European Journal of Orthopaedic Surgery & Traumatology (2019) 29:1771–1779
https://doi.org/10.1007/s00590-019-02494-4

ORIGINAL ARTICLE • KNEE - SPORT

Factors affecting return to sport following hamstrings anterior cruciate ligament reconstruction in non-elite athletes

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Received: 4 March 2019 / Accepted: 6 July 2019 / Published online: 18 July 2019

Abstract

Background Anterior cruciate ligament (ACL) rupture is a common injury affecting non-elite and elite athletes. Although most ACL reconstructions restore the mechanical stability of the injured knee, the rate of return to sport (RTS) is varied.

Hypothesis/purpose We aimed to identify why non-elite athletes fail to return to pre-injury sport level. The primary objective was to assess the frequency of RTS (including type of sport, timing, level, and duration), and the secondary objective was to assess the surgical (injury, type of surgery, re-injury) and patient (demographics, function, symptoms, social, psychological) factors affecting RTS, using a multivariate analysis.

Study design Level III, retrospective cohort study.

Methods We evaluated 78 consecutive non-elite athletes undergoing hamstring ACL reconstruction using medical records and questionnaires. Mean follow-up was 50 months (24–224 months). Athletes were divided into return to sport (RTS) and not returning to sport (NRTS) groups for comparative and multivariate analyses, to identify independent predictors of RTS status.

Results Mean age was 31.5 years (18–51), and 46 were male (59%). The RTS rate was 56.4% (44), with most athletes returning between 9 and 12 months, and then continuing to play for > 60 months. Fear of re-injury was the highest reported reason for NRTS. There were no significant differences in demographics, concomitant injury, adjuvant surgery, and type of sport between the two groups. Mean Tegner scores were significantly higher in RTS group post-injury (6.9 vs 4.6) and at present (6.6 vs 4.6). The International Knee Documentation Committee (IKDC) score for the RTS group also increased significantly from pre-injury 70.8 (49.1–93.4) to 83.9 (24.1–100) post-injury ($p < 0.001$). Fear of re-injury, lack of confidence, lack of time, and change in job were significant factors in the NRTS group. Playing soccer, giving way, and change of job independently predicted RTS status from multivariate analysis.

Conclusion A significant number of non-elite athletes did not RTS following ACL reconstruction, and this was influenced by a combination of activity level, sport, self-reported knee instability, and psycho-social factors. Importantly, some of these can be predicted and managed with improved, individualized post-operative physical and psychological rehabilitation programmes. These data also allow surgeons to better counsel athletes before ACL reconstruction on their likelihood of RTS.

Keywords Surgery · Anterior cruciate ligament · Non-elite athletes · Rehabilitation · Return to sport

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Introduction

Anterior cruciate ligament (ACL) rupture is a common injury affecting non-elite and elite athletes. While a minority of patients with ACL ruptures do not develop functional instability (instability with daily function or 'copers'), the majority (> 90%) experience knee instability during cutting and pivoting activities [1–3]. Thus, it is not surprising that athletes reduce or modify their activity levels to avoid secondary injury, which may lead to cessation of sport. The current standard of care for ACL injury is ACL reconstruction, which aims to restore knee function and stability, thus

facilitating a return to sport (RTS) [4, 5]. It also prevents secondary knee injury and may reduce the risk of osteoarthritis long-term [2].

Although most ACL reconstructions restore the mechanical stability of the injured knee, the rate of RTS is varied. Functional knee outcomes return to normal or near normal in 85–90% of ACL reconstructions often within 6 months post-operatively [6, 7]. These outcomes include impairment-based outcomes such as laxity and strength, and activity-based outcomes such as the International Knee Documentation Committee (IKDC) knee evaluation form [6]. However, there are a wide range of findings with some studies reporting that 8–50% do not return to the same sport and level post-operatively [8–13]. It has also been found that there is a decline in participation after 2–3 years [12] with a RTS rate of 50–62% at 4–5 years [7, 13, 14]. Roos et al. [15] reported that up to 70% of individuals in contact sports were unable to RTS post-operatively. For those who do RTS, functional sport limitations in up to 21% of athletes may cause poor performance [16].

