ACL reconstruction in youth athletes results in an improved rate of return to athletic activity when compared with non-operative treatment: a systematic review of the literature

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ABSTRACT

Background Anterior cruciate ligament (ACL) tears are being seen and treated with increasing frequency in youth athletes, with the goal of returning patients to sports activity. This is particularly important for youth athletes, for whom sports provide physical, social and psychological development.

Objectives To perform a systematic review of the orthopaedic surgery literature to investigate for any associations between treatment strategy and return to athletic activity after ACL tear in youth athletes under age 18 years.

Data sources PubMed, EMBASE and Cochrane computerised databases.

Study eligibility criteria Inclusion criteria: (1) <18 years of age, (2) investigation of a relationship between time to treatment and consequent rates of returning to preinjury levels of athletic activity, (3) original research article (eg, not a review, case report or meta-analysis). Exclusion criteria: (1) revision ACL surgery, (2) language other than English, and (3) not a clinically based study.

Participants Youth <18 years old with ACL tears.

Interventions Acute ACL reconstruction, delayed ACL reconstruction, non-operative management.

Synthesis methods Qualitative synthesis.

Results Twenty studies met inclusion and exclusion criteria, of which four evaluated return to play after acute ACL reconstruction (ACLR), five studies evaluated return to play after delayed ACLR, and nine evaluated return to play after ACLR with an unspecified injury-to-surgery time interval. Two studies investigated return to play in a non-operative cohort. Of the 18 surgical studies, 14 employed a soft tissue transphyseal reconstruction. Rates of return to play were 78–100% after acute ACLR, 84–100% after delayed ACLR, 41–100% after ACLR with an indeterminate injury-to-surgery time interval and 6–52% after non-operative treatment of ACL tear.

Limitations Several studies did not provide details about the timing of injury-to-surgery, and study heterogeneity precluded combining results in quantitative meta-analysis. Furthermore, the amount of time to full postinjury recovery remains largely unstudied.

Conclusions and implications of key findings Based on available literature, there appears to be an improved rate of return to athletic activity after ACLR when compared with non-operative treatment. Future research should directly focus on time to return to sports activity, while taking into account the unique aspects of ACL reconstruction and non-operative management in youth athletes. This is of particular importance in children and adolescents given the physical, social and psychological development that occurs with sports participation.

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INTRODUCTION

The increased rate of anterior cruciate ligament (ACL) tears in youth athletes have been attributed to multiple factors including an increase in early sports specialisation and competition, lack of free play and increased awareness of ACL injuries in children.[1] A recent epidemiological study revealed that the rate of ACL reconstruction in youth athletes under age 20 years had increased nearly three-fold over a 20 year period from 1990 to 2009, and indicated that adolescents and teenagers represent the largest per capita demographic of ACL reconstruction.[1]

The superiority of treating ACL tears in youth athletes with acute reconstruction, delayed reconstruction or non-operative treatment remains controversial in the orthopaedic literature.[2–4] While non-operative or delayed surgical management until skeletal maturity was a historically ubiquitous treatment for complete ACL rupture due to the risk of transphyseal damage inherent to surgical treatment,[5] newer surgical techniques and instrumentation have improved options for acute physeal-respecting ACL reconstruction.[6 7] One indication for surgical stabilisation of an ACL-deficient knee is to return a patient to athletic activity. This is particularly important for children and adolescents, for whom sports provide physical, social and psychological development.[8 9] Historically, clinical results following non-operative management of ACL tears in youth athletes have been poor with a high rate of sport dropout (up to 50%) due to recurrent instability,[10] and up to 94% unable to return to their preinjury level of activity.[11]

While recent quantitative synthesis of available literature has been performed evaluating a combination of recurrent instability, pathological laxity and return to activity[12] with operative versus non-operative treatment, less is known about the effect of surgical intervention or delay in return to sports. The purpose of this study was therefore to perform a qualitative systematic review of the orthopaedic surgery literature to investigate for any associations

between non-operative treatment, delayed ACL reconstruction (ACLR), or acute ACLR and the rate of return to athletic activity after ACL tears in youth athletes under age 18 years.

