

Return to Level I Sports After Anterior Cruciate Ligament Reconstruction

Evaluation of Age, Sex, and Readiness to Return Criteria

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Background: Return to sport (RTS) after anterior cruciate ligament (ACL) reconstruction is a topic of current interest. The high reinjury rates reported in younger athletes may be due in part to an early RTS.

Purpose: To determine the proportion of athletes who return to level I (jumping, hard pivoting, and cutting) sport at less than 1 year after ACL reconstruction and compare return rates by age and sex. A secondary purpose was to examine whether RTS is associated with some commonly used outcome criteria.

Methods: A cohort of 1440 athletes (992 males, 448 females) satisfied criteria for inclusion in this study (primary ACL reconstruction, normal contralateral knee, no additional surgery within the first year after the reconstruction, and participation in level I sport on a weekly basis prior to injury). The proportion of athletes in this sample who had resumed level I sport by 12 months after surgery was recorded, along with measurements of knee function (single-legged hop symmetry), laxity (KT-1000 arthrometer), and self-reported outcomes (International Knee Documentation Committee [IKDC] subjective score). Limb symmetry index scores of 90 or higher, side-to-side difference in anterior knee laxity of 2 mm or less, and IKDC scores of 95 or higher were considered indicators of satisfactory recovery from surgery.

Results: Rates of return to level I sport were significantly higher for athletes aged 25 years and younger (48% return rate) compared with older athletes (26-35 years, 32% return rate [$P < .0001$]; ≥ 36 years, 19% return rate [$P < .001$]). Male athletes who were in the ≤ 25 -year and 26- to 35-year age brackets had significantly higher return rates than female athletes (52% vs 39% and 37% vs 18%, respectively), whereas no sex-based differences in RTS were seen after 36 years of age. A significantly higher proportion of younger patients met the selected indicators of a satisfactory recovery. Regardless of age, athletes had twice the odds of RTS if they had limb symmetry index scores of 90 or higher ($P \leq .0001$) and 3 times the odds of RTS if they had IKDC scores of 95 or higher ($P < .0001$).

Conclusion: Almost half of younger athletes (aged ≤ 25 years) in the current cohort returned to level I sports within 12 months after ACL reconstruction. Younger athletes were also more likely to meet criteria that indicate a satisfactory functional recovery and that have been used to indicate readiness to RTS. There may be a role for adjusting thresholds for these criteria based on age.

Keywords: return to sport; return criteria; athlete; functional recovery; ACL reconstruction

The fate of the younger athlete who sustains an anterior cruciate ligament (ACL) injury has recently received considerable attention, as accumulating evidence shows that

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younger athletes are at considerable risk of having multiple ACL injuries.^{5,13,17,18,21-23} One of the apparent reasons for this increased risk is that younger athletes are more likely to return to jumping and pivoting sports, where the risk for ACL injury is high.²²

The timing of return to sport (RTS) is another important factor to consider, as approximately half of all graft ruptures have been shown to occur within the first postoperative year in younger athletes.²¹ The high reinjury rates seen in younger athletes may therefore be due to the combined effect of an early RTS and a return to jumping, hard pivoting, and cutting (level I) sports such as football and soccer. However, there are limited data on the rates of return to such sports within the first year after ACL reconstruction surgery in younger athletes and how these rates compare with an older age group.

Criteria that indicate readiness to RTS have become increasingly popular, although consensus is lacking about which criteria to use and the effectiveness of such criteria.^{3,7,11,19} A number of studies have reported that few athletes are able to pass RTS criteria, despite participating in controlled rehabilitation programs.^{6,9} Therefore, athletes may RTS regardless of whether they meet the return criteria. Previous studies have shown that up to 75% of patients RTS after ACL reconstruction despite failing to meet RTS criteria,⁷ and only 14% of younger athletes were recently found to meet combined hop, strength, and symptom criterion measures despite being cleared to RTS.²⁰ Clearly, more work is needed in this area.

There were 2 aims to the current study. The first was to determine the proportion of athletes who returned to level I competitive sports within 12 months of reconstruction surgery and to compare return rates by age and sex. It was hypothesized that rates would be greatest in younger male athletes. The second aim was to determine whether an association exists between an early return to such sports and some commonly used outcome criteria that have also been used as RTS criteria. It was hypothesized that athletes who had returned would be more likely to have attained indicators of satisfactory recovery.

