Low Rate of Return to Preinjury Tegner Activity Level Among Recreational Athletes

Results at 1 Year After Primary ACL Reconstruction

Su-Hyun Kim,* MD, Ja-Woon Lee,† MD, Sang-Gyun Kim,‡ MD, Hyun-Woo Cho,† MD, and Ji-Hoon Bae,†§ MD, PhD

Investigation performed at Korea University Guro Hospital, Seoul, Republic of Korea

Background: There is limited information about the functional recovery and rate of return to preinjury levels of sports among recreational athletes after anterior cruciate ligament reconstruction (ACLR).

Purpose: To investigate the recovery of quadriceps or hamstring strength, assess functional performance, and determine the rate of return to preinjury sports levels among recreational athletes at 1 year after ACLR.

Study Design: Cohort study; Level of evidence, 3.

Methods: A total of 91 recreational-level athletes who underwent anatomic single-bundle ACLR were enrolled. We evaluated the limb symmetry index (LSI) of the quadriceps and hamstring peak torque strength at 60°, in addition to hop test performance (single-leg, triple, crossover, and 6-m timed), patient-reported outcomes, and pre- versus postoperative Tegner activity levels. Outcomes were compared between younger (age <25 years) and older patients (age ≥25 years).

Results: There were 48 patients in the younger group and 43 patients in the older group. At 1-year follow-up, the overall LSIs for quadriceps strength and hamstring strength were 77% and 86%, respectively, and the LSIs of the hop tests were 79% for single-leg, 81% for triple, 84% for crossover, and 85% for 6-m timed hop. Overall, only 24% patients returned to their preinjury Tegner level, and only 8% of patients met the criteria for return to pivoting, cutting, and jumping sports. At 1-year follow-up, the younger group showed significantly more quadriceps strength than the older group (85% vs 64%; $P = .0001$), better single, triple, crossover, and 6-m timed hop test results (85% vs 69%, $P = .003$; 84% vs 75%, $P = .046$; 91% vs. 74%, $P < .001$; and 91% vs 76%, $P = .003$, respectively), higher Lysholm score (87 vs 74; $P < 0.001$) and International Knee Document Committee score (82 vs 66; $P < .001$), and a higher rate of return to preinjury Tegner level (35% vs 12%; $P = .009$).

Conclusion: Only 24% of patients returned to the preinjury Tegner level at 1 year after ACLR (35% younger group vs 12% older group; $P = .009$). This information might be helpful in setting realistic expectations for recreational athletes after surgery.

Keywords: anterior cruciate ligament; reconstruction; sports; athlete

After an anterior cruciate ligament (ACL) injury, returning to preinjury levels of sports is a major goal among athletes. A recent systematic review reported that only 65% of athletes returned to their preinjury sports levels; athletes who were not professionally engaged in sports were less likely to return to preinjury levels.[3] Nonprofessional athletes may have less time for intensive rehabilitation, support from rehabilitation professionals, and motivation to return to sports (RTS).[16,18,21] In addition, the primary concern of most nonprofessional athletes is not the return to their previous sports activity but rather the return to their jobs. Therefore, it can be speculated that the recovery of the quadriceps or hamstring strength and functional performance of nonprofessional athletes may progress more slowly than that of elite athletes. Simply put, it may take longer for nonprofessional athletes to return to their preinjury sports levels.

A previous systematic review reported that 60% of nonelite athletes return to their preinjury sports levels after ACL reconstruction (ACLR).[3] However, several other studies have reported considerably lower rates than that, ranging from 19% to 100%.[2,4,5,26,30,33] The reason for the different rates among studies has not been described, but the level of athletic activity is probable. Recent studies have suggested that athletes with higher competition levels are more likely to return to their preinjury sports levels.[11,35] Therefore, it would be useful to apply the athletic competition level in differentiating the rates of return to preinjury levels for sports. In many clinics, most patients who have undergone ACLR are recreational-level athletes. They have

The Orthopaedic Journal of Sports Medicine, 9(1), 2325967120975751
DOI: 10.1177/2325967120975751

been considered to be less likely to return to preinjury sports levels. However, there are limited reports on the recovery of muscle strength, functional performance, and rates of return to preinjury levels after ACLR among recreational-level athletes.

