Health-related quality of life following anterior cruciate ligament reconstruction: a systematic review.

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Abstract

Background:

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

Purpose: The objectives of this study were to report HRQoL ≥ 5 years following ACLR, compare HRQoL outcomes with available population norms, and describe factors that may impact on HRQoL in this population.

Study Design: Systematic review.

Methods: All studies reporting HRQoL ≥ 5 years following hamstring or patellar tendon autograft ACLR were eligible for review. Common HRQoL outcomes were pooled using random effects meta-analysis and compared with published population norms. Spearman's rank correlation coefficient (rho) 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 individuals at a mean 9 years (range 5-16) following ACLR. Pooling of knee-related quality of life outcomes (KOOS-QOL) found impairments following ACLR when compared to population norms. In comparison, studies using the SF-36 reported similar or better HRQoL compared with normative data. KOOS-QOL sub-scores correlated strongly with KOOS-Sport/Recreation

(rho = 0.70, p = 0.04) and KOOS-Pain (rho = 0.85, p = 0.003) sub-scores. Severe radiographic osteoarthritis, meniscal injuries sustained after surgery, and revision ACLR were associated with poorer HRQoL outcomes at minimum 5 year follow-up. The negative influence of concomitant meniscal surgery on HRQoL became apparent more than 10 years following ACLR.

Conclusion:

This review found that individuals assessed using a knee-specific measure (KOOS-QOL) were more likely to report poorer HRQoL values, compared to 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 following 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 following ACLR, and to develop strategies for optimising post-operative HRQoL.

Key Words:

- Knee injury, osteoarthritis, patient reported outcomes, long-term follow-up

What is known about the subject:

More than 40% of young athletes who undergo an ACL reconstruction will not return to their pre-injury level of sport and as many as half of these patients develop osteoarthritis at ten years following ACLR. There is a relationship between psychological factors and participation restrictions. However, the impact of such factors on long-term HRQoL outcomes following ACLR is not well understood.

What this study adds to existing knowledge:

This study is the first systematic review of HRQoL outcomes following ACLR. By pooling findings from multiple studies, we identified factors associated with poor HRQoL outcome following ACLR. Additionally, by comparing outcome measures with population norms, we found that knee-specific measures were more likely to show poorer HRQoL values than generic HRQoL measures, and recommend the combined use of a specific and generic measure when reporting HRQoL in this patient group. We also identified a potential relationship between follow-up duration, meniscal injury or surgery and HRQoL outcomes and recommend further research in this area.

INTRODUCTION

Anterior cruciate ligament (ACL) rupture and subsequent reconstructive surgery can lead to ongoing knee symptoms with associated impairments, participation restrictions and related psychosocial implications.[3,28] 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[8] and 32 per 100,000 in Sweden.[19] The overall aim of ACL reconstruction is to restore knee biomechanics, allow resumption of pre-injury activities, and optimise health-related quality of life (HRQoL). However, a recent systematic review involving 5770 patients found that only 44% of competitive athletes returned to their pre-injury level of sport at three years following ACLR.[4] Psychological factors, such as fear of injury, can contribute to participation restrictions and have been associated with poor HRQoL outcomes two to four years following ACLR.[28, 35] Other factors, such as persistent pain[31] and post-traumatic osteoarthritis (OA),[40] may be inter-related and could impact on HRQoL after ACLR.

Of most concern is research showing that up to 13% of people with isolated ACL rupture and up to 48% with concomitant meniscal injury will develop knee OA as early as ten years following ACLR, irrespective of surgical or conservative management.[40] The personal impact of OA following ACLR is heightened by the age of those undergoing this procedure, since the majority of ACL ruptures occur in adolescents and young adults.[19, 44] 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 then their older counterparts.[17] Additionally, teenagers who rupture their ACL are three times more likely to

undergo a revision ACLR, and revision surgeries are associated with poorer HRQoL outcomes.[29]

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.[12, 18, 45] The impact of ACLR on HRQoL could be exacerbated by limitations in participation 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,[52] while the Knee injury and Osteoarthritis Outcome Score (KOOS) measures knee-related quality of life (KOOS-QOL).[47] Both measures have been shown to be valid and reliable in ACL and OA populations.[46, 49, 54] Despite the high prevalence of ACLR internationally and the potential longer term implications for young, active populations, no systematic reviews have focussed on HRQoL following ACLR. The aims of this systematic review are: (i) to report HRQoL in people five years or more following ACLR; (ii) to compare HRQoL outcomes with available population norms; and (iii) to explore the relationship between HRQoL and participant factors (follow-up duration, sex, graft type).