METHODS

Patients

Patients who had undergone primary ACL reconstruction between April 2007 and March 2014 were included if they met the following inclusion criteria: participation in a level I (jumping, hard pivoting, cutting) sport on a weekly basis prior to their ACL injury, attendance at a 12-month postoperative review appointment, and no complications requiring surgery within the first 12 postoperative months. The exclusion criteria were a previous ACL injury or surgery to the contralateral knee, subsequent contralateral ACL injury before the 12-month review, and graft rupture before the 12-month review.

Level I sport was defined by the type of sport undertaken, based on the Cincinnati Sports Activity Scale (CSAS),¹⁶ with a minimum frequency of 1 to 3 days per week. Thus, patients who reported participating in sports that involved jumping, hard pivoting, or cutting at a frequency of 3 or 4 days per week (CSAS score of 100) or 1 or 2 days per week (CSAS score of 85) met the definition, which was consistent with the previously reported level I definitions of Hefti et al⁸ and Daniel et al.⁴

During this study period, 2729 patients were eligible for 12-month review, of whom 2134 had attended. Of the reviewed patients, 694 did not meet inclusion and exclusion criteria. A total of 1440 athletes (992 males, 448 females; mean age, 26 years; range, 12-55 years) were therefore included in this retrospective cross-sectional study and participated at a mean 56 weeks (SD, 11 weeks) after surgery (Figure 1). Sports played by the cohort included Australian Rules football (40%), netball (22%), soccer (18%), basketball

(16%), and rugby/volleyball (4%). The study procedures were approved by an institutional ethics committee.

Surgical and Rehabilitation Details

All ACL reconstruction surgeries were performed arthroscopically. The most common graft source was a hamstring tendon autograft (n = 1414), and the remaining patients were treated with patellar tendon autograft (n = 8) or the Ligament Augmentation and Reconstruction System (LARS; Corin) (n = 18). For hamstring and patellar tendon grafts, femoral fixation was by means of an Endobutton (Smith & Nephew) and tibial fixation by means of an interference screw. For the LARS devices, interference screw fixation was used for both sides. The average time between injury and surgery was 11 months (SD, 20 months). Postoperatively, all patients underwent the same rehabilitation protocol, with the early focus on recovery of full active knee extension and quadriceps function. Weight-bearing was allowed as tolerated from the first postoperative day. The minimum requirements for an RTS were no effusion, an essentially full range of motion, good quadriceps strength and control of a single-legged squat, normal running and landing, and at least 4 weeks of unrestricted training.

Assessment

Return to Sport. The RTS variable of interest in this study was whether participants had returned to level I sport, which was dichotomous and reported as yes or no. Only those who had returned to competition were considered to have returned.

Knee Function. Athletes completed a single-legged hop for distance.¹⁵ They were instructed to hop as far as possible while controlling their landing. The testing was conducted by an independent research assistant in the clinic, which has a carpeted surface. A familiarization trial was permitted, and any trial in which the landing was not controlled (ie, touch down with the opposite foot) was excluded. Two successful trials from both limbs were recorded, and the average of the 2 was used to calculate a limb symmetry index ($\text{operated side score} \div \text{contralateral side score} \times 100\%$). If there was a notable discrepancy (>30 cm difference) between trials on the 1 limb, suggesting that a submaximal effort may have occurred, additional hops were permitted. A limb symmetry index of less than 100 indicates a deficit in the operated limb.

Knee Laxity. Measurements of side-to-side differences in anterior tibial displacement were made with a KT-1000 arthrometer (Medmetric Corp) at 134 N. Three measures were taken from both knees, and the average displacement in millimeters was recorded. Side-to-side differences in translation were recorded as the operated knee score minus the contralateral knee score.