This study aimed to investigate the recovery of the quadriceps or hamstring strength, functional performance, and rate of return to preinjury levels for sports among nonprofessional, recreational-level athletes after ACLR. Furthermore, since previous studies have demonstrated superior outcomes for patients under 25 years of age,[13,28,29,32] the secondary aim of this study was to compare the outcomes between younger (age <25 years) and older (age ≥25 years) patients. We defined the recreational athlete as a person who participates in any sport more than once a month to be physically fit, socially involved, and have fun when he or she is not working. We hypothesized that the recovery of quadriceps/hamstring strength, functional performance, and rates of RTS among recreational athletes would be lower than previously reported rates in elite athletes.

METHODS

We used a prospective, longitudinal, single-center cohort in 2016 to investigate the functional and clinical outcomes of all types of treatment (nonoperative, primary reconstruction, and revisional reconstruction) for ACL injuries in nonprofessional athletes or the general population. This cohort study was approved by the ethical review board at our institution, and all patients provided informed consent before participation. The study data for the current retrospective analysis were extracted from the aforementioned cohort. The patients in the current study were those who underwent primary anatomical, single-bundle ACLR performed by a single surgeon between January 2016 and March 2018.

Demographic information and intraoperative data were collected from electronic medical records and entered into the database. The exclusion criteria were as follows: professional or competitive athletes (Tegner activity level of 9 or 10); open physis; bilateral ACL injuries; concomitant fracture or other ligament surgery of an injured or contralateral knee; past history of fracture, ligament, cartilage, or meniscal injuries of an injured or contralateral knee; loss to follow-up before 1 year after the index ACLR; and incomplete evaluation during the 6-month and 1-year follow-ups.

Surgical Technique

All patients underwent an anatomic, single-bundle ACLR. If there was a meniscal tear, concomitant meniscal repair or meniscectomy was performed before the ACLR procedure depending on the repairability of the meniscus. In all cases, a 2-incision, outside-in technique was used for the anatomic femoral tunnel placement. The graft types used for reconstruction consisted of an ipsilateral bone–patellar tendon–bone autograft, 4-strand gracilis and semitendinosus tendons autograft, and an Achilles tendon allograft. The graft type was chosen after informed discussions with each patient before surgery. Metal interference screws were used for fixation of the bone–patellar tendon–bone autograft. These were also used as a bone block for the Achilles allograft. Bioabsorbable interference screws were used for fixation of the hamstring autograft and a tendinous portion of the Achilles allograft. Additionally, sutures tied over a cancellous screw and washer were used on the tibial side. The tunnel diameter was equaled to the bone block (10 mm), and the soft tissue portion was 1 mm smaller than the cross-sectional diameter of the graft (range, 6-8.5 mm).

Postoperative Rehabilitation

The same postoperative rehabilitation was applied for every patient, regardless of the graft type and whether the patient was undergoing meniscal repair or meniscectomy. Early progressive range of motion, quadriceps muscle strengthening exercises, and neuromuscular training were started, as tolerated, during the first postoperative week. Partial weightbearing with crutches was allowed immediately after ACLR. This progressed, again, as tolerated, to full weightbearing. A knee brace was recommended for 4 to 6 weeks until ambulation became comfortable. Three months after ACLR, patients who achieved a limb symmetry index (LSI) of ≥70% on the quadriceps strength and had no knee pain, effusion, or giving way were allowed to run on a treadmill and progress to agility exercises and sports-specific drills.[24] After 12 months, patients were cleared to return to nonpivoting, cutting, and jumping sports activities if they achieved an LSI of ≥80% on quadriceps and hamstring strength and a single-leg hop test (RTS criteria 1). Patients were cleared to proceed with pivoting, cutting, and jumping sports activities if they achieved an LSI of ≥90% on quadriceps and hamstring strength and 4 hop tests (RTS criteria 2).[1,9,10]

§Address correspondence to Ji-Hoon Bae, MD, PhD, Department of Orthopaedic Surgery, Korea University Guro Hospital, Korea University College of Medicine, 148 Gurodong-ro, Guro-gu, Seoul 08308, Republic of Korea (email: osman@korea.ac.kr) (Twitter: @drjhbae).

*Department of Orthopaedic Surgery, Naval Maritime Medical Center, Jinju, Republic of Korea.

†Department of Orthopaedic Surgery, Korea University Guro Hospital, Korea University College of Medicine, Seoul, Republic of Korea.

‡Department of Orthopaedic Surgery, Korea University Ansan Hospital, Korea University College of Medicine, Ansan, Republic of Korea.