METHODS

This systematic review followed the PRISMA guidelines for reporting systematic reviews and meta-analyses.[36]

Eligibility Criteria

To be eligible for inclusion, studies were required to report generic or knee-specific HRQoL outcomes from arthroscopic hamstring or patellar tendon autograft ACLR at a minimum five year follow-up. Studies were excluded from the review if: (i) all ACLR were performed with polyester ligament scaffold, synthetic ligament grafts or reinforced with LARS artificial ligament; (ii) all ACLR were performed using an open surgical or robot-assisted operative technique; (iii) all surgeries involved primary repair of the ACL; (iv) all ACLR were revision surgeries; (v) all patients had meniscal or concomitant ligament repairs in addition to ACLR; or (vi) the paper was published in a language other than English.

Studies involving patients who underwent ACLR using an eligible autograft technique and patients whose surgeries utilised techniques mentioned in our exclusion criteria (allografts, open procedures, primary repair 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 papers utilised 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 four weeks, the paper was deemed to be ineligible for the purposes of this review. Where multiple publications reported outcomes at various time-points from 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 five 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 full search strategy). The search was performed independently by two of the authors ([redacted]). 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 ([redacted]). The full text versions of identified studies were reviewed for final eligibility screening. Reference lists of key papers were cross-checked to ensure all relevant studies were included in the final yield. Finally, the search was repeated in October 2012 prior to data analysis to ensure all eligible publications had been included.

