Relationship Between Sports Participation After Revision Anterior Cruciate Ligament Reconstruction and 2-Year Patient-Reported Outcome Measures

MARS Group*
Investigation performed at Slocum Research and Education Foundation, Eugene, Oregon, USA

Background: Anterior cruciate ligament (ACL) revision cohorts continually report lower outcome scores on validated knee questionnaires than primary ACL cohorts at similar time points after surgery. It is unclear how these outcomes are associated with physical activity after physician clearance for return to recreational or competitive sports after ACL revision surgery.

Hypotheses: Participants who return to either multiple sports or a singular sport after revision ACL surgery will report decreased knee symptoms, increased activity level, and improved knee function as measured by validated patient-reported outcome measures (PROMs) and compared with no sports participation. Multisport participation as compared with singular sport participation will result in similar increased PROMs and activity level.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: A total of 1205 patients who underwent revision ACL reconstruction were enrolled by 83 surgeons at 52 clinical sites. At the time of revision, baseline data collected included the following: demographics, surgical characteristics, previous knee treatment and PROMs, the International Knee Documentation Committee (IKDC) questionnaire, Marx activity score, Knee injury and Osteoarthritis Outcome Score (KOOS), and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). A series of multivariate regression models were used to evaluate the association of IKDC, KOOS, WOMAC, and Marx Activity Rating Scale scores at 2 years after revision surgery by sports participation category, controlling for known significant covariates.

Results: Two-year follow-up was obtained on 82% (986 of 1205) of the original cohort. Patients who reported not participating in sports after revision surgery had lower median PROMs both at baseline and at 2 years as compared with patients who participated in either a single sport or multiple sports. Significant differences were found in the change of scores among groups on the IKDC ($P < .0001$), KOOS-Symptoms ($P = .01$), KOOS–Sports and Recreation ($P = .04$), and KOOS–Quality of Life ($P < .0001$). Patients with no sports participation were 2.0 to 5.7 times more likely than multiple-sport participants to report significantly lower PROMs, depending on the specific outcome measure assessed, and 1.8 to 3.8 times more likely than single-sport participants (except for WOMAC-Stiffness, $P = .18$), after controlling for known covariates.

Conclusion: Participation in either a single sport or multiple sports in the 2 years after ACL revision surgery was found to be significantly associated with higher PROMs across multiple validated self-reported assessment tools. During follow-up appointments, surgeons should continue to expect that patients who report returning to physical activity after surgery will self-report better functional outcomes, regardless of baseline activity levels.

Keywords: anterior cruciate ligament; outcomes; revision ACL; sports participation

Return to sport is one of the key indicators of a successful outcome for patients who undergo revision anterior cruciate ligament (ACL) reconstruction.[1,20] However, as compared with primary ACL reconstruction, revision surgery has resulted in lower patient-reported outcome measures (PROMs) during 2- and 6-year follow-up windows.[6,10,26]

The Multicenter ACL Revision Study (MARS)—a large multicenter prospective longitudinal cohort—provides the best opportunity to assess short- and long-term predictors of improved revision ACL treatment outcomes and to identify risk factors affecting patient-reported functional status, pain, and performance.[16] In the 2010 MARS report,[16] PROMs improved from baseline (ie, time of revision surgery), but activity levels declined 2 years postoperatively. Although activity levels declined, it is unclear if the decrease was associated with reported sports participation after revision surgery.

After primary ACL reconstruction, International Knee Documentation Committee (IKDC) scores were significantly higher in patients who returned to their preinjury

The American Journal of Sports Medicine
2019;47(9):2056–2066
DOI: 10.1177/0363546519856348

sports as compared with no sports.[23] Additionally, in another large multicenter prospective cohort study (Multicenter Orthopaedic Outcomes Network [MOON] Study), participants were able to maintain high sport function and quality-of-life measurements 10 years after the initial reconstruction, even as reported activity levels declined.[21] It is unknown how sports participation after revision surgery versus no sports participation is associated with PROMs after return to activity. There may be benefit to providers and patients to understand whether participation type—specifically, multiple sports versus singular sport—after revision surgery influences the magnitude of PROM scores over time. When compared with multisport participation, singular sport specialization is known to increase the risk of injury in youth athletes, yet the effect of single- or multiple-sport participation in older individuals and ACL revision cohorts is unknown.[18]

The objective of this analysis was to determine whether sports participation is associated with patient-reported outcomes related to sports function, activity level, and knee symptom scores at 2 years after revision ACL surgery. We hypothesized that patients who did not return to sports participation after revision ACL reconstruction surgery would have decreased sports-related function, lower activity levels, and increased knee symptoms 2 years postoperatively when compared with patients who returned to sport, after controlling for baseline sports participation and activity status. We further hypothesized that multisport athletes would have similar gains in PROMs as compared with single-sport athletes.

METHODS

Study Population and Setting

The MARS group is a collaboration of 83 sports medicine fellowship–trained surgeons who represent an approximately 50:50 mix of practitioners from private and academic sites (N = 52 sites). Surgeon inclusion criteria included maintenance of institutional review board approval; completion of a training session of articular cartilage and meniscal agreement studies; and review of the study design, patient inclusion criteria, and surgeon questionnaire.

Site enrollment began in 2006, once approval was received from each institution's institutional review board, and ended in 2011. Patients were included if they were between the ages of 12 and 65 years while undergoing a revision of a failed primary ACL reconstruction by a participating MARS surgeon. Failure of the previous ACL reconstruction was determined through arthroscopic surgery, orthopaedic clinical examination, or magnetic resonance imaging, as described elsewhere.[11] Exclusion criteria included prior infection, multiligament reconstruction, complex regional pain syndrome, and arthrofibrosis. Additionally, patients who did not successfully complete the 2-year follow-up questionnaire were excluded for this particular study.

Data Sources and Measurement

Once informed consent was obtained, all patients completed a 13-page questionnaire to collect demographic information, sports participation, injury mechanism, comorbidities, and knee injury history.[12,14] A series of previously validated PROMs were completed by each patient, which measured general and knee-specific outcomes at the time of revision[24,25]: IKDC questionnaire, Marx Activity Rating Scale (Marx), Knee injury and Osteoarthritis Outcome Score (KOOS), and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC; as calculated from the KOOS questionnaire).[13] Additionally, surgeons completed a 48-page questionnaire, including physical examination findings, surgical procedures and implants, arthroscopic findings, and the management of any current meniscal or chondral damage to the injured knee.[11]

Completed data forms were mailed to the data coordinating center by each participating site. Data were abstracted from the patients' and surgeons' questionnaires through TeleForm software (Cardiff Software) with optical character recognition. Abstracted data were verified and transferred to a master database. Multiple quality control checks were performed before data analyses.