Many factors influence whether athletes RTS following ACL reconstruction. Successful surgery and rehabilitation are crucial to address instability and function [4]. Nwachukwu et al. [17] found that patients who had patellar tendon autograft had a high likelihood to RTS over other graft types with an odds ratio of 5.6. However, differences in graft types have not been demonstrated in other studies [10, 11], despite meta-analyses showing that patellar tendon autograft restores rotation stability better to allow patients return to higher level of activity [18] and that patellar tendon autograft had higher Tegner scores than allograft in subgroup analysis [19]. Quadriceps strength has shown to be a factor in RTS time [20], and Hamrin et al. [21] found that male sex, younger age, higher pre-injury activity level, and lack of concomitant injuries lead to a higher RTS. Simultaneous meniscal surgery may negatively affect short-term clinical outcomes and increase the risk of osteoarthritis long-term [10, 22, 23].

There is an important influence of demographic, social, and psychological factors in RTS [6, 24]. Notably, studies have reported that up to 20% of young athletes will sustain a second knee injury (ACL reconstruction or contralateral ACL rupture), and older athletes are less likely to resume pre-injury sport [10]. The rate of RTS is lower in females and female soccer players, with variance according to the type of sport played [2, 21, 25, 26]. Other reasons for NRTS include persistent knee symptoms (e.g. pain), changes in job or family commitments, and lack of interest [24, 25, 27]. Importantly, fear of re-injury is also a very common psychological factor for NRTS [6, 13, 24].

Previous studies have not always considered the pre-injury characteristics of the cohort with inconsistencies in terminology when examining rates of RTS. Ardern et al. [14] examined 314 participants at 9.6 months follow-up with a 45% RTS rate, but did not have stringent inclusion/exclusion criteria, nor a specific definition of their RTS. In addition, there are limited data on how to predict whether they will RTS according to patient demographics and surgical factors. Lentz et al. [4] examined return to pre-injury sports participation following ACL reconstruction and found that self-reported knee function, instability, and effusion were associated with a RTS status using multivariate analysis, but only at 1 year post-operatively. Further, Lee [13] reported a 62% RTS rate at 5 years, but many were lost to follow-up, which affected this percentage. A recent systematic review by Coronado et al. [28] demonstrated that only four randomized studies have examined psychological intervention following ACL reconstruction, but not enough data were generated to draw obvious conclusions.

We aimed to identify why non-elite athletes fail to return to pre-injury sport level. The primary objective was to assess the frequency of RTS (including type of sport, timing, level, and duration), and the secondary objective was to assess the surgical (injury, type of surgery, re-injury) and patient (demographics, function, symptoms, social, psychological) factors affecting RTS, using a multivariate analysis.

Patients and methods

Patient selection

We reviewed all consecutive patients aged 16–50 years undergoing autologous hamstrings ACL reconstruction by a single surgeon (XX) over 84 months, at a regional centre for knee surgery (Fig. 1). All patients participated in regular sporting activity before injury (Tegner activity score [29] of at least 5). Exclusion criteria included less than 2-year follow-up, Tegner activity score < 5, previous ipsilateral ACL reconstruction, and non-meniscal concomitant ligamentous reconstruction (e.g. posterior cruciate ligament).

Surgical technique and rehabilitation

All procedures were performed arthroscopically under general anaesthesia by the attending orthopaedic surgeon (XX) using autologous hamstrings (semitendinosus and gracilis) tendons. Intravenous cephalosporin antibiotic was given on induction, and an inflatable thigh tourniquet was used. The femoral tunnel was drilled using a standard anteromedial portal and the tibial tunnel via a separate incision, independently into the respective anatomical footprints. A single-bundle quadrupled hamstring autograft was fixed to the femur with an Endobutton® (Smith and Nephew, Andover, MA, USA) and the tibia with an interference screw. Post-operatively, patients were weight