Final revision submitted August 4, 2020; accepted September 14, 2020.

The authors declared that there are no conflicts of interest in the authorship and publication of this contribution. 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.

Ethical approval for this study was obtained from Korea University Guro Hospital Institutional Review Board (Study No. 2016GR0161).

Assessment of Functional and Patient-Reported Outcomes

All patients were prospectively evaluated during their regular visits to the outpatient clinic. The independent staff (experienced athletic trainers and physical therapists) from our sports rehabilitation center conducted all the functional tests and obtained the necessary data. These data were collected before ACLR and at 3 months, 6 months, and 1 year after ACLR. The hop tests were performed 6 months and 1 year after ACLR.

The isokinetic concentric quadriceps and hamstring strength was measured with an electromechanical dynamometer (Biodex6000; Biodex Medical Systems) with the knee at an angle of 60°. Three submaximal practice trials were followed by a 1-minute rest period before 3 maximum-effort repetitions were recorded. After strength testing, 4 hop tests were performed in the following order: single hop for distance; triple crossover hop for distance; triple hop for distance; and 6-m timed hop.[22,25] All patients performed 2 trial hops after 2 practical hops. The 2 trial hops were then averaged. The uninjured leg was tested first. The LSIs of the quadriceps and hamstring strength peak torques and of the hop test distance/time were calculated as (*injured/uninjured*) × 100. The 6-m timed hop test, however, was calculated as (*uninjured/injured*) × 100. After the functional tests, patients completed 3 patient-reported assessments, including the Lysholm knee scoring scale, the 2000 International Knee Documentation Committee (IKDC) subjective scale, and the Tegner activity level.[8,12]

Assessment of Return to Previous Sports Activity Levels

We obtained information regarding each patient's expectations for return to previous sports activity, participation in any sports, return to preinjury sports activity, and clearance of our RTS guidelines. Patients were asked to respond to the following question: "Do you think you are likely to return to your preinjury sports activity level?" We also asked whether each patient played any sport. A return to the preinjury level of sports activity was defined as the return to the same or higher Tegner level 1 year after ACLR compared with the preinjury Tegner level. Clearance of our RTS guidelines was assessed according to the previous description of rehabilitation.

Statistical Analysis

Because previous studies have shown a higher rate of failure in patients aged <25 years (6%),[13,28,29,32] patients in this study were divided into 2 groups according to age: younger (age <25 years) and older (age ≥25 years). Demographic and intraoperative variables (including sex, age, height, body mass index, graft type, graft diameter, and presence of meniscal or cartilage tear), functional and clinical outcomes, and the rates of RTS activity were compared between the 2 groups during the follow-ups at 6 months and 1 year after ACLR. An independent *t* test (for comparison between 2 groups) or a 1-way analysis of variance test (for 3 time points within groups) was used for continuous variables. The chi-square test was used for categorical variables. Statistical significance was established at the 5% level ($P < .05$). All statistical analyses were performed using the SPSS for Windows, Version 25.0 (SPSS Inc).

RESULTS

A total of 118 patients met the inclusion criteria of this study. Of these patients, complete follow-up and serial test data were obtained in 91 patients (younger group, n = 48; older group, n = 43). Fifteen patients were lost to follow-up, while 12 patients had incomplete serial test results. The demographic data of the 91 patients are presented in Table 1. The sports played before injury included soccer (n = 48), basketball (n = 22), baseball (n = 4), badminton (n = 3), tennis (n = 3), table tennis (n = 3), running (n = 1), skiing (n = 3), skating (n = 1), taekwondo (n = 2), and judo (n = 1).

Functional Outcomes, Clinical Outcomes, and RTS

At the 1-year follow-up, the preoperative quadriceps and hamstring strength and the patient-reported outcomes significantly improved after ACLR (Table 2). The preoperative quadriceps strength did not improve at 6 months; however, this improved significantly at 1 year. The overall LSIs of the quadriceps strength and hamstring strength at 1-year follow-up were 77% and 86%, respectively. The LSIs of the hop tests at 1 year were 79% for single-leg, 81% for triple, 84% for crossover, and 85% for 6-m timed. The percentage of patients who reached an LSI >90% at the 1-year follow-up were as follows: single-leg, 33%; triple, 31%; crossover, 42%; and 6-m timed, 40%. During the first year after ACLR, 74% of patients returned to any sports level, but only 24% returned to their preinjury Tegner level. Of the patients, 76% had positive expectations for RTS to their preinjury level; however, only 34% and 8% of patients passed our RTS readiness criteria 1 and 2, respectively. No graft rupture or meniscal or cartilage injuries had been noticed during the clinical follow-up period in any of the patients.