Self-Reported Symptoms and Function. The International Knee Documentation Committee (IKDC) 2000 subjective knee evaluation score¹⁰ was used as a patient-reported outcome. For this well-validated measure, scores

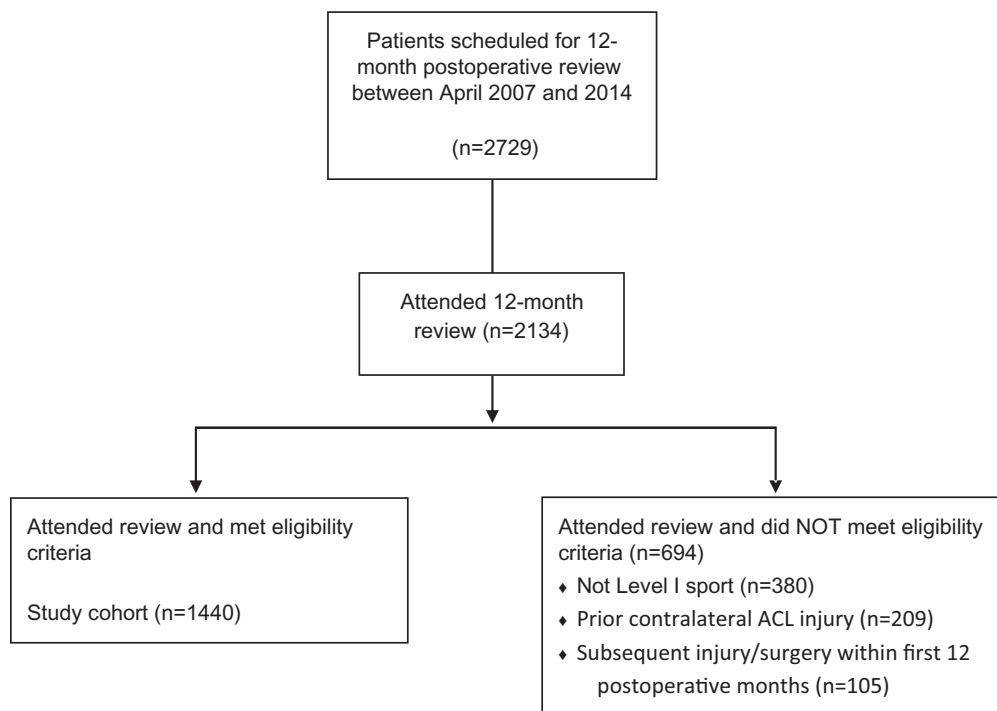


Figure 1. Flow diagram of participant selection.

range from 0 to 100, with higher scores indicating fewer knee symptoms and better function.

Statistical Analysis

RTS rates were calculated for the whole cohort and then separately for male and female athletes and for the following age groups: ≤25 years, 26-35 years, and ≥36 years. Return rates are presented as percentages (with 95% CIs). Contingency tables were used to determine whether returning to sport differed according to sex or age, with odds ratios calculated.

A limb symmetry index score of 90 or higher, a side-to-side difference in anterior knee laxity of 2 mm or less, and an IKDC score of 95 or higher were considered indicators of a satisfactory functional outcome. The number of patients who met each of these criteria was calculated and compared between each age groups by use of contingency tables and odds ratios to determine whether an association existed between meeting criteria and patient age. Following this, the number of patients who met each of the criteria was calculated separately for those who had and had not returned to sport in order to determine whether patients who met the criteria were more likely to have returned to sport. For this analysis, patients were grouped as ≤25 years or >25 years because not enough patients in the older age groups had returned to sport. The data were again analyzed by use of contingency tables and odds ratios. All data were analyzed with SPSS (version 23, IBM Corp) software. *P* < .05 was used to indicate statistical significance.

TABLE 1
Rates of Return to Level I Sport at 12 Months Following Anterior Cruciate Ligament Reconstruction^a

Age at Surgery	All Patients	Male Athletes	Female Athletes
≤25 years (n = 817)	48 (45-52) [394/817]	52 (48-56) [296/567]	39 (33-45) [98/250]
26-35 years (n = 440)	32 (28-37) [141/440]	37 (32-42) [120/325]	18 (12-26) [21/115]
≥36 years (n = 183)	19 (14-25) [34/183]	17 (11-26) [17/100]	21 (13-30) [17/83]

^aValues are percentages (95% CI). The number of patients who returned and the total group sizes are shown in brackets.

RESULTS

RTS Rates

RTS rates were significantly higher for athletes aged 25 years and younger than for all other age groups, with almost half of this group having returned to level I sports within the first postoperative year (Table 1). The ≤25-year-old group had 2.0 (95% CI, 1.6-2.5) times the odds of making an early return compared with the 26- to 35-year-old group ($\chi^2 = 30.6, P < .0001$) and 4.1 (95% CI, 2.7-6.1) times the odds of an early return compared with the ≥36-year-old group ($\chi^2 = 53.7, P < .0001$).

Male athletes in both the ≤25-year and the 26- to 35-year age groups had significantly higher return rates than female athletes (Table 1). Male athletes had 1.7 (95% CI,

TABLE 2

Percentages of Patients Who Met Threshold Criteria for Functional and Self-Reported Outcome Measures, Grouped by Age^a

Age Group	Functional Limb Symmetry	Laxity	IKDC Subjective	Met All 3 Criteria
≤25 years ^b	77 [609/786]	79 [634/803]	25 [205/815]	19 [147/776]
26-35 years ^b	64 [264/412]	79 [341/428]	13 [57/435]	10 [39/402]
≥36 years ^b	51 [87/170]	76 [138/181]	12 [21/182]	7 [11/168]
≤25 vs 26-35 years ^c	1.9 (1.5-2.5) ^d	1.0 (0.7-1.3)	2.2 (1.6-3.1) ^d	2.2 (1.5-3.2) ^d
≤25 vs ≥36 years ^c	3.3 (2.3-4.6) ^d	1.2 (0.8-1.7)	2.6 (1.6-4.2) ^d	3.3 (1.8-6.3) ^d

^aIKDC, International Knee Documentation Committee.^bValues are percentages. The number of patients who met threshold criteria and the total group sizes are shown in brackets.^cValues are odds ratios (95% CI).^dStatistically significant difference ($P < .0001$).

TABLE 3

Percentage of Patients, Categorized by Age, Who Met the Individual Threshold Criteria and Did or Did Not Return to Sport^a

	Functional Limb Symmetry		Laxity		IKDC Subjective	
	≤25 y	>25 y	≤25 y	>25 y	≤25 y	>25 y
Returned to sport and met RTS criterion	83	71	80	85	34	24
Did not RTS and met RTS criterion	72	56	78	76	17	8
Odds ratio (95% CI)	1.9 (1.4-2.7)	1.9 (1.3-2.8)	1.2 (0.9-1.1)	1.8 (1.1-2.8)	2.5 (1.8-3.5)	3.4 (2.1-5.5)
<i>P</i> value	.001	.001	.4	.02	<.0001	<.0001

^aIKDC, International Knee Documentation Committee; RTS, return to sport.

1.3-2.3) times the odds of an early return than female athletes in the ≤25-year age group ($\chi^2 = 11.8$, $P < .001$) and 2.6 (95% CI, 1.6-4.4) times the odds of an early return in the 26- to 35-year age group ($\chi^2 = 13.6$, $P < .001$). No sex difference was found in return rates after 36 years of age.

RTS and Return Criteria

A higher proportion of younger athletes met the threshold criteria for the functional and self-reported outcome measures (Table 2). Athletes 25 years or younger had 1.9 (compared with 26- to 35-year-olds) and 3.3 (compared with ≥36-year-olds) times the odds for a 90 or higher limb symmetry index score, and they had 2.2 (compared with 26- to 35-year-olds) and 2.6 (compared with ≥36-year-olds) times the odds for a 95 or higher IKDC subjective knee score. No age-related difference for knee laxity was found, with the majority of both younger and older athletes having good stability (Table 2).

Regardless of age, athletes who had returned to sport had 2 to 3 times the odds of having limb symmetry scores of 90 or higher and IKDC scores of 95 or higher (Table 3). Patients older than 25 years who had returned to sport had almost twice the odds of having passed the knee laxity criteria threshold, whereas no association was found between RTS and knee laxity for the patients in the ≤25-year age group (Table 3).

DISCUSSION

This study showed that almost half of the athletes aged 25 years and younger returned to level I sport within the first year following ACL reconstruction surgery. This rate was significantly greater than for athletes aged 26 to 35 years, of whom a third returned, and for athletes 36 years or older, of whom only a fifth returned. The current results complement existing data collected at later time points following surgery, which have shown that younger athletes are more likely to return to their preinjury level of sport compared with older athletes,¹ but these results also extend previous research by focusing on specific age groups over a specified time frame. Doing so allowed for a more detailed understanding of the sport exposure that athletes of various ages were experiencing at this postsurgical time point. That a substantial proportion of younger athletes returned to pivoting sports within the first year of surgery has implications that are potentially both positive and negative. On the positive side, younger athletes may be able to more quickly achieve the goal of returning to their preinjury sport; however, a negative consequence of this may be a greater risk of further ACL injury.