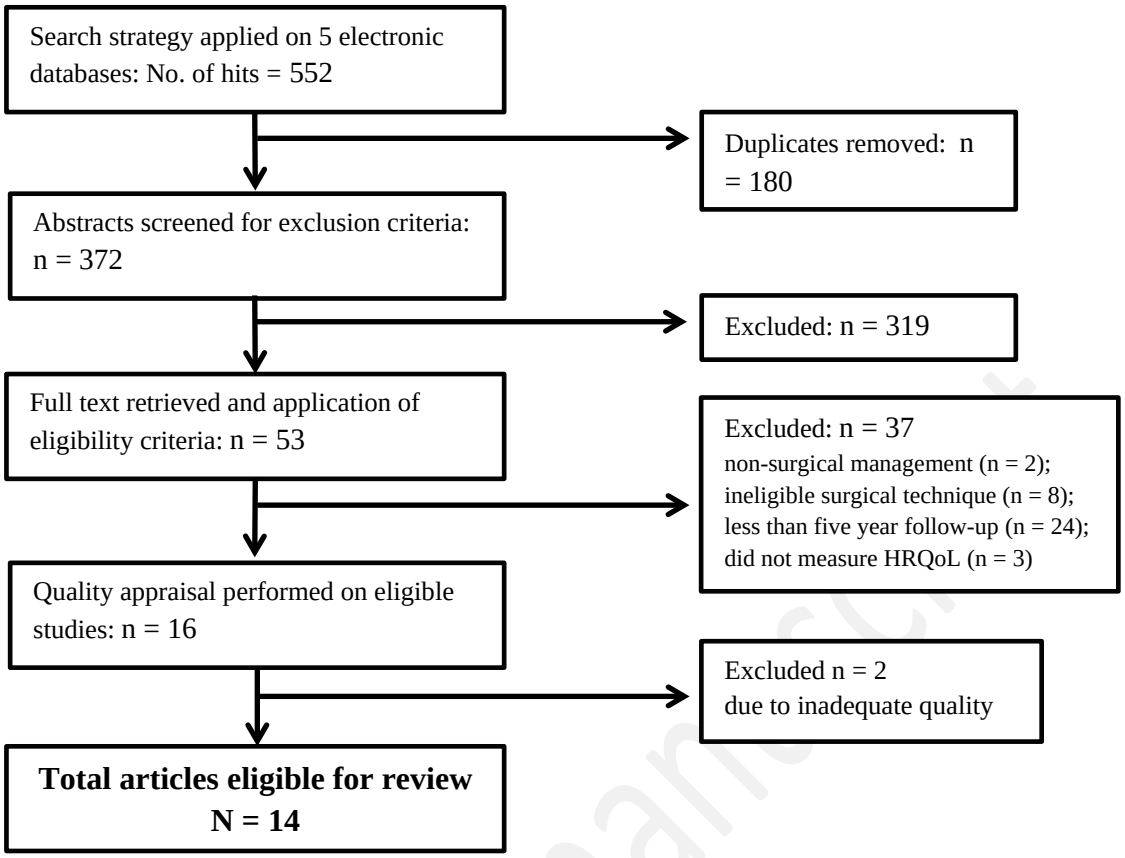


Figure 1. Search strategy

Quality Appraisal

The methodological quality of the included studies was appraised using a 21-item checklist adapted from the Downs and Black criteria.[11] The Downs and Black tool has been identified as a useful tool for assessing both randomised and non-randomised studies.[10] Some items on the tool were deemed not applicable to the study aims and designs of papers 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 check-list (a total of six items were excluded – see Appendix 2). 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 zero or one, where zero was allocated to studies with no sample-size calculation or reporting of insufficient power, and a score of one 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 scored one point for satisfaction of the criterion, and zero 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 two independent assessors ([redacted]); where agreement was not achieved, an independent arbitrator ([redacted]) was utilised to reach consensus.

Data management

All data were extracted and collated by two independent reviewers ([redacted]), including patient demographics (for example age, gender and time from injury to surgery), surgical details (graft type, concomitant injuries), outcome measures and adverse events (re-rupture, additional injuries, subsequent surgeries, rates of OA). Means and standard deviations (SD) were extracted for each patient-reported outcome measure. Where only mean and p-values were reported, SDs and standard error values were estimated by using the mean difference between groups and converting p-values to t-scores.[7] 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 (e.g. full scale visible). Additionally, if a study characteristic was reported for two separate eligible subgroups (e.g. age at follow-up reported separately for males and females) the subgroups were combined using a formula from The Cochrane Handbook for Systematic Reviews of Interventions[7] 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 were calculated for KOOS-QOL data. Using a random effects model 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 meta-analysis was deemed inappropriate due to the small number of studies reporting this outcome. To provide context for interpreting HRQoL outcomes following ACLR, HRQoL scores were compared with previously published population norms from similar age groups where possible. Two-tailed Spearman's rank correlation coefficient (rho) was used to explore correlations between potential predictive variables (graft choice [% patella tendon], gender [% 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. Following the removal of 180 duplicate papers and the exclusion of 319 ineligible studies, we obtained and reviewed the full text of 53 papers (Figure 1). Of these, 37 papers did not meet the inclusion criteria. Due to 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, seven authors (for eight studies) replied, and provided data for six studies.[5, 16, 33, 34, 39, 48] Six studies were subsequently excluded due to not providing details or data necessary for inclusion, or confirming ineligibility by correspondence. This resulted in the quality appraisal of 16 papers.

Methodological appraisal

Quality appraisal scores ranged from 4 to 18. Two studies did not satisfy more than 10 of the criteria and were therefore excluded from the review.[2, 13] The mean modified Downs and Black score for included studies was 14 (SD 2). When evaluated according to study design, prospective studies achieved a higher mean quality score (16 versus 13 for retrospective studies). The quality appraisal scores for each of the included studies are presented in Table 1.

Study characteristics

The 14 studies included reported HRQoL outcomes for a total of 2493 participants at a mean 9 (range 5-16) years following ACLR. The mean age of all participants at follow-up was 34 (range 18-42) years. The most commonly used HRQoL measure was the KOOS-QOL subscale, which was used in nine studies. The only generic (non-disease-specific) HRQoL measures used were the SF-36 version one (used in five studies) and the SF-36 version two (used in one study). An ACL-specific HRQoL measure, the ACL-QOL,[37] was used in one study (Table 1). Aside from HRQoL, other commonly utilised outcome measures included the Tegner activity score[51] (used in ten studies), the Lysholm knee scoring scale[32] (seven studies), the KT-1000 arthrometer[9] for assessing anterior/posterior tibio-femoral displacement (eight studies) and the Kellgren and Lawrence tool[27] for classifying radiographic OA (six studies).

