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Anne Fältström, Martin Hägglund and Joanna Kvist

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**Title: Patient- reported Knee Function, Quality of Life, and Activity Level After
Bilateral Anterior Cruciate Ligament Injuries**

Authors: Anne Fältström, * † RPT, Martin Hägglund*, RPT, PhD, and Joanna Kvist*, RPT, PhD

* †Department of Physiotherapy, Ryhov County Hospital, Jönköping, Sweden.

*Department of Medical and Health Sciences, Division of Physiotherapy, Linköping
University, Sweden

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ABSTRACT

Background: About 12% of patients who have undergone a primary anterior cruciate ligament (ACL) reconstruction sustain a contralateral ACL injury within five years.

Purpose: To investigate patient-reported knee function, quality of life, and activity level in subjects with bilateral ACL injuries.

Study Design: Cross-Sectional Study.

Methods: A search of hospital records identified 147 subjects, 18-45 years, with bilateral ACL injuries. Of these, 83 met the inclusion criteria, having had their first ACL injury up to 12 years ago with no other major injuries to the knee joint. Sixty-six of these subjects (80%), 47% women, mean age 29.1 years (SD 7.2), answered a questionnaire packet. Subjects with unilateral ACL reconstruction (n=182) were used for comparison.

Results: Subjects with bilateral ACL injuries had a median Lysholm knee score of 82 (range 34-100). The mean EQ-5D index of the overall health status was 0.77 (0.22) and the EQ-5D VAS was 75.5 (17.6). The median (range) Tegner activity level was 9 (1-9) before any injuries, 7 (1-9) before the second ACL injury, and 4 (1-9) at the time of follow-up. The activity level before the second injury was higher compared with the follow-up for subjects with unilateral ACL-reconstruction. At follow-up, 23% of the subjects with bilateral ACL injuries were back to their previous activity and 12% of subjects were at the same level as before their injuries, compared with 43% ($P=.004$) and 28% ($P=.01$) in subjects with unilateral ACL reconstruction. Bilaterally ACL injured subjects had significantly lower scores in the Knee Injury and Osteoarthritis Outcome Score (KOOS) subscales pain, function in sports and recreation and knee-related quality of life and in ACL deficiency Quality of Life (ACL-QOL) score compared with subjects with unilateral ACL reconstruction.

Conclusions: Subjects with bilateral ACL injuries reported poorer knee function and quality of life compared with unilateral ACL reconstructed subjects, their activities had changed, and

they were dissatisfied with their current activity level. They had a high activity level before their first and second ACL injuries, but an impaired activity level after their contralateral injury at follow-up.

Keywords: ACL, contralateral, follow-up, return to sport, subsequent injury, Tegner activity scale

What is known about the subject: The outcome and knee related quality of life after a unilateral ACL injury is well described, especially after an ACL reconstruction.

Approximately 85-90% of subjects have normal or nearly normal knee function after an ACL reconstruction according to impairment- and activity-based patient-reported outcomes. About two-thirds of subjects return to their pre-injury activity level and 50% to competitive sports after an ACL reconstruction. About 12% of patients sustain a contralateral ACL injury within five years after a primary ACL reconstruction, and the risk is higher among young, active people.

What this study adds: The study demonstrates that subjects with bilateral ACL injuries reported that their knee function and quality of life were impaired up to 12 years after the first injury, and these impairments were worse compared with subjects with a unilateral ACL injury. Subjects with bilateral ACL injuries reported changing their activities and activity level, mainly due to reduced knee function, and they were dissatisfied with their current activity level. At follow-up, 23% were back to their previous activities and only 12% were at the same level as before any of the ACL injuries. Activity levels were significantly lower compared with subjects with unilateral ACL reconstruction. Subjects with bilateral ACL injuries had high activity levels before their first and second injuries, which may be one reason for incurring a contralateral ACL injury.

INTRODUCTION

The incidence of anterior cruciate ligament (ACL) injury in the general population is assumed to be between 32-70/100 000 people/year.⁹ The incidence increases several-fold in sports, and is as high as 500-8500/100 000 participants/year in soccer,⁴¹ which is the main sport in Sweden. It has been reported that 3% will have a contralateral ACL injury within two years after the first injury⁴² and 11.8% after a minimum duration of five years of follow-up.⁴⁴ Paterno et al.²⁹ reported that in an active, young population, who went back to cutting and pivoting activities after an ACL reconstruction, 25.4% sustained a new ACL injury within 12 months. Seventy-five percent of these injuries were to the contralateral knee.

Clinical and patient-reported evaluations do not always correlate,²⁶ and in recent years, assessments have focused on the ACL injured patient's self-reported knee function and quality of life using various knee questionnaires.^{17, 26-28, 38} Recently published systematic reviews show good patient-reported knee function after primary ACL reconstruction³ and after non-reconstructive treatment.²⁴ A recent meta-analysis showed that, overall, 82% of patients had returned to some kind of sports participation, 63% to their pre-injury level and 44% to a competitive sport after a mean follow-up time of 41.5 months after unilateral ACL reconstruction. Despite the low return to sports rate, approximately 85-90% of patients had achieved a successful outcome in impairment-based measures of knee function and in patient-reported function.³ A return to sports is also possible after non-reconstructive treatment.^{14, 38} It was not determined from these studies whether or not a subsequent injury affected a subject's return to pre-injury activities.

An ACL injury is a major trauma to young and active athletes. Subsequent additional trauma to the ACL injured knee has been associated with poor patient-reported outcome.³⁸ Subjects

undergoing revision ACL reconstruction reported poorer knee function and quality of life compared with subjects undergoing primary ACL reconstruction.⁴³ To suffer a contralateral ACL injury is another considerable trauma for the patient. To the authors' knowledge, studies evaluating patient-reported outcomes in subjects with bilateral ACL injuries are lacking. Therefore, the aim of this study was to investigate patient-reported knee function, quality of life, and activity level in subjects with bilateral ACL injuries and to compare with subjects with unilateral ACL reconstruction. Our hypothesis was that subjects with bilateral ACL injuries would have lower values on these parameters compared with subjects with unilateral ACL reconstruction.

