Recurrence and return to play after shoulder instability events in young and adolescent athletes: a systematic review and meta-analysis

Jason L Zaremski,[1] Juan Galloza,[2] Fernando Sepulveda,[2] Terrie Vasilopoulos,[1,3] William Micheo,[2] Daniel C Herman[1]

▶ Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/bjsports-2016-096895).

[1]Department of Orthopaedics and Rehabilitation, University of Florida, Gainesville, Florida, USA
[2]Department of Physical Medicine, Rehabilitation and Sports Health, Sports Medicine Fellowship Program, University of Puerto Rico School of Medicine, San Juan, Puerto Rico
[3]Department of Anesthesiology, University of Florida, Gainesville, Florida, USA

Correspondence to
Dr Jason L Zaremski, Department of Orthopedics and Rehabilitation, Divisions of PM&R, Sports Medicine, & Research, UF Orthopaedics and Sports Medicine Institute (OSMI), The University of Florida College of Medicine, P.O. Box 112727, Gainesville, FL 32611, USA; zaremjl@ortho.ufl.edu

Accepted 19 October 2016
Published Online First 10 November 2016

ABSTRACT

Background Shoulder instability in athletics is a common occurrence. However, there is controversy as to whether non-operative versus operative management is the most effective treatment in youth athletes. We systematically reviewed recurrence and return to play (RTP) after shoulder instability events in youth athletes based on surgical versus non-surgical intervention.

Design The systematic review concerned studies published before August 2016. Statistical analysis was performed to compare rates of recurrence for each extracted risk factor. Pooled ORs were analysed using random-effects meta-analysis.

Results 17 studies comprising 654 total shoulder instability events met the criteria for inclusion (438 men and 158 women; 507 cases traumatic and 20 atraumatic). Patients were grouped by whether they received non-operative or operative treatment. The primary non-operative group was more likely to have recurrence compared to the primary operative group (OR=13.41; 99% CI 3.60 to 49.93, p<0.001). Patients <14 years old in the primary non-operative group were less likely to recur compared to those aged ≥14 years (OR=0.16; 99% CI 0.06 to 0.43, p<0.001). The rate of recurrence in patients aged <14 years was high (44.44%). For RTP, there is evidence that RTP rates were higher for primary operative patients (95.3%) versus primary non-operative (41.3%, Z=6.12, p<0.001) and secondary operative patients (77.6%, Z=2.66, p=0.008).

Conclusions This meta-analysis summarises a mix of 17 acceptable quality level II and III prospective and retrospective cohort studies. Given the superior rates of recurrence and RTP, primary operative treatment for shoulder instability should be considered in youth athletes aged ≥14 years. Additionally, the recurrence rate in athletes aged <14 years is significant.

INTRODUCTION

There are over 7.8 million high school athletes in the USA.[1] In younger athletes, there are over 44 million boys and girls participating in sports with over 75% of these young athletes participating all year round.[2] This high level of participants results in a significant number of injuries. High school athletes experienced over two shoulder injuries per 10 000 exposures for over 800 000 total shoulder injuries from 2005 to 2013.[3] One such upper extremity injury that is commonly encountered in the young athlete is shoulder instability, which may be due to either traumatic or atraumatic causes.

The literature with respect to young skeletally mature athletes has shown that there are high levels of recurrence rates of instability.[4–8] One systematic review found that the rate of recurrence after non-operative management for primary anterior shoulder instability was as high as 88%, and that male sex and younger age predicted a higher risk of recurrence.[9] Another review found that the in-season risk of recurrence after return to play (RTP) is >60% and may be as high as 90%.[10] Instability after operative intervention with various surgical procedures is dramatically lower than with non-operative management.[7 11 12] There are also data that suggest as the number of instability episodes increases, the risk of postsurgical recurrence increases, as does the risk for glenohumeral arthritis.[13–15] Thus, it is imperative to provide appropriate treatment in an efficient manner to prevent recurrent instability events and improve short-term and long-term outcomes.

It should be noted that there are major differences between a skeletally immature and skeletally mature shoulder that may confer significant differences in treatment decision-making between the two groups. The amount of type III collagen produced in children is significantly greater than that in adults and may result in an increased amount of joint laxity.[16] Additionally, at younger skeletally immature ages, the level of bony congruity restraining the humeral head in the glenoid cavity is not fully developed.[17] The combination of these factors may allow for shoulder instability events to occur without the same level of risk for significant structural damage, thus conferring a relative protective effect and potentially obviating the need for operative intervention. Conversely, this relative lack of stability in the setting of significant forces and torque about the shoulder region during athletics may predispose the youth athlete to shoulder instability and recurrence.[17]

As a result of these conflicting factors, controversy exists with respect to treatment of shoulder instability events in youth athletes. Some authors have posited that recurrence in young (<14 years old) patients is rare and that surgical management is not necessary in these cases.[18] Other proposals range from considering surgical intervention after primary cases of instability in all patients, only to those of age ≥14 years, or only to those who have reached skeletal maturity (closed proximal humeral physis).[19 20] Algorithmic approaches have also been proposed with the determination of non-operative versus operative treatment, as well as the timing of potential operative intervention being dependent on multiple factors, such as age, type of sport

To cite: Zaremski JL, Galloza J, Sepulveda F, *et al*. *Br J Sports Med* 2017;**51**:177–184.

(contact, non-contact, throwing or non-throwing), time within season and pathology on imaging studies.[19 21–24]

In order to engage in appropriate evidence-based care of youth athletes with shoulder instability, a comprehensive understanding of the available literature and how it may vary by aspects such as age and sex is needed. Thus, the goal of this manuscript is to determine, through a systematic review, the efficacy of different treatment options for shoulder instability in the youth with respect to recurrence of shoulder instability events and RTP, and how this efficacy varies with respect to patient factors such as age, sex, mechanism of injury and direction of instability.