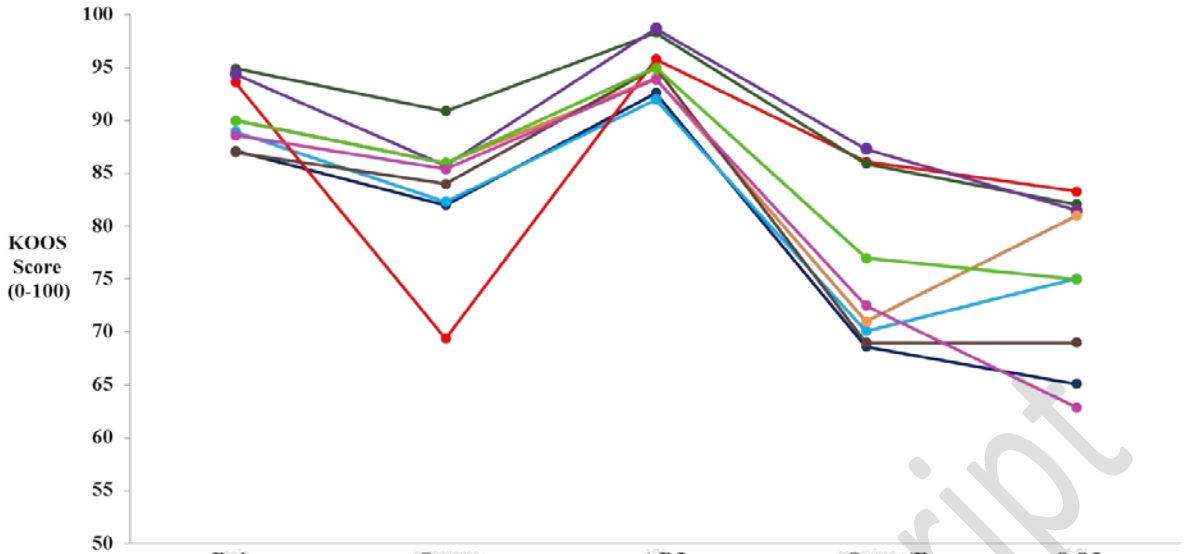
Table 1. Study Characteristics

Study	Quality	*N*	*N* eligible [a]	Follow-up (years)	HT (%)	PT (%)	Age at follow-up (years)	Sex % women	Time from injury to surgery (months)	RCT	Pro or Ret	HRQoL measure(s)
Ahlden[1]	16	10473	1452 [b]	5.4	82	18	NR	NR	24	no	Pro	KOOS
Barenius[5]	17	153	153	8.4 ± 0.98	49	51	34.0 ± 15.0	42	16.0 ± 24.2	yes	Pro	KOOS [c], SF36 [c]
Ferrari[14]	12	200	137 [d]	5.0 ± 25.4	0	100	35.25 [e]	0	1.3 ± 1.8	no	Ret	$SF36_1$
Gerhard[15]	12	63	63	16 ± 1	0	100	43 [e]	14	11 ± 23	no	Ret	KOOS [f], SF36 [g]
Gifstad[16]	13	93	93	7 (5.3-7.8)	49	51	34 [e]	37	NR	yes	Pro	KOOS [c]
Hoffelner[20]	13	28	28	10	0	100	32.2 ± 6.4	25	5 ± 6	no	Ret	KOOS
Mascarenhas[34]	12	38	19 [b]	9.1 ± 2.7	0	100	27.9 ± 8.1	37	NR	no	Ret	SF36 [c]
Mascarenhas [33]	12	46	23 [d]	5 ± 2	0	100	18 ± 3	57	NR	no	Ret	SF36 [c]
Möller[38]	18	56	56	11.5 (11-12)	0	100	39 [e]	52	6 (2-240)	yes	Pro	KOOS, SF36 [f]
Neuman[39]	18	93	22 [b]	12.8 ± 3.5	0	100	NR	36	48	yes	Pro	KOOS [c]
Ott[42]	13	151	151	5	0	100	27.6 $_F$, 32.5 $_M$ [e]	51	1.3 $_E$, 37.3 $_L$ (0.2-209)	no	Ret	ACLQOL
Øiestad[41]	16	210	210	13.7 ± 4.4	14	86	39.1 ± 8.7	43	24.8 ± 48.7	no	Pro	KOOS
Sajovic[48]	16	64	64	11	50	50	36 $_{HT}$, 38 $_{PT}$	42	25 $_{HT}$, 23 $_{PT}$ (1-84)	yes	Pro	$SF36_{v2}$ [c]
Swirtun[50]	13	46	22 [b]	5.6 ± 0.52	32	68	32 ± 8.1	48	9	no	Pro	KOOS [f]