Patient Follow-up

Patients completed the same questionnaire at baseline (ie, time of revision surgery) and at 2-year follow-up. PROMs were returned via mailed questionnaires, and study participants were contacted by phone to determine if any successive operations were performed on either knee since their initial ACL revision. Operative reports were obtained when possible to verify subsequent injury and treatment.

Statistical Analysis

To describe the characteristics of the study sample, continuous variables were summarized as percentiles (ie, 25th, 50th, and 75th) and categorical variables as frequencies and percentages. One-way analysis of variance with a Bonferroni correction was used to compare sports participation groups at both time intervals (baseline and 2-year follow-up) and the change in score between groups. Multivariate

*Address correspondence to Erin Owen, PhD, MPH, Slocum Research and Education Foundation, 55 Coburg Rd, Eugene, OR 97401, USA (email: erin.owen@slocumfoundation.org).

All authors are listed in the Authors section at the end of the article.

One or more of the authors has declared the following potential conflict of interest or source of funding: This study received funding from the AOSSM, Smith & Nephew, National Football League Charities, and Musculoskeletal Transplant Foundation. This project was partially funded by grant 5R01-AR060846 from the National Institutes of Health / National Institute of Arthritis and Musculoskeletal and Skin Diseases. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

regression analyses were used to study which baseline risk factors were independently associated with each outcome variable. The primary outcome variables of interest were 2-year PROM scores from the IKDC, KOOS, Marx, WOMAC, and their subscales. Linear regression models were used, as all of our primary outcome variables were treated as continuous variables. Results were reported as odds ratios (ORs) and 95% CIs indicating odds of having a worse outcome.

The primary exposure of interest was sports participation after ACL revision surgery. Sports participation variables were defined from the following questions from the patient questionnaire administered at 2-year follow-up: "What sport have you participated in most in the past 2 years?" and "What second sport have you participated in most in the past 2 years?" Potential responses included none, basketball, baseball/softball, football, gymnastics, skiing, soccer, volleyball, and "other." Activities in the "other" category from previous MARS data included cycling, cheerleading, dancing, Frisbee, hockey, lacrosse, martial arts, roller skating, rugby, tennis, track and field, and trampolining.[16] "Multisport" participants were defined as patients who participated in a primary sport plus a different, secondary sport during the past 2 years. "Single-sport" participants were defined as patients who self-reported playing a primary sport and no secondary sport or who reported the same sport for both responses. Participants who reported no sports participation (ie, "none") to both sports participation questions were coded as "no sport."

All models controlled for the following covariates: demographics (age, sex, body mass index, smoking status, education level, baseline sport specialization in the 2 years before revision ACL, and baseline activity level), revision ACL surgical details (revision number; time since last ACL reconstruction procedure in years; and history of medial and lateral meniscal surgical treatment, articular cartilage surgery, and/or contralateral knee ACL reconstruction), current surgical findings (mechanism of injury, graft type, meniscal injury [medial, lateral], articular cartilage injury [medial femoral condyle, lateral femoral condyle, medial tibial plateau, lateral tibial plateau, patella, and trochlea]), and baseline PROM scores. Previous articular cartilage surgery and current meniscal injuries and articular cartilage injuries were treated as binary variables (yes/no), owing to low frequency counts. Categorical variables were fit per their degrees of freedom (ie, n – 1). All continuous variables were fit with a linear effect, as there was little to no evidence of a nonlinear relationship through nonlinear testing.

Previous reports have identified minimal clinically important differences (MCIDs) in the PROMs used: 11 points for the IKDC,[7] 8 to 10 points for the KOOS[19] and WOMAC,[24,25] and 2 points for the Marx activity scale.[26] Additionally, the level of sports participation was self-reported (recreational, amateur [team or club], high school, college [Division I and non–Division I], semiprofessional/professional), but it demonstrated collinearity with level of sports participation; therefore, level of sports participation was excluded. Statistical analysis was performed with STATA (v 14; StataCorp LLC).

RESULTS

Revision ACL reconstruction was performed on 1205 patients during the enrollment period. Approximately 58% of the cohort was male, and the median age was 26 years (range, 12-63 years). Descriptive statistics of the cohort at baseline were described in-depth in previous reports.[11,15,16]

Overall, 82% (986 of 1205) of participants completed the follow-up questionnaire at 2 years. Baseline characteristics of participants who completed the 2-year follow-up are provided in Table 1. At baseline, 71% of participants reported playing multiple sports; 18% reported playing a single sport; and 11% reported no sports participation. At 2-year follow-up, 58% (n = 568) of patients reported playing multiple sports; 21% (n = 205) reported playing a single sport; and 21% (n = 207) reported playing no sports.

Patient-Reported Outcome Scores

Table 2 summarizes each PROM by sports participation and compares median scores within each group at baseline and 2-year follow-up. A significant difference ($P < .001$) was found among groups throughout each PROM and during both time intervals. Patients who reported no sports participation had lower median PROMs than single-sport and multisport participants at both baseline and 2-year follow-up. At baseline, the largest magnitude of difference was seen on the KOOS-Pain, where the median score for no-sport participants was 66 (interquartile range [IQR], 53-81) and 78 for single-sport (IQR, 61-86) and multiple-sport (IQR, 64-89) participants. At 2-year follow-up, those patients who reported no sports participation continued to have lower PROMs as compared with the other groups. The biggest difference among groups was seen on the median IKDC score: no-sport participants, 60 (IRQ, 39-76); single-sport participants, 77 (IQR, 60-86); and multisport participants, 82 (IQR, 69-89), which was greater than the 11 points established as the MCID for the IKDC. The lack of an active lifestyle by no-sport participants may have contributed to the severity of knee injury. Individuals who reported no sports participation at 2 years were older (median age, 30 years) and obese (median body mass index, 30 kg/m^2).