Subgroup Analysis

There were no significant differences between the 2 groups in terms of demographic data, except for age (Table 1). There were no significant differences in the preoperative quadriceps and hamstring muscle strengths, the 2000 IKDC subjective scores, and the Tegner level between the 2 groups (Tables 2 and 3). However, the younger group showed significantly higher patient-reported outcomes, more quadriceps strength, and better hop test performance at 6 months and 1 year after ACLR compared with the older group (Tables 2 and 3).

In the younger group, quadriceps strength LSI significantly improved from preoperatively to 1-year follow-up (65.4% vs 84.8%; $P = .001$). This improvement in quadriceps

TABLE 1
Patient Demographic Data[a]

	Total (N = 91)	Younger Group (n = 48)	Older Group (n = 43)	*P* Value
Male sex	80 (88)	44 (92)	36 (86)	.135
Age, y	26.8 ± 11.4	18.9 ± 3.0 (median, 18)	37.4 ± 9.8 (median, 33)	**<.001**
BMI, kg/m^2	24.1 ± 4.3	23.8 ± 3.3	24.3 ± 5.4	.42
Competitive/ recreational sports	72/18	39/9	33/10	.42
Graft type, n; graft diameter, mm				.45; .76
Hamstring autograft	51; 8.2 ± 1.4	30; 8.1 ± 2.1	21; 8.3 ± 1.9	
BPTB autograft	21; 10.1 ± 0.3	10; 10.0 ± 0.4	11; 10.3 ± 0.5	
Achilles allograft	19; 10.2 ± 0.5	8; 10.1 ± 0.2	11; 10.2 ± 0.5	
Time from injury to surgery, months	3.0 ± 3.7	3.2 ± 3.2	3.1 ± 2.7	

[a]Data are reported as n (%) or mean ± SD unless otherwise indicated. Younger group: age <25 years; older group: age ≥25 years. *P* values in bold indicate a statistically significant difference between groups ($P < .05$). BMI, body mass index; BPTB, bone–patellar tendon–bone.

TABLE 2
Comparison of Muscle Strength and Hop Performances between 2 Groups[a]

Limb Symmetry Index, %		Younger Group (n = 48)	Older Group (n = 43)	*P* Value
Quadriceps strength	Preop	65.4 ± 4.0	63.4 ± 5.6	.55
	6 months	70.4 ± 2.9	55.9 ± 4.9	**.002**
	1 y	84.8 ± 3.2[b]	66.4 ± 5.2	**.0001**
Hamstring strength	Preop	73.6 ± 5.1	64.2 ± 7.5	.12
	6 months	83.9 ± 3.1[b]	78.9 ± 5.0[b]	.12
	1 y	88.3 ± 2.6[b]	83.0 ± 2.9[b]	.107
Single-leg hop	6 months	77.5 ± 3.6	65.2 ± 5.2	**.017**
	1 y	85.2 ± 3.3	68.7 ± 5.4	**.003**
Triple hop	6 months	80.4 ± 3.3	67.3 ± 6.0	**.012**
	1 y	84.1 ± 2.7	75.1 ± 3.9	**.046**
Crossover hop	6 months	81.3 ± 3.5	62.8 ± 6.4	**.002**
	1 y	91.4 ± 2.6	73.5 ± 5.2	**<.001**
6-m timed hop	6 months	87.0 ± 2.5	72.4 ± 6.4	**.006**
	1 y	90.6 ± 2.3	76.3 ± 5.6	**.003**

[a]Data are reported as mean ± SD. Younger group: age <25 years, older group: age ≥25 years. *P* values in bold indicate a statistically significant difference between groups ($P < .05$). Preop, preoperative.
[b]Significant difference compared with preoperatively.

strength was not seen in older patients, however (63.4% vs 66.4%; $P = .076$) (Table 2). In younger patients, the hop test performance was an LSI of ≥85% at 1 year after ACLR, while older patients still had an LSI of <80% (Table 2). There were no significant differences in the rates of positive subjective expectations about the confidence in returning to their previous sports activity levels between the groups (Table 4). However, older patients were less likely to participate in sports activities at their preinjury levels (Table 4); younger patients were more likely to meet the criteria for return to nonpivoting, cutting, and jumping sports (44% vs 23%; $P = .039$). However, no significant differences regarding the rates of readiness for return to pivoting, cutting, and jumping sports were found between the younger and older groups (10% vs 5%; $P = .302$).