MATERIALS AND METHODS

Study design and subjects

The study had a cross-sectional design. All collected data concerned the subjects' current situations except the questions about activities performed when they sustained their ACL injuries and before the first and second injuries. Subjects were identified through a search of hospital records at five orthopaedic clinics in southeast of Sweden. Data were collected from September 2010 to March 2011. The inclusion criteria were: subjects aged between 18-45 years old at the time of follow-up who visited any of the orthopaedic clinics between the years 2004-2009 with a bilateral total ACL injury, verified by arthroscopy, magnetic resonance imaging (MRI), or clinical examination by an orthopaedic surgeon. The first ACL injury should have occurred after 1997 (the maximum time from injury was 12 years). Subjects should be able to read and understand the Swedish language. Subjects were excluded if they had other major activity-limiting disorders, a combined intracondylar fracture, a total rupture of the medial or lateral collateral ligament, or a posterior cruciate ligament injury. Data collected from hospital records included associated injuries to the knees, age at the time of

injuries, time interval between injuries, and information about reconstructions or any other surgical or non-surgical treatment.

A review of hospital records was carried out for 3038 subjects with a diagnostic code representing an ACL injury, distortion of the knee, or knee instability, according to the diagnosis system ICD10. Of these, 1738 subjects (38% female) had a verified unilateral ACL injury, 147 (7.8% of the population, 38% female) had bilateral ACL injuries (Table 1). Sixty-four subjects were excluded because they sustained their first injury before 1998 (n=39), had a partial rupture in any of the knee (n=20), had other activity limiting disorders (n=3) or the diagnosis ACL injury was unclear (n=2). Finally, 83 (45% female) met the inclusion criteria. Sixty-six of the 83 subjects (80%) answered the questionnaires and 63 (76%) participated in the telephone interview (Lysholm knee score, Tegner activity scale, activity at injury and before the second injury).

A group of 182 unilaterally ACL reconstructed subjects with specific inclusion criteria's were extracted from nearly the same cohort for comparison. That cohort is described in a recently published study.¹⁹ Mean age was 28.5 years (SD 8.2) (42% female) and the ACL reconstruction was performed 2 to 5 years before completing the questionnaires.

Data collection

Four questionnaires were sent to the subjects with bilateral ACL injuries included in the study: a study-specific questionnaire, the Knee Injury and Osteoarthritis Outcome score (KOOS),³³ ACL deficiency Quality of Life (ACL-QOL),²³ and EuroQol (EQ-5D)³¹. Two reminders were sent within four weeks to non-respondents. After consent, two further questionnaires were filled in via a telephone interview: the Lysholm knee score⁴⁰ and the Tegner activity scale.⁴⁰ Activity level before the first and second injury as well as at follow-up, was reported. This procedure was chosen to ensure correct data entry on the two latter

questionnaires since they were not specifically developed for bilateral injuries. Questions about the activities performed when subjects sustained their first and second ACL injuries were asked.

The study-specific questionnaire included information about body mass index (BMI), occupation, if subjects had to change professions or study plans because of their knee/knees, if subjects had other injuries that affected their activity, family history of ACL injury (defined as an ACL injury in a first relative), questions about the type of activity and activity level before their ACL injuries and currently, any reason for not returning to sports, and satisfaction with their knees and activity level. The subjects estimated their current global knee function and satisfaction with their knee function in the first and second injured knees on four ten-point Likert scales ranging from 1 (not satisfied at all) to 10 (very satisfied). They also estimated if they were satisfied with their current activity level using the same Likert scale. Symptom satisfaction was measured with the question: “If you had to live with your current knee function for the rest of your life, would you feel” and graded in a seven-point Likert scale with the choices: delighted, pleased, mostly satisfied, mixed , mostly dissatisfied, unhappy, and terrible.⁷

The KOOS evaluates knee related problems in five subscales: pain, symptoms, activities in daily living (ADL), function in sports and recreation (sport/rec), and knee-related quality of life (QOL). Sub-scores are given separately and range from 0 (worst) to 100 (best). The KOOS has been tested for validity in a variety of diagnoses such as osteoarthritis, meniscus injury, and ACL injuries and is a standardized assessment instrument with good reliability.³²

The Lysholm knee score consists of eight questions on subjective perception of pain and instability. The score ranges from 0 (worst) to 100 (best), and a score ≥ 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).^{17, 40} The Lysholm knee score has good reliability and validity.^{4, 22} In the telephone interview, the subjects graded both the first and second injured knee and scores were noted for each knee. For the analysis of the Lysholm knee score, the lower score for either knee was used for each question.

The ACL-QOL is an injury specific questionnaire evaluating health-related quality of life. It consists of 31 items, 32 in the Swedish version, divided into five different sub-scales: symptoms, physical complaints, work-related concerns, physical activity and sport participation, and life-style and social concerns.²³ In the original version, subject's responses are reported on a 100 mm VAS, but the estimate was converted into a ten-point Likert scale in the XXX version. A higher score represents a better quality of life. The Swedish translation has shown good reliability and validity (Kvist, unpublished data, 2006).

The EQ-5D assesses health-related quality of life.³¹ It consists of two parts; the EQ-5D descriptive system and the EQ VAS. The EQ-5D descriptive system comprises 5 dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension has a three point scale: no problems, some problems, and extreme problems. The scores are presented as different index values ranging from < 0 (worst) to 1 (best) elicited from a general population. The UK EQ-5D index was used, which is the original for estimating EQ-5D index scores.⁸ The EQ VAS records self-rated health on a vertical VAS (0-100) where the endpoints are "Worst imaginable health state" (0) and "Best imaginable health state" (100). The EQ-5D is reliable and valid.⁵

The Tegner activity scale assesses activity level and grades activity with regard to knee function on a scale from 0 to 10, where 0 corresponds to the least strenuous activity for the knee and 10 is equal to participation in soccer on a national level.⁴⁰ Sports not included in the original Tegner activity scale were graded based on the consensus of an expert group of orthopaedic surgeons, physical therapists, and researchers (Figure 1). The subjects reported the kind of physical activity they participated in before the first injury, before the second injury, and currently and the researcher noted the appropriate grading on the scale.

For subjects with unilateral ACL reconstruction the KOOS, ACL-QOL, Tegner activity scale, questions about the type of activity and activity level before their ACL injury and currently, satisfaction with their knee and activity level and symptom satisfaction were used for comparison with subjects with bilateral ACL injuries.

The study was approved by the Regional Ethical Committee at Linköping University (Dnr 2010/10-31) and written informed consent was obtained from all subjects.

Statistical methods

The Statistical Package for Social Sciences version 20.0 (SPSS Inc., Chicago, Illinois) was used for all statistical analyses. Means and standard deviations (SD) were calculated for descriptive statistics except for the Tegner activity scale, the Lysholm knee score, and the subjects' estimations on a Likert scale in the study specific questionnaire, where median, range, and inter-quartile range (IQR) were used. Comparisons of males vs. females and first vs. second injured knee in the bilateral ACL-group, as well as comparisons with the subjects with unilateral ACL reconstruction were made by Student- *t*-test (age, KOOS, ACL-QOL, EQ-5D) and by Mann-Whitney *U* test (Tegner activity scale, Lysholm knee score, satisfaction

with activity level). Proportions (male/females, activity before injury, back to activity and activity level, change in training habits) were compared with the χ^2 test. The significance level was set at $P < .05$.