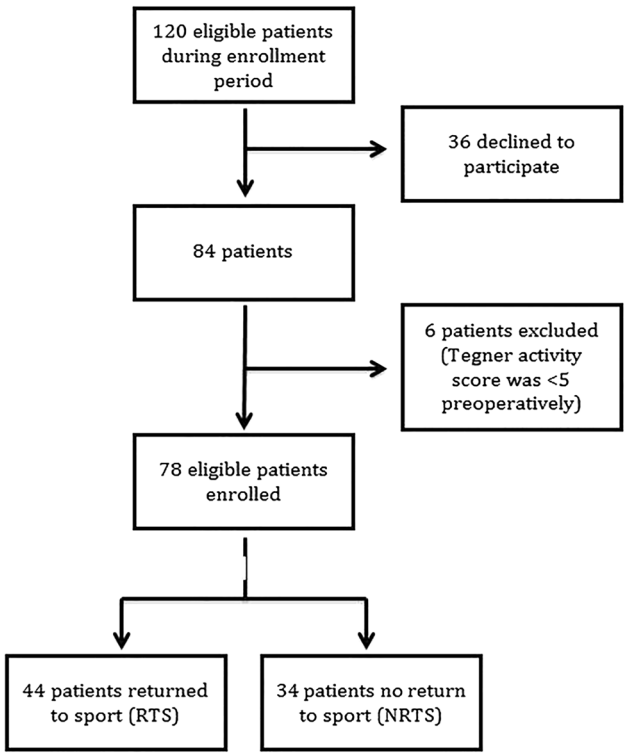

Fig. 1 Study participant flow chart

Table 1 Adjunctive procedures performed in addition to hamstrings ACL reconstruction in those return to sport (RTS) and no return to sport (NRTS)

Procedure	RTS (*n*)	NRTS (*n*)	*P*
Total	29	25	0.73
Partial medial meniscectomy	4	7	0.13
Partial lateral meniscectomy	6	4	0.54
Medial meniscal repair	8	5	0.49
Lateral meniscal repair	9	6	0.52
Microfracture	0	1	0.44
Chondroplasty	1	1	0.69
Notchplasty	1	1	0.66

bearing as tolerated, crutches if required, and no brace. Adjunctive procedures were performed at the same time (Table 1). Patients with meniscal repair (using an all-inside technique) and microfracture (using an awl) were partially weight bearing in a brace for 2–4 weeks. All patients completed a standardized ACL reconstruction rehabilitation programme with a physical therapist. Depending on the nature of the sport (e.g. pivoting, contact), return to play clearance was based on the surgeon's assessment (adequate range of motion, knee stability, and quadriceps muscle bulk) and functional assessment (by a physical therapist). Patients were reviewed in clinic by the surgeon at 2 and 6 weeks, and at 3, 6, 9, and 12 months post-operatively.

Data collection

A list of ACL reconstructions was obtained from the surgeon's logbook database. Medical records were reviewed to confirm eligibility, obtain baseline demographics (e.g. age, sex, sport, mechanism of injury) and further details of the injury, operation, and rehabilitation. Complications, failure, and re-injury were recorded with clinical examination findings at latest follow-up. Patients were sent an online questionnaire using 'SurveyMonkey®' [30]. This included questions on date of injury, pre-injury sports participation, highest post-operative sports participation, and current sports participation, if applicable. For each sport, the 11-point Tegner activity level and duration of participation were recorded. A successful RTS was defined as returning to the same pre-injury or higher type and level of sport(s) for at least one episode.

The reasons for not returning to sport (NRTS) were taken from the questionnaire including those relating to the patient (pain, swelling, instability, and stiffness); sport (failure to regain pre-injury performance and fitness); injury (ipsilateral and contralateral knee ACL injury, another injury or medical problem); social (lack of time, lack of family support, change in job, change in family, change in location); psychological (fear of re-injury, lack of confidence); and other. These were graded on an 11-point numeric scale (0-no influence and 10-main reason). Current subjective knee function, sports activities, and symptoms were assessed using the 2000 Subjective IKDC knee evaluation form [31].

Data analysis

Initial analysis was performed according to whether patients were in the RTS (timing, duration, sport) or NRTS (reasons) group. Within these groups, differences in baseline characteristics, sport, Tegner activity level, IKDC scores, and reasons for NRTS were examined to look for predictors of RTS status.

Statistical analysis

Statistical analysis was completed using SPSS 22.0 for Windows (SPSS Inc., Chicago, Illinois). Student's *t* test (continuous variables) and Pearson's Chi-squared/Fisher's exact tests (categorical variables) were used to determine differences in clinical factors (demographics, injury/type of surgery, sport, and reasons for NRTS) and scores (Tegner activity and IKDC) between the two groups. The identified univariate variables (where $p < 0.1$) were used for multivariate logistic regression analysis (using odds ratio (OR) and

95% confidence intervals (CI)) to identify independent predictors of RTS status. A p value of ≤ 0.05 was considered statistically significant.

Institutional and regional ethical review board approval was obtained for the study.