Table 3 summarizes the change in PROM score from baseline to 2 years and compares it among sports participation groups. Overall, PROMs significantly improved from baseline to 2 years in all groups on the IKDC, KOOS, WOMAC, and their subscales, except for the WOMAC-Stiffness. On this scale, no change in median score from baseline was reported in the no-sport and single-sport participation groups, while the multisport participants had an increase in their median score by 12.5 points.

Significant differences were found in the change of scores among groups on the IKDC ($P < .0001$), KOOS-Symptoms ($P = .01$), KOOS–Sports and Recreation ($P = .04$), and KOOS–Quality of Life ($P < .0001$). Although scores did improve within all sports participation groups, the lack of physical activity in the no-sport group may

TABLE 1
Baseline Characteristics of Cohort Who Completed a 2-Year Follow-up[a] (n = 986)

	Value
Baseline patient demographics	
Sex: male	545 (55)
Age, y	26 (20, 35)
Body mass index	25 (23, 28)
Smoking status[b]	
Never	767 (78)
Quit	122 (13)
Current	84 (9)
Primary sport participation in the 2 y before revision ACL surgery[b]	
No sport	111 (11)
Baseball/softball	60 (6)
Basketball	142 (14)
Football	85 (9)
Gymnastics	13 (1)
Skiing	66 (7)
Soccer	160 (16)
Volleyball	51 (5)
Other[c]	293 (30)
Secondary sport participation in the 2 y before revision ACL surgery[b]	
No sport	288 (29)
Baseball/softball	66 (7)
Basketball	125 (13)
Football	41 (4)
Gymnastics	7 (1)
Skiing	56 (6)
Soccer	68 (7)
Volleyball	41 (4)
Other[c]	290 (30)
Sports participation in the 2 y before revision ACL surgery[b,d]	
No sports participation	180 (19)
Single-sport participation	689 (70)
Multisport participation	110 (11)
Previous surgical information	
Previous graft type[b,e]	
Allograft-BTB	113 (11)
Allograft–soft tissue	106 (11)
Autograft-BTB	411 (42)
Autograft–soft tissue	263 (27)
Both autograft + allograft	18 (2)
Other/unknown	74 (7)
Time since last ACL reconstruction, y	3.6 (1.4, 9.0)
Revision number	
1	871 (88)
2	96 (10)
≥3	19 (2)
Previous medial meniscal surgery[b]	
Yes, repair healed/stable	293 (30)
Yes, repair not healed/stable	26 (3)
Yes, excision	49 (5)
Previous lateral meniscal surgery[b]	
Yes, repair healed/stable	146 (15)
Yes, repair not healed/stable	21 (2)
Yes, excision	17 (2)
Previous articular cartilage surgery	113 (12)
Previous ACL reconstruction on contralateral knee	106 (11)
Mechanism of injury[b]	
Nontraumatic gradual onset	266 (27)
Nontraumatic sudden onset	60 (6)
Traumatic noncontact	119 (12)
Traumatic contact	539 (55)

(continued)

TABLE 1
(continued)

	Value
Current surgical information	
Current graft type[b,d]	
Allograft-BTB	237 (24)
Allograft–soft tissue	241 (24)
Autograft-BTB	269 (27)
Autograft–soft tissue	207 (21)
Other/unknown	31 (3)
Current medial meniscal injury	446 (45)
Current lateral meniscal injury	351 (36)
Current articular cartilage injury	
Medial femoral condyle	424 (43)
Lateral femoral condyle	279 (28)
Medial tibial plateau	101 (10)
Lateral tibial plateau	165 (17)
Patella	295 (30)
Trochlea	209 (21)
Postrevision sports participation information	
Primary sport participation in the 2 y after revision ACL surgery[b]	
No sports	209 (21)
Baseball/softball	60 (6)
Basketball	110 (11)
Football	29 (3)
Gymnastics	7 (1)
Skiing	56 (6)
Soccer	100 (10)
Volleyball	42 (4)
Other[c]	363 (37)
Secondary sport participation in the 2 y after revision ACL surgery[b]	
No sports	403 (41)
Baseball/softball	46 (5)
Basketball	97 (10)
Football	33 (3)
Gymnastics	3 (<1)
Skiing	60 (6)
Soccer	50 (5)
Volleyball	32 (3)
Other[c]	252 (26)
Sports participation in the 2 y after revision ACL surgery[b,d]	
No sports participation	207 (21)
Single-sport participation	203 (21)
Multi-sport participation	564 (58)

[a]Categorical data are reported as n (%) of nonmissing values. Continuous variables are reported as median (lower quartile, upper quartile). ACL, anterior cruciate ligament; BTB, bone-tendon-bone.

[b]Category contains missing data that represent <5% of the total population.

[c]Other sports were self-reported by patients to include biking, cheerleading, dancing, Frisbee, hockey, lacrosse, martial arts, roller skating, rugby, tennis, track and field, and trampolining.

[d]No sports participation included individuals who reported no primary or secondary sport participation; single-sport participation included individuals who reported only 1 sport; multisport participation included individuals who reported >1 sport or other sport in their primary and secondary sport participation.

[e]All previous and current surgical information was determined by the patient's individual surgeon.

have been associated with its ability to reach higher PROMs. These results show that individuals who did not play sports were less active at baseline, before revision ACL surgery, which could have influenced the severity of their knee injury.

Regarding MCIDs, all groups passed the threshold for improvement in their scores on the IKDC, KOOS-Pain, KOOS–Sports and Recreation, and KOOS–Quality of Life, indicating that revision surgery had a significant effect on their functional outcomes. Unlike the no-sport and single-sport participants, multisport participants improved their WOMAC-Stiffness score over the MCID threshold. Regardless of sports participation type, scores did not reach the threshold for significance in KOOS–

TABLE 2
Comparison of Median PROMs Between Sports Participation Status Separately at Baseline and Two-Year Follow-up (n = 980)[a]