METHODS

The systematic review was carried out in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol (see table 1).[25] A search algorithm (see table 1) was developed, combined with the Boolean term 'AND' and then used by three independent investigators (JLZ, JG and DCH) to search the following databases: CINAHL, Web of Science, PubMed, Sports Discus and SCOPUS. The Boolean Search terms included: 'shoulder', 'instability', 'rehabilitation', 'adolescent' and 'sports'. The term 'skeletally immature' was not used because there were significantly less citations when using this term as opposed to the term 'adolescent'. The search was performed on 1 August 2016, and there was no timeframe restriction. All journals were considered, and all relevant studies were analysed. Using the Oxford Center of Evidence-Based Medicine Guidelines, Level II and III articles were found in the literature and included in our study. We also included 'human species' as a subset to remove any non-human data. Potential articles were identified by screening titles and abstracts, and if these met the inclusion criteria, the full text of the articles were obtained. The three investigators separately reviewed the abstract of each publication and then performed a close reading of all articles and extracted data to minimise selection bias and errors. To avoid bias, the selected articles, the relative list of references and the articles excluded from the study were reviewed, assessed and discussed by all the authors, and if there was disagreement among investigators regarding the inclusion and exclusion criteria, the primary investigator (JLZ), second investigator (WM) and senior investigator (DCH) collaboratively made the final decision.

Inclusion and exclusion criteria

Studies were included if they were prospective and retrospective investigating outcomes of different management approaches for an instability event with the outcomes representing recurrent instability events and/or RTP. Our question was limited to youth athletes; hence, studies were excluded if patients were over the age of 18 years. Studies were also excluded if they were case reports, letters to the editors, literature reviews, did not involve live humans or did not report on patient involvement with athletics.

Assessment of study quality

The methodological quality of each of the included studies was evaluated by five reviewers (JLZ, WM, JG, FS and DCH) using the Coleman Methodology Score (CMS) method.[26] This method assesses methodology with 10 criteria, giving a total score between 0 and 100. A score of 100 indicates that the

Table 1 Summary of included studies

Article	Total CMS Score*	N (shoulders)	Male	Female	Ave. age* (years)	Atraumatic	Traumatic	Initial treatment	Ave. follow-up time* (months)
Buss, *et al*[41]†	73	27	22	5	16.7	NA	NA	27 Non-Op	1 sport season
Castagna *et al*[22]	72	65	44	21	16	0	65	65 Non-Op	63
Cordischi *et al*[40]	72	14	12	2	12	0	14	14 Non-Op	40.8
Deitch *et al*[39]	66	32	25	7	15.3	0	32	32 Non-Op	48
Gigis *et al*[38]	81	65	41	24	16.7	0	65	38 1° Op, 27 Non-Op	36
Jones *et al*[20]	73	32	18	14	17.4	2	30	16 1° Op, 16 2° Op	25.2
Kawam *et al*[35]	65	7	4	2	10.8	3	4	7 Non-Op	113
Khan *et al*[36]	82	53	35	14	13.9	0	53	28 2° Op, 25 Non-Op	99.6
Kraus *et al*[37]	64	7	6	1	11	1	6	6 2° Op, 1 Non-Op	26
Lampert *et al*[18]	76	56	32	22	14.5	0	56	14 1° Op, 42 Non-Op	12
Marans *et al*[33]	79	21	15	6	13.4	0	21	21 Non-Op	78
Ochs *et al*[32]	76	33	21	11	14.5	0	33	33 Non-Op	60
Postacchini *et al*[31]	69	28	23	5	15.7	7	21	28 Non-Op	85.2
Roberts *et al*[30]	95	133	115	18	16.3	4	129	133 Non-Op	95.2
Shymon *et al*[27]‡	69	46	NA	NA	NA	0	46	46 2° Op	NA
Wagner *et al*[28]	75	10	6	3	13.5	0	10	10 Non-op	72
Wooten *et al*[29]	69	25	19	3	17	3	22	25 2° Op	63
Total	78.4	654	438	158	15.5	20	607	68 1° Op, 115 2° Op, 393 Non-Op	63

*Weighted averages. Shymon *et al*[27] was not included in weighted age, and Buss *et al*[41] and Shymon *et al*[27] are not included in weighted follow-up.
†Study was not specific regarding the mechanism of injury.
‡Demographics were provided on 99 patients who qualified for inclusion; however, sufficient data regarding recurrence were only available on 46, and no specific demographic data were provided for this subset of patients.
1° Op, primary operative; 2° Op, secondary operative; CMS, Modified Coleman Methodology Score; Non-Op, non-operative.

study largely avoids chance, various biases and confounding factors. The subsections that make up the CMS are based on the subsections of the Consolidated Standards of Reporting Trials (CONSORT) and are modified to allow for other trial designs. The Coleman criteria were modified to make them reproducible and relevant for this manuscript. Disagreements were resolved by discussion. No articles were excluded from analysis based on quality scores. A breakdown of the CMS scoring for each article can be found in online supplementary table S1.