METHODS

Study design and search strategy

The current study was registered with the international prospective register of systematic reviews, registration number CRD42015027536. A systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. An electronic search of the PubMed, EMBASE and Cochrane computerised databases was conducted by two independent reviewers (NL and ES) on 16 June 2015. The sequence of used terms was as follows: *('ACL' OR 'Anterior Cruciate Ligament') AND ('pediatric' OR 'adolescent' OR 'immature') AND ('return' OR 'recovery') AND ('sport' OR 'activity' OR 'athlet*')*. A complete search strategy and results are presented in table 1. The references of each unique full-text article were subsequently examined in order to identify additional articles that could potentially be relevant to the study. Because this systematic review did not directly involve human subjects, institutional review board approval was not required.

Study selection

The titles and abstracts of each manuscript as well as their bibliographies were then examined for relevance to the study question. A full-text review was subsequently performed for potentially relevant studies and final inclusion was determined based on the following criteria: (1) youth subject population (defined as <18 years of age), (2) investigation of a relationship between time to treatment and consequent rates of returning to preinjury levels of athletic activity, and (3) original research article, rather than a review, case report or meta-analysis. Exclusion criteria were: (1) revision ACL surgery, (2) full-text article in a language other than English, and (3) not a clinically based study.

Data extraction

Three authors (PDF, NL and AIC) independently extracted data from each of the studies that met the established inclusion/exclusion criteria directly into a research database, with subsequent automated and manual cross-checking of extracted data. Discrepancies were resolved unanimously through repeated review and discussion of each study. The following variables were recorded: general characteristics of each article including the name of the first author, journal, year of publication, level of evidence and intervention technique were collected. Further, we collected: mean time to treatment, average follow-up time and percentage of patients returning to baseline levels of athletic activity. For the purposes of reporting these data, a delayed ACLR was defined as an interval between initial injury and surgery of greater than 16 weeks. A full list of the included articles along with the corresponding data is depicted in table 2.

Table 1 Search terms used in the systematic review

Search terms	Reference database	Number of identified studies
1. 'ACL' OR 'Anterior Cruciate Ligament'	PubMed	12 355
	EMBASE	15 872
	Cochrane	1218
2. #1 AND ('pediatric' OR 'adolescent' OR 'immature' OR 'youth')	PubMed	2850
	EMBASE	2741
	Cochrane	341
3. #2 AND ('return' OR 'recovery')	PubMed	473
	EMBASE	310
	Cochrane	78
4. #3 AND ('sport' OR 'activity' OR 'athlet*')	PubMed	231
	EMBASE	221
	Cochrane	46

Search performed on 16 June 2015.

RESULTS

Study inclusion

The original electronic database search yielded 326 unique articles, 8 of which were identified via a manual search of the references of those studies. One hundred and sixty-two of these were deemed to not be relevant to the research topic based on title and abstract review, resulting in 164 full-text articles being assessed for inclusion/exclusion criteria. A total of 144 studies were excluded because they were: adult-focused (N=62), not examining outcome variables of interest (N=62), review articles (N=10), not in English (N=7), representing revision cohorts (N=1), case reports (N=1) or reporting a subset of a larger case series that was already included (N=1). Twenty studies were included in the final qualitative synthesis, as demonstrated in the PRISMA flow diagram (figure 1).

General study characteristics

Of the 20 included studies (table 2), 18 involved surgical reconstruction of the torn ACL while 2 evaluated a non-operative treatment cohort. Fourteen of the operative studies (78%) employed a transphyseal ACLR technique, two (11%) used a partial transphyseal ACLR, one (6%) used a variety of techniques and one (6%) did not report their ACLR technique. Out of the investigations that included operative treatment, four[13–16] contained cohorts with patients receiving acute ACL reconstruction (defined for this study as mean time to treatment <16 weeks) while five[17–21] described series with patients undergoing delayed treatment (>16 weeks). The remaining studies did not specify the mean time between injury and ACL reconstruction, or included both acute and chronic ACLR subjects. This analysis included 17[10 11 13–27] studies of level IV evidence, two[28 29] of level III evidence and one[30] of level II evidence. Studies included in the final analysis along with corresponding characteristics and data of interest are presented in table 2.