Results

Baseline characteristics

One hundred and twenty hamstring ACL reconstructions were performed in 119 athletes. Eighty-four completed the questionnaire, giving a response rate of 70.1%. There were no significant differences in baseline characteristics and adjunctive procedures between responders and non-responders. Six athletes were excluded, because their Tegner activity score was < 5 pre-operatively. The total number analysed was 78, and the mean follow-up was 50 months (range, 24–224 months). There were no significant differences in baseline characteristics (Table 2) and number of adjunctive procedures (Table 1) between the RTS and NRTS groups.

All patients underwent standardized ACL rehabilitation at locations convenient to the patient. There were no reported graft failures from examining medical records and questioning patients. Two patients developed infections treated successfully, one requiring antibiotics alone and the other requiring antibiotics and a washout. One patient had a fixed flexion contracture treated successfully with arthroscopic notchplasty, with an intact graft. Two patients had a deep vein thrombosis, one bilateral (hamstrings harvested from contralateral side due to graft breakage) and the other developed a pulmonary embolism. All patients had a stable knee on clinical examination, which was defined as an anterior drawer and Lachman's testing with a firm end point, comparable to the contralateral native knee where possible, at latest follow-up

Return to sport

Of the 44 (56.4%) patients that RTS, the timing and duration are shown in Figs. 2 and 3, respectively. There were 34 (43.4%) athletes in the NRTS group. The reasons for NRTS (on a weighted scale) are shown in Fig. 4. Other cited reasons included pregnancy in 4 (5.1%) athletes, moving to a new school half way through the competitive year in 1 (1.3%) athlete, and age in 1 (1.3%) athlete.

Return to sport versus no return to sport

The mean highest Tegner level for those RTS versus NRTS pre-injury was 7.3 (range, 5–10) versus 7.2 (range, 5–10) ($p = 0.75$), and at latest follow-up post-operatively was 6.6 (range, 3–9) versus 4.6 (range, 2–8) ($p < 0.001$). The mean current IKDC score for RTS was 83.9 (range, 24.1–100) and for NRTS was 70.8 (range, 49.1–93.4) ($p < 0.001$). Eleven athletes (25%) in the RTS group reported reasons

Table 2 Baseline characteristics in those returning to sport (RTS) and no return to sport (NRTS)

	RTS ($n = 44$)	NRTS ($n = 34$)	P
Mean age in years (range)	31.4 (17–49)	31.6 (16–50)	0.938
Gender (%)			
Male	27 (61.4)	19 (55.9)	0.398
Female	17 (38.6)	15 (44.1)	
Sport (n)			
Football	23	12	0.103
Rugby	8	3	0.199
Cricket	2	2	0.589
Running	6	9	0.128
Cycling	2	1	0.597
Tennis	7	1	0.063
Golf	2	1	0.597
Squash/badminton	3	0	0.174
Swim	2	4	0.224
Ski/snow boarding	7	3	0.199
Climbing	1	0	0.315
Gymnasium	2	1	0.597
Dance	0	2	0.187
Martial arts	2	3	0.378
Lacrosse/hockey/handball	0	3	0.079
Netball/basketball	2	5	0.124
Injury (n)			
Medial meniscal tear	14	12	0.466
Lateral meniscal tear	13	12	0.101
Bucket handle tear	2	5	0.224
Chondral injury	1	4	0.110
Medial collateral ligament injury	0	4	0.436