Data extraction and synthesis

Data were extracted and tabulated into an Excel database by three of the authors (JLZ, DCH and JG). Treatment for patients was classified as primary non-operative, primary operative and secondary operative treatment. Primary non-operative treatment is defined as non-surgical treatment (such as but not limited to immobilisation using a sling and/or a structured physical therapy programme) after a shoulder instability event without operative intervention. Primary operative treatment is defined as operative intervention after a shoulder instability event without attempting non-operative management. Secondary operative treatment is defined as operative intervention after failure (eg, shoulder instability recurrence) with primary non-operative treatment. Recurrence of instability was extracted for primary and secondary treatments when provided in the same study; RTP, defined as being able to return to sport at preinjury levels. Recurrences of shoulder instability and RTP after the three different treatment options were the primary study outcomes. Patient age, sex, injury mechanism (traumatic or atraumatic) and direction of instability (posterior vs anterior instability) were also extracted when reported for secondary analyses.

DATA ANALYSIS

Review Manager (RevMan) V.5.3 (The Cochrane Collaboration, Copenhagen, Denmark) was used for the meta-analysis. The effects of independent variables on outcomes were summarised with ORs with 99% CIs. Heterogeneity was assessed using a χ^2 test and the Higgins I^2 value. If there was no significant heterogeneity, pooled effects (ORs) were estimated with fixed-effects models. If there was significant heterogeneity, random-effects models were used. For comparisons with not enough data to perform meta-analyses, z-tests were performed to compare proportions of patients with recurrence between groups, though these results would be more biased compared to those from the meta-analyses. $p<0.05$ was considered statistically significant.

RESULTS

The initial search resulted in 140 citations (see figure 1). An additional 22 studies were found by cross-referencing the bibliographies of full-text articles, resulting in a total of 162 initial citations. We were left with 18 manuscripts.[18 20 22 27–41] However, one manuscript only reported outcomes from 24 months and onwards with sparse and incomplete data on short-to-moderate (6–24 months) outcomes.[34] Given this censoring of the data and that recurrence tends to be highest in the first 2 years after shoulder instability, the decision was made to exclude this manuscript from the meta-analysis (figure 2).

The 17 studies which met the criteria for inclusion comprised 654 shoulders with subluxation or dislocation instability events

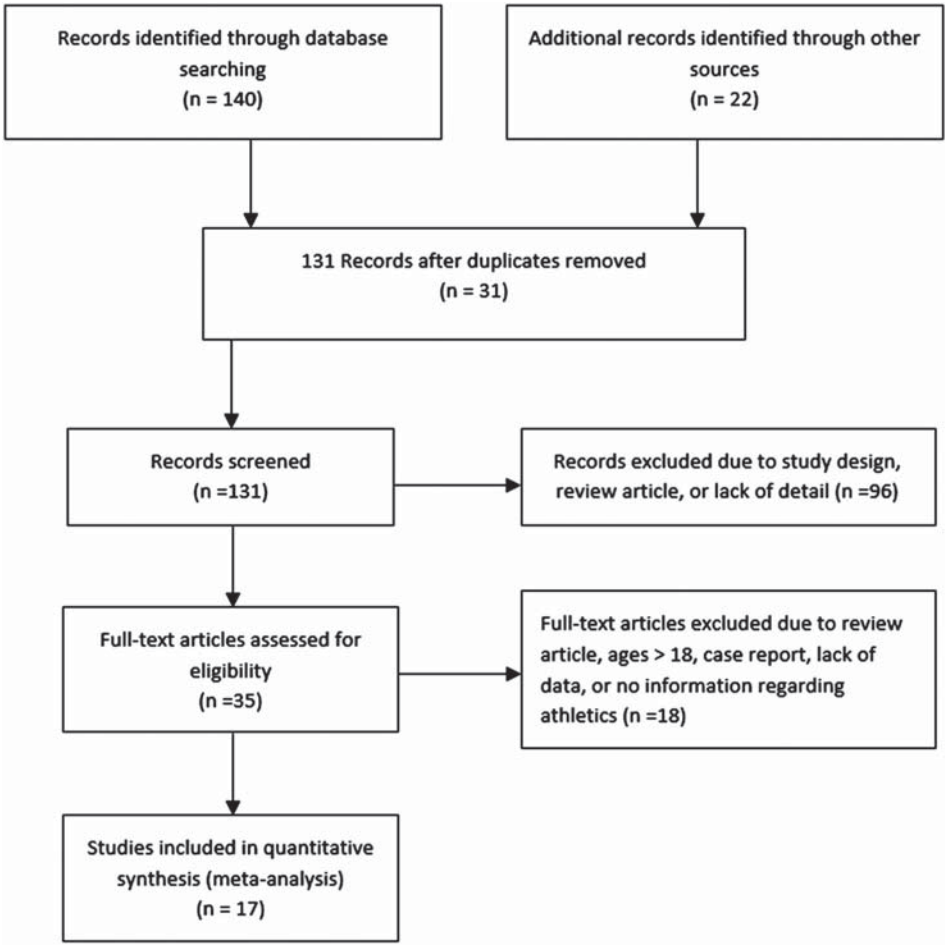

Figure 1 PRISMA flow diagram. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Figure 2 Forest plot for recurrence rate differences between primary non-operative and primary operative treatment.