		Baseline Score[b]			2-Year Follow-up Score[b]		
	Scale	No Sport (n = 207)	Single Sport (n = 205)	Multisport (n = 568)	No Sport (n = 207)	Single Sport (n = 205)	Multisport (n = 568)
IKDC	0-100	44 (30, 57)	53 (39, 63)	54 (42, 66)	60 (39, 76)	77 (60, 86)	82 (69, 89)
KOOS							
Symptoms	0-100	60 (46, 79)	68 (54, 82)	68 (54, 82)	71 (54, 86)	79 (64, 93)	82 (68, 89)
Pain	0-100	66 (53, 81)	78 (61, 86)	78 (64, 89)	81 (61, 92)	92 (75, 97)	92 (81, 97)
ADL	0-100	78 (59, 91)	85 (69, 97)	90 (74, 97)	91 (72, 99)	97 (90, 100)	97 (92, 100)
Sports and Recreation	0-100	35 (15, 55)	45 (25,65)	50 (30, 70)	60 (20, 80)	75 (55, 90)	80 (60, 90)
QOL	0-100	25 (13, 38)	32 (19, 44)	38 (19, 50)	44 (25, 56)	63 (44, 75)	63 (44, 75)
WOMAC							
Stiffness	0-100	63 (50, 75)	75 (50, 88)	75 (50, 88)	75 (50, 88)	75 (63, 100)	75 (63, 100)
Pain	0-100	75 (60, 85)	85 (70, 95)	85 (75, 95)	85 (65, 95)	95 (80, 100)	95 (85, 100)
ADL	0-100	78 (59, 91)	85 (69, 97)	90 (74, 97)	91 (72, 98)	97 (90, 100)	97 (93, 100)
Marx activity score	0-16	5 (0, 11)	11 (4, 16)	12 (7, 16)	1 (0, 4)	6 (2, 12)	9 (4, 12)

[a]Data are reported as median and interquartile ranges (25th and 75th percentiles). ADL, Activities of Daily Living; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; PROM, patient-reported outcome measure; QOL, Quality of Life; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
[b]Significance level for comparisons of all PROMs within sub-groups at each time point, $P < .001$.

TABLE 3
Median Difference in PROMs by Sports Participation Group at 2-Year Follow-up (n = 980)[a]

		Differences in Scores From Baseline			
	Scale	No Sport (n = 207)	Single Sport (n = 205)	Multisport (n = 568)	*P* Value
IKDC	0-100	12 (0, 25)	20 (7, 32)	23 (10, 37)	<.0001
KOOS					
Symptoms	0-100	7 (–4, 17)	7 (–4, 21)	10 (0, 25)	.01
Pain	0-100	8 (–3, 19)	8 (0, 20)	11 (0, 25)	.12
ADL	0-100	7 (0, 19)	7 (0, 18)	6 (0, 18)	.74
Sports and Recreation	0-100	20 (–5, 39)	25 (5, 45)	25 (5, 45)	.04
QOL	0-100	12.5 (0, 31)	25 (6, 43)	25 (6, 43)	<.0001
WOMAC					
Stiffness	0-100	0 (–12.5, 25)	0 (–12.5, 25)	12.5 (0, 25)	.07
Pain	0-100	5 (–5, 20)	5 (0, 15)	5 (0, 15)	.89
ADL	0-100	7 (0, 19)	7 (0, 18)	6 (0, 18)	.73
Marx activity score	0-16	–2 (–8, 0)	–1 (–6, 1)	–2 (–6, 0)	.22

[a]Data are reported as median and interquartile ranges (25th and 75th percentiles). ADL, Activities of Daily Living; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; PROM, patient-reported outcome measure; QOL, Quality of Life; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

Activities of Daily Living, WOMAC-Pain, and WOMAC–Activities of Daily Living. As expected, all groups reported a decrease in their activity levels on the Marx activity scale relative to preinjury baseline; however, no significant differences were found in the decrease in activity level scores among sports participation groups ($P = .22$).

Influence of Sports Participation on 2-Year Outcomes

No sports participation (no sports vs single sport vs multisport) in the 2 years after revision surgery was found to be significantly associated with lower PROMs at 2 years after revision ACL reconstruction. Additionally, other patient demographic factors, previous surgical information, and current meniscal and articular cartilage injuries at the time of revision were associated with lower outcome scores. The odds ratios for sports participation variables and covariates that were significantly associated with lower outcome scores are reported in Appendix Table A1 (available in the online version of this article).

International Knee Documentation Committee. Sports participation was significantly associated with higher IKDC scores at 2 years. Not participating in sports after revision ACL reconstruction was significantly associated with higher odds of lower IKDC scores when compared

with participation in multiple sports ($P < .0001$; OR, 3.73; 95% CI, 2.64-5.28). IKDC scores in multisport participants were 12 points higher than in no-sports participants ($P < .001$; 95% CI, 9.12-15.70). Single-sport participants scored 9 points higher on the IKDC ($P < .001$; 95% CI, 4.92-12.30), which approached the MCID. Similarly, multisport participants had significantly higher IKDC scores at 2 years when compared with single-sport participants ($P = .024$); however, the results did not reach the 11-point threshold of change for the MCID ($P = .024$; difference = 3.8 points; 95% CI, 0.96-6.64). Other covariates found to be significant predictors of worse outcomes on the 2-year IKDC were lower baseline IKDC score, female sex, lower baseline activity scores, higher body mass index, less time since the previous ACL reconstruction, previous lateral meniscectomy or an unstable lateral meniscal repair, and a current grade $\geq$2 articular cartilage injury.

Knee injury and Osteoarthritis Outcome Score. Throughout the KOOS subscales, no-sport participants had significantly higher odds of reporting lower scores as compared with multisport participants ($P < .0001$; OR range, 2.25-3.29; 95% CI, 1.60-4.67). When compared with single-sport participants at 2 years, individuals who participated in multiple sports scored, on average, 8 points higher on the KOOS-Symptoms ($P < .0001$), 12 points higher on the KOOS–Sports and Recreation ($P < .0001$), and 14 points higher on the KOOS–Quality of Life ($P < .0001$). Again, similar results were found for no-sport participants as compared with single-sport participation ($P = .006$; OR range, 1.77-2.70; 95% CI, 1.18-4.03). Participating in a single sport versus no sports was associated with an increase of 12 points ($P < .0001$; 95% CI, 7.30-16.65) on the KOOS–Quality of Life, while participating in a single sport over multiple sports was associated with higher KOOS–Sports and Recreation scores ($P = .006$; OR, 1.79; 95% CI, 1.19-2.70). Other covariates that were associated with worse outcomes on the 2-year KOOS were similar to those for the 2-year IKDC, with the addition of current smoker and previously excised medial meniscus.