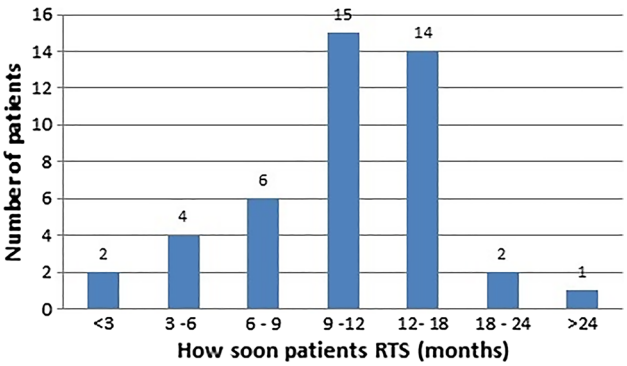

Fig. 2 Patient reported length to return to play

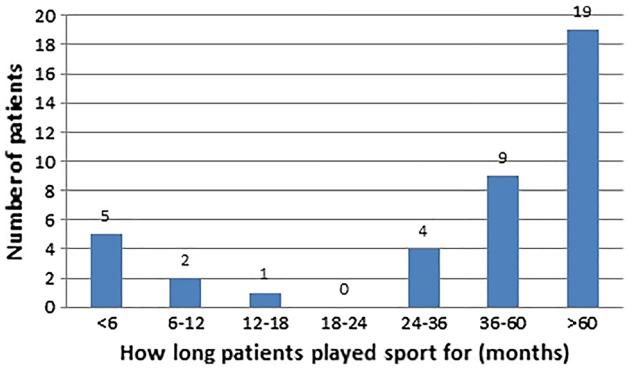

Fig. 3 Patient reported length of return to play

for a change to their Tegner level/sport at some stage post-operatively (Table 3).

The variables derived from univariate analysis and that were subsequently used in the multivariate analysis were soccer, tennis, lacrosse/hockey/handball, lateral meniscal tear, giving way, failure to regain performance, fear of re-injury, change in job, lack of confidence, and lack of time. Playing soccer (OR = 11.12 (95% CI: 1.12–110.64, $p = 0.04$)), giving way (OR = 0.07 (95% CI: 0.006–0.9, $p = 0.04$)), and change in job (OR = 0.04 (95% CI 0.002–0.69, $p = 0.03$)) were significant independent predictors of RTS status, whereas giving way and change in job situation were independent predictors of NRTS status.

Discussion

Anterior cruciate ligament rupture is a common injury in athletes and reconstruction successfully restores knee stability. However, despite improved surgical outcomes, we found that 54% of non-elite athletes successfully RTS at a mean follow-up of 50 months. Most returned between 9 and 12 months post-operatively and continued to play for > 60 months. Multivariate analysis showed that playing soccer was an independent predictor of RTS, whereas the presence of giving way and a change in job situation were independent predictors of NRTS.

The rate of RTS was 56% in our study, similar to 55% at 1 year by Lentz et al. [4], 45% at 2 years by Dunn [2], and 62.2% at 5 years by Lee [13]. Overall, this affirms a significant proportion of reconstructed athletes do not return to their previous sporting levels [2, 12, 32]. However, higher rates were found in a systematic review and meta-analysis of 48 studies (5770 patients), with 90% achieving normal impairment (laxity/strength)-based outcomes, and 85% achieving normal activity (IKDC)-based outcomes at 41.5-month follow-up [6]. Nevertheless, all these rates are higher than those treated non-operatively (42 [26]–46% [33]). Another consideration is the level of sport, whereby elite athletes have a higher RTS rate such as 100% of rugby players at 6 months, 81% at 12 months, and 71.4% at 43 months [16, 34, 35]. Another meta-analysis of 24 studies on elite athletes by Lei et al. [36] found a RTS rate of 83%. The lack of elite athletes in our cohort may explain the lower RTS rates.

Fear of re-injury and a lack of confidence were the most common reasons for NRTS. Other studies have highlighted that psychological factors influence successful RTS