| [a] number of participants for which data is reported (excluding all non-eligible participants) | [b] data from group of participants with less than 5 year follow-up were excluded | [c] data was provided through personal correspondence with author | [d] data from group of participants who did not undergo autograft ACLR were excluded | [e] age at follow-up calculated from age at surgery and time to follow-up data | [f] data extracted from graph | [g] did not report data for each SF-36 domain | *N*: sample size | HT: hamstring tendon autograft | PT: patella tendon autograft | RCT: randomised controlled trial | Pro: prospective | Ret: retrospective | KOOS: Knee injury and Osteoarthritis Outcome Score | SF36: Short-Form 36 (version 1) | $SF36_{v2}$: Short-Form 36 (version 2) | HRQoL: health-related quality of life | NR: not reported | $_F$: females | $_M$: males | $_E$: early ACLR group | $_L$: late ACLR group | all data is mean ± SD or median (range)

Knee injury and Osteoarthritis Outcome Scores

Mean KOOS-QOL scores were available from nine studies[1, 5, 15, 16, 20, 38, 39, 41, 50] and ranged from 63 to 83 out of a possible 100 (Figure 2). Analysis of the relationship between KOOS-QOL and other KOOS subscales revealed a strong, positive correlation between the KOOS-QOL and KOOS-Pain subscales (rho = 0.85, p = 0.003), and the KOOS-Sport/Rec subscales (rho = 0.70, p = 0.04). In comparison, there appeared to be a moderate correlation with KOOS-ADL subscales (rho = 0.66, p = 0.05) and little relationship with the KOOS-Symptoms scores (rho = 0.08, p = 0.70). Follow-up duration (p = 0.19) was not significantly associated with KOOS-QOL scores. Random effects meta-analysis resulted in a pooled KOOS-QOL summary effect of 74.5 (95% CI: 68.3 to 80.7). Comparison of pooled KOOS-QOL values with previously published population norms showed that ACLR populations reported poorer KOOS-QOL compared with healthy population norms with no knee symptoms (mean 90; 95% CI: 83.7 to 96.3)[50] and with general population norms (mean 82.4; 95% CI: 79.9 to 84.9)[47] (Figure 3).



	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[15]	93.6±12.5	69.4±16.7	95.8±11.1	86.1±19.4	83.3±18.1
Gifstad[16]	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[38]	90	86	94	71	81
Neuman[39]	87±13	84±17	95±10	69±25	69±23
Oiestad[41]	90±14	86±16	95±10	77±24	75±22
Swirtun[50]	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 mean ± standard deviation; lower score indicates poorer outcomes in all domains.

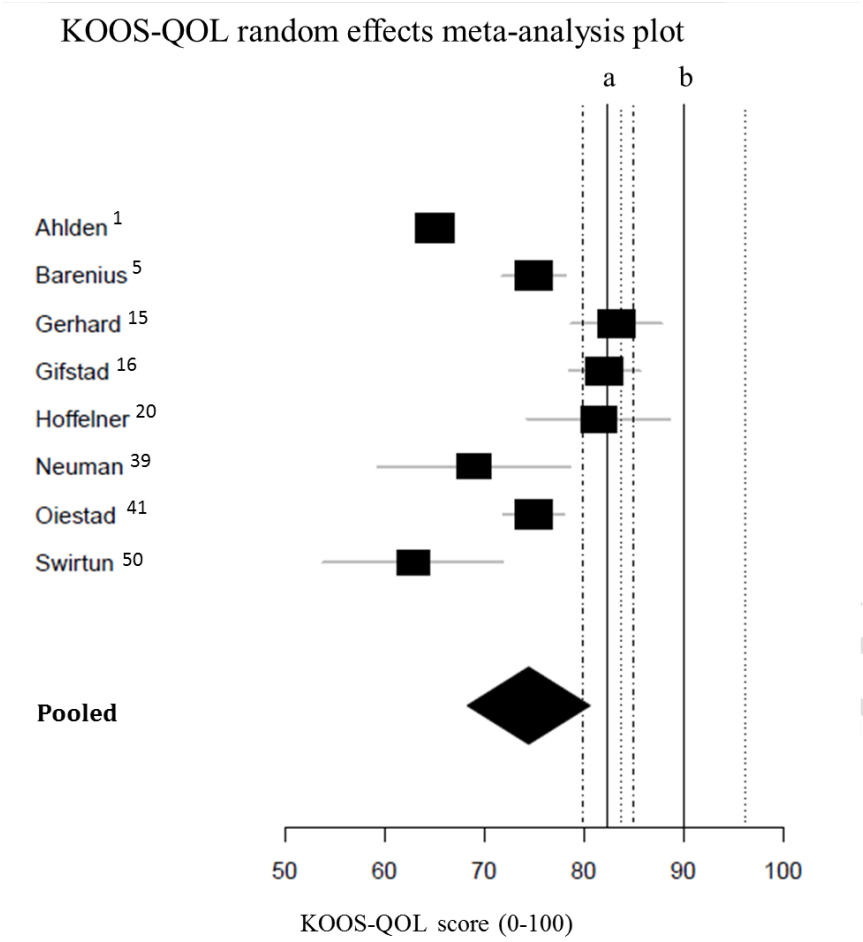
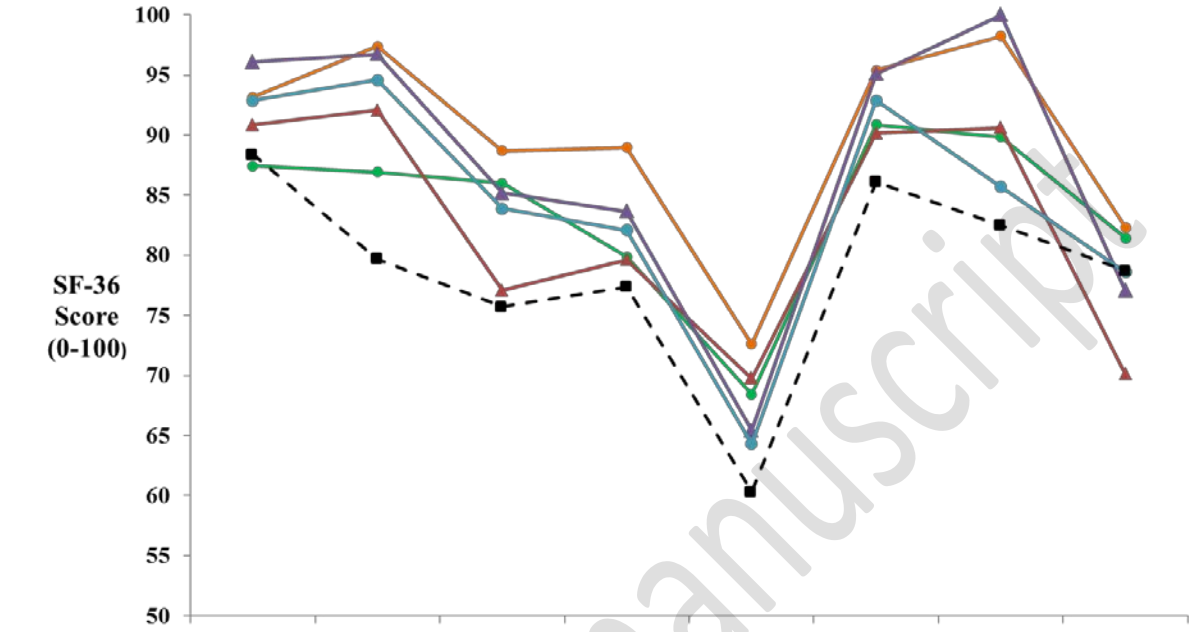


Figure 3. Forest plot of random-effects meta-analysis of KOOS-QOL mean, standard error (box) and 95% CI data (whiskers) data from individual studies in addition to pooled summary mean and 95% CI. Population normative values are reported vertically; **a** is normative data extracted from Paradowski et al[43] n = 291, age 18-54 years, mean (solid line "a") 95% CI (dashed lines), and; **b** is normative data extracted from Roos et al[46] n = 25, age 37-50 years, mean (solid line "b") 95% CI (dotted lines). Lower score indicates poorer outcomes.

Short-Form 36 (SF-36) scores

The SF-36 measure comprises eight individual health-related domains. For the SF-36 version one, the Role Emotional (RE) domain demonstrated the greatest variation, with mean scores ranging from 85 to 100 (Figure 4). In contrast, mean scores for the Social Functioning (SF) domain were fairly consistent across all studies. All ACLR studies reported higher mean SF-

36 values in six domains than previously published population norms (n=2323),[30] indicating better HRQoL (Figure 4).



	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 [14]	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[33]	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 [38]	92.9	94.6	83.9	82.1	64.3	92.9	85.7	78.6
Loge [a]	**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 one results for individual studies and normative population. All values are mean ± standard deviation; lower SF-36 score indicates poorer outcome in all domains; PF: Physical Function, RP: Role Physical, BP: Bodily Pain, GH: General Health, V: Vitality, SF: Social Function, RE: Role Emotional, MH: Mental Health; [a] Normative data from Norwegian population n = 2323, age 44.9±16.5.[30] Results from Sajovic et al[48] are not featured in this graph as SF-36 version 2 was used in this study and standardised scores are not directly comparable.

ACL-QOL scores

The ACL-QOL outcome measure was used to measure HRQoL in only one study.[42] As the primary aim of this study was to compare outcomes between men and women following ACLR, separate ACL-QOL mean values were reported according to sex. No significant differences were found in ACL-QOL scores (mean for men 80.2; mean for women 76.3) at

mean five 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 five studies.[14, 38, 41, 42, 50] The majority of these studies found no significant differences in respect of sex for SF-36, KOOS-QOL or ACL-QOL outcomes.[38, 41, 42, 50] We observed a non-significant trend towards studies with a higher portion of women reporting lower KOOS-QOL (rho = -0.63, $p = 0.07$) scores and no significant correlations between sex and SF-36 scores ($p > 0.10$ for all domains).

The relationship between age at ACL surgery and HRQoL was investigated in four studies.[20, 38, 42, 50] Participant age did not influence HRQoL outcomes measured with the KOOS[20, 38, 50] or SF-36.[38] Ott et al[42] categorised participants by age and sex, and found the greatest discrepancy in ACL-QOL values in 12-18 year old women, who scored 15 points lower than their male counterparts (93 versus 78). 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 patients (4%, $p < 0.001$) and age matched males (5%, $p = 0.02$).

Revision ACLR surgery

The reported rates of ACL re-rupture ranged from 1%[42] to 9%.[48] Only two studies analysed HRQoL outcomes in those who underwent revision ACLR, and these studies found significantly poorer HRQoL outcomes post-revision surgery, compared with primary ACLR.[1, 38] Notably, a large Swedish ACL register study found participants who underwent revision ACLR (n = 194) scored worse in all KOOS subscales at five year follow-up ($p < 0.001$) compared with those who underwent primary reconstructions (n = 1258). It should also be noted that the studies that reported the highest KOOS-QOL scores excluded patients who had revision surgeries, concomitant injuries at baseline or subsequent injuries or complications.[16, 20] Likewise, one of two studies which excluded revision surgeries from their cohorts scored highest in each of the SF-36 domains, indicating a higher HRQoL.[33, 34]

Meniscal or cartilage injury

The impact of sustaining concomitant meniscal or cartilage injury prior to ACLR on HRQoL outcomes at follow-up was investigated in five studies.[1, 5, 15, 38, 50] Meniscal injury (treated surgically at the time of ACLR) was associated with lower KOOS-QOL and SF-36 scores at greater than 10 years follow-up.[16, 40] In contrast, studies with follow-up periods of five, six and eight years found no significant differences in KOOS-QOL[1, 5, 50] or SF-36 scores[5] in those with and those without associated intra-articular injuries. However, these studies found significantly worse KOOS-QOL scores in those who underwent concomitant medial meniscus surgery ($p = 0.035$)[5] or sustained subsequent trauma following ACLR ($p = 0.002$)[50] at eight and six year follow-up.

Time from injury to surgery

353 Time from injury to surgery was reported in 11 of the 14 studies reviewed, with mean times
354 ranging from five months to two years (Table 1). Of these, three studies further investigated
355 the relationship between time from injury to surgery and HRQoL outcomes. Two studies
356 found no correlation between time from injury to surgery and KOOS and SF-36 scores[41] or
357 ACL-QOL outcomes.[48] In contrast, Barenius et al [5] found that participants who waited less
358 than five months to have surgery had significantly better SF-36 scores in three subscales (PF:
359 $p = 0.014$, BP: $p = 0.013$, SF: $p = 0.037$) and better KOOS-QOL scores ($p = 0.059$) at eight
360 year follow-up, which may have been related to the fewer meniscal injuries (37% versus 62%
361 $p = 0.008$) at the time of ACLR.

362

363 *Graft type*

364 Four studies investigated differences in HRQoL outcomes between a bone-patellar-tendon-
365 bone (BPTB) autograft and a double or single looped hamstring autograft.[5, 16, 34, 48] All of
366 these studies found no significant differences in KOOS or SF-36 scores between groups at
367 five, seven, eight, and eleven year follow-ups. Similarly, we found no significant correlations
368 between graft type and KOOS-QOL ($p = 0.33$) or SF-36 ($p > 0.44$ for all domains) outcomes.

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Radiographic osteoarthritis

Despite eight studies reporting the prevalence of radiographic OA following ACLR, only two studies compared HRQoL in those with and those without OA.[39, 41] Øiestad et al[41] found that the presence of 'any' OA (≥ grade 2) was not associated with KOOS-QOL scores, however those with 'severe' OA (grade 4) reported significantly poorer KOOS-QOL subscale scores ($p = 0.002$). Neuman et al[39] reported a trend towards 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 patient-reported outcome measure used to assess HRQoL can impact on the interpretation of results. Studies that used the knee-specific KOOS reported poorer HRQoL, compared with published population norms.[24, 46] In contrast, studies utilising the generic SF-36 questionnaire commonly reported similar or higher HRQoL scores than age-equivalent population norms.[22, 30] Second, we identified various factors that may be associated with poorer HRQoL following ACLR including concomitant or subsequent meniscal injury, 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 to previously published population norms.[21, 22, 30, 53] Visual comparison of SF-36 means between studies and population normative data,[30]

revealed a similar pattern of scores across all domains (Figure 4). The SF-36 is a generic measure of HRQoL and features 36 items over 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 the majority of ACL injuries occur in a young sporting population,[44] 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 17-23 years (n=696).[23] These college athletes scored significantly better in all SF-36 domains ($p < 0.01$) except for Bodily Pain ($p = 0.05$) 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 old, 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 compared with a healthy population with no history of ACL or meniscal injury, 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 due to the small degree of overlap in 95% CI between ACLR and population norms (mean 75; 95% CI: 68.3 to 80.7 versus mean 82; 95% CI: 79.9 to 84.9).[43] This result could reflect the nature of the questionnaire, which is intended to assess knee injuries with the potential of causing post-traumatic OA.[47] The knee-related quality of life subscale of the KOOS comprises four 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 ACLR patients revealed poorer KOOS-QOL than for controls without knee symptoms.[46] None of the studies we reviewed specifically reported KOOS-QOL in a subgroup of participants who were clinically symptomatic. Considering the positive relationship we observed between KOOS-Pain and KOOS-QOL sub-scores, this may underestimate impairment in HRQoL.

The relationship between baseline meniscal injury and HRQoL may be at least partly mitigated by follow up duration. The two 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[38] and 16 years[15] following ACLR. In comparison, studies reporting no significant influence of concomitant intra-articular injuries on HRQoL outcome did so at five,[1] six[50] and eight year[5] follow-ups. These data suggest that the negative consequences of concomitant meniscal injury may develop over time, becoming most apparent after 10 years. This is in line with a systematic review that reported low OA prevalence following isolated ACL injuries (0-13%) and higher prevalence of OA in those with additional meniscal injures (21-48%) at a minimum 10 years following ACL injury.[40] Concomitant articular injury may also contribute to poor HRQoL outcomes following ACLR revision.[1, 38] A literature review on revision ACLR identified a trend for higher rates of chondral and meniscal injuries in those having revision surgeries.[26] Similarly, a single study reported significantly poorer KOOS-QOL in those who sustained subsequent knee trauma,[50] which may be related to the acceleration of OA progression.[6] The temporal relationship between meniscal and other concomitant injury, 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. Due to the small number of studies reporting SF-36 and ACL-QOL outcomes, meta-analysis and estimation of effect sizes were not appropriate for these measures. 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 impact of specific demographic and surgical factors on HRQoL outcomes. This limited our ability to draw strong conclusions regarding factors which 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 five years after ACLR, compared to population norms for those without knee pain or injury. Impairment in HRQoL was less apparent when compared to 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. Revision surgery, subsequent injuries following ACLR and the presence of severe radiographic OA were associated with poorer HRQoL at a minimum five years following ACLR. Meniscal injuries had a negative impact on HRQoL 10 years or more following 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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