Western Ontario and McMaster Universities Osteoarthritis Index. Not participating in sports at postoperative 2 years was significantly associated with increased odds of having lower (ie, worse) WOMAC scores across subscales as compared with multisport participation ($P < .0001$; OR range, 1.99-2.39; 95% CI, 1.37-3.41). On the WOMAC-Stiffness, multisport participants scored 8 points higher than single-sport participants ($P < .001$; 95% CI, 4.17-11.84) on their 2-year score. Additionally, participating in a single sport as opposed to multiple sports increased the odds of reporting lower scores on the WOMAC-Stiffness subscale at 2 years ($P = .019$; OR, 1.48; 95% CI, 1.07-2.06). Additional factors associated with poorer outcomes across all WOMAC subscales were as follows: lower baseline outcome scores, less time since a previous ACL reconstruction, and a previous lateral meniscal repair that is unstable or not healed. Having a previous lateral meniscal repair that was unstable or not healed was associated with lower scores across the WOMAC subscales by 10 to 13 points at 2-year follow-up ($P < .05$; 95% CI, –0.06 to 24.03).

Marx Activity Level. As expected, participation in sports after revision ACL reconstruction was significantly associated with increased activity levels. No sports participation was significantly associated with higher odds of reporting lower Marx scores when compared with multisport participation ($P < .0001$; OR, 5.68; 95% CI, 3.93-8.21) and single-sport participation ($P < .0001$; OR, 3.77; 95% CI, 2.48-5.75).

No sports participation was associated with lower Marx scores by 3 points versus single-sport participation and 4 points versus multisport participation. While significant ($P = .003$), the difference in associated Marx scores between single- and multisport participants did not meet the threshold for the MCID. Other covariates that were significantly associated with lower Marx scores are reported in Table 4; however, none of these scores reached the 2-point threshold required for an MCID on the Marx activity scale.

DISCUSSION

Results from our analysis indicate that 2-year patient-reported outcomes vary depending on the level of sports participation after revision ACL surgery, after taking into account baseline activity levels and previous surgical and current revision injury characteristics. These findings support our hypothesis that individuals who participated in any combination of sports after revision ACL surgery would have higher outcomes across all subscales as compared with those who did not participate in any sports. These findings confirm intuited thoughts that in the short term, sports participation after ACL revision surgery is associated with higher PROMs at 2 years.

Participants with no sports participation were 2.0 to 5.7 times more likely to report significantly lower PROMs when compared with multiple-sport participants, depending on the specific outcome measure, and 1.8 to 3.8 times more likely than single-sport participants (except for WOMAC-Stiffness, $P = .18$) after controlling for covariates in each model. Our statistical approach allows for the assessment of postsurgical sports participation independent of a patient's preinjury activity level and PROM scores. One possible explanation for the difference in PROMs is the overall activity levels of the cohort. Primary analysis of the MARS cohort found 2-year Marx activity levels to be lower than those of other primary ACL cohorts at the same follow-up period, leaving it unclear whether the overall decrease was due to the condition of the knee or intentional to the patient's perceived intent to lower his or her risk of future injury.[11] We found no significant difference in the change of Marx scores among participation groups ($P = .22$), suggesting that the change in activity level may resemble the natural decline of activity seen as people age in this population.[11] Long-term follow-up of primary ACL reconstructions have found stable KOOS, IKDC, and WOMAC scores at 10-year follow-up, even as Marx activity scores declined over time.[21]

Overall, Marx activity level scores still declined by 3 points for single-sport and 4 points for multisport

participants, after controlling for baseline Marx activity level, baseline PROMs, previous surgical treatment, and current surgical findings. While the Marx scale has been validated[17] to measure activity of different functions (running, cutting, deceleration, etc) that occur in various sports, recent evidence has called into question the extrapolation of physical activity based on the questionnaire. Recent studies in the ACL reconstruction literature found self-reported Marx scores to be unrelated to objective moderate to vigorous physical activity measurements.[5,8] Additionally, ACL reconstruction cases matched to healthy controls based on activity level, age, and sex were found to have lower step counts and decreased moderate to vigorous physical activity.[5] Grouping sports participation based on the self-reported count of sports participated in does not address the frequency or intensity of sports participation. This is a key limitation of the MARS study data, as we do not have any objective physical activity measurement or self-reported measurement of the intensity of sports activity after surgery. Our findings provide preliminary evidence that even as patients who underwent ACL revision are cleared and return to sports, they may not participate at the same intensity or frequency level in their chosen sports.

Our results cannot explain why participants did not pursue sports participation postoperatively. The condition of the knee may be compromised in those who do not participate in sports after their revision surgery. As we saw across KOOS, WOMAC, and IKDC scores at 2 years, there was an increased association of lower reported scores in patients who did not play sports. These results remained consistent after controlling for secondary injuries (meniscal, articular cartilage, ligamentous, etc) to the knee. Nevertheless, we can simply state that engagement in sports after ACL revision surgery is correlated with higher outcomes at 2-year follow-up.

Return to sports and participation level are considered key indicators of successful ACL surgery. Results of the current study support the goal of a successful return to activity after ACL revision surgery. Previous reports have found that return to sports was similar between primary ACL reconstructions (91%) and revision ACL reconstructions (87%) at 1-year follow-up.[9] However, at 2-year follow-up, only 45% of individuals reported returning to their preinjury level of participation.[3,4] Similarly, a recent systematic review found that 57% of patients who undergo ACL revision do not return to the same level of sports activity after surgery.[2] While some may not be able to return to their specific level of sport or the same preinjury sport, the current study emphasizes that continued activity after revision surgery is associated with a significant increase in function, quality of life, and decreased pain and stiffness at 2 years. It is still unclear if being active through sports participation leads to an increase in function or if patients with better function are able to participate in sports. Future analysis should examine if those who were actively engaged in sports before revision surgery but ceased participation afterward report different PROMs than those of patients who return to sports.