Acute ACL reconstruction and return to athletics

A total of four studies[13–16] examined the rates of return to athletic activity following acute ACL reconstruction in youth. The proportions of patients returning to baseline participation in sports for these studies are 100%, 100%, 89% and 78%, with a weighted mean follow-up time of 15.6 months. The largest of these investigations, performed by Nikolaou *et al*,[14] evaluated a cohort of 94 paediatric patients who underwent transphyseal reconstruction at an average time of 16 weeks following injury. The authors reported 78% of these patients returning to their preinjury levels of athletic participation, with an average follow-up time of 38 months. However, four of the patients ended up undergoing revision surgery due to graft rupture.

Delayed ACL reconstruction and return to athletics

Five studies[17–21] reported data regarding participation in sports following delayed ACL reconstruction. In these, approximately 100%, 90.9%, 88.8%, 86% and 84% of patients continued to

Table 2 Characteristics of studies comparing ACL reconstruction with non-operative treatment

Author (year)	N	Journal	LOE	Mean time to ACLR (weeks)	Intervention technique (s)	Mean follow-up (mo)	Rate of return to preinjury (or higher) levels of athletic activity			Notes
							Acute ACLR	Delayed ACLR	Non-operative treatment	
Acute ACLR										
Calvo *et al* (2015)[13]	27	*AJSM*	IV	15.2	TP	127	89%	–	n/a	Four patients underwent revision surgery due to graft rupture. Wide treatment range of 0.5–17 months, subjects not broken down by time
Nikolaou *et al* (2011)[14]	94	*KSSTA*	IV	16	TP	38	78%	–	n/a	Four revisions for graft rupture. Treatment range of 0.2–10 months
Redler *et al* (2012)[15]	18	*Arthroscopy*	IV	15.6	TP	43	100%	–	n/a	
Kocher *et al* (2007)[16]	61	*JBJS*	IV	15.2	TP	43	100%	–	n/a	Two patients experienced rerupture after returning to sports. 59/59 (100%) non-revision knees returned to cutting and pivoting sports.
Delayed ACLR										
Cassard *et al* (2014)[17]	28	*JPO*	IV	59	PTP (AE femur)	34	–	100%	n/a	Two subjects sustained graft ruptures.
Cohen *et al* (2009)[18]	26	*Arthroscopy*	IV	21.6	TP	45	–	88.8%	n/a	Three patients experienced rerupture
Seon *et al* (2005)[19]	11	*JKMS*	IV	16.8	TP	78	–	90.9%	n/a	
Goddard *et al* (2013)[20]	29	*AJSM*	IV	28	TP	24	–	86%	n/a	Wide treatment range of 1 month to 6 years post injury. 2 patients (6%) sustained rerupture and were not included in the original study analysis. 86% of those included were involved in 'strenuous' or 'very strenuous' activities 24 months postoperatively
Aronowitz *et al* (2000)[21]	19	*AJSM*	IV	21.2	TP	25	–	84%	n/a	All of the patients were initially treated non-operatively with bracing until delayed surgery at age 14 years
Unspecified interval to ACLR or combined cohorts										
McCarroll *et al* (1988)[10]	60	*AJSM*	IV	24	TP	50.4	91.7%		0%	Of the 38 patients initially treated non-operatively (delayed ACLR), 16 attempted to return to activity during the non-operative treatment and all were unsuccessful. 55 (91.7%) patients in the overall cohort returned to pre-injury levels of activity following ACLR, however were not stratified in the manuscript based on acute or delayed ACLR
Matava and Siegel (1997)[27]	8	*Am J Knee Surg*	IV	(See notes)	TP	32	100%	100%	n/a	Four acute tears with an average of 5.5 weeks between the injury and ACLR and four patients with chronic tears (average of 29 weeks between injury and surgery). All patients returned to sports postoperatively
Edwards and Grana (2001)[25]	20	*AJKS*	IV	NR	TP	34	95%		n/a	Two graft ruptures occurred after return to sport
Shelbourne *et al* (2009)[24]	402	*Sports Health*	IV	NR	TP	118	87% basketball 90% soccer		n/a	Rate of return to soccer recalculated from study data
Hui *et al* (2012)[26]	16	*AJSM*	IV	(See notes)	TP	25	100%		n/a	Reconstruction was performed within 3 weeks of injury in 6%, between 3 weeks and 12 weeks in 50%, and after 12 weeks in 44%
McCullough *et al* (2012)[28]	53	*AJSM*	III	NR	BTB Hamstring Various Allograft	24	45%		n/a	High school (freshman-junior) subcohort. Examined return to competitive football. Specific surgical techniques not reported