Convincing evidence demonstrates that younger athletes have a greater number of second ACL injuries compared with older athletes.^{12,22} It has been suggested that a contributing factor to this high second injury rate in young athletes is that a greater proportion return to pivoting

sports.²² A unique aspect of the current study was that it included only athletes who participated in level I (jumping, hard pivoting, cutting) sports prior to injury, and it determined whether the athlete had returned to the same sport within the first year. This study therefore extends previous data by showing that not only are younger athletes more likely to return to high-risk sports, but they also return to these sports relatively earlier after surgery than their older counterparts. Grindem et al⁷ reported that for every 1-month delay in RTS, up to 9 months, the risk of further knee injury was reduced by 51% in a group of patients with ACL reconstruction who participated in pivoting sports. Although this reduced risk was not specific to ACL injury or younger athletes, the detrimental consequences of an early RTS are clear. The current data may therefore help explain the high reinjury rates that are currently being reported in younger athletes, at least for those who receive hamstring tendon autografts.^{5,13,18,21}

In the current study, younger male athletes had significantly higher return rates than younger female athletes. This finding is consistent with previous data showing that male athletes make a quicker return to their preinjury sport than do female athletes.² Although these sex-based differences were statistically significant, it is relevant to note that for the youngest age group (≤ 25 years), almost 40% of female athletes returned within the first year, which is still a sizable proportion, and potentially places both these young male and young female athletes at risk for further injury. No sex-based difference was found for athletes older than 36 years, and in fact, a slightly higher percentage of female athletes in this age category had returned.

Advising an athlete on the right time to RTS is a challenge, and various RTS criteria have been used to aid in the decision-making process.¹⁴ However, which criteria should be used and what score is needed to meet the criteria are subjective and highly debatable. Some studies show that meeting return criteria reduces the risk of subsequent injury, but others indicate that the risk is increased for athletes who pass return criteria.^{3,7,11,19} Sousa et al¹⁹ found that athletes who passed isokinetic strength and functional testing (3 hop and jump tests) criteria at 6 months after surgery and were allowed to RTS had a significantly greater rate of contralateral ACL injuries at an average of 4 years than those who did not meet return criteria and delayed their return. In contrast, Kyritsis et al¹¹ showed that not passing an RTS criteria test battery, which included strength, running, and hop tests, led to a 4-fold increase in the risk for graft rupture in male professional athletes. These contrasting results show that more work is needed with regard to understanding the utility of RTS criteria and, in particular, whether such criteria should be applied equally to all athletes. In the current study, a significantly higher proportion of younger athletes were found to meet the selected criteria at 12 months postoperatively, and those who met criteria were more likely to have returned to sport. To our knowledge, these are the first data to report an association between age and meeting criteria that are used to indicate readiness to RTS.

A number of studies have shown that few athletes pass RTS test batteries or that many athletes RTS even if they do not meet return criteria.^{7,9} Toole et al²⁰ recently reported that only 13.9% of 115 younger athletes (mean age, 17 years) met strength, limb symmetry, and IKDC subjective criteria after being cleared to RTS, but the authors did not have an older group for comparison. Results of the current study indicate an association between meeting criteria and having returned to sport. Specifically, athletes who had returned had 2 to 3 times the odds of meeting functional limb symmetry and IKDC subjective criteria, regardless of age. Caution should be exercised when interpreting these findings, as these athletes had returned to sport before being tested.

This study has several limitations. Although we used one of the most common RTS tests, the single-legged hop, we did not examine an extensive RTS test battery. The exact timing for RTS was not documented for the athletes who did return. Finally, outcome measures were not obtained on patients who sustained an early (< 12 months) graft rupture or contralateral ACL injury. Therefore, we cannot determine whether earlier RTS was associated with any reinjuries that occurred within a year postoperatively, because those patients would have been excluded from the study.

CONCLUSION

The current data show that almost half of athletes aged 25 years or younger return to level I sports within the first year after ACL reconstruction surgery. The return rates were higher for younger male athletes than younger female athletes. Regardless of age, athletes who had returned to sport were more likely to have met criteria that are used to indicate readiness to return. Younger athletes were also more likely to have met the criteria, which may indicate that such criteria should be adjusted according to patient age if they are to be of use in facilitating a safe return to competitive sports in this age group.

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