RESULTS

Subjects with bilateral ACL injuries

Thirty-three subjects experienced their initial injury to the left knee, 32 to the right, and one had both ACL injuries simultaneously. A flowchart of the subjects with bilateral ACL injuries and subjects' characteristics are summarized in Figure 2 and Table 1, respectively. The females were significantly younger than males when they suffered their first ACL injury (19.0 vs. 24.6 years, $P < .001$) and at the time of follow-up (25.8 vs. 32.0 years, $P < .001$). Twenty-eight (42%) subjects were ≤ 18 years when they sustained their first ACL injury, and 29 (44%) sustained their second injury within two years from either the first injury (n=10) or reconstruction (n=19). The mean time between reconstruction of the first injury and the second injury was 36.8 (24.2) months (Table 2).

Ten subjects had isolated ACL tears in both knees without any concomitant injuries. In six knees, where the diagnosis was confirmed with clinical examination, associated injuries were not known. Seventeen (26%) had a family history of ACL injury.

There were no significant sex differences in scoring on the KOOS, Lysholm knee score, EQ-5D, ACL-QOL, Tegner activity scale, or in the subjects' satisfaction with their knee function and the level of activity ($P > .05$). Therefore, the following results are presented for the whole group. Six subjects had an ACL reconstruction or revision within 12 months prior to follow-

up (5-6 months, n=2; 7-12 months, n=4). The rehabilitation period after ACL reconstruction usually lasts about 6-12 months; therefore, those subjects may still have been rehabilitating. An analysis performed without these six subjects showed no differences in overall results; therefore, they were included in the study analyses.

Knee function and quality of life

Thirteen subjects (20%) had to change their plans for work or studies because of their ACL injuries. The current median Lysholm knee score was 82 (range 34-100, IQR 71-94).

Fourteen (22%) subjects had excellent (≥ 95), 15 (24%) good (84-94), 24 (38%) fair (83-65), and 10 (16%) poor (< 65) results. Results are summarized in Table 3.

Activity level

The activity level according to Tegner is presented in Figure 3 and Table 3. Fifty-six (85%) subjects were active in contact sports such as soccer, basketball, handball, floorball, and ice hockey before the first injury, 46 (67%, two missing answers) before the second injury, and 12 (18%) at follow-up. Forty-eight (75%, two missing answers) subjects returned to their pre-injury activity before the second injury. Fifteen subjects (23%) reported that they had returned to their previous activity at follow-up, with eight (12%) at the same activity level as prior to their ACL injuries. The most common reasons why subjects had not returned to their previous activities were reduced function of the knee or knees (38%), a sense of not trusting the knee or knees (23%), fear of re-injury (19%), a family situation (8%), a work situation (8%), team/training had changed (for example not the same coach or team mates) (2%), or others (2%). At follow-up, sixty-one subjects (92%) had changed their training habits because of their knee injuries.

Comparisons with subjects with unilateral ACL reconstruction

The subjects with unilateral ACL reconstruction were comparable with the subjects with bilateral ACL injuries in age and sex distribution ($P > .05$). Subjects with unilateral ACL reconstruction reported higher scores in KOOS subscales pain, sport/rec, QOL and in ACL-QOL ($P < .05$) (Table 3, Figure 4). Compared with subjects with bilateral ACL injuries, the subjects in the unilateral ACL reconstructed group had returned to their previous activity at follow-up to a higher degree (43%, $P = .004$), more often at the same activity level as prior to the ACL injury (28%, $P = .01$), and had changed their training habits because of their knee injury to a lesser degree (77%, $P = .005$).

DISCUSSION

Subjects with bilateral ACL injuries had impaired self-reported knee function, quality of life, and activity levels up to 12 years after their first injury. They had changed their activities and activity levels, mainly due to reduced knee function. The return to pre-injury activity and activity level at follow-up, i.e. after the second injury, was lower compared with subjects with unilateral ACL reconstruction. Subjects with bilateral ACL injuries had a high activity level before the second injury, which may be one reason for incurring a contralateral ACL injury.³⁹

Subjects with bilateral ACL injuries in the present study reported low quality of life in all three questionnaires used. On the KOOS subscales for pain, sport/rec and QOL and in ACL-QOL, they scored significantly lower compared with subjects with unilateral ACL reconstruction used for comparisons in the present study, and also lower compared with previously published results^{12, 13, 17, 26-28, 38} The result was similar to subjects with ACL revision at a median follow-up time of 6 years, but the revision subjects had worse results in the subscale pain²¹ (Figure 4). Health-related quality of life was also worse in our subjects with bilateral ACL injuries (UK EQ-5D index 0.77, VAS 75.5) compared with a general

Swedish population aged 20-40 years (UK EQ-5D index 0.88-89, VAS 88-90),⁶ a soccer population (UK EQ5D index 0.90, VAS 81) (Olsson and Kvist, unpublished data, 2012), and subjects with unilateral ACL reconstruction at 1-5 years follow-up after surgery (UK EQ-5D index 0.80-3, VAS 77.2-78.9).⁹ Minimal clinically important differences for the instruments have been suggested: KOOS 8-10 points,³² ACL-QOL 10-15 points (for the 0-100 scale),^{23, 28} UK EQ-5D index 0.08, and EQ-5D VAS 8-12.³⁰ Swirtun et al.³⁸ reported, for subjects with an ACL injured knee, that the main reason for a poor outcome in the KOOS was additional subsequent trauma. Thus, to incur two ACL injuries, often during a short time period, is likely to have a negative effect on the overall satisfaction with knee function and quality of life.

According to the Lysholm knee score, only 46% of our subjects had good or excellent results (i.e. ≥ 84). Kostogiannis et al. found that 92% and 78% of subjects, with unilateral ACL injuries treated without reconstruction, had good or excellent results in the Lysholm knee score at 3 and 15 years follow-up, respectively.¹⁷ For ACL reconstructed patients, the mean or median Lysholm knee score is usually reported to be over 90 in a follow-up time of 5-16 years postoperatively.^{12, 15, 26} Wright et al. reported a low mean Lysholm knee score (82) for ACL revision patients with a pooled mean duration of follow-up of 5.4 years,⁴³ similar to the results for subjects with bilateral injury in the present study. The subjects with unilateral ACL reconstruction used for comparisons did not fill in the Lysholm knee score and EQ-5D.