Continued

Table 2 Continued

Author (year)	N	Journal	LOE	Mean time to ACLR (weeks)	Intervention technique (s)	Mean follow-up (mo)	Rate of return to preinjury (or higher) levels of athletic activity			Notes
							Acute ACLR	Delayed ACLR	Non-operative treatment	
Ardern *et al* (2012)[29]	43	*AJSM*	III	NR	NR	40	49%		n/a	Youth subcohort of an age-comprehensive study. Retrospective case-series but designated as level III evidence
Demange and Camanho (2014)[22]	12	*AJSM*	IV	NR	PTP (OTT femur)	220	83%		n/a	Three patients presented with sports-related reruptures. 41.6% of cohort returned to competitive sports and 41.6% who returned to recreational sports. No preoperative level of competition reported
Schmale *et al* (2014)[23]	29	*CORR*	IV	NR	TP	48	41%		n/a	Four patients experienced rerupture
Nonoperative										
Mizuta *et al* (1995)[11]	18	*JBJS Br.*	IV	n/a	Non-operative	204	n/a	n/a	6%	Of this non-operative study cohort, none returned to sports and six eventually required ACLR for recurrent instability
Moksnes *et al* (2013)[30]	46	*BJSM*	II	n/a	Non-operative	12 and 24	n/a	n/a	52%	Percentage returned reported at 1 year post injury. 22% of cohort underwent ACLR due to persistent instability; 19.5% underwent new symptomatic meniscal surgeries. 52% maintained 'level 1' sports participation at 1 year. Number who dropped down from less competitive levels not reported

ACLR, anterior cruciate ligament reconstruction; AE, all-epiphyseal ACL reconstruction; BTB, bone-patellar tendon-bone; NR, not reported; LOE, level of evidence; OTT, over the top femur; PTP, partial transphyseal (hybrid) ACL reconstruction; TP, transphyseal ACL reconstruction.

stay involved at their baseline levels of sport participation. The weighted mean follow-up for these cohorts was 32.0 months. One large study was conducted by Goddard *et al*,[20] in which 29 youth athletes underwent transphyseal reconstruction at a mean of 28 weeks following their initial rupture. At a mean follow-up of 24 months, 86% of these patients were involved in 'strenuous' or 'very strenuous' activity, with two patients who sustained a rerupture not included in the analysis. Other investigations describe similar outcomes, with Cassard *et al*[17] reporting 100% return to play of their initial 28 patients returning to preinjury levels of activity. For this cohort, the average time to surgery was 59 weeks and only two experienced a rerupture of their graft.

Unspecified or varied time to treatment and return to athletics

Nine studies[10 22–29] did not specify the mean time from injury to surgery for their series, or had acute and chronic ACLR subjects in the study cohort. The rates of return to sport for these various investigations are 100%, 100%, 95%, 91.7%, 88.5%, 83%, 49%, 45% and 41%, with a weighted mean follow-up time of 91.5 months. The largest of these studies, performed by Shelbourne *et al*[24] reported an 87% return to competitive basketball and a 90% return to soccer for 402 paediatric patients. However, the average time between injury and subsequent treatment could not be elucidated.

Non-operative treatment and return to athletics

Two studies examined the rates of return to sports for patients whose ACL tears were treated non-operatively, with a weighted mean follow-up of 74.6 months. Moksnes *et al*[30] prospectively evaluated children with ACL tears who received non-operative therapy. The authors reported 52% of their conservatively treated patients returning to their preinjury levels of activity 1 year after the initial injury, suggesting that a non-operative algorithm may be appropriate for some patients. However, 22% of their initial non-operative cohort eventually underwent ACL reconstruction due to persistent instability and 9% required meniscal surgery. Mizuta *et al*[11] reported on the conservative treatment of 18 paediatric athletes with ACL tears. Of these, 94% did not return to preinjury levels of activity and 22% did not return to play any kind of sport. Although McCarroll *et al*[10] examined acute and delayed operative cohorts, they reported that of the 16 patients initially treated non-operatively who attempted to return to sports in the non-operative period, none were successful.