Table 2 Recurrence rates in all patients

	Primary non-operative treatment		Primary operative treatment		Secondary operative treatment	
Study	Events	Total	Events	Total	Events	Total
Buss *et al*[41]	11	27	0	0	0	0
Castagna *et al*[22]	0	0	0	0	14	65
Cordischi *et al*[40]	3	14	0	0	0	3
Deitch *et al*[39]	24	32	0	0	5	16
Gigis *et al*[38]	19	27	5	38	0	0
Jones *et al*[20]	0	0	2	16	3	16
Kawam *et al*[35]	0	0	0	0	1	6
Khan *et al*[36]	14	25	0	0	2	28
Kraus *et al*[37]	0	1	0	0	0	6
Lampert *et al*[18]	27	42	2	14	0	0
Marans *et al*[33]	21	21	0	0	1	13
Ochs *et al*[32]	31	33	0	0	8	21
Postacchini *et al*[31]	24	28	0	0	2	7
Roberts *et al*[30]	102	133	0	0	19	60
Shymon *et al*[27]	0	0	0	0	14	46
Wagner *et al*[28]	8	10	0	0	0	7
Wooten *et al*[29]	0	0	0	0	2	25
Totals	284	393	9	68	71	319
Frequencies	72.3%		13.2%		22.3%	

in 642 patients (see table 1). The participants included 438 men and 158 women; 1 study of 46 patients did not provide adequate information on patient's sex and is not included in these values.[27] The cases included 607 with traumatic onset and 20 with atraumatic onset; 1 study of 27 cases did not specifically provide a description of the mechanism of injury and is not included in these values.[41]

Table 2 reports recurrence events in all patients across all studies. Patients in the primary non-operative group were more likely to have recurrence compared to those in the primary operative group (OR=13.41; 99% CI 3.60 to 49.93, p<0.001) (see table 2). Recurrence rates between primary operative and secondary operative treatment were similar across studies but with a trend favouring primary operative treatment (Z=1.68, p=0.09).

In patients receiving primary non-operative treatment, patients <14 years old were less likely to have recurrence compared to those 14 years and older (OR=0.16; 99% CI 0.06 to 0.43, p<0.001) (see figure 3A). No data on primary non-operative versus primary operative treatment outcomes were reported for patients of <14 years old; hence, no statistical analyses based on age group were performed for this comparison. For patients in the secondary operative treatment, there were no statistically significant differences in the likelihood of recurrence between patients <14 years old and those aged 14 years and older (OR=2.02; 99% CI 0.34 to 12.13, p=0.31) (see figure 3B). All recurrence rate data stratified by age (<14 years old vs ≥14 years old) are reported in online supplementary table S2.

For primary non-operative treatment, there were no statistically significant differences in the likelihood of recurrence between men and women (OR=1.62; 99% CI 0.67 to 3.94, p=0.16) (see figure 4A). Similarly, there were no differences in recurrence rates between men and women for primary operative treatment (OR=1.13; 99% CI 0.13 to 9.48, p=0.89) nor for secondary operative treatment (OR=1.15; 99% CI 0.36 to 3.71, p=0.76) (see figure 4B, C). All recurrence rate data stratified by gender are reported in online supplementary table S3.

Meta-analyses could not be performed for comparisons of atraumatic versus traumatic mechanism of injury, posterior versus anterior instability and return-to-play, so our comparisons were limited to the use of Z-tests. Comparing overall proportions of recurrence rates, there is evidence that recurrences rates were higher for atraumatic injury (57.1%) versus traumatic (22.8%) for secondary operative patients (Z=2.28, p=0.02) (see online supplementary table S4). For posterior versus anterior instability, there was a trend for differences in recurrence rates for secondary operative treatment, but it did not reach statistical significance (9.7% vs 21.9%, respectively, Z=1.72, p=0.09) (see online supplementary table S5). For RTP, there is evidence that RTP rates were higher for primary operative patients (95.3%) versus primary non-operative (41.3%, Z=6.12, p<0.001) and secondary operative patients (77.6%, Z=2.66, p=0.008) (see table 3).

DISCUSSION

We engaged in a comprehensive systematic review to determine the rates of RTP and recurrence in youth athletes with shoulder instability after receiving primary non-operative, primary operative and secondary operative treatments. The results we obtained offer several points for discussion which could have a significant influence on clinical decision-making and future research.

Primary analyses

Our analyses demonstrate that primary non-operative treatment after a shoulder instability event results in a high rate of recurrence in youth athletes. This finding mirrors outcomes which have been observed in large studies with skeletally mature young adult patients and mixed populations of adolescents and young adults.[4 6 42 43] Robinson *et al*[43] investigated the rate of instability after primary dislocation with non-operative treatment in patients aged 15–20 years and observed an 86.6% rate of instability at the end of 5 years. Similarly, Hovelius *et al*[6] observed recurrence of shoulder instability in 62.7% of athletes of age 12–22 years at 5 years of follow-up. The total percentage of recurrent instability after non-operative treatment among the studies included in our review was 72.3% over a weighted