Our subjects with bilateral ACL injuries had a high pre-injury activity level and many were involved with cutting and pivoting activities. Most of them (75%) returned to their pre-injury activities and two-thirds had returned to contact sports before the second injury. This is a high rate of return to sports, that was significantly higher compared with subjects with unilateral reconstruction used for comparisons and compared with a previous review stating that about 66% of patients return to their previous activity level and 44% to competitive sports after a

unilateral ACL reconstruction.³ Another review reported that non-reconstructed ACL injured subjects dropped from a pooled mean Tegner of 7.1 to 5.6, which corresponds to a 21% reduction in activity, at follow-up 12-66 months after injury.²⁴ A return to a high activity level after an ACL injury is the most important risk factor to sustain a contralateral injury.³⁹ About two-thirds of our subjects incurred their second ACL injury while performing the same activity as when sustaining their first injury, most commonly soccer. Only 18% returned to contact sports after their second ACL injury. Fear of re-injury, negative emotions, and low confidence in their ability are factors associated with not returning to sports.^{18, 20} Interestingly, the proportion of subjects with bilateral ACL injuries who indicated fear of re-injury as a reason not to return to previous activities was similar to subjects with a unilateral ACL reconstructed knee¹⁸ and not increased, as might be expected.

Similar to the majority of previous studies on subjects who underwent unilateral ACL reconstruction,^{16, 26, 28} we could not find any sex differences in patient-reported knee function, quality of life, and activity level for subjects with bilateral injuries. However, some studies demonstrated sex differences where females reported worse KOOS scores compared with males.^{1, 38} Females were five years younger when sustaining their first ACL injury, which is in accordance with other studies on soccer players.⁴¹ The proportion of males:females was equal in this study. Shelbourne et al.³⁵ found that females suffer more contralateral ACL injuries than males and that the incidence is associated with being younger than 18 years at the initial injury. Similarly, Paterno et al.²⁹ showed that females, 10-25 years old, had a six times higher risk of a contralateral injury than males. Other studies found no sex differences in the incidence of a contralateral injury. These discrepancies may be due to age difference between the subjects in studies.^{34, 37, 42}

The subjects were reconstructed in different orthopaedic clinics, with different surgical methods and different rehabilitation protocols. Thus, the results are likely to represent the general outcome after bilateral ACL injuries, which can be considered a strength of this study. However, some limitations of the study should be acknowledged. First, none of the questionnaires used are developed specifically for bilateral ACL injuries. However, many questions assess function, for example, the EQ-5D, the QOL and the ADL and sport participation subscales in the KOOS, and are not side-specific. Another limitation is that subjects had to recall their activity and activity level retrospectively, which could be up to 12 years ago, and recall error cannot be ruled out. Activity level also decreases with age² due to factors other than ACL injury, such as ability, motivation, and lifestyle changes. In the present study, 20% of subjects reported that they did not return to their previous activities for reasons other than the ACL injuries. The material was quite small and heterogenic. Some subjects had graft ruptures and revisions. The purpose of the study was to describe the subjects with bilateral ACL injuries irrespective of whether they were reconstructed or not and we did not analyze subgroups because of the limited sample. However, patients with bilateral ACL injuries is a small and heterogenic group that is increasing⁹ and this particular ACL population has not been described previously in the literature.

Our data included a few ACL injuries that were verified only clinically. Studies have shown that if the clinical examination of the knee joint is performed after the acute phase without hemarthrosis and by an orthopaedic surgeon it is highly predictive of an ACL injury.³⁶ However, many ACL injuries in subjects with a rotational knee trauma are missed if they are not followed up and the incidence of ACL is probably higher.¹⁰ Another limitation of clinical examination is that associated injuries are not reported, and the possible influences of any associated injuries of the knee on the results of the patient-reported outcomes are unknown. In this study, most subjects did not have isolated ACL injuries. It is very common that associated injuries to the articular surface, meniscus, and MCL occur with an ACL injury.^{15, 17} Previous

studies show that associated injuries can lower self-reported outcomes,^{25, 27} but other studies have not shown any difference in patient-reported outcomes between associated or isolated ACL injuries.^{17, 38} Furthermore, the aim of the study was not to differentiate between subjects with isolated or associated ACL injuries.

CONCLUSIONS

Subjects with bilateral ACL injuries had impaired patient-reported knee function, quality of life, and activity levels up to 12 years after their first injury. They changed their activities and activity level, mainly due to reduced knee function, and they were dissatisfied with their activity level. The rate of return to previous activity after the second injury was lower compared with subjects with unilateral ACL reconstruction. Subjects with bilateral ACL injuries had a high activity level before their first and second ACL injuries, which may be one reason for incurring a contralateral ACL injury.

REFERENCES

1. Ageberg E, Forssblad M, Herbertsson P, Roos EM. Sex differences in patient-reported outcomes after anterior cruciate ligament reconstruction: data from the Swedish knee ligament register. *Am J Sports Med.* 2010;38(7):1334-1342. PMID:20410376.
2. Ardern CL, Taylor NF, Feller JA, Webster KE. Return-to-sport outcomes at 2 to 7 years after anterior cruciate ligament reconstruction surgery. *Am J Sports Med.* 2012;40(1):41-48. PMID:21946441.
3. Ardern CL, Webster KE, Taylor NF, Feller JA. Return to sport following anterior cruciate ligament reconstruction surgery: a systematic review and meta-analysis of the state of play. *Br J Sports Med.* 2011;45(7):596-606. PMID:21398310.
4. Bengtsson J, Mollborg J, Werner S. A study for testing the sensitivity and reliability of the Lysholm knee scoring scale. *Knee Surg Sports Traumatol Arthrosc.* 1996;4(1):27-31. PMID:8819060.
5. Brooks R. EuroQol: the current state of play. *Health Policy.* 1996;37(1):53-72. PMID:10158943.
6. Burström K, Johannesson M, Diderichsen F. Swedish population health-related quality of life results using the EQ-5D. *Qual Life Res.* 2001;10(7):621-635. PMID:11822795.
7. Cherkin DC, Deyo RA, Street JH, Barlow W. Predicting poor outcomes for back pain seen in primary care using patients' own criteria. *Spine (Phila Pa 1976).* 1996;21(24):2900-2907. PMID:9112715.
8. Dolan P. Modeling valuations for EuroQol health states. *Med Care.* 1997;35(11):1095-1108. PMID:9366889.
9. Forssblad M. Swedish national knee ligament register. Swedish national ACL database homepage. Available at: www.aclregister.nu, 2012-05-27.
10. Frobell RB, Lohmander LS, Roos HP. Acute rotational trauma to the knee: poor agreement between clinical assessment and magnetic resonance imaging findings. *Scand J Med Sci Sports.* 2007;17(2):109-114. PMID:17394470.
12. Gifstad T, Sole A, Strand T, Uppheim G, Grontvedt T, Drogset JO. Long-term follow-up of patellar tendon grafts or hamstring tendon grafts in endoscopic ACL reconstructions. *Knee Surg Sports Traumatol Arthrosc.* 2012. PMID:22407182.
13. Grant JA, Mohtadi NG. Two- to 4-year follow-up to a comparison of home versus physical therapy-supervised rehabilitation programs after anterior cruciate ligament reconstruction. *Am J Sports Med.* 2010;38(7):1389-1394. PMID:20360607.
14. Grindem H, Eitzen I, Moksnes H, Snyder-Mackler L, Risberg MA. A Pair-Matched Comparison of Return to Pivoting Sports at 1 Year in Anterior Cruciate Ligament-Injured Patients After a Nonoperative Versus an Operative Treatment Course. *Am J Sports Med.* 2012. PMID:22962290.

15. Hui C, Salmon LJ, Kok A, Maeno S, Linklater J, Pinczewski LA. Fifteen-year outcome of endoscopic anterior cruciate ligament reconstruction with patellar tendon autograft for "isolated" anterior cruciate ligament tear. *Am J Sports Med.* 2011;39(1):89-98. PMID:20962336.
16. Kocher MS, Steadman JR, Briggs K, Zurakowski D, Sterett WI, Hawkins RJ. Determinants of patient satisfaction with outcome after anterior cruciate ligament reconstruction. *J Bone Joint Surg Am.* 2002;84-A(9):1560-1572. PMID:12208912.
17. Kostogiannis I, Ageberg E, Neuman P, Dahlberg L, Friden T, Roos H. Activity level and subjective knee function 15 years after anterior cruciate ligament injury: a prospective, longitudinal study of nonreconstructed patients. *Am J Sports Med.* 2007;35(7):1135-1143. PMID:17351121.
18. Kvist J, Ek A, Sporrstedt K, Good L. Fear of re-injury: a hindrance for returning to sports after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc.* 2005;13(5):393-397. PMID:15703963.
19. Kvist J, Osterberg A, Gauffin H, Tagesson S, Webster K, Ardern C. Translation and measurement properties of the Swedish version of ACL-Return to Sports after Injury questionnaire. *Scand J Med Sci Sports.* 2012. PMID:22257241.
20. Langford JL, Webster KE, Feller JA. A prospective longitudinal study to assess psychological changes following anterior cruciate ligament reconstruction surgery. *Br J Sports Med.* 2009;43(5):377-378. PMID:19019910.
21. Lind M, Lund B, Fauno P, Said S, Miller LL, Christiansen SE. Medium to long-term follow-up after ACL revision. *Knee Surg Sports Traumatol Arthrosc.* 2011. PMID:21800165.
22. Marx RG, Jones EC, Allen AA, et al. Reliability, validity, and responsiveness of four knee outcome scales for athletic patients. *J Bone Joint Surg Am.* 2001;83-A(10):1459-1469. PMID:11679594.
23. Mohtadi N. Development and validation of the quality of life outcome measure (questionnaire) for chronic anterior cruciate ligament deficiency. *Am J Sports Med.* 1998;26(3):350-359. PMID:9617395.
24. Muaidi QI, Nicholson LL, Refshauge KM, Herbert RD, Maher CG. Prognosis of conservatively managed anterior cruciate ligament injury: a systematic review. *Sports Med.* 2007;37(8):703-716. PMID:17645372.
25. Murray JR, Lindh AM, Hogan NA, et al. Does anterior cruciate ligament reconstruction lead to degenerative disease?: Thirteen-year results after bone-patellar tendon-bone autograft. *Am J Sports Med.* 2012;40(2):404-413. PMID:22116668.
26. Möller E, Weidenhielm L, Werner S. Outcome and knee-related quality of life after anterior cruciate ligament reconstruction: a long-term follow-up. *Knee Surg Sports Traumatol Arthrosc.* 2009;17(7):786-794. PMID:19360401.

27. Oiestad BE, Holm I, Engebretsen L, Risberg MA. The association between radiographic knee osteoarthritis and knee symptoms, function and quality of life 10-15 years after anterior cruciate ligament reconstruction. *Br J Sports Med.* 2011;45(7):583-588. PMID:20647299.
28. Ott SM, Ireland ML, Ballantyne BT, Willson JD, McClay Davis IS. Comparison of outcomes between males and females after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc.* 2003;11(2):75-80. PMID:12664198.
29. Paterno MV, Rauh MJ, Schmitt LC, Ford KR, Hewett TE. Incidence of Contralateral and Ipsilateral Anterior Cruciate Ligament (ACL) Injury After Primary ACL Reconstruction and Return to Sport. *Clin J Sport Med.* 2012. PMID:22343967.
30. Pickard AS, Neary MP, Cella D. Estimation of minimally important differences in EQ-5D utility and VAS scores in cancer. *Health Qual Life Outcomes.* 2007;5:70. PMID:18154669.
31. Rabin R, de Charro F. EQ-5D: a measure of health status from the EuroQol Group. *Ann Med.* 2001;33(5):337-343. PMID:11491192.
32. Roos EM, Lohmander LS. The Knee injury and Osteoarthritis Outcome Score (KOOS): from joint injury to osteoarthritis. *Health Qual Life Outcomes.* 2003;1:64. PMID:14613558.
33. Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynnon BD. Knee Injury and Osteoarthritis Outcome Score (KOOS)--development of a self-administered outcome measure. *J Orthop Sports Phys Ther.* 1998;28(2):88-96. PMID:9699158.
34. Salmon L, Russell V, Musgrove T, Pinczewski L, Refshauge K. Incidence and risk factors for graft rupture and contralateral rupture after anterior cruciate ligament reconstruction. *Arthroscopy.* 2005;21(8):948-957. PMID:16084292.
35. Shelbourne KD, Gray T, Haro M. Incidence of subsequent injury to either knee within 5 years after anterior cruciate ligament reconstruction with patellar tendon autograft. *Am J Sports Med.* 2009;37(2):246-251. PMID:19109531.
36. Solomon DH, Simel DL, Bates DW, Katz JN, Schaffer JL. The rational clinical examination. Does this patient have a torn meniscus or ligament of the knee? Value of the physical examination. *JAMA.* 2001;286(13):1610-1620. PMID:11585485.
37. Souryal TO, Moore HA, Evans JP. Bilaterality in anterior cruciate ligament injuries: associated intercondylar notch stenosis. *Am J Sports Med.* 1988;16(5):449-454. PMID:3189676.
38. Swirtun LR, Renstrom P. Factors affecting outcome after anterior cruciate ligament injury: a prospective study with a six-year follow-up. *Scand J Med Sci Sports.* 2008;18(3):318-324. PMID:18067527.
39. Swärd P, Kostogiannis I, Roos H. Risk factors for a contralateral anterior cruciate ligament injury. *Knee Surg Sports Traumatol Arthrosc.* 2010;18(3):277-291. PMID:20062970.

40. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. *Clin Orthop Relat Res.* 1985;198(198):43-49. PMID:4028566.
41. Waldén M, Hägglund M, Werner J, Ekstrand J. The epidemiology of anterior cruciate ligament injury in football (soccer): a review of the literature from a gender-related perspective. *Knee Surg Sports Traumatol Arthrosc.* 2011;19(1):3-10. PMID:20532868.
42. Wright RW, Dunn WR, Amendola A, et al. Risk of tearing the intact anterior cruciate ligament in the contralateral knee and rupturing the anterior cruciate ligament graft during the first 2 years after anterior cruciate ligament reconstruction: a prospective MOON cohort study. *Am J Sports Med.* 2007;35(7):1131-1134. PMID:17452511.
43. Wright RW, Gill CS, Chen L, et al. Outcome of revision anterior cruciate ligament reconstruction: a systematic review. *J Bone Joint Surg Am.* 2012;94(6):531-536. PMID:22438002.
44. Wright RW, Magnussen RA, Dunn WR, Spindler KP. Ipsilateral Graft and Contralateral ACL Rupture at Five Years or More Following ACL Reconstruction: A Systematic Review. *J Bone Joint Surg Am.* 2011;93(12):1159-1165. PMID:21776554.

TABLE 1
 Characteristics of Subjects with Bilateral ACL Injuries (n=66).

Variables		First ACL injury	Second ACL injury
Sex, male/female, n (%)	35/31(53/47)		
Age, years	29.1 (7.2)		
Age, male, years	32.0 (7.4)		
Age, female, years	25.8 (5.6) ^a		
BMI (kg/m ²)	25.2 (3.0)		
Age at ACL injury male, years		24.6 (6.3) ^b	28.5 (6.8) ^c
Age at ACL injury female, years		19.0 (5.9) ^a	22.2 (5.9)
Time between injury and follow-up, years		7.8 (2.7) ^d	4.1 (2.0) ^e
Time between injury and surgery, months		11.2 (10.1) ^f	13.2 (13.3) ^g
Time between injuries, months	44.4 (28.7) ^e		
Not reconstructed, n (%)	5 (7.6)		
Reconstructed one knee, n (%)	18 (27.3)	13 (76.5)	5 (23.5)
Reconstructed both knees, n (%)	43 (65.2)		
Graft type, HT/BPTB ⁱ , n (%)		35/20 ^h (63.6/36.4) (n=56)	44/4 (91.5/8.5) (n=48)
Concomitant injuries, n^j (%)			
Isolated ACL tear		22 (33.8)	15 (24.6)
Medial meniscal tear		10 (15.4)	19 (31.1)
Lateral meniscal tear		10 (15.4)	8 (13.1)
Medial and lateral meniscal tears		3 (4.6)	2 (3.3)
Chondral lesion		4 (6.2)	5 (8.2)
Chondral lesions and meniscal tears		16 (24.6)	12 (19.7)
Activity performed at injury^k, n (%)			
Soccer		35 (53.0)	30 (45.5)
Handball		8 (12.1)	7 (10.6)
Basketball		4 (6.1)	3 (4.5)
Floorball		5 (7.6)	4 (6.1)
Downhill skiing		5 (7.6)	8 (12.1)
Motor sport		3 (4.5)	2 (3.0)
Other sport (boxing, dance, ice hockey, javelin, frisbee, trampoline)		3 (4.5)	5 (7.6)
Daily living activities		3 (4.5)	7 (10.6)

Values are means (SD) unless otherwise stated.

^a $P < .001$ compared to men.

^b n=34 (1 missing), ^c n=33 (2 missing) ^d n=65 (1 missing), ^e n=64 (2 missing) because of no exact date of injury.

^f n=54 (2 missing), ^g n=47 (1 missing) because of no exact date of injury or surgery.

^h one unknown.

ⁱ HT denotes hamstring tendons, BPTB denotes Bone Patellar Tendon Bone graft.

^j missing data from 6 knees (1 first injury and 5 second injury) due to clinical diagnosis.

^k 41 (62%) subjects experienced both their injuries while performing the same activity, 25 in soccer.

TABLE 2.
Times Periods from the Injuries or Reconstructions to the Second Injury or Follow-up in
Subjects with Bilateral ACL Injuries.

Time period	n	<6 months	6-12 months	1-2 years	2-3 years	3-5 years	5-10 years	>10 years
1 st inj to 2 nd inj	66	2	4	11	16	20	13	
1 st inj to 2 nd inj (non ACL rec)	5	1	1	2			1	
1 st rec to 2 nd inj	52 ^a	1	3	15	11	12	10	
1 st inj to follow-up	66				1	6	44	15
2 nd inj to follow-up	66		1	8	11	26	20	
Last rec to follow-up	61	2	4	9	14	18	14	

Numbers of subjects in each timeframe are shown.

Inj denotes injury, rec denotes reconstruction.

^a n=52 instead of 61 because five were only reconstructed in the second injured knee and four injured their second knee before the first reconstruction.

TABLE 3.
Summary of the Results of the Questionnaires (KOOS (0-100), Lysholm (0-100), ACL-QOL (1-10) and EQ-5D (0-1, VAS 0-100)) and satisfaction scales (1-10).

