Risk Factors of Overuse Shoulder Injuries in Overhead Athletes: A Systematic Review

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Context: Shoulder injuries are highly prevalent in sports involving the upper extremity. Some risk factors have been identified in the literature, but consensus is still lacking.

Objectives: To identify risk factors of overuse shoulder injury in overhead athletes, as described in the literature.

Data Sources: A systematic review of the literature from the years 1970 to 2018 was performed using 2 electronic databases: PubMed and Scopus.

Study Selection: Prospective studies, written in English, that described at least 1 risk factor associated with overuse shoulder injuries in overhead sports (volleyball, handball, basketball, swimming, water polo, badminton, baseball, and tennis) were considered for analysis.

Study Design: Systematic review.

Level of Evidence: Level 3.

Data Extraction: Data were extracted from 25 studies. Study methodology quality was evaluated using the Modified Coleman Methodology Score.

Results: Intrinsic factors, previous injury, range of motion (lack or excess), and rotator cuff weakness (isometric and isokinetic) highly increase the risk of future injuries. Additionally, years of athletic practice, body mass index, sex, age, and level of play seem to have modest influence. As for the effect of scapular dysfunction on shoulder injuries, it is still controversial, though these are typically linked. Extrinsic factors, field position, condition of practice (match/training), time of season, and training load also have influence on the occurrence of shoulder injuries.

Conclusion: Range of motion, rotator cuff muscle weakness, and training load are important modifiable factors associated with shoulder injuries. Scapular dysfunction may also have influence. The preventive approach for shoulder injury should focus on these factors.

Keywords: overhead athletes; sports; strength; range of motion; prevention

Shoulder injuries are common in athletes. In baseball, for example, 12% to 19% of injuries are located at the shoulder,[42] whereas in swimming, shoulder injuries are estimated to be between 23% and 38% within a single year.[8,52]

Overhead athletes often perform shoulder movements with high velocity and extreme range of motion, thus making them more likely to suffer from shoulder issues. Modifications can be found in these athletes' shoulders not only after several years of

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practice but also after a single season.[49] Some authors have measured an increase in external rotation as well as a decrease in internal rotation and in total range of motion in overhead athletes.[48,49] These changes tend to be prolonged in time[3,28,54] and could be associated with an increase in humeral head retroversion.[7,56] Shoulder strength is also modified because of practice. Additionally, a decrease in the external rotators/internal rotators ratio is observed in overhead athletes.[14,19,24,38] Scapular dyskinesis has been widely explored during the past few years because of its high prevalence among overhead athletes (61%) versus among nonoverhead athletes (33%).[4] The evidence has shown a lack of scapular upward rotation in baseball pitchers[27] as well as an increase in scapular anterior tilting in swimmers.[22]

Nowadays, clinicians are looking for prevention strategies to decrease injuries and time loss, resulting in enhanced performance.[15] Prior to implementing a preventative program for athletes, the first step is to identify the various risk factors associated with the sport in question. Without this approach, quality work cannot be achieved.

At present, few systematic reviews have evaluated risk factors for shoulder pain or shoulder injuries in overhead sports. Webster et al[54] focused primarily on water polo, while Challoumas et al[6] focused on volleyball; however, their sample sizes were too limited to draw any conclusions.

Therefore, the objective of this systematic review is to highlight risk factors for shoulder injuries in athletes practicing overhead sports with regard to other nonrelated sports.

METHODS

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) checklist was used to gauge the quality of this systematic review.

Research Strategy

A search was performed at the beginning of October 2017 on the PubMed and Scopus databases. A combination of keywords and Medical Subject Headings terms was used, as shown in the Appendix (available in the online version of this article). Additional studies were found using the references of articles and were added to the database if they met the inclusion criteria. The study search was again performed in October 2018 to include articles published in 2018.

Inclusion and Exclusion Criteria

Articles included in the study needed to describe at least 1 possible risk factor associated with shoulder injuries in overhead sports. Only prospective studies were included, as that study design is the most efficient way to identify risk factors in a population.[28] Athletes assessed in the retained studies needed to practice 1 of the following sports: volleyball, handball, basketball, swimming, water polo, baseball, badminton, or tennis.

Moreover, articles meeting at least 1 of the following criteria were excluded from the study: (1) experimenting on animals, (2) not written in English, (3) not available in full text, (4) assessing a region other than the shoulder complex, (5) concerning traumatic or contact injuries, (6) not including patient examination, (7) including Paralympic athletes, and (8) concerning surgical procedures or outcomes.

Study Selection

Two investigators independently selected the articles based on title and abstract, in accordance with the inclusion and exclusion criteria. Investigators were not blinded to author names and affiliations or journal names. If there was disagreement between the 2 investigators, a third was consulted to find consensus. The full text of the selected articles was independently read by the 2 investigators to identify risk factors described in the articles, and only relevant articles were kept for analysis.

Data Extraction and Quality Assessment

The following data were extracted from the articles by the 2 investigators: author names, year of publication, country, number of participants, sex and age of participants, randomization, blinding method, incidence of shoulder injury, risk factors examined, risk factors identified, assessment method, outcome measures, length of tracking, definition of shoulder pain or shoulder injury, level of play, field position, percentage of participants who completed the study, and risk ratios (Table 1).

The quality of the articles was assessed by each author independently using the Modified Coleman Methodology Score (MCMS), adapted from Cowan et al[13] and previously used and described by Burn et al[4] in 2016. The last 5 items were excluded from the analysis because no data on treatment were provided in the included studies. Group comparability was also not considered for the analysis as it was not appropriated with prospective studies. A total score was calculated for each article by summing the different individual scores, with a maximum total of 64 points. Degree of agreement between investigators in the quality assessment was estimated using 2 statistical tests: a Student *t* test for absolute reproducibility and an intraclass correlation test (2-way mixed, single measures, absolute agreement) for relative reproducibility.

RESULTS

Literature Search

The search strategy identified 1214 potentially relevant articles on PubMed and 2059 on Scopus, amounting to a total of 3273 articles. After title and abstract review, only 198 articles were retained and fully read. After screening the 198 articles, 180 were excluded from analysis. Seven other studies that met the inclusion criteria were added to the database based on references of other articles or systematic reviews. Finally, 25 articles were considered relevant and retained for analysis. This search strategy is outlined in Figure 1.

Table 1. Risk factors of shoulder injuries identified in the studies included, classified by sport

Author, Year of Publication	Study Participants (Age)	Rate of Shoulder Injury	Material, Equipment	Risk Factors Identified	Length of Tracking	Quality Score
Baseball						
Wilk et al, 2015[55]	296 pitchers (≈25 ± 5.1 years)	75 shoulder injuries and 20 shoulder surgeries in 51 pitchers	Bubble goniometer	• Side-to-side difference <5° in ER ROM (×2.2 shoulder injury and ×4 shoulder surgery)[a]	8 seasons	32
Shanley et al, 2015[42]	115 pitchers (8-18 years)	33 injured players	Digital goniometer	• Side-to-side difference of HA ROM >15° (×4 shoulder injury)[a] • Side-to-side difference of IR ROM >13° (×6 shoulder injury)[a]	4 seasons	38
Tyler et al, 2014[50]	101 high school pitchers	19 shoulder injuries	Goniometer, handheld dynamometer	• <20° or no IR ROM loss (bilateral difference)[a] • Preseason supraspinatus weakness[a] • >75 pitches per match[a]	4 seasons	27.5
Shanley et al, 2012[43]	103 female softball and 143 male baseball players (13-18 years)	27 shoulder and elbow injuries (9 in softball and 18 in baseball)	Bubble goniometer	• Decrease in HA ROM • GIRD >25° (×4 upper extremity injuries) in baseball players[a] • Decrease in total rotation ROM (>20°) (×1.5-2 upper extremity injuries)	2 seasons	43
Byram et al, 2010[5]	144 professional baseball pitchers	41 shoulder injuries, with 12 shoulders treated operatively	Handheld dynamometer	• Supraspinatus weakness injury[a] • Low ER (prone + supine) strength surgery[a] • Low strength ratio ER/IR (prone) injury[a]	5 seasons	25.5
Shitara et al, 2017[44]	78 high school baseball pitchers (15-17 years)	21 shoulder and elbow injuries	Goniometer, handheld dynamometer	• Reduced total rotation ROM[a] • Decreased IR ROM[a] • Decreased prone ER ratio (dominant/nondominant side)[a]	1 season	37
Noonan et al, 2016[37]	255 pitchers	30 shoulder injuries	Indirect US techniques + digital inclinometer	• Decrease in humeral retrotorsion (4°)[a]	4 years	33
Smith et al, 2015[45]	48 pitchers and 50 position players (≈14 years)	49 injuries in 98 athletes (61% involved the shoulder)	Web-based questionnaire	• Moment of the season (6 first weeks)[a] • Pitchers > position players[a]	1 season	30.5

(continued)

Table 1. (continued)

Author, Year of Publication	Study Participants (Age)	Rate of Shoulder Injury	Material, Equipment	Risk Factors Identified	Length of Tracking	Quality Score
Fleisig et al, 2011[17]	481 pitchers (9-14 years)	5% (cumulative incidence)	Annual telephone call	• Pitching more than 100 innings in a year (×3.5 shoulder injury)[a] • Concomitantly playing catcher and pitcher	10 years	26
Lyman et al, 2001[30]	476 pitchers (9-14 years)	50% (elbow or shoulder pain)	Questionnaires + pitch count logs + video analysis	• Curveball (52% increased risk)[a] • Number of pitches in a match and in a season[a]	1 season	33.5
Matsuura et al, 2017[32]	900 players (7-11 years)	18.3% shoulder pain	Follow-up questionnaire after 1 year (mail)	• Pitcher position[a] • Catcher position[a] • Longer training hours per week[a] • History of shoulder or elbow pain[a]	1 year	23.5
Handball						
Forthomme et al, 2018[18]	106 male high-level handball players (24 ± 4 years)	22% shoulder injuries during the season (14% microtraumatic and 8% traumatic) Incidence rate of 1.13 shoulder injuries/1000 play hours	Isokinetic dynamometer (Cybex)	• Backcourt players (×3.5 shoulder injury)[a] For traumatic injuries: • Weakness IR conc 240 deg/s[a] • More game hours per month[a]	1 season	32.5
Clarsen et al, 2014[9]	206 elite handball players (≈24 years)	28% of shoulder injuries	Digital inclinometer, handheld dynamometer	• Decrease total ROM[a] • Decrease ER strength[a] • Obvious scapular dyskinesis[a]	1 season	43
Möller et al, 2017[35]	679 handball players (14-18 years)	106 shoulder injuries (85 in the dominant arm) Incidence rate of 1.4/1000 playing hours	Goniometer + handheld dynamometer + phone, SMS, and medical examination	• Increasing >60% handball load[a] • Increasing >60% handball load + ER weakness[a] • Increasing 20%-60% handball load + scapular dyskinesis[a] • Increasing 20%-60% handball load + ER weakness[a]	31 weeks	29
Seil et al, 1998[41]	186 handball players (≈25.8 years)	91 injuries (37% upper limb) 2.5 injuries/1000 play hours	Questionnaire	• Games > training (×20)[a] • Regional level > local level (practice)[a] • Wing players (36%) and backcourts players (33%)[a]	1 season	25.5

(continued)

Table 1. (continued)

Author, Year of Publication	Study Participants (Age)	Rate of Shoulder Injury	Material, Equipment	Risk Factors Identified	Length of Tracking	Quality Score
Edouard et al, 2013[14]	16 female elite handball players and 14 healthy female nonathletes (≈18 ± 1 years)	9 injuries on the dominant side Incidence rate of 1.07 injuries/1000 training hours	Isokinetic dynamometer (Con-Trex)	• ER conc/IR conc at 240 deg/s <0.69[a] • IR ecc/ER conc at 60 deg/s >1.61[a] • High BMI[a] • High height[a]	1 season	24.5
Giroto et al, 2017[21]	339 handball players (156 men and 183 women) (≈23.4 ± 4.6 years)	312 injuries and 201 athletes injured Incidence rate of 3.7/1000 training hours and 20.3/1000 game hours	Questionnaire	Overuse injuries • History of injury[a] • Playing 1 more match per week[a]	7 months	34.5
Tennis						
Hjelm et al, 2012[23]	55 tennis players (35 men, 20 women) (12-18 years)	100 new and recurrent injuries (39 players) (24% upper extremity)	Goniometer, inclinometer	• History of injury[a] • Total number of play by year[a] • Number of years of practice[a]	2 years	35
Basketball						
Meeuwisse et al, 2003[34]	318 basketball players	10 shoulder injuries	Questionnaire	• Games > practice (×3.7 injuries)[a] • History of injury[a]	2 years	25.5
Volleyball						
Forthomme et al, 2013[19]	66 volleyball players (first and second division) (34 men, 32 women) (24 ± 5 years)	23% (15) of the volleyball players experienced dominant shoulder pain	Isokinetic dynamometer (Cybex)	• History of injury (×9)[a] • Less ecc 60 deg/s IR strength[a] • Less ecc 60 deg/s ER strength[a]	6 months (indoor season 2008-2009)	30
Wang and Cochrane, 2001[53]	16 elite volleyball players	7 patients had shoulder injury or pain	Goniometer, isokinetic dynamometer (Kin-ComAP Muscle Testing System)	• Ecc ER < conc IR[a]	1 season	23

(continued)

Table 1. (continued)

Author, Year of Publication	Study Participants (Age)	Rate of Shoulder Injury	Material, Equipment	Risk Factors Identified	Length of Tracking	Quality Score
Swimming						
Chase et al, 2013[8]	34 swimmers (16 men and 18 women) (≈19.5 ± 1.4 years)	31 injuries in 20 swimmers (13 by 9 male and 18 by 11 female) Incidence men = 5.33/1000 hours; incidence women = 6.5/1000 hours	Injury report interview	• History of injury (at the same localization or at another localization)	8 months	21
Walker et al, 2012[52]	74 competitive swimmers (37 men, 37 women) (≈15 ± 3 years)	38% shoulder pain and 23% shoulder injury Incidence shoulder pain = 0.3/1000 swim km; incidence shoulder injury = 0.2 injuries per 1000 swim km	Goniometer	• ER ROM <93° (12.5× shoulder pain and 32.5× shoulder injury) or >100° (8.1× shoulder pain and 35.4× shoulder injury)[a] • History of injury (4.1× shoulder pain and 11.3× shoulder injury)[a] • Training (90%) > competition[a]	1 year	26
McKenna et al, 2012[33]	39 swimmers and 43 nonswimmers (≈14 years)	23.9% shoulder pain in swimmers and 30.8% (12 of 39) in nonswimmers	Measuring tape	• High BMI • Scapular dyskinesis (inferior distance scapula and thoracic spine) • Lower horizontal distance between anterior part of glenohumeral head and anterior part of the acromion (more posterior humeral head)	1 year	31.5
Others						
Struyf et al, 2014[46]	113 recreational overhead athletes (59 women, 54 men) (≈34 years)	22% shoulder pain	Sliding caliper, inclinometer, "Mean Disability Shoulder Questionnaire"	• Less scapular upward rotation at 45° and 90° of shoulder abduction (frontal plane)[a]	2 years	31.5

BMI, body mass index; conc, concentric; ecc, eccentric; ER, external rotation; GIRD, glenohumeral internal rotation deