT, %	PT, %	Age at Follow-up, y	Female Sex, %	Time From Injury to Surgery, mo	RCT	Pro or Ret	HRQoL Measure(s)
Ahlden et al[1]	16	10,473	1452[c]	5.4	82	18	NR	NR	24	No	Pro	KOOS
Barenius et al[5]	17	153	153	8.4 ± 0.98	49	51	34.0 ± 15.0	42	16.0 ± 24.2	Yes	Pro	KOOS,[d] SF-36[d]
Ferrari et al[13]	12	200	137[e]	5.0 ± 25.4	0	100	35.25[f]	0	1.3 ± 1.8	No	Ret	SF-36
Gerhard et al[14]	12	63	63	16 ± 1	0	100	43[f]	14	11 ± 23	No	Ret	KOOS,[g] SF-36[h]
Gifstad et al[15]	13	93	93	7 (5.3-7.8)	49	51	34[f]	37	NR	Yes	Pro	KOOS[d]
Hoffelner et al[20]	13	28	28	10	0	100	32.2 ± 6.4	25	5 ± 6	No	Ret	KOOS
Mascarenhas et al[35]	12	38	19[c]	9.1 ± 2.7	0	100	27.9 ± 8.1	37	NR	No	Ret	SF-36[d]
Mascarenhas et al[34]	12	46	23[e]	5 ± 2	0	100	18 ± 3	57	NR	No	Ret	SF-36[d]
Möller et al[39]	18	56	56	11.5 (11-12)	0	100	39[f]	52	6 (2-240)	Yes	Pro	KOOS, SF-36[g]
Neuman et al[40]	18	93	22[c]	12.8 ± 3.5	0	100	NR	36	48	Yes	Pro	KOOS[d]
Ott et al[43]	13	151	151	5	0	100	27.6 F, 32.5 M[f]	51	1.3 E, 37.3 L (0.2-209)	No	Ret	ACL-QOL
Øiestad et al[42]	16	210	210	13.7 ± 4.4	14	86	39.1 ± 8.7	43	24.8 ± 48.7	No	Pro	KOOS
Sajovic et al[49]	16	64	64	11	50	50	36 HT, 38 PT	42	25 HT, 23 PT (1-84)	Yes	Pro	SF-36 version 2[d]
Swirtun and Renström[51]	13	46	22[c]	5.6 ± 0.52	32	68	32 ± 8.1	48	9	No	Pro	KOOS[g]

[a]Values are expressed as mean ± standard deviation or median (range). ACL-QOL, anterior cruciate ligament–specific HRQoL measure; E, early ACL reconstruction group; F, female; HRQoL, health-related quality of life; HT, hamstring tendon autograft; KOOS, Knee injury and Osteoarthritis Outcome Score; L, late ACL reconstruction group; M, male; NR, not reported; Pro, prospective; PT, patellar tendon autograft; RCT, randomized controlled trial; Ret, retrospective; SF-36, Short Form–36 (version 1).
[b]Number of participants for which data are reported (excluding all noneligible participants).
[c]Data from group of participants with <5-year follow-up were excluded.
[d]Data were provided through personal correspondence with author.
[e]Data from group of participants who did not undergo ACL reconstruction with autografts were excluded.
[f]Age at follow-up estimated from age at surgery and time to follow-up data.
[g]Data extracted from graph.
[h]Did not report data for each SF-36 domain.

evaluated according to study design, prospective studies achieved a higher mean quality score (16 vs 13 for retrospective studies). The quality appraisal scores for each of the included studies are presented in Table 1.

Study Characteristics

The 14 included studies reported HRQoL outcomes for a total of 2493 participants at a mean of 9 years (range, 5-16 years) after ACLR. The mean age of all participants at follow-up was 34 years (range, 18-42 years). The most commonly used HRQoL measure was the KOOS-QOL subscale, which was used in 9 studies. The only generic (non–disease-specific) HRQoL measures used were the SF-36 version 1 (used in 5 studies) and the SF-36 version 2 (used in 1 study). An ACL-specific HRQoL measure, the ACL-QOL,[38] was used in 1 study (Table 1). Aside from HRQoL, other commonly utilized outcome measures included the Tegner activity score[52] (used in 10 studies), the Lysholm knee scoring scale[33] (7 studies), the KT-1000 arthrometer[8] for assessing anterior/posterior tibiofemoral displacement (8 studies), and the Kellgren and Lawrence tool[27] for classifying radiographic OA (6 studies).

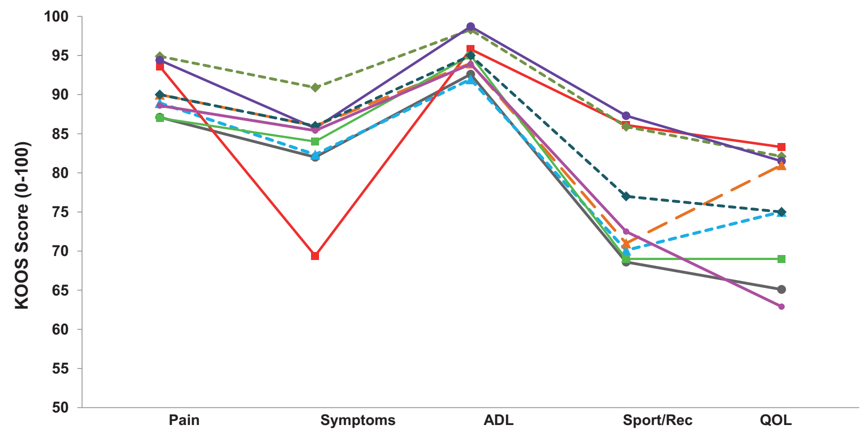
KOOS Subscores

Mean KOOS-QOL subscores were available from 9 studies[‖] and ranged from 63 to 83 of a possible 100 (Figure 2). Analysis of the relationship between the KOOS-QOL and other KOOS subscales revealed a strong positive correlation between the KOOS-QOL and the KOOS-pain subscale (ρ = .85, P = .003) and the KOOS-sport/recreation subscale (ρ = .70, P = .04). In comparison, there appeared to be a moderate correlation with the KOOS-activities of daily living subscale (ρ = .66, P = .05) and little relationship with the KOOS-symptoms subscale (ρ = .08, P = .70). Follow-up duration (P = .19) was not significantly associated with the KOOS-QOL subscores. The random-effects meta-analysis resulted in a pooled KOOS-QOL summary effect of 74.5 (95% CI, 68.3-80.7). Comparison of pooled KOOS-QOL values with previously published population norms showed that patients who underwent ACLR reported poorer KOOS-QOL subscores compared with healthy population norms with no knee symptoms (mean, 90; 95% CI, 83.7-96.3)[51] and with general population norms (mean, 82.4; 95% CI, 79.9-84.9)[48] (Figure 3).

[‖]References 1, 5, 14, 15, 20, 39, 40, 42, 51.

SF-36 Scores

The SF-36 measure comprises 8 individual health-related domains. For the SF-36 version 1, the Role Emotional domain demonstrated the greatest variation, with mean scores ranging from 85 to 100 (Figure 4). In contrast, mean scores for the Social Function domain were fairly consistent across all studies. All ACLR studies reported higher mean SF-36 values in 6 domains than previously published population norms (n = 2323),[31] indicating better HRQoL (Figure 4).



	Pain	Symptoms	ADL	Sport/Rec	QOL
Ahlden[1]	87.1 ± 15.3	82.0 ± 16.9	92.6 ± 12.7	68.6 ± 27.4	65.1 ± 24.2
Barenius[5]	88.9 ± 13.2	82.3 ± 16.5	92.0 ± 12.5	70.1 ± 25.3	75.0 ± 19.5
Gerhard[14]	93.6 ± 12.5	69.4 ± 16.7	95.8 ± 11.1	86.1 ± 19.4	83.3 ± 18.1
Gifstad[15]	94.9 ± 8.20	90.9 ± 10.5	98.3 ± 4.56	85.9 ± 19.1	82.1 ± 17.5
Hoffelner[20]	94.4 ± 8.0	85.7 ± 11.1	98.7 ± 14.2	87.3 ± 18.7	81.5 ± 19.3
Möller[39]	90	86	94	71	81
Neuman[40]	87 ± 13	84 ± 17	95 ± 10	69 ± 25	69 ± 23
Øiestad[42]	90 ± 14	86 ± 16	95 ± 10	77 ± 24	75 ± 22
Swirtun[51]	88.6 ± 14.8	85.4 ± 11.3	93.9 ± 33.4	72.5 ± 22.7	62.9 ± 21.5

Figure 2. Knee injury and Osteoarthritis Outcome Score (KOOS) values for individual studies. All values are expressed as mean ± standard deviation; a lower score indicates poorer outcomes in all domains.

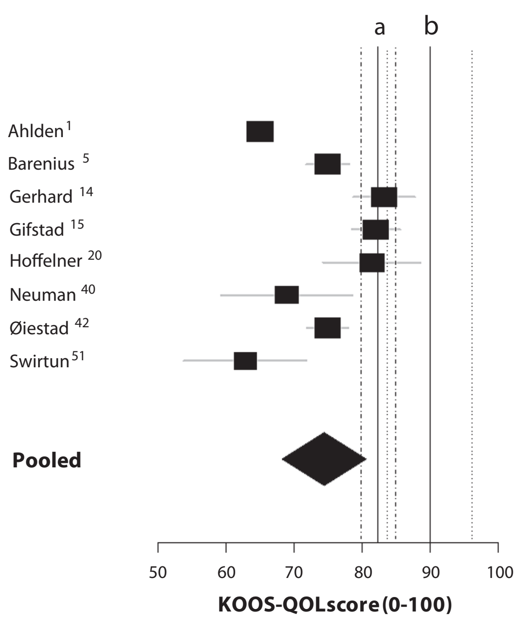


Figure 3. Forest plot of random-effects meta-analysis of Knee injury and Osteoarthritis Outcome Score–quality of life (KOOS-QOL): mean, standard error (box), and 95% confidence interval (CI) (whiskers) data from individual studies in addition to pooled summary mean and 95% CI. Population normative values are reported vertically: (a) normative data extracted from Paradowski et al[44] (n = 291; age, 18-54 years) with mean (solid line ''a'') and 95% CI (dashed lines) and (b) normative data extracted from Roos et al[47] (n = 25; age, 37-50 years) with mean (solid line ''b'') and 95% CI (dotted lines). A lower score indicates poorer outcomes.

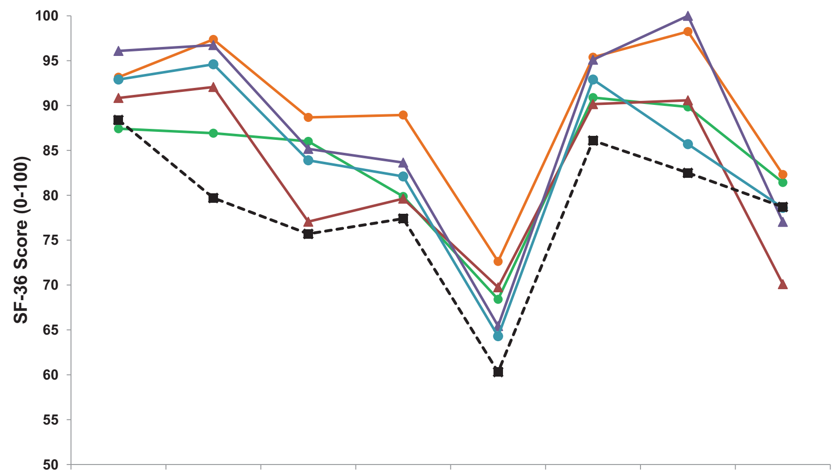
ACL-QOL Scores

The ACL-QOL outcome measure was used to measure HRQoL in only 1 study.[43] As the primary aim of this study was to compare outcomes between men and women after ACLR, separate mean ACL-QOL values were reported according to sex. No significant differences were found in the mean ACL-QOL scores (men, 80.2; women, 76.3) at a mean 5-year follow-up. Population norms for this instrument were not available for comparison.

Factors Potentially Influencing HRQoL After ACLR

Sex and Age. The effect of sex on HRQoL outcomes after ACLR was investigated in 5 studies.[13,39,42,43,51] The majority of these studies found no significant differences with respect to sex for the SF-36, KOOS-QOL, or ACL-QOL outcomes.[39,42,43,51] We observed a nonsignificant trend toward studies with a higher percentage of women reporting lower KOOS-QOL subscores ($\rho = -.63$, $P = .07$) and no significant correlations between sex and SF-36 scores ($P > .10$ for all domains).

The relationship between age at ACL surgery and HRQoL was investigated in 4 studies.[20,39,43,51] Participant age did not influence HRQoL outcomes measured with the KOOS[20,39,51] or SF-36.[39] Ott et al[43] categorized participants by age and sex and found the greatest discrepancy in ACL-QOL values in 12- to 18-year-old female patients, who scored 15 points lower than their male counterparts (78 vs 93, respectively). Ahlden et al[1] reported a significantly higher rate of revision surgeries (12%) in a similar aged female subgroup (15-18 years) compared with all



	PF	RP	BP	GH	V	SF	RE	MH
Barenius[5]	87.4 ± 15	86.9 ± 28	86.0 ± 22	79.9 ± 18	68.4 ± 20	90.9 ± 18	89.9 ± 27	81.4 ± 16
Ferrari [13]	90.9 ± 13	92.1 ± 22	77.1 ± 18	79.6 ± 18	69.8 ± 14	90.2 ± 16	90.6 ± 24	70.1 ± 10
Mascarenhas[35]	93.2 ± 12	97.4 ± 8	88.7 ± 12	89.0 ± 10	72.6 ± 14	95.4 ± 12	98.3 ± 8	82.3 ± 12
Mascarenhas[34]	96.1 ± 6	96.7 ± 11	85.2 ± 15	83.7 ± 15	65.4 ± 19	95.1 ± 9	100 ± 0	77.0 ± 14
Möller [39]	92.9	94.6	83.9	82.1	64.3	92.9	85.7	78.6
Normative (Loge[31])	**88.4 ± 17**	**79.7 ± 34**	**75.7 ± 26**	**77.4 ± 22**	**60.3 ± 17**	**86.1 ± 22**	**82.5 ± 32**	**78.7 ± 16**

Figure 4. Short Form–36 (SF-36) version 1 results for individual studies and the normative population. All values are expressed as mean ± standard deviation; a lower SF-36 score indicates poorer outcomes in all domains. Normative data from the Norwegian population (n = 2323; age, 44.9 ± 16.5 years).[31] Results from Sajovic et al[49] are not featured in this graph, as the SF-36 version 2 was used in this study and standardized scores are not directly comparable. BP, Bodily Pain; GH, General Health; MH, Mental Health; PF, Physical Function; RE, Role Emotional; RP, Role Physical; SF, Social Function; V, Vitality.

patients (4%; $P < .001$) and age-matched male patients (5%; $P = .02$).

Revision ACLR Surgery. The reported rates of ACL reruptures ranged from 1%[43] to 9%.[49] Only 2 studies analyzed HRQoL outcomes in those who underwent revision ACLR, and these studies found significantly poorer HRQoL outcomes after revision surgery compared with primary ACLR.[1,39] Notably, a large Swedish ACL register study found that participants who underwent revision ACLR (n = 194) scored worse in all KOOS subscales at 5-year follow-up ($P < .001$) compared with those who underwent primary reconstruction (n = 1258). It should also be noted that the studies that reported the highest KOOS-QOL subscores excluded patients who underwent revision surgeries or had concomitant injuries at baseline or subsequent injuries or complications.[15,20] Likewise, 1 of 2 studies that excluded people who had revision surgeries from their cohorts had the highest scores in each of the SF-36 domains, indicating a higher HRQoL.[34,35]

Meniscal or Cartilage Injury. The effect of sustaining concomitant meniscal or cartilage injuries before ACLR on HRQoL outcomes at follow-up was investigated in 5 studies.[1,5,14,39,51] A meniscal injury (treated surgically at the time of ACLR) was associated with lower KOOS-QOL subscores and SF-36 scores at more than 10 years' follow-up.[15,41] In contrast, studies with follow-up periods of 5, 6, and 8 years found no significant differences in KOOS-QOL subscores[1,5,51] or SF-36 scores[5] in those with and those without associated intra-articular injuries. However, these studies found significantly worse KOOS-QOL subscores in those who underwent concomitant medial meniscus surgeries ($P = .035$)[5] or sustained subsequent trauma after ACLR ($P = .002$)[51] at 8- and 6-year follow-up, respectively.

Time From Injury to Surgery. Time from injury to surgery was reported in 11 of the 14 studies reviewed, with mean times ranging from 5 months to 2 years (Table 1). Of these, 3 studies further investigated the relationship between the time from injury to surgery and HRQoL outcomes. Two studies found no correlation between the time from injury to surgery and KOOS subscores and SF-36 scores[42] or ACL-QOL outcomes.[49] In contrast, Barenius et al[5] found that participants who waited less than 5 months to have surgery had significantly better SF-36 scores in 3 subscales (Physical Function: $P = .014$; Bodily Pain: $P = .013$; Social Function: $P = .037$) and better KOOS-QOL subscores ($P = .059$) at 8-year follow-up, which may have been related to fewer meniscal injuries (37% vs 62% at <5 months and >5 months, respectively; $P = .008$) at the time of ACLR.

Graft Type. Four studies investigated differences in HRQoL outcomes between a bone–patellar tendon–bone autograft and a double- or single-looped hamstring tendon autograft.[5,15,35,49] All of these studies found no significant differences in KOOS subscores or SF-36 scores between groups at 5-, 7-, 8-, and 11-year follow-ups. Similarly, we found no significant correlations between graft type and KOOS-QOL ($P = .33$) or SF-36 ($P > .44$ for all domains) outcomes.

Radiographic OA. Despite 8 studies reporting the prevalence of radiographic OA after ACLR, only 2 studies compared HRQoL in those with and those without OA.[40,42] Øiestad et al[42] found that the presence of "any" OA (≥grade 2) was not associated with KOOS-QOL subscores; however, those with "severe" OA (grade 4) reported significantly poorer KOOS-QOL subscores (P = .002). Neuman et al[40] reported a trend toward lower scores in all subscales of the KOOS in patients with radiographic OA compared with those without OA.

DISCUSSION

This systematic review presents a clear overview of HRQoL after ACLR and has shown that these outcomes were associated with several factors. First, the choice of the patient-reported outcome measure used to assess HRQoL can affect the interpretation of results. Studies that used the knee-specific KOOS reported poorer HRQoL compared with published population norms.[24,47] In contrast, studies utilizing the generic SF-36 questionnaire commonly reported similar or higher HRQoL scores than age-equivalent population norms.[22,31] Second, we identified various factors that may be associated with poorer HRQoL after ACLR including concomitant or subsequent meniscal injuries, revision ACLR surgery, and the presence of severe radiographic OA. Participant sex, graft type, age at surgery, and time from injury to surgery were not significantly associated with HRQoL outcomes.

Overall, studies that used a generic health status measure, the SF-36, reported similar or better HRQoL outcomes compared with previously published population norms.[21,22,31,54] Visual comparison of mean SF-36 values between studies and population normative data[31] revealed a similar pattern of scores across all domains (Figure 4). The SF-36 is a generic measure of HRQoL and features 36 items in 8 defined domains covering physical, mental, and social health. Unlike the KOOS, the SF-36 addresses topics such as tiredness, sadness, and nervousness, which are relevant to many patient populations. Considering that the majority of ACL injuries occur in a young athletic population,[45] it is possible that this patient group scored more highly than aged-matched, less active counterparts. This may explain the similarities between SF-36 values for all ACLR studies and SF-36 values obtained from a healthy population of American college athletes aged 17 to 23 years (n = 696).[23] These college athletes scored significantly better in all SF-36 domains (P < .01) except for Bodily Pain (P = .05) than an age-matched sample of the general population. Also, it is important to note that SF-36 normative data used for comparison in this review included older adults up to 80 years of age, which may also partly explain the differences in HRQoL scores among these studies.

Pooled results from studies using the knee-specific KOOS indicate significantly poorer KOOS-QOL subscores compared with a healthy population with no history of ACL or meniscal injuries and no radiographic OA. Comparison between pooled KOOS-QOL results and general population norms showed a statistically insignificant difference; however, this difference may be of clinical importance because of the small degree of overlap in 95% CIs between ACLR and population norms (mean, 75; 95% CI, 68.3-80.7 vs mean, 82; 95% CI, 79.9-84.9, respectively).[44] This result could reflect the nature of the questionnaire, which is intended to assess knee injuries with the potential of causing posttraumatic OA.[48] The KOOS-QOL subscale comprises 4 questions, which address knee awareness, knee-related lifestyle modification, lack of knee confidence, and knee-related difficulties. It is therefore not surprising that medium- to long-term follow-up of patients who underwent ACLR revealed poorer KOOS-QOL subscores than those for controls without knee symptoms.[47] None of the studies that we reviewed specifically reported KOOS-QOL subscores in a subgroup of participants who were clinically symptomatic. Considering the positive relationship that we observed between KOOS-pain and KOOS-QOL subscores, this may underestimate impairment in HRQoL.

The relationship between baseline meniscal injuries and HRQoL may be at least partly mitigated by follow-up duration. The 2 studies in this review that reported significantly poorer HRQoL outcomes in those with surgically treated meniscal injuries had follow-up durations of 11.5 years[39] and 16 years[14] after ACLR. In comparison, studies reporting no significant influence of concomitant intra-articular injuries on HRQoL outcomes did so at 5-,[1] 6-,[51] and 8-year[5] follow-ups. These data suggest that the negative consequences of concomitant meniscal injuries may develop over time, becoming most apparent after 10 years. This is in line with a systematic review that reported a low prevalence of OA after isolated ACL injuries (0%-13%) and a higher prevalence of OA in those with additional meniscal injuries (21%-48%) at a minimum 10 years after ACL injury.[41] Concomitant articular injuries may also contribute to poor HRQoL outcomes after revision ACLR.[1,39] A literature review on revision ACLR identified a trend for higher rates of chondral and meniscal injuries in those who underwent revision surgeries.[26] Similarly, a single study reported significantly poorer KOOS-QOL subscores in those who sustained subsequent knee trauma,[51] which may be related to the acceleration of OA progression.[6] The temporal relationship between meniscal and other concomitant injuries, OA development, and HRQoL after ACLR is not well understood and requires further investigation.

Although this review is the first to evaluate HRQoL after ACLR, we acknowledge several limitations of this research. Because of the small number of studies reporting SF-36 and ACL-QOL outcomes, a meta-analysis and estimation of effect sizes were not appropriate for these measures. As only 1 study used an ACLR-specific outcome measure (the ACL-QOL), we were unable to explore the sensitivity of this measure in comparison to generic and knee-specific HRQoL measures. We excluded ACLR techniques with an allograft and a LARS artificial ligament from this review to enable in-depth comparisons between the more commonly used hamstring and patellar tendon autograft techniques. However, we recognize that reviewing HRQoL outcomes after these surgeries would be an interesting area for future research and warrants further study. We also recognize that exploring differences in HRQoL in patients who underwent meniscectomy compared with meniscal repair would be of value. However, we were unable to make comparisons, as meniscal operative techniques were not clearly reported in the included articles. Additionally, as the majority of studies did not evaluate HRQoL as their primary aim, data were often reported separately for subgroups, and only a small number of studies investigated the effect of specific demographic and surgical factors on HRQoL outcomes. This limited our ability to draw strong conclusions regarding factors that may predict poor HRQoL outcomes and highlights the need for further research in these areas.

CONCLUSION

This systematic review has shown that knee-related quality of life is impaired at a minimum of 5 years after ACLR compared with population norms for those without knee pain or injury. Impairment in HRQoL was less apparent when compared with normative data for the general population. In contrast, studies using the generic SF-36 measure reported HRQoL outcomes that were similar to or better than population norms. As a result, we recommend the use of both a generic and a knee-specific outcome measure when assessing HRQoL after ACLR. Revision surgery, subsequent injuries after ACLR, and the presence of severe radiographic OA were associated with poorer HRQoL at a minimum 5 years after ACLR. Meniscal injuries had a negative effect on HRQoL $\geq$10 years after ACLR; however, graft type, sex, age at surgery, and time from injury to surgery were not associated with HRQoL outcomes. A caveat to these findings is that only a limited number of studies investigated these factors, although the evidence to support these relationships was consistent. No research into the influence of psychological factors on longer term HRQoL was identified, and this would be a valuable direction for future research.

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