	Bilateral injured subjects n=66	Unilateral ACL reconstructed subjects n=182	<i>P</i>
Knee function^b			
First injured knee	7 (1-10, IQR 5-8)	7 (1-10, IQR 5-8)	
Second injured knee	6 (1-10, IQR 4-7) ^a		
Satisfaction with knee function^b			
First injured knee	7 (1-10, IQR 5-8)	7 (1-10, IQR 4-8)	
Second injured knee	6 (1-10, IQR 4-7) ^a		
Satisfaction with activity level	4 (1-10, IQR 2-7)	5 (1-10, IQR 3-8)	.14
Symptom satisfaction (delighted-terrible)			
% (delighted-pleased)	37	44	
% (unhappy-terrible)	18	11	
Tegner activity scale			
Before injury	9 (1-9, IQR 7-9)	9 (1-9, IQR 7-9)	.59
Before second injury	7 (1-9, IQR 7-9)		<.001 ^g
At follow-up ^c	4 (1-9, IQR 3-6.25)	4 (1-9, IQR 2-7)	.18
KOOS^d			
Pain	81±16 (77.3-85.2)	86±15 (83.5-88.0)	.04
Symptoms	74±19 (69.2-78.6)	78±19 (75.2-80.7)	.14
ADL	91±10 (88.4-93.4)	92±14 (89.5-93.6)	.73
Sports/rec	58±27 (51.5-64.8)	70±25 (66.2-73.8)	.002
QOL	53±22 (47.2-57.9)	62±23 (58.9-65.8)	.003
Lysholm knee score^e			
First injured knee	90 (45-100, IQR 80-99)		
Second injured knee	84 (34-100, IQR 76-94)		
Both knees	82 (34-100, IQR 71-94)		
ACL-QOL^f	5.8±1.9 (5.3-6.3)	6.6±2.0 (6.3-6.9)	.008
EQ-5D^b	0.77±0.22 (0.72-0.83)		
EQ-VAS	75.5±17.6 (70.8-70.9)		

Data are presented as means ±SD (confidence intervals) or as median (range and inter-quartile range, IQR).

^a *P* = .022 compared to the first injured knee

^b n=65

^c missing answers for unilateral ACL reconstructed subjects 39 (n=143)

^d 2 missing answers in all the five subscales for bilateral ACL injured subjects (n=64), for unilateral ACL reconstructed 2,5,3,8,6 for each subscale

^e n=63

^f 2 missing answers in all the five subscales for bilateral ACL injured subjects (n=64), 10 missing answers for unilateral ACL reconstructed subjects (n=172)

^g Compared with unilateral ACL reconstructed subjects Tegner activity score at follow-up.

10.	Competitive sports:	Soccer- national or international level, <i>Acrobatics, Football, Figure-skating, Rugby</i>
9.	Competitive sports:	Soccer – lower divisions, Ice hockey, Wrestling, Gymnastics, <i>Mogul skiing</i>
	Recreational sports:	<i>Acrobatics, Football. Figure-skating, Rugby</i>
8.	Competitive sports:	Bandy, Squash, Badminton, Athletics (jumpings, etc), Downhill skiing, <i>Ski jumping, Javelin, Floorball, Taekwondo, Budo sports</i>
	Recreational sports:	<i>Mogul skiing, Wrestling</i>
7.	Competitive sports:	Tennis, Athletics (running), Motocross, Speedway, Handball, Basketball, <i>Volleyball</i>
	Recreational sports:	Soccer, Bandy, Ice hockey, Squash, Athletics (jumping), Cross-country track findings, <i>Ski jumping, Javelin, Floorball, Budo sports</i>
6.	Competitive sports:	<i>Snowboard, Telemark skiing</i>
	Recreational sports:	Tennis, Badminton, Handball, Basketball, <i>Volleyball</i> , Downhill skiing, Jogging at least 5 times/week
5.	Competitive sports:	Cycling, Cross-country skiing, <i>Fencing, Aerobics</i>
	Recreational sports:	Jogging on uneven ground at least twice a week, <i>Snowboard, Telemark skiing</i>
	Work:	Heavy labor (<i>e.g. fireman</i>)
4.	Recreational sports:	Cycling, Cross-country skiing, Jogging on even ground at least twice a week, <i>Boxing, Aerobics, Weight lifting, Discus throwing</i>
	Work:	Moderately heavy labor (<i>e.g. truck driving</i>)
3.	Competitive/ recreational sports:	Swimming, Walking in forest possible, <i>Dancing, Table tennis, Water polo, Windsurfing</i>
	Work:	Light labor (<i>e.g. nursing</i>)
2.	Recreational sports:	Walking on uneven ground, <i>Strength training, Bowling, Curling, Golf, Sailing, Horse riding</i>
	Work:	Light labor (<i>e.g. shop assistant, Preschool teacher</i>)
1.	Recreational sports:	Walking on even ground, <i>Bridge, Archery, Canoeing, Shooting</i>
	Work:	Sedentary work (<i>e.g. barber, office work</i>)
0.	Sick leave or disability pension because of knee problems	

Figure 1. Tegner activity scale with some sports added (italics) based on the consensus of an expert group.

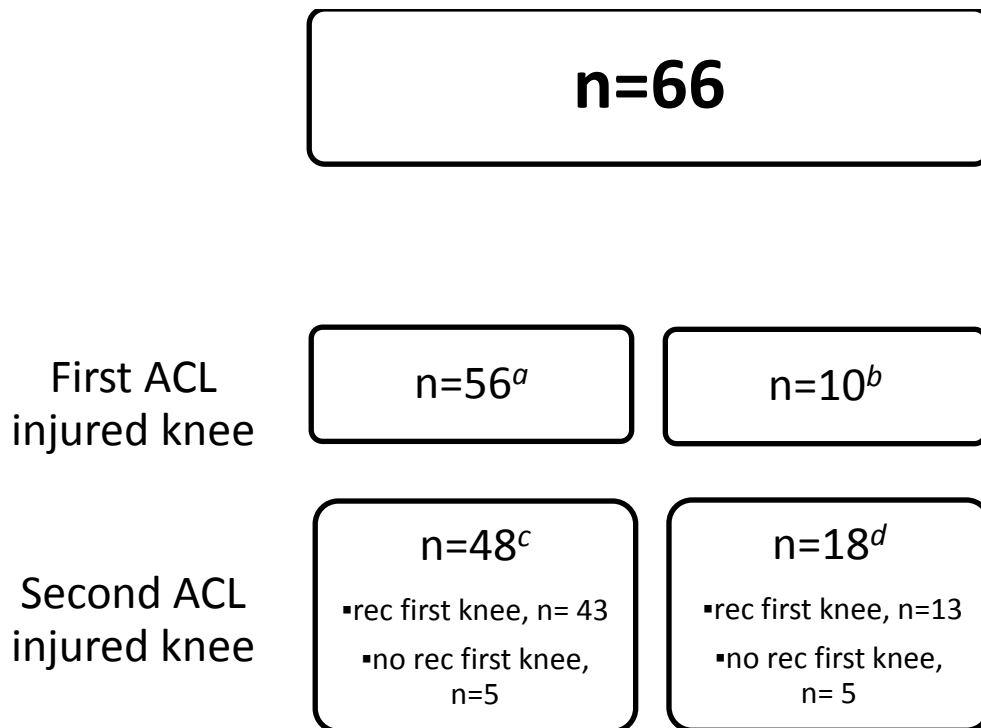


Figure 2. Flowchart of the subjects with bilateral ACL injuries.