DISCUSSION

ACL ruptures account for a significant and increasing number of sports related injuries in youth athletes.[31] This noted increase in injury rates has given rise to increased interest in the surgical treatment of ACL injuries in this patient population.[1 32] Surgical treatment of ACL ruptures in those under 18 years of age, particularly skeletally immature patients, presents unique challenges because of the growing physis.[33] Because of this, the treatment of ACL ruptures in paediatric patients has historically been with initial non-operative management, followed by delayed surgical reconstruction at skeletal maturity.

There are multiple reasons why the above treatment strategy may not be acceptable to treating surgeons, patients and their families. In addition to the known risk of further intra-articular injury in the ACL deficient knee,[34–38] activity modification—which is the mainstay of non-operative treatment—may not be desirable or feasible in the paediatric patient. The rate of symptomatic knee instability in this patient population is high[39] and

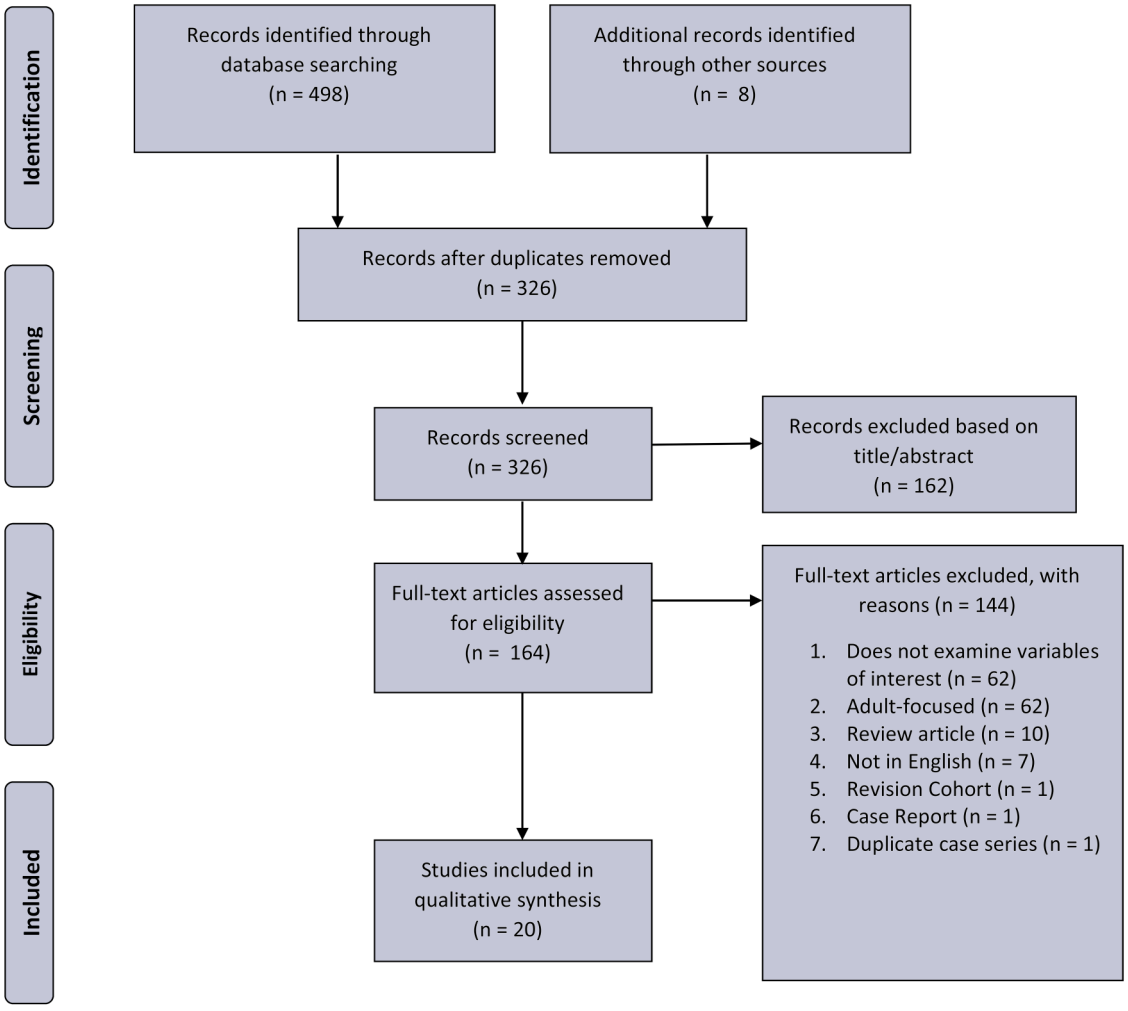

Figure 1 Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram.