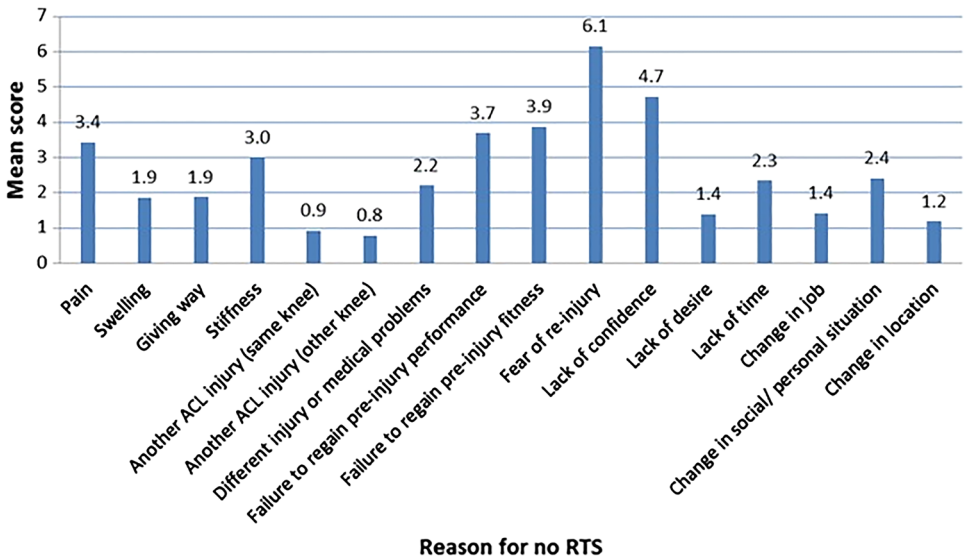

Fig. 4 Patient reported reason for not returning to play

Table 3 Reasons cited by patients for no return to sport (NRTS), compared to the reasons given by those returning to sport (RTS) (10-point scale, where 0 = no effect, and 10 = maximum effect, with $*p < 0.05$)

Reason	RTS (mean score)	NRTS (mean score)	*P*
Pain	3.1	3.7	0.59
Swelling	1.6	2.1	0.444
Giving way	0.9	2.7	0.24
Stiffness	2	3.8	0.104
Another ACL injury (same knee)	0.8	1.1	0.698
Another ACL injury (other knee)	0.5	1.1	0.243
Different injury or medical problems	2.1	2.3	0.56
Failure to regain pre-injury performance	3	4.3	0.086
Failure to regain pre-injury fitness	3.7	4	0.601
Fear of re-injury	4.7	7.6	**0.028***
Lack of confidence	3.4	6	**0.040***
Lack of desire	1	1.9	0.468
Lack of time	1.6	3.1	**0.042***
Change in job	0.6	2.3	**0.040***
Change in social/personal situation	2.4	2.4	0.5
Change in location	1	1.4	0.645

following ACL reconstruction, notably fear of re-injury in 20–50% of NRTS groups [2, 9, 13, 27]. One study found that the prevalence of fear was 66.1% at 9.3 months post-operatively, and in another it was 71.7% of those NRTS, despite the majority (70%) reporting no instability [37]. Interestingly, fear of re-injury was not a significant variable in our multivariate analysis, unlike other studies [12, 13]. This was also the case for Lentz et al. [4], who postulated that fear of re-injury may underlie activity restrictions and most other factors, but is not significant enough alone. Kvist [12] found those that NRTS had higher Tampa Scale of Kinesiophobia scores, which quantifies fear of re-injury due to movement and physical activity. The Knee Self-Efficacy Scale, which measures patients' perceived self-efficacy of knee function, would help in those lacking confidence [38]. Self-efficacy belief, optimism, and motivation are important in rehabilitation outcomes after sports injuries and can predict activity 1-year post-ACL reconstruction [37, 39, 40]. These are important considerations for RTS when knee outcomes are good, so emphasis on psychological profiling and post-operative psychological rehabilitation is critical [6, 9, 11, 38].

We showed that the Tegner scores were similar in the RTS and NRTS groups pre-injury and significantly higher in the RTS group at latest follow-up. As previously noted, it has been demonstrated that elite athletes, with higher activity/Tegner scores, RTS more successfully [16, 34]. However, this does not always translate to improved knee outcome scores and non-elite athlete baseline activity level may not significantly influence whether they RTS [11, 16]. Once again, other factors may account for the higher Tegner scores in the RTS group. In contrast, Dunn [2] found that baseline activity level was a predictor of activity level at 2 years, and Thomee (2008) [40] demonstrated that pre-injury Tegner score predicted the score at 1 year. As expected, the RTS group had a higher IKDC score at latest follow-up. This was similar to Lee and colleagues [13], who found the RTS group had the best functional knee scores: a Lysholm score of 88.5 and an IKDC of 84.6. These athletes appear to be maintaining excellent knee function having RTS successfully, with less physical and psychological complaints. Indeed, this has been demonstrated in elite athletes with who have few functional complaints while maintaining high sporting activity, even after stopping competition [16].

Although there were no unstable knees on clinical examination, athlete reports of instability were an independent predictor of NRTS. Self-reported instability was non-significantly higher, whereas lack of confidence was significantly higher in the NRTS group, and these may be linked. Self-reported knee instability impairs knee proprioception and neuromuscular control, reducing performance and heightens fear of re-injury. Lee and co-workers [13] showed that those NRTS because of reports of knee instability had the poorest subjective and objective knee scores. Interventions to improve such physical control, with psychological profiling, may help improve the rate of RTS [12]. Of note, a few studies have reported knee pain as a significant factor in precluding a RTS [13, 24, 25]. This was not found in our study and may relate to improved availability pain control modalities.