In the current study, 2-year IKDC scores were higher in patients who participated in sports and lower among those who did not, as compared with other reported cohorts.[1,26] In a revision ACL cohort at postoperative 5 years, Anand et al[1] found a median IKDC score of 73 for individuals who returned to sports and 65 for those who did not. Multisport participants (82) and single-sport participants (77) had similar or slightly higher median IKDC scores when compared with a primary ACL reconstruction cohort at 2-year (75) and 6-year (77) follow-up.[22] Previous analyses of the MARS cohort found that KOOS subscale measurements were significantly lower than in a primary ACL reconstruction cohort at 2 years.[11,22] Our results substantiate prior reports and supplement them by stratifying by sports participation level. In the KOOS–Quality of Life and KOOS–Sports and Recreation outcome measures, scores in the sports participation groups were lower than reported findings in the literature and significantly lower in those who did not participate in sports. Anand et al[1] reported a median KOOS–Quality of Life score of 73 in individuals who returned to sports at 5-year follow-up, which was in contrast to single- and multiple-sport MARS participants, who had median KOOS–Quality of Life scores of 63. The difference in scores could be attributed to the length of follow-up between the studies. After primary ACL reconstruction, median KOOS–Quality of Life scores increased from 75 to 81 at 2- to 6-year follow-up intervals.[22] These results indicate even if patients were able to return to sports participation after revision ACL reconstruction, they may not have the same level of self-reported sports function as patients who underwent primary ACL reconstruction. Contrary to our hypothesis, few clinically meaningful differences were seen between participants who participated in multiple sports and a single sport. Multisport participants had higher odds of increased activity levels on the Marx activity scale and WOMAC-Stiffness than single-sport participants. These results could suggest a gradient effect between sports participation levels in which diversifying sports activities—even among the older MARS cohort (median age, 26 years)—was associated with improved PROMs as compared with single-sport participation. Yet, the number of sports participated in may simply reflect one's personal preference after revision surgery and not a surrogate of knee function. Further research is needed to determine if participating in multiple sports reduces the risk of injury in adult athletes at various levels of sports participation and is protective against future reinjury.

The MARS cohort is the largest known prospective longitudinal study of patients who underwent revision ACL. This study established that sports participation is associated with higher PROMs than no sport, but it did not take into account the sports participation level (eg, recreational vs collegiate). Interestingly, single-sport participants were more likely than multisport athletes to have higher outcome scores on the KOOS–Sports and Recreation subscale. This may be due to the type of sporting events single-sport patients participated in or the level of sport for this cohort. Level of sports participation was collinear with the Marx activity scale, and as a result, we did not include this variable in our model. Only 1 other analysis of the MARS cohort examined the influence of sport type and level of sport activity on

determining graft choice in revision ACL reconstruction, and it found no association.[12] Future studies should aim to better understand how modifications of the level of sports participation affect short- and long-term PROMs. For translation to clinical practice, these results suggest that surgeons may only need simple questions on the return to physical activity in determining the health of the knee during follow-up visits.

Although this study relies on self-reported measures, the PROMs collected are well validated and reported. While our statistical approach controlled for previously reported predictors of decreased PROMs, we did not address the amount of time that an individual had been cleared for sports participation as a potential confounder. The 6- and 10-year follow-up data planned for the MARS cohort can be used to assess the longitudinal effect of sports participation on PROMs.

CONCLUSION

Participation in either a single or multiple sports in the 2 years after ACL revision surgery was found to be significantly associated with higher PROMs across multiple validated self-reported assessment tools. The causal mechanism remains unknown as to why individuals who do not participate in sport reported lower PROMs. During follow-up appointments, surgeons should expect that patients reporting a return to physical activity (organized or unorganized) will have good functional outcomes, regardless of baseline activity levels. Diversifying the number of activities participated in after clearance from revision surgery may reflect one's personal preference and does not significantly change associated PROMs. Last, the decline in Marx scores across groups may not represent declining physical activity but rather a change in the intensity of activities pursued within the sport. Further work is needed to determine how limiting physical activity after revision surgery influences long-term outcomes.