authors have reported that even in the setting of partial ACL ruptures, up to a third of patients who are initially treated non-operatively continue to have instability which requires reconstruction.[40] ACL deficiency has been shown to lead to a high rate of sport dropout and poor functional results in adults.[41 42] These findings, however, are not necessarily well studied in the paediatric population although past investigations have reported that up to 50% of youth athletes are unable to return to athletic activity because of persistent knee instability,[10] and up to 94% unable to return to their preinjury level of activity.[11]

The purpose of this systematic review was to critically appraise the literature and investigate whether conservative treatment of ACL ruptures in youth athletes (defined as patients <18 years old) is associated with a lower rate of sports participation when compared with early or late reconstruction. In general, return to sport following non-operative treatment of ACL ruptures in youth is infrequently studied, but tends to have poor rates of return compared with operative cohorts. We were only able to identify two studies that specifically assessed return to sports activity following non-operative treatment as the primary treatment modality for paediatric patients with an ACL rupture. Moksnes *et al*[30] prospectively examined 46 skeletally immature children (aged 12 years and younger) who were treated with a non-operative treatment regimen that consisted of a structured physical therapy programme and bracing with the goal of restoring functional stability of the knee. At final follow-up, 22% of patients had undergone surgical reconstruction for symptomatic ACL deficiency. Overall, 52% of patients were able to return to their previous level of sport at 1-year follow-up and 50% of those available for evaluation at 2 years were able to return to their previous level of sport. The authors of this study concluded that non-operative treatment may be appropriate for some ACL-injured youth, however, some may require a reduced level of activity. A reduced activity level in this active patient population is not always desirable or feasible, however. Sixteen of 38 patients initially treated non-operatively in the McCarroll *et al*[10] study attempted to return to sport with none proving successful, and the Mizuta *et al*[11] cohort likewise had a poor rate of return to play with only 6% (1 of 18) athletes returning to athletic activity after non-operative management of ACL tear. This systematic review identified fewer studies investigating non-operative management than surgical management, however this may reflect the orthopaedic surgery literature at large. The included non-surgical studies had sufficient methodological rigour such that the results should be strongly regarded in the comparison to acute surgical intervention.

The literature examining return to sports participation following surgical treatment of ACL ruptures in youth athletes is more robust than the literature examining non-operative treatment, however, most published studies consist of level III or level IV evidence. The authors of this systematic review were unable to identify any studies directly comparing ACLR to non-operative treatment of ACL injuries in youth athletes. The lack of direct

comparative studies between treatments makes it difficult to make definitive conclusions regarding the primary study questions of whether non-operative treatment results in lower sports participation compared with operative treatment. In the identified studies, rates of return to the same level of youth sports participation following ACL reconstruction ranged from 41% to 100% (with most >80%) while the non-operative cohorts returned at rates of 0–52%.

Most of the operative studies included in this systematic review consisted of relatively small case series. The largest series that met our inclusion criteria evaluated 402 school-aged children and adolescents[24] and reported overall return to soccer and basketball rates of 90% and 87%, respectively, following ACL reconstruction. The mean follow-up in this patient cohort was 9.8 years, and the patients in this study reported return to prior level of sport at a mean time of approximately 5 months after surgery. This study, however, is exceptional within the literature examining return to sports activity in youth athletes in terms of the number of study subjects, mean follow-up time, mean return to sports rate and mean time to return to sports. Recently, outcomes studies of adult patients following ACL reconstruction have benefited from robust, multicentre, prospectively collected registries which has provided much insight to the short-term and long-term results following surgical treatment of ACL ruptures.[43–49] Unfortunately, similar registries do not exist for youth and the optimal surgical treatment of ACL ruptures in this demographic are generally extrapolated from adult studies. Whether applying the results of adult treatment to youth athletes with ACL ruptures with varying skeletal development, maturity levels, athletic demand and neuromuscular control is appropriate remains a topic of continued research interest.