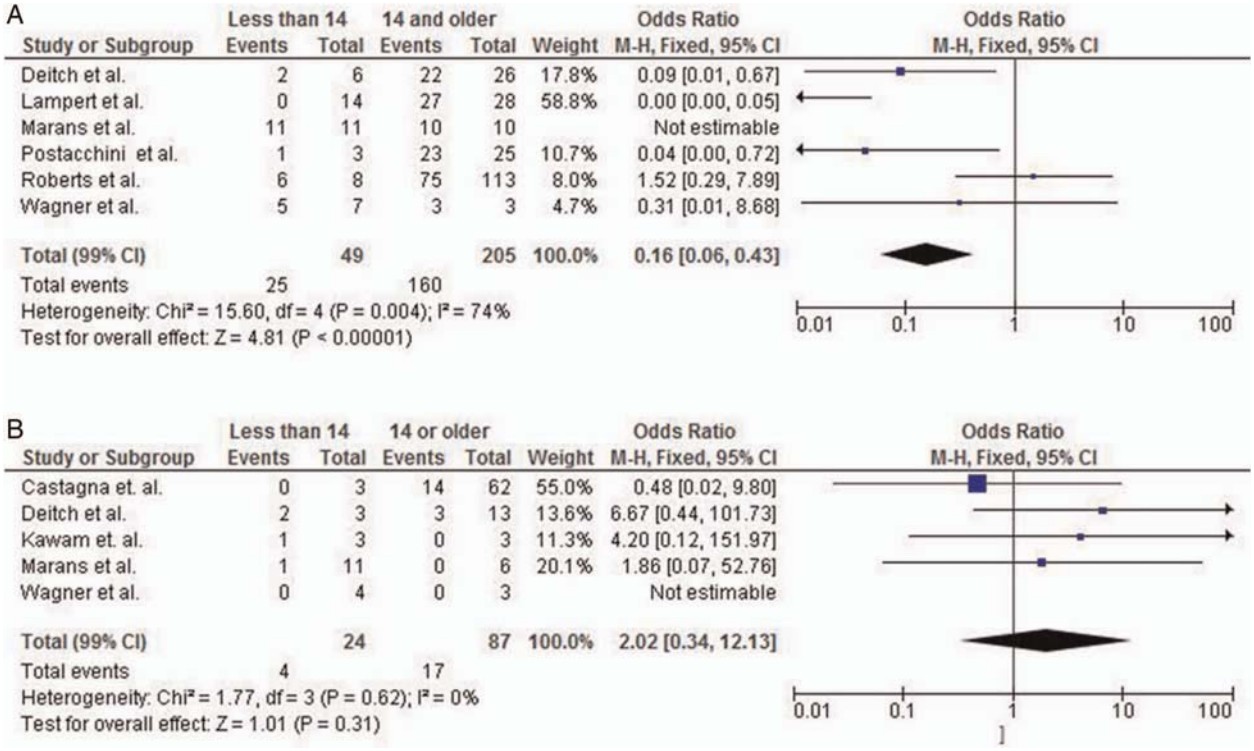

Figure 3 Forest plots for recurrence rate differences between patients by age group for primary non-operative (A) and secondary operative (B) treatments.

average of 5.3 years and is of similar magnitude in comparison to these studies.

In comparison to patients receiving primary non-operative treatment, patients receiving primary operative treatment had a greatly reduced rate of recurrent instability. This finding is also similar to previous studies investigating the effects of primary operative treatment in young adults. It should be noted that these findings are based on a relatively limited number of total patients cases (54 patients in the meta-analysis; 68 patients overall) and that these cases were limited to the ≥14-year-old age group. Additionally, none of the included studies used randomisation of treatment. However, we feel that the magnitude of the OR for recurrence (13.4) and difference in total percentage between these groups (57.1%) combined with the similar outcomes seen in young adults make these data very compelling. At minimum, these results support those who have advocated the viewpoint that significant consideration towards primary operative treatment is warranted after the primary shoulder instability event, particularly in the setting of patient goals to resume overhead or contact sports.[19 20 44]

There was a trend towards improved rates of recurrence in patients with primary operative versus secondary operative treatment. We noted large differences between studies with respect to the number of recurrent instability events experienced by a patient prior to receiving surgical intervention after a course of conservative management. Studies included ranges of 1–5 preoperative recurrence events in Castagna *et al*, 1–30 in Postacchini *et al* and 2–50 in Jones *et al*.[20 22 31] Studies in older populations have noted a relationship between the number of preoperative instability events and the risk of postoperative instability recurrence.[13 14] It is possible that this relationship exists for youth athletes as well; hence, it is possible that the magnitude of the difference in recurrence rates between the primary operative and secondary operative treatment groups could have increased or decreased if the number of preoperative instability events among patients in the pooled data was uniformly higher or lower, respectively. Interestingly, the study with the largest number of secondary operative patients[22] failed to find an association between the number of preoperative instability events and the risk of postoperative recurrence. However, it is important to note that the small spread of preoperative instability events in this study may not have afforded the level of variance necessary to detect a relationship.

RTP was our other primary outcome in this review; unfortunately, meta-analyses could not be performed for comparisons of different treatments on this outcome. Despite this, in using Z-tests to compare proportions we found evidence that RTP rates were highest for primary operative patients. Similar as with recurrence rates, the magnitude of the difference in comparing primary operative and primary non-operative treatments was stark (54 percentage points). However, the evidence supporting a difference (17.7 percentage points) between primary operative and secondary operative patients is potentially more informative on clinical practice given that recurrence rates only suggested a trend favouring primary operative treatment. As such, these observed differences in RTP rates between the three groups serve to strengthen the argument in favour of primary surgical intervention in youth athletes. Primary surgical intervention may allow athletes to maximise their chances of completing a full RTP to their sport of choice with a potentially lower risk of further sequelae and interruption of sports participation from recurrent events. However, such decisions should be made in the context of individual patient characteristics, some of which we explored with secondary analyses.

Secondary analyses

We found that patients aged <14 years were less likely to have recurrence compared to those patients aged ≥14 years.

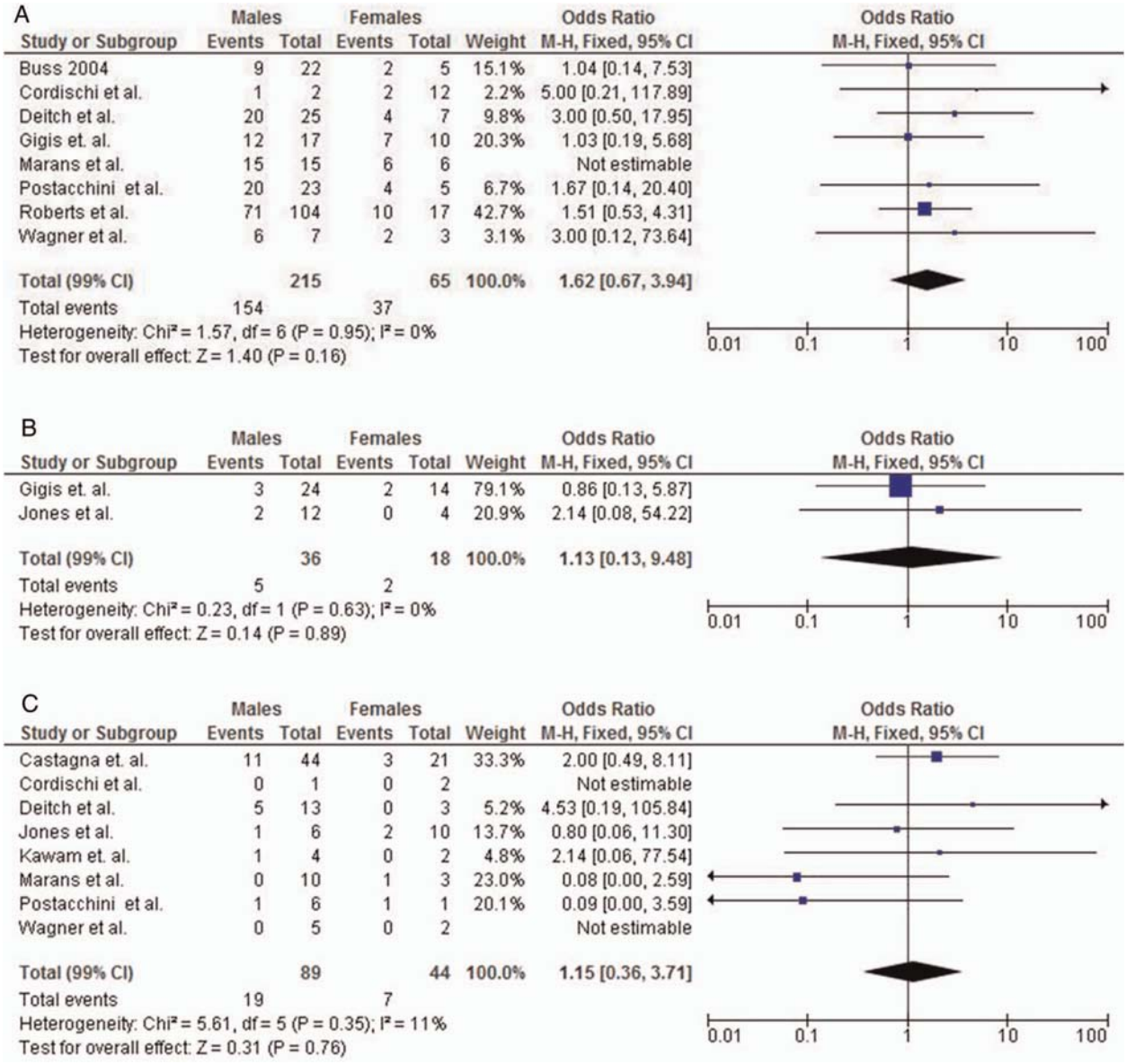

Figure 4 Forest plots for recurrence rate differences between men and women for primary non-operative (A), primary operative (B) and secondary operative (C) treatment.

This result follows the findings of a population-based study which found recurrence rates of up to 25% in patients aged <14 years but 42.3% in patients aged 14–16 years.[44] Our findings were also very similar to the analysis conducted by Olds *et al*,[45] albeit with the magnitude of our OR being slightly attenuated due to our inclusion of the study by Roberts *et al*. However, we diverge from the support granted by Olds *et al* that these data necessarily support the position taken by some groups that recurrence rates in the <14-year-old cohort are low. In particular, the two studies in the <14-year-old group with particularly low recurrence rates had some traits that warrant further discussion.[18 40] In Lampert *et al*,[18] the follow-up period was 12 months, which was particularly short in comparison to other studies reporting data in patients aged <14 years. For example, the studies reporting the highest rates including Marans *et al* (78 months), Roberts *et al* (95.2 months) and Wagner *et al* (75 months), all had significantly greater average follow-up periods.[28 30 33] While other studies have generally noted the risk of recurrence to be particularly high in the first 1–2 years after the primary instability event, such results have typically been based on study populations of age 16 years and older. It is quite possible that young patients follow a very different course in terms of recurrence, given that the athletic stresses and demands placed on the shoulder are likely to significantly increase as they age into the mid-to-late teens. Indeed, Hovelius *et al*[46] noted 70% of patients with an initial instability event at ages 12–16 years old would have either surgical stabilisation or continued recurrence (two or more events) within 10 years. Thus, it is possible that the study by Lampert *et al* censored instability events in the <14 years old age group by virtue of their relative short follow-up period.