DISCUSSION

The main findings of this study were that only 24% of patients returned to their preinjury Tegner sports activity levels, while only 8% achieved >90% improved measurements of muscle strength and 4 hop tests taken 1 year after ACLR. Patients aged ≥25 years had lesser functional and clinical outcomes at 6 months and 1 year after ACLR in terms of patient-reported outcomes, quadriceps muscle strength, hop test performance, and rate of return to preinjury sports activity. Our findings may aid clinicians in setting realistic expectations for functional recovery and RTS time points for nonprofessional, recreational athletes undergoing ACLR.

In our study, 24% of patients returned to their preinjury sports levels 1 year after ACLR. This was lower than the

TABLE 3
Comparison of Patient-Reported Outcomes Between 2 Groups[a]

		Younger Group (n = 48)	Older Group (n = 43)	*P* Value
Lysholm score	Preop	68.1 ± 3.8	53.1 ± 5.7	**.007**
	6 months	81.5 ± 2.5	69.8 ± 3.3	**.003**
	1 y	86.8 ± 2.5	73.7 ± 3.3	**<.001**
IKDC subjective score	Preop	53.4 ± 2.6	47.4 ± 4.2	.15
	6 months	74.5 ± 2.6	58.9 ± 3.4	**<.001**
	1 y	81.5 ± 2.4	66.1 ± 3.3	**<.001**
Tegner activity score	Preop	7.3 ± 0.3	7.0 ± 0.3	.52
	6 months	5.6 ± 0.3	4.3 ± 0.3	.095
	1 y	6.5 ± 0.4	4.8 ± 0.3	**<.001**

[a]Data are reported as mean ± SD. Younger group: age <25 years; older group: age ≥25 years. *P* values in bold indicate a statistically significant difference between groups ($P < .05$). IKDC, International Knee Document Committee; Preop, preoperative.

TABLE 4
Rate of Return to Sports Activity[a]

	Younger Group (n = 48)	Older Group (n = 43)	*P* Value
RTS (subjective expectation)[b]	37 (77)	32 (74)	.954
RTS (any sport)	33 (69)	34 (79)	.264
RTS (preinjury Tegner level)[c]	17 (35)	5 (12)	**.009**
Passed RTS criteria 1[d]	21 (44)	10 (23)	**.039**
Passed RTS criteria 2[e]	5 (10)	2 (5)	.302

[a]Data are reported as n (%). Younger group: age <25 years; older group: age ≥25 years. *P* values in bold indicate a statistically significant difference between groups ($P < .05$). RTS, return to sports.

[b]Participant answered "yes" to the question about whether he was subjectively confident about returning to his previous sports activity level.

[c]Patient returned to the same or higher preinjury Tegner level.

[d]Criteria 1 for non–high risk recreational sports: >80% quadriceps and hamstring strength; >80% single hop test; no pain, effusion, or giving way; full range of motion.

[e]Criteria 2 for high-risk recreational or competitive sports: >90% quadriceps and hamstring strength; >90% 4 hop tests; no pain, effusion, or giving way; full range of motion.

rate (60%; nonelite athletes) reported by a previous systematic review.[3] The reason for the difference in preinjury RTS rates remains unclear. One probable explanation is the performance level of the included athletes. The motivation for return to competitive-level sports may prompt athletes to undergo intensive rehabilitation. Thus, they would be more likely to return to their preinjury sports level. For recreational-level athletes, the reported rates of return to preinjury sports levels have been lower (Ardern et al,[4] 19%; Hamrin Senorski et al,[11] 17.6%; Tjong et al,[30] 35%; Webster et al,[35] 32%). Another probable explanation may be the publication bias of a meta-analysis. Since there is a tendency to publish studies that show good results, it is harder to find studies with inferior results beyond outliers. However, negative or inferior results should also be reported to determine the factors affecting unsatisfactory outcomes and improve clinical practice.

In our study, most patients did not achieve >90% of quadriceps strength. Only 8% of patients passed the RTS criteria for pivoting, cutting, and jumping sports at 1 year after ACLR. This suggests that nonprofessional athletes require more time to recover symmetric muscle strength and function after ACLR. The rate of return to preinjury levels in our study was lower than that previously reported in professional or elite athletes (14%-73%).[7,15,17,31] The possible reasons may be the conservative rehabilitation protocol in the early phase, and, more likely, the amount of time invested for rehabilitation. Due to their jobs being during working hours, nonprofessional athletes were less likely to receive intensive rehabilitation than professional or elite athletes. However, it is questionable whether the current RTS criteria for professional or elite athletes can be applied to recreational athletes.[10,15] Since the RTS criteria for competitive sports is set high, it would be difficult for recreational athletes to pass these criteria 1 or 2 years after ACLR. Considering a lower competitive level, a lower threshold of the RTS criteria would be needed for these nonprofessional athletes. In addition, a recent systematic review and meta-analysis[34] reported that there was limited evidence that passing an RTS test battery would reduce the risk for any subsequent knee and ACL injuries. The authors also questioned the validity of the current RTS test batteries.[34] Further studies are required to develop and validate an appropriate RTS criteria for recreational athletes.

It is well-recognized that psychological readiness is also important in RTS and the prevention of subsequent knee injuries.[4,19,20,27,35] In this study, we investigated patients' expectations of returning to their preinjury level of sports activity at 1 year after ACLR through 1 simple question. Only 24% of patients successfully returned to their preinjury Tegner sports activity levels; however, 76% still had positive expectations of returning to their preinjury sports levels. In addition, the rate of positive expectations in the older group was similar to that of the younger group. Considering that 76% of patients had positive expectations, a high possibility of physical function improvement by intensive rehabilitation exists. However, the simple question used in the present study was not a validated measurement for psychological readiness. Further studies using validated measurement methods such as the Anterior Cruciate Ligament–Return to Sport after Injury scale are warranted.[33]

A previous study has suggested that patients aged <30 years have a similar recovery of knee functions after ACLR, regardless of their age. Beischer et al[6] reported no differences in the quadriceps/hamstring muscle strengths, hop performances, and patient-reported outcomes (Knee injury and Osteoarthritis Outcome Score) between adolescents (age <20 years) and adults (age 20-30 years) at the 1-year follow-up after ACLR. Our study included 26 patients aged

>30 years. We also performed a subgroup analysis. We found that older patients (age ≥25 years) had inferior quadriceps muscle strength and hop performances, lesser patient-reported outcomes, and lower return to preinjury sports levels at 6 months and 1 year after ACLR than younger patients (age <25 years). In addition, older patients showed little improvements in quadriceps strength, hop performances, and patient-reported outcomes compared with younger patients during the follow-ups at 6 months and 1 year after ACLR. These patients still had decreased quadriceps strength and hop performances <80% for the contralateral knees. Since there are limited studies reporting the normal and 1-year recovery phase values of muscle strengths and hop performances in patients aged ≥25 years, it is questionable whether our results are outliers. Although several studies have reported satisfactory clinical outcomes after ACLR in older patients,[14,23] different rehabilitation strategies and time frames may be required in older patients.

The main strength of the present study is the provision of information regarding the recovery of the quadriceps or hamstring muscle strength and the hop performances with time for nonprofessional, recreational athletes after ACLR. This information may help clinicians in providing preoperative counseling to nonprofessional, recreational athletes and setting realistic goals after ACLR. However, there are several limitations to this study. First, 22% of patients were lost to follow-up during the study period. This may have significantly affected the results. Second, this study reported only the short-term follow-ups of the functional and clinical outcomes after ACLR. To date, we are continuously evaluating these patients to obtain more data on the functional and clinical outcomes. Further long-term results shall be reported in the future. Third, some subgroup analyses may have been affected by the limited number of patients. Fourth, heterogeneous grafts were used for ACLR. These may have affected the isokinetic test results of the quadriceps (bone–patellar tendon–bone autograft) and hamstring muscles (hamstring autograft). Fifth, a sample size calculation was not performed before the study. The study may have likely been underpowered for statistical analyses. Sixth, our conservative rehabilitation protocol in the early phase might have affected the functional recovery and clinical outcomes of patients. Finally, an unidentified graft rupture/laxity, an unidentified meniscal or cartilage injury, authors' indications for ACLR, and patient expectations can also be reasons for not returning to sport. However, these were not evaluated in detail in our study.

CONCLUSION

Only 24% of patients returned to their preinjury Tegner sports activity levels 1 year after ACLR. This information might be helpful in setting realistic expectations for recreational athletes after surgery.

ACKNOWLEDGMENTS

The authors acknowledge the support of the sports medical center staff at our institution for obtaining patient-reported scores and functional results. They also thank Editage (www.editage.co.kr) for the English-language editing.

REFERENCES

1. Adams D, Logerstedt DS, Hunter-Giordano A, Axe MJ, Snyder-Mackler L. Current concepts for anterior cruciate ligament reconstruction: a criterion-based rehabilitation progression. *J Orthop Sports Phys Ther*. 2012;42(7):601-614.
2. Aglietti P, Buzzi R, Menchetti PM, Giron F. Arthroscopically assisted semitendinosus and gracilis tendon graft in reconstruction for acute anterior cruciate ligament injuries in athletes. *Am J Sports Med*. 1996; 24(6):726-731.
3. Ardern CL, Taylor NF, Feller JA, Webster KE. Fifty-five per cent return to competitive sport following anterior cruciate ligament reconstruction surgery: an updated systematic review and meta-analysis including aspects of physical functioning and contextual factors. *Br J Sports Med*. 2014;48(21):1543-1552.
4. Ardern CL, Taylor NF, Feller JA, Whitehead TS, Webster KE. Psychological responses matter in returning to preinjury level of sport after anterior cruciate ligament reconstruction surgery. *Am J Sports Med*. 2013;41(7):1549-1558.
5. 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.
6. Beischer S, Hamrin Senorski E, Thomeé C, Samuelsson K, Thomeé R. Young athletes return too early to knee-strenuous sport, without acceptable knee function after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2018;26(7): 1966-1974.
7. Beischer S, Hamrin Senorski E, Thomeé C, Samuelsson K, Thomeé R. Knee strength, hop performance and self-efficacy at 4 months are associated with symmetrical knee muscle function in young athletes 1 year after an anterior cruciate ligament reconstruction. *BMJ Open Sport Exerc Med*. 2019;5(1):e000504.
8. Briggs KK, Lysholm J, Tegner Y, Rodkey WG, Kocher MS, Steadman JR. The reliability, validity, and responsiveness of the Lysholm score and Tegner activity scale for anterior cruciate ligament injuries of the knee: 25 years later. *Am J Sports Med*. 2009;37(5): 890-897.
9. Burgi CR, Peters S, Ardern CL, et al. Which criteria are used to clear patients to return to sport after primary ACL reconstruction? A scoping review. *Br J Sports Med*. 2019;53(18):1154-1161.
10. Grindem H, Snyder-Mackler L, Moksnes H, Engebretsen L, Risberg MA. Simple decision rules can reduce reinjury risk by 84% after ACL reconstruction: the Delaware-Oslo ACL cohort study. *Br J Sports Med*. 2016;50(13):804-808.
11. Hamrin Senorski E, Svantesson E, Beischer S, et al. Low 1-year return-to-sport rate after anterior cruciate ligament reconstruction regardless of patient and surgical factors: a prospective cohort study of 272 patients. *Am J Sports Med*. 2018;46(7):1551-1558.
12. 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.
13. Kamien PM, Hydrick JM, Replogle WH, Go LT, Barrett GR. Age, graft size, and Tegner activity level as predictors of failure in anterior cruciate ligament reconstruction with hamstring autograft. *Am J Sports Med*. 2013;41(8):1808-1812.
14. Kim KT, Kim HJ, Lee HI, et al. A comparison of results after anterior cruciate ligament reconstruction in over 40 and under 40 years of age: a meta-analysis. *Knee Surg Relat Res*. 2018;30(2):95-106.
15. Kyritsis P, Bahr R, Landreau P, Miladi R, Witvrouw E. Likelihood of ACL graft rupture: not meeting six clinical discharge criteria before return to sport is associated with a four times greater risk of rupture. *Br J Sports Med*. 2016;50(15):946-951.

16. Lin CH, Lien YH, Wang SF, Tsauo JY. Hip and knee proprioception in elite, amateur, and novice tennis players. *Am J Phys Med Rehabil*. 2006;85(3):216-221.
17. Logerstedt D, Di Stasi S, Grindem H, et al. Self-reported knee function can identify athletes who fail return-to-activity criteria up to 1 year after anterior cruciate ligament reconstruction: a Delaware-Oslo ACL cohort study. *J Orthop Sports Phys Ther*. 2014;44(12):914-923.
18. Lorenz DS, Reiman MP, Lehecka BJ, Naylor A. What performance characteristics determine elite versus nonelite athletes in the same sport? *Sports Health*. 2013;5(6):542-547.
19. McPherson AL, Feller JA, Hewett TE, Webster KE. Psychological readiness to return to sport is associated with second anterior cruciate ligament injuries. *Am J Sports Med*. 2019;47(4):857-862.
20. McPherson AL, Feller JA, Hewett TE, Webster KE. Smaller change in psychological readiness to return to sport is associated with second anterior cruciate ligament injury among younger patients. *Am J Sports Med*. 2019;47(5):1209-1215.
21. Muaidi QI, Nicholson LL, Refshauge KM. Do elite athletes exhibit enhanced proprioceptive acuity, range and strength of knee rotation compared with non-athletes? *Scand J Med Sci Sports*. 2009;19(1):103-112.
22. Noyes FR, Barber SD, Mangine RE. Abnormal lower limb symmetry determined by function hop tests after anterior cruciate ligament rupture. *Am J Sports Med*. 1991;19(5):513-518.
23. Panisset JC, Gonzalez JF, de Lavigne C, et al. ACL reconstruction in over-50 year-olds: Comparative study between prospective series of over-50 year-old and under-40 year-old patients. *Orthop Traumatol Surg Res*. 2019;105(8)(suppl):S259-S265.
24. Rambaud AJM, Ardern CL, Thoreux P, Regnaux JP, Edouard P. Criteria for return to running after anterior cruciate ligament reconstruction: a scoping review. *Br J Sports Med*. 2018;52(22):1437-1444.
25. Reid A, Birmingham TB, Stratford PW, Alcock GK, Giffin JR. Hop testing provides a reliable and valid outcome measure during rehabilitation after anterior cruciate ligament reconstruction. *Phys Ther*. 2007;87(3):337-349.
26. Roos H, Ornell M, Gardsell P, Lohmander LS, Lindstrand A. Soccer after anterior cruciate ligament injury—an incompatible combination? A national survey of incidence and risk factors and a 7-year follow-up of 310 players. *Acta Orthop Scand*. 1995;66(2):107-112.
27. Sadeqi M, Klouche S, Bohu Y, Herman S, Lefevre N, Gerometta A. Progression of the psychological ACL-RSI score and return to sport after anterior cruciate ligament reconstruction: a prospective 2-year follow-up study from the French Prospective Anterior Cruciate Ligament Reconstruction Cohort Study (FAST). *Orthop J Sports Med*. 2018;6(12):2325967118812819.
28. Schlumberger M, Schuster P, Schulz M, et al. Traumatic graft rupture after primary and revision anterior cruciate ligament reconstruction: retrospective analysis of incidence and risk factors in 2915 cases. *Knee Surg Sports Traumatol Arthrosc*. 2017;25(5):1535-1541.
29. 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.
30. Tjong VK, Murnaghan ML, Nyhof-Young JM, Ogilvie-Harris DJ. A qualitative investigation of the decision to return to sport after anterior cruciate ligament reconstruction: to play or not to play. *Am J Sports Med*. 2014;42(2):336-342.
31. Toole AR, Ithurburn MP, Rauh MJ, Hewett TE, Paterno MV, Schmitt LC. Young athletes cleared for sports participation after anterior cruciate ligament reconstruction: how many actually meet recommended return-to-sport criterion cutoffs? *J Orthop Sports Phys Ther*. 2017;47(11):825-833.
32. Webster KE, Feller JA. Return to level I sports after anterior cruciate ligament reconstruction: evaluation of age, sex, and readiness to return criteria. *Orthop J Sports Med*. 2018;6(8):2325967118788045.
33. Webster KE, Feller JA, Lambros C. Development and preliminary validation of a scale to measure the psychological impact of returning to sport following anterior cruciate ligament reconstruction surgery. *Phys Ther Sport*. 2008;9(1):9-15.
34. Webster KE, Hewett TE. What is the evidence for and validity of return-to-sport testing after anterior cruciate ligament reconstruction surgery? A systematic review and meta-analysis. *Sports Med*. 2019;49(6):917-929.
35. Webster KE, McPherson AL, Hewett TE, Feller JA. Factors associated with a return to preinjury level of sport performance after anterior cruciate ligament reconstruction surgery. *Am J Sports Med*. 2019;47(11):2557-2562.