Many of the factors that differed between the RTS and NRTS groups such as fear of re-injury and self-reported knee function have been associated with knee function in prior studies [12, 13, 15]. The lack of demographic and concomitant injury differences in the groups suggests that non-modifiable factors do not play a significant role in RTS status, which has been demonstrated in the literature well [2, 4, 41]. On the contrary, females and older age have been associated with lower activity levels [25, 41, 42]. Modifiable factors such as adjuvant surgery did not influence the results of this study which is unexpected, as cartilage injury has been shown to be a negative predictor for RTS, and meniscal repair can negatively affect short-term outcomes [22, 25]. Finally, lack of time and change in job were significantly more important to patients in the NRTS group. Several studies have shown reduced activity post-ACL reconstruction due to social or family reasons, with social support a positive predictor of RTS [2, 27, 37, 43]. Sporting activity clearly requires a time commitment, and changes in life circumstances may impact this. Specifically, a change in job was an independent predictor of NRTS, as this is often a stressful

time with possible changes in location, working patterns, and income [10, 27].

Soccer was found to be independent predictor of RTS, and previous studies have shown that the type of sport influences the rate [26]. Other studies in professional soccer players have shown 95% and 62% RTS at 1- and 4-year post-ACL reconstruction, respectively, with 71% still able to play after stopping [7]. In addition, there were notable changes in the sports that patients returned to initially, and play at latest follow-up. These included an initial increase in cycling, swimming, and attending the gymnasium which involve lower impact and no cutting/jumping, and thus explains an earlier RTS (e.g. less than 6 months) in some athletes. The Tegner scores post-injury and at latest follow-up were similar, suggesting that athletes maintain activity levels on average. In contrast, studies have shown that sport participation generally declines after 2–3 years [10]. Specifically, Kostogiannis et al. [26] found the median Tegner score to be 7 at the time of ACL injury, 6 at 1 year and 3 years, then 4 at 15 years, possibly due to a natural adaptation to ageing and evolving stages of life. Our spread of follow-up times and relatively short follow-up may explain these differences.

There are limitations to this study. Firstly, the number of patients is relatively small, making the results less generalizable. This is mainly attributable to a low response rate, which may relate to the predominantly young and mobile ACL reconstruction population, who may relocate. Despite attempts at follow-up by email, mail, and telephone, the response rate could not be improved upon, which introduces non-response bias. This was minimized by a lack of baseline demographic differences between responders and non-responders. Specifically, we acknowledge that lack of graft failures in this study was unusual and may relate to these cases being missed or presenting elsewhere. The series was a single surgeon, centre, and demographic. Although this provides reliability, again the results may be less applicable to the general population, as the centre is well known for ACL reconstruction. Knee stability was assessed purely by clinical examination, and a more objective measurement (e.g. KT-1000 knee arthrometer to measure anterior tibial translation) would be more robust. However, clinical examination is simple, reproducible, widely used in clinical practice and, in this study, by a single examiner to provide reliability. We used a non-validated questionnaire with a self-reported measure of RTS which, despite its limitations, allowed us to assess athletes at lower levels and different sports. Allied to this, comparing the level of sport, even with the Tegner activity score does not account for varying performance levels. Nevertheless, it is worth noting that the Tegner and IKDC scores are validated and incorporated into the same questionnaire.

In conclusion, a significant number of non-elite athletes did not RTS following ACL reconstruction. Those that RTS commonly did so between 9 and 12 continued to play for > 60 months. Fear of re-injury, lack of confidence, lack of time, and change in job were significantly more important to the NRTS group. Soccer was an independent predictor of RTS, whereas giving way and change in job were independent predictors of NRTS. Our results suggest activity levels, sport, self-reported knee instability, and psycho-social factors influence whether patients RTS. Importantly, some of these can be predicted and managed with improved, individualized post-operative physical and psychological rehabilitation programmes. These data also allow surgeons to better counsel athletes before ACL reconstruction on their likelihood of RTS.

Compliance with ethical standards

Conflict of interest Nirav K. Patel, Christopher Hadley, Sanjeeve Sabharwal and Erica Blanchard declare no potential conflicts of interest. Sam Church has declared a potential conflict of interest.

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