AUTHORS

John P. Bigouette, MPH, MS, ATC (Oregon State University, Corvallis, Oregon, USA); Erin C. Owen, PhD, MPH (Slocum Research and Education Foundation, Eugene, Oregon, USA); Brett (Brick) A. Lantz, MD (Slocum Research and Education Foundation, Eugene, Oregon, USA); Rudolf G. Hoellrich, MD (Slocum Research and Education Foundation, Eugene, Oregon, USA); Laura J. Huston, MS (Vanderbilt University, Nashville, Tennessee, USA); Amanda K. Haas, MA (Washington University in St Louis, St Louis, Missouri, USA); Christina R. Allen, MD (University of California, San Francisco, San Francisco, California, USA); Allen F. Anderson, MD (Tennessee Orthopaedic Alliance, Nashville, Tennessee, USA); Daniel E. Cooper, MD (W.B. Carrell Memorial Clinic, Dallas, Texas, USA); Thomas M. DeBerardino, MD (The San Antonio Orthopaedic Group, San Antonio, Texas, USA); Warren R. Dunn, MD, MPH (Reedsburg Area Medical Center, Reedsburg, Wisconsin, USA); Barton Mann, PhD (AOSSM, Rosemont, Illinois, USA); Kurt P. Spindler, MD (Cleveland Clinic, Cleveland, Ohio, USA); Michael J. Stuart, MD (Mayo Clinic, Rochester, Minnesota, USA); Rick W. Wright, MD (Washington University in St Louis, St Louis, Missouri, USA); John P. Albright, MD (University of Iowa Hospitals and Clinics, Iowa City, Iowa, USA); Annunziato (Ned) Amendola, MD (Duke University, Durham, North Carolina, USA); Jack T. Andrish, MD (Cleveland Clinic, Cleveland, Ohio, USA); Christopher C. Annunziata, MD (Commonwealth Orthopaedics and Rehabilitation, Arlington, Virginia, USA); Robert A. Arciero, MD (University of Connecticut Health Center, Farmington, Connecticut, USA); Bernard R. Bach Jr, MD (Rush University Medical Center, Chicago, Illinois, USA); Champ L. Baker III, MD (The Hughston Clinic, Columbus, Georgia, USA); Arthur R. Bartolozzi, MD (3B Orthopaedics, University of Pennsylvania Health System, Philadelphia, Pennsylvania, USA); Keith M. Baumgarten, MD (Orthopedic Institute, Sioux Falls, South Dakota, USA); Jeffery R. Bechler, MD (University Orthopaedic Associates LLC, Princeton, New Jersey, USA); Jeffrey H. Berg, MD (Town Center Orthopaedic Associates, Reston, Virginia, USA); Geoffrey A. Bernas, MD (State University of New York at Buffalo, Buffalo, NY); Stephen F. Brockmeier, MD (University of Virginia, Charlottesville, Virginia, USA); Robert H. Brophy, MD (Washington University in St Louis, St Louis, Missouri, USA); Charles A. Bush-Joseph, MD (Rush University Medical Center, Chicago, Illinois, USA); J. Brad Butler V, MD (Orthopedic and Fracture Clinic, Portland, Oregon, USA); John D. Campbell, MD (Bridger Orthopedic and Sports Medicine, Bozeman, Montana, USA); James L. Carey, MD, MPH (University of Pennsylvania, Philadelphia, Pennsylvania, USA); James E. Carpenter, MD (University of Michigan, Ann Arbor, Michigan, USA); Brian J. Cole, MD (Rush University Medical Center, Chicago, Illinois, USA); Jonathan M. Cooper, DO (HealthPartners Specialty Center, St Paul, Minnesota, USA); Charles L. Cox, MD, MPH (Vanderbilt University, Nashville, Tennessee, USA); R. Alexander Creighton, MD (University of North Carolina Medical Center, Chapel Hill, North Carolina, USA); Diane L. Dahm, MD (Mayo Clinic, Rochester, Minnesota, USA); Tal S. David, MD (Synergy Specialists Medical Group, San Diego, California, USA); David C. Flanigan, MD (The Ohio State University, Columbus, Ohio, USA); Robert W. Frederick, MD (The Rothman Institute/Thomas Jefferson University, Philadelphia, Pennsylvania, USA); Theodore J. Ganley, MD (Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, USA); Elizabeth A. Garofoli (Washington University in St Louis, St Louis, Missouri, USA); Charles J. Gatt Jr, MD (University Orthopaedic Associates LLC, Princeton, New Jersey, USA); Steven R. Gecha, MD (Princeton Orthopaedic Associates, Princeton, New Jersey, USA); James Robert Giffin, MD (Fowler Kennedy Sport Medicine Clinic, University of Western Ontario, London, Ontario, Canada); Sharon L. Hame, MD (David Geffen School of Medicine at UCLA, Los Angeles, California, USA); Jo A. Hannafin, MD, PhD (Hospital for Special Surgery, New York, New York, USA); Christopher D. Harner, MD (University of Texas Health Center, Houston, Texas, USA); Norman Lindsay Harris Jr, MD (Grand River Health in Rifle, Colorado, USA); Keith S. Hechtman, MD (UHZ Sports Medicine Institute, Coral Gables, Florida, USA); Elliott B. Hershman, MD (Lenox Hill Hospital, New York, New York, USA); Timothy M. Hosea, MD (University Orthopaedic Associates LLC, Princeton, New Jersey, USA); David C. Johnson, MD (National Sports Medicine Institute, Leesburg, Virginia, USA); Timothy S. Johnson, MD (National Sports Medicine Institute, Leesburg, Virginia, USA); Morgan H. Jones, MD (Cleveland Clinic, Cleveland, Ohio, USA); Christopher C. Kaeding, MD (The Ohio State University, Columbus, Ohio, USA); Ganesh V. Kamath, MD (University of North Carolina Medical Center, Chapel Hill, North Carolina, USA); Thomas E. Klootwyk, MD (Methodist Sports Medicine, Indianapolis, Indiana, USA); Bruce A. Levy, MD (Mayo Clinic Rochester, Minnesota, USA); C. Benjamin Ma, MD (University of California, San Francisco, California,

USA); G. Peter Maiers II, MD (Methodist Sports Medicine Center, Indianapolis, Indiana, USA); Robert G. Marx, MD (Hospital for Special Surgery, New York, New York, USA); Matthew J. Matava, MD (Washington University in St Louis, St Louis, Missouri, USA); Gregory M. Mathien, MD (Knoxville Orthopaedic Clinic, Knoxville, Tennessee, USA); David R. McAllister, MD (David Geffen School of Medicine at UCLA, Los Angeles, California, USA); Eric C. McCarty, MD (University of Colorado Denver School of Medicine, Denver, Colorado, USA); Robert G. McCormack, MD (University of British Columbia/Fraser Health Authority, Vancouver, British Columbia, Canada); Bruce S. Miller, MD, MS (University of Michigan, Ann Arbor, Michigan, USA); Carl W. Nissen, MD (Connecticut Children's Medical Center, Hartford, Connecticut, USA); Daniel F. O'Neill, MD, EdD (Littleton Regional Healthcare, Littleton, New Hampshire, USA); Brett D. Owens, MD (Warren Alpert Medical School, Brown University, Providence, Rhode Island, USA); Richard D. Parker, MD (Cleveland Clinic, Cleveland, Ohio, USA); Mark L. Purnell, MD (Aspen Orthopedic Associates, Aspen, Colorado, USA); Arun J. Ramappa, MD (Beth Israel Deaconess Medical Center, Boston, Massachusetts, USA); Michael A. Rauh, MD (State University of New York at Buffalo, Buffalo, New York, USA); Arthur C. Rettig, MD (Methodist Sports Medicine, Indianapolis, Indiana, USA); Jon K. Sekiya, MD (University of Michigan, Ann Arbor, Michigan, USA); Kevin G. Shea, MD (Intermountain Orthopaedics, Boise, Idaho, USA); Orrin H. Sherman, MD (NYU Hospital for Joint Diseases, New York, New York, USA); James R. Slauterbeck, MD (Robert Larner College of Medicine, University of Vermont, Burlington, Vermont, USA); Matthew V. Smith, MD (Washington University in St Louis, St Louis, Missouri, USA); Jeffrey T. Spang, MD (University of North Carolina Medical Center, Chapel Hill, North Carolina, USA); LTC Steven J. Svoboda, MD (Keller Army Community Hospital, United States Military Academy, West Point, New York, USA); Timothy N. Taft, MD (University of North Carolina Medical Center, Chapel Hill, North Carolina, USA); Joachim J. Tenuta, MD (Albany Medical Center, Albany, New York, USA); Edwin M. Tingstad, MD (Inland Orthopaedic Surgery and Sports Medicine Clinic, Pullman, Washington, USA); Armando F. Vidal, MD (University of Colorado Denver School of Medicine, Denver, Colorado, USA); Darius G. Viskontas, MD (Royal Columbian Hospital, New Westminster, British Columbia, Canada); Richard A. White, MD (Fitzgibbon's Hospital, Marshall, Missouri, USA); James S. Williams Jr, MD (Cleveland Clinic, Euclid, Ohio, USA); Michelle L. Wolcott, MD (University of Colorado Denver School of Medicine, Denver, Colorado, USA); Brian R. Wolf, MD (University of Iowa Hospitals and Clinics, Iowa City, Iowa, USA); James J. York, MD (Orthopaedic and Sports Medicine Center, LLC, Pasedena, Maryland, USA).