Cordischi *et al*[40] also featured relatively low recurrence rates (3 of 14 patients). While this study did have an appreciable follow-up period (average of 40.8 months), this study notably included eight patients with concomitant fractures of the greater tuberosity of the humeral head, with one of these eight patients experiencing recurrence. Fractures of the greater tuberosity have

Table 3 Return to play rates in all patients

	Primary non-operative treatment		Primary operative treatment		Secondary operative treatment	
Study	RTP	Total	RTP	Total	RTP	Total
Buss *et al*[41]*	25	27	0	0	0	0
Castagna *et al*[22]†	0	0	0	0	53	65
Gigis *et al*[38]	15	19	25	27	0	0
Jones *et al*[20]‡	0	0	16	16	11	13
Kawam *et al*[35]	0	0	0	0	5	6
Khan *et al*[36]†	3	20	0	0	21	26
Kraus *et al*†	0	1	0	0	6	6
Marans *et al*[33]	3	21	0	0	10	13
Ochs *et al*[32]†	4	33	0	0	12	20
Wooten *et al*[29]†	0	0	0	0	17	25
Totals	50	121	41	43	135	174
Frequencies	41.3%		95.3%		77.6%	

Successful RTP is defined as equal to or greater than the preinjury level of play.
*Eleven athletes with successful in-season RTP had postseason operative intervention. If these cases are considered RTP failures, then the total frequency for the primary non-operative treatment group is 32.2%.
†These studies had combined additional 11 primary non-operative treatment patients and 23 secondary non-operative treatment patients RTP at a lower level than their preinjury level of play.
‡One patient in the primary operative group had successful RTP, subsequently needed a revision surgery, and then again was able to successfully RTP.
RTP, return to play.

previously been associated with improved rates of recurrence, which may thus factor into the relatively low recurrence rates reported in this study.[8 14] Excluding Lampert *et al* and the cases with tuberosity fractures from Cordischi *et al* would result in a recurrence rate of 65.9% (27 cases of recurrence in 41 patients) compared to 73.4% in patients aged ≥14 years. If we were to consider only those studies with long-term follow-up such that the study by Lampert *et al* in our meta-analysis (Cordischi *et al* did not qualify for inclusion), the difference in recurrence rate with primary non-operative treatment based on age was significantly attenuated (OR=0.38; 99% CI 0.11 to 1.32, p=0.05).

Even with the inclusion of these studies, we consider the pooled overall recurrence rate of 44.4% in <14-year-old patients to be of significant concern. Recurrent instability events in this age group have previously been described as rare.[18 31 39] Although the recurrence rate provided from our review is derived from a relatively small number of patients, we feel the pooled recurrence rate in the context of the relative strengths of the included articles supporting this rate demonstrate that recurrent instability in this population is not trivial. Yet current treatment decisions may be influenced by this assertion and have the potential to result in suboptimal outcomes. As previously noted, the risk for postsurgical recurrence and glenohumeral arthritis in adult patient populations appears to increase with an increasing number of instability episodes.[13 14 47] If surgical stabilisation in <14-year-old patients is not offered until multiple recurrences or until the patient is at a certain age or level of skeletal maturity, these patients may be at higher risk for negative sequelae than previously appreciated.

This concern is lessened somewhat by the promising levels of postoperative stability in these patients with secondary operative treatment, for which we noted a recurrence rate of 14.8%. Again, this rate is derived from a small number of cases (4 cases of 27 with recurrence) and is not informative regarding the question of the risk of subsequent arthritis in this population. These limited data and attendant caveats certainly highlight the need for additional research in this area. However, until such time that further data provide additional clarity, we would suggest an algorithmic approach such as that put forth by Li *et al*[19] be considered in this population. In this algorithm, a recurrent event after non-operative treatment would prompt advanced imaging and potential surgical intervention should pathology be observed, as opposed to continuing rehabilitation and other conservative measures until skeletal maturity or some other milestone is met. It is worth noting that the recommendations by Jones *et al*[20] take this a step further and advocate early primary operative treatment (within 2 weeks of primary traumatic dislocation) in athletes as young as 11 years old. However, the data from our review do not include outcomes from cases of primary operative treatment in patients aged <14 years as cases from Jones *et al* which may have been in this population were not sufficiently detailed by age. Hence, we feel there are insufficient data to support (or refute) early primary operative interventions after a primary shoulder instability event in patients aged <14 years.

Prior studies investigating outcomes in young adult populations have noted male sex to be a moderate risk factor for recurrent shoulder instability events.[11 43 48] Our meta-analyses of the studies comprising this review failed to show any statistically significant difference in recurrence rates for primary non-operative, primary operative or secondary operative treatments based on sex. The reason for this apparent age-dependency of sex-based risk is unclear. The effect of pubescence on joint laxity may be one possible factor while studies have noted that joint laxity tends to be higher in women of all age groups, a particularly large discrepancy in joint laxity between boys and girls may be present during puberty.[49] One study noted the median difference in Beighton Scores between boys and girls to increase from one to three between the ages of 12 and 15 years.[50] This change in laxity during puberty may increase the risk of recurrence in girls sufficiently to partially offset the higher rates of participation of boys in contact sports until other factors contribute to a higher risk of recurrence in men at older ages. Regardless of the mechanism, this lack of a sex-based difference in recurrence rates has potentially important clinical implications, as recurrence rates are considered to be higher in men compared to women based on the adult literature. Surgeons may be more inclined to offer primary or secondary operative intervention to male youth athletes compared to female athletes due to this perceived difference in risk of recurrence. Our data suggest that physicians should be mindful of the similarity of recurrence rates between the sexes with non-operative management in this age group. However, we note that as we selected at least one recurrent shoulder instability event as the outcome, additional context regarding the total number of instability events during the follow-up period may have been obscured.

There was a paucity of available data from the studies in this review on patients with atraumatic primary events. While Z-tests suggest that recurrences rates were higher for atraumatic injury versus traumatic for secondary operative patients, the minimal number of atraumatic patients in the analysis makes this finding suspect. However, we note that some previous studies have found that a traumatic mechanism of injury for the primary shoulder instability event may be associated with lower risk of postoperative recurrence.[51] Other studies have noted variable outcomes with conservative and operative management strategies in patients with atraumatic shoulder instability.[52]

A relatively low volume of cases was also available for patients with posterior instability, and a meta-analysis was not possible.

A trend was observed favouring recurrence rates in patients with posterior instability in the secondary operative treatment group compared to those patients with anterior instability in the same group, but this was not significant. The potential magnitude of the difference in secondary recurrence may not significantly alter clinical decision-making, particularly with a lack of context provided by a comparison of primary non-operative and primary operative outcomes between these two groups.

STUDY LIMITATIONS

There are some limitations that may hinder the generalisation of our findings. The heterogeneous nature of using a mix of retrospective and prospective studies may limit the power of the results. The detail of patient demographics and outcomes was sporadic among the studies comprising this review, and in some cases, a small number of non-athletes were included in the overall data (these cases were removed when possible). This highlights the need for a more considered approach to reporting study data. Of note, studies which list individual case data such as Castagna *et al*[22] and Deitsch *et al*[39] allow for a more granular approach; we feel this level of reporting should be encouraged when feasible. As previously discussed, some of our comparisons used a relatively small number of cases of shoulder instability, and a greater and more varied selection of cases may have allowed for more robust primary and secondary analyses. There was minimal description on the articles regarding the specific non-operative and postoperative rehabilitation protocols followed. A poorly implemented rehabilitation programme could potentially lead to suboptimal results. Furthermore, there was a large spread of sports played among these studies, but a relatively high number of instability cases came from contact sports such as American football. Recommendations regarding treatment may be different for other non-contact sports, as well as whether or not such sports feature overhead demands. For example, any athlete who participates in baseball, softball, lacrosse, swimming, shot put, hammer throw, gymnastics, cricket or the javelin throw will have additional demands placed on the glenohumeral joint relative to non-overhead athletes.

CONCLUSIONS

This systematic review was carried out in order to determine the efficacy of different treatment options for shoulder instability in the youth athletes with respect to recurrence of shoulder instability events and RTP, and how this efficacy varies with respect to patient factors such as age, sex, mechanism of injury and the direction of instability.

Owing to the high rates of recurrence, low RTP rates and concern for long-term sequelae in athletes receiving primary non-operative treatment, we feel that this approach should be reserved for athletes aged <14 years, particularly those who play sports which may feature a lower level of glenohumeral joint stress. This approach may also be considered with older youth athletes seeking to finish a competitive season, but with a clear understanding of the potential risks involved with experiencing subsequent recurrent events.

Conversely, we favour strong consideration of primary operative treatment in athletes aged ≥14 years in order to maximise glenohumeral stability and RTP rates. However, we feel that there is insufficient evidence at this time in support of primary operative treatment in younger athletes; this is an area of opportunity for further research. Finally, for all athletes who experience recurrence after a course of non-operative treatment, we favour strong consideration of secondary operative treatment prior to the progression to multiple recurrent events and prolonged periods of restriction from or impairment of participation in athletics.

Recommendations for future research include carrying out blinded, randomised controlled trials with larger sample sizes of patients aged ≤18 years, with different subsets based on age, contact/non-contact athletes, overhead/non-overhead athletes and with standardised treatment protocols in order to provide higher quality research to better inform clinical decision-making in this population.

What is already known?

Shoulder instability is a common occurrence in adolescence. There is a significant amount of research into non-operative versus operative management after shoulder instability events in adults. However, outcomes in skeletally immature athletes after shoulder instability events are not as clear. Given the numbers of youths participating in athletics, it is important to provide a systematic review on this topic to provide greater knowledge on treatment of this injury in this specific population.

What are the findings?

- Primary non-operative management is a prominent risk factor for recurrence of shoulder instability.
- Sex was not observed to be a significant risk factor for recurrence.
- While age ≥14 years is a risk factor for recurrent instability of the shoulder, the absolute percentage of patients aged <14 years with recurrence is higher than previously appreciated.
- Return to play rates appear to be higher for primary operative patients versus primary non-operative and secondary operative patients.

Twitter Follow Jason Zaremski at @zaremjl

Competing interests None declared.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1 National High School Participation Statistics. National Federation of State High School Associations [cited 2016 July 5th]. http://www.nfhs.org/ParticipationStatistics/ParticipationStatistics
2 Membership Survey 2008 edition. The National Council on Youth Sports [cited 2016 April 10th]. http://www.ncys.org/pdfs/2008/2008-ncys-market-research-report.pdf
3 Robinson TW, Corlette J, Collins CL, *et al*. Shoulder injuries among US high school athletes, 2005/2006–2011/2012. *Pediatrics* 2014;133:272–9.
4 Hoelen MA, Burgers AM, Rozing PM. Prognosis of primary anterior shoulder dislocation in young adults. *Arch Orthop Trauma Surg* 1990;110:51–4.
5 Dickens JF, Owens BD, Cameron KL, *et al*. Return to play and recurrent instability after in-season anterior shoulder instability: a prospective multicenter study. *Am J Sports Med* 2014;42:2842–50.
6 Hovelius L. Anterior dislocation of the shoulder in teen-agers and young adults. Five-year prognosis. *J Bone Joint Surg Am* 1987;69:393–9.
7 Wheeler JH, Ryan JB, Arciero RA, *et al*. Arthroscopic versus nonoperative treatment of acute shoulder dislocations in young athletes. *Arthroscopy* 1989;5:213–17.
8 Te Slaa RL, Wijffels MP, Brand R, *et al*. The prognosis following acute primary glenohumeral dislocation. *J Bone Joint Surg Br* 2004;86:58–64.
9 Wasserstein DN, Sheth U, Colbenson K, *et al*. The true recurrence rate and factors predicting recurrent instability after nonsurgical management of traumatic primary anterior shoulder dislocation: a systematic review. *Arthroscopy* 2016.