Most of the identified studies assessed return to sports participation via self-reported questionnaires, patient interviews and/or validated adult outcomes questionnaires (ie, Tegner activity scale or International Knee Documentation Committee subjective score). These questionnaires, however, have not been validated for use in paediatric and adolescent patients[7 50–52] and analogous to the aforementioned limitation of ACL treatment in children (ie, extrapolating adult principles to youth patients), this is a limitation of paediatric sports medicine outcomes literature in general. Return to the same level of sports activity in youth athletes is likely to be much different than the same definition in adults. Therefore, applying adult outcomes evaluations to youth athletes may not properly assess return to prior level of sports participation and is a limitation of all the studies included in this systematic review.

It is important to note the limitations inherent to this systematic review and the studies it contains in answering the study question. First, the heterogeneity of ACLR techniques (including the technique not being reported in one of the studies and one study using multiple techniques), group reporting of time to surgery, a lack of consensus definition of surgical delay, and variable length of follow-up precluded meta-analysis of the included studies. In addition, while surgical delay was defined here as surgery >16 weeks after injury, this was based upon mean study cohort time to surgery, and certainly included variance within each cohort. Furthermore, many studies provided aggregate patient age but did not specifically mention skeletal maturity. It is possible that parts of some cohorts included here are skeletally mature despite being in the paediatric/adolescent age range. Despite this, however, understanding return to sport in youth patients under age 18 years is still important, as there are differences between adults and young patients who are skeletally mature, including increased demand, higher activity levels and unique considerations with regards to proprioception and neuromuscular control. Finally, while we limited our search criteria to English studies only, it has been reported that restricting systematic reviews to English-only does not introduce bias into systematic reviews and metaanalyses.[53]

Perhaps most importantly, while return to athletic activity is an aspect of treatment of great clinical interest to patients and surgeons alike, there are reasons why it may not serve as an ideal clinical outcome research variable. First, many child and adolescent athletes will independently choose to change their level of sports activity (for a variety of reasons) through youth or after graduating from high school. Natural history of activity dropout may impart study heterogeneity through a difficult-to-measure phenomenon as well as account for some studies' relatively low rates of return to sport following surgical reconstruction in youth athletes.[23 28 29] Furthermore, in patients who are treated acutely, they may expect a return to activity after a full course of postoperative rehabilitation (typically up to 1 year). Those who are successfully treated non-operatively may return to sport after rehabilitation, and those who fail non-operative management and receive delayed surgical treatment will also return to sport after their postoperative rehabilitation. Therefore, all three groups (acute surgical, delayed surgical and non-operative) may eventually return to sports at the same rate, albeit not at the same time post injury, making rate of return to sports a suboptimal clinical outcome variable. Perhaps focusing on time to return to sports activity is a more appropriate outcome variable, especially in light of the understanding that athletic activity provides children and adolescents with physical, social, and psychological development and overall well-being.[8 9]

Finally, 14 out of 18 studies that examined surgical treatment of ACL ruptures in youth athletes used transphyseal ACL reconstruction with soft tissue grafts. This reconstruction technique relies on relatively vertical tibial and femoral tunnels in order to minimise the amount of physeal damage.[31 54 55] Recently, there has been increasing interest in performing ACL reconstruction in skeletally immature patients with all epiphyseal tunnels.[56–59] Additionally, there are other 'physeal-respecting' ACL reconstruction techniques that can be used in this patient population[7 60] and return to sports following various techniques cannot necessarily be assessed based on this review.

CONCLUSION

There are relatively few studies directly examining rate of return to sports participation following ACL ruptures in youth athletes. Based on available literature, there appears to be an improved rate of return to athletic activity after ACLR when compared with non-operative treatment, however several studies did not provide details about the timing of injury-to-surgery, and study heterogeneity precluded combining results in meta-analysis. Therefore, it was not possible to draw a conclusion regarding timing of surgery (eg, acute vs delayed ACLR) and rate of return to sport. While the question of optimal treatment of ACL ruptures in youth athletes as it pertains to return to sports remains a relevant clinical question, the proportion of those who eventually return to any sports activity may be a suboptimal clinical outcome variable. Patients treated with acute or delayed surgery may equally return to sports, albeit with varying amounts of time to full recovery post injury. Future research should directly focus on time to surgery and time to return to sports activity as a more appropriate predictor and outcome variables, while taking into account the unique aspects of ACL reconstruction and non-operative management in youth athletes.

Competing interests None declared.

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