ACKNOWLEDGMENT

The authors express their appreciation to the late Barton Mann, PhD (AOSSM, Rosemont, Illinois, USA), Timothy M. Hosea, MD (University Orthopaedic Associates LLC, Princeton, New Jersey, USA), and Allen F. Anderson, MD (Tennessee Orthopaedic Alliance, Nashville, Tennessee, USA), whose contribution to this work was of great significance.

REFERENCES

1. Anand BS, Feller JA, Richmond AK, Webster KE. Return-to-sport outcomes after revision anterior cruciate ligament reconstruction surgery. *Am J Sports Med*. 2016;44(3):580-584.
2. Andriolo L, Filardo G, Kon E, et al. Revision anterior cruciate ligament reconstruction: clinical outcome and evidence for return to sport. *Knee Surg Sports Traumatol Arthrosc*. 2015;23(10):2825-2845.
3. 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.
4. Ardern CL, Taylor NF, Feller JA, Whitehead TS, Webster KE. Sports participation 2 years after anterior cruciate ligament reconstruction in athletes who had not returned to sport at 1 year. *Am J Sports Med*. 2015;43(4):848-856.
5. Bell DR, Pfeiffer KA, Cadmus-Bertram LA, et al. Objectively measured physical activity in patients after anterior cruciate ligament reconstruction. *Am J Sports Med*. 2017;45(8):1893-1900.
6. Borchers JR, Kaeding CC, Pedroza AD, et al. Intra-articular findings in primary and revision anterior cruciate ligament reconstruction surgery. *Am J Sports Med*. 2011;39(9):1889-1893.
7. Irrgang JJ, Anderson AF, Boland AL, et al. Responsiveness of the International Knee Documentation Committee subjective knee form. *Am J Sports Med*. 2006;34(10):1567-1573.
8. Kuenze C, Cadmus-Bertram L, Pfieffer K, Trigsted S, et al. Relationship between physical activity and clinical outcomes after ACL reconstruction. *J Sport Rehabil*. 2019;28(2):180-187.
9. Lefevre N, Klouche S, Mirouse G, Herman S, Gerometta A, Bohu Y. Return to sport after primary and revision anterior cruciate ligament reconstruction: a prospective comparative study of 552 patients from the FAST cohort. *Am J Sports Med*. 2016;45(1):34-41.
10. Magnussen R, Trojani C, Granan L-P, et al. Patient demographics and surgical characteristics in ACL revision: a comparison of French, Norwegian, and North American cohorts. *Knee Surg Sports Traumatol Arthrosc*. 2015;23(8):2339-2348.
11. MARS Group. Effect of graft choice on the outcome of revision anterior cruciate ligament teconstruction in the multicenter ACL revision study (MARS) cohort. *Am J Sports Med*. 2014;42(10):2301-2310.
12. MARS Group. Factors influencing graft choice in revision anterior cruciate ligament reconstruction in the MARS Group. *J Knee Surg*. 2016;29(6):458-463.
13. MARS Group. Meniscal and articular cartilage predictors of clinical outcome after revision anterior cruciate ligament reconstruction. *Am J Sports Med*. 2016;44(7):1671-1679.
14. MARS Group. Radiographic findings in revision anterior cruciate ligament reconstructions from the Mars cohort. *J Knee Surg*. 2013;26(4):239.
15. MARS Group, Allen CR, Anderson AF, et al. Surgical predictors of clinical outcomes after revision anterior cruciate ligament reconstruction. *Am J Sports Med*. 2017;45(11):2586-2594.
16. MARS Group, Wright RW, Huston LJ, et al. Descriptive epidemiology of the Multicenter ACL Revision Study (MARS) cohort. *Am J Sports Med*. 2010;38(10):1979-1986.
17. Marx RG, Stump TJ, Jones EC, Wickiewicz TL, Warren RF. Development and evaluation of an activity rating scale for disorders of the knee. *Am J Sports Med*. 2001;29(2):213-218.
18. Pasulka J, Jayanthi N, McCann A, Dugas LR, LaBella C. Specialization patterns across various youth sports and relationship to injury risk. *Phys Sportsmed*. 2017;45(3):344-352.
19. Roos EM, Lohmander LS. The Knee injury and Osteoarthritis Outcome Score (KOOS): from joint injury to osteoarthritis. *Health Qual Life Outcomes*. 2003;1:64.
20. Shelbourne KD, Benner RW, Gray T. Return to sports and subsequent injury rates after revision anterior cruciate ligament reconstruction with patellar tendon autograft. *Am J Sports Med*. 2014; 42(6):1395-1400.
21. Spindler KP, Huston LJ, Chagin KM, et al. Ten-year outcomes and risk factors after anterior cruciate ligament reconstruction: a MOON longitudinal prospective cohort study. *Am J Sports Med*. 2018; 46(4):815-825.
22. Spindler KP, Huston LJ, Wright RW, et al. The prognosis and predictors of sports function and activity at minimum 6 years after anterior cruciate ligament reconstruction. *Am J Sports Med*. 2011;39(2):348-359.

23. Webster KE, Feller JA. Younger patients and men achieve higher outcome scores than older patients and women after anterior cruciate ligament reconstruction. *Clin Orthop Relat Res*. 2017;475(10):2472-2480.
24. Wright RW. Knee injury outcomes measures. *J Am Acad Orthop Surg*. 2009;17(1):31-39.
25. Wright RW. Knee sports injury outcome measures. *J Knee Surg*. 2005;18(1):69-72.
26. Wright RW, Spindler KP, Huston LJ, et al. Revision ACL reconstruction outcomes—MOON cohort. *J Knee Surg*. 2011;24(4):289-294.