Rec= reconstruction

^a n=2 re-rupture ACL graft (no revisions), n=1 revision

^b Confirmed by; arthroscopy (n=8), MRI (n=1), clinically (n=1)

^c n=4 revisions (one subject had revisions in both knees)

^d Confirmed by; arthroscopy (n=9), MRI (n=4), clinically (n=5)

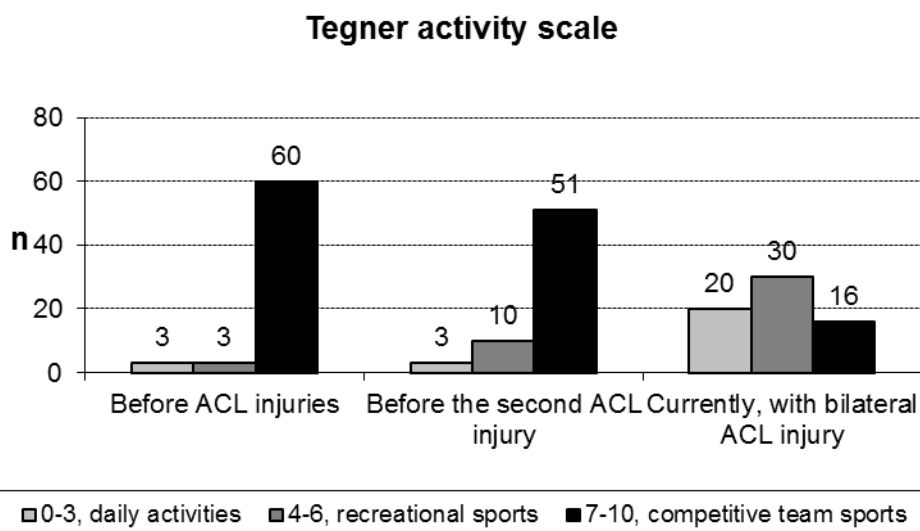


Figure 3. Tegner activity scale before any ACL injury, before the second ACL injury (2 missing answers), and currently with bilateral ACL injuries. Levels 0-3 correspond to activities of daily living, levels 4-6 to recreational and individual sports, and levels 7-10 to competitive team sports.

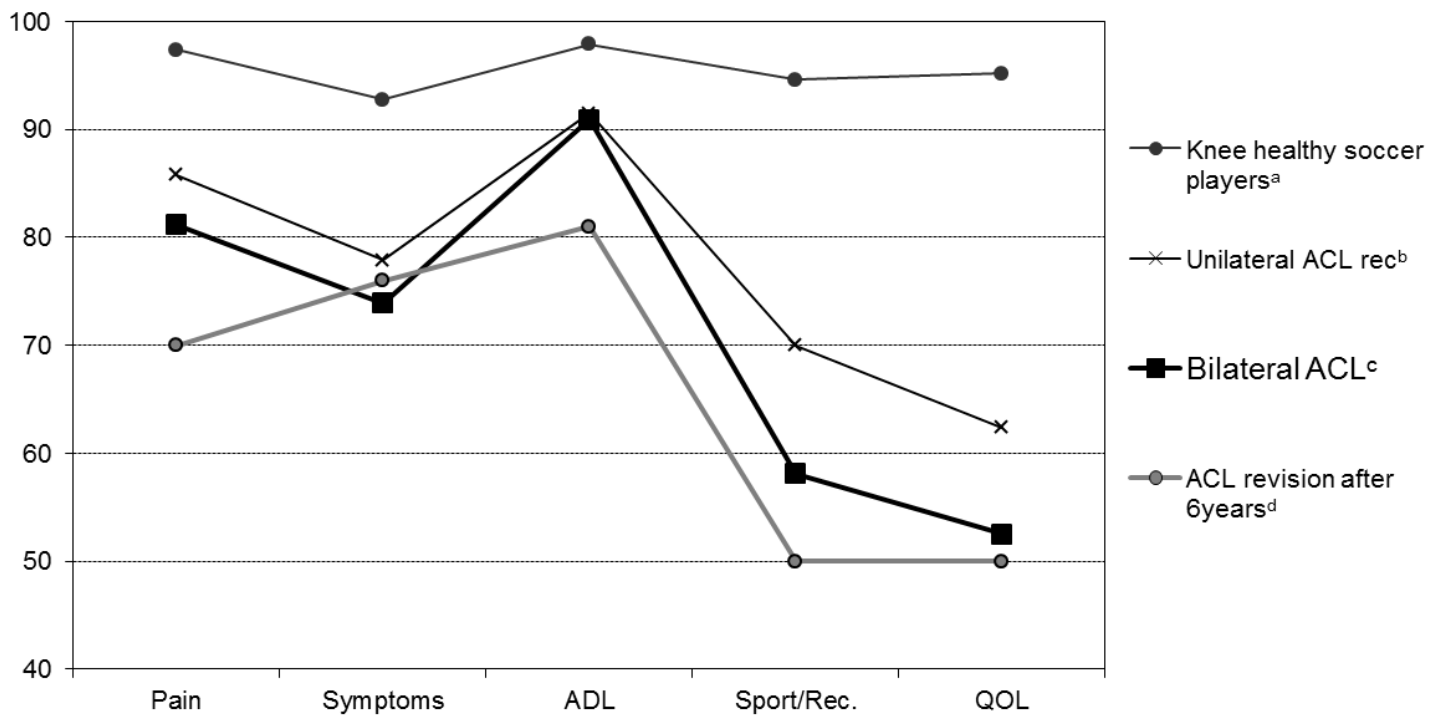


Figure 4. KOOS scores given as mean values for subjects with bilateral ACL injuries, n=64, 2 missing answers, compared with subjects with unilateral ACL reconstruction and previously published results.

^a Soccer players with healthy knees, n=118¹¹

^b Unilateral ACL reconstructed subjects for comparisons, n=182 $P < .05$ compared to bilateral ACL injured subjects in all subscales except symptoms and ADL.

^c Bilateral ACL injuries in the present study, n=64

^d ACL revision subjects with a median follow up time of 6 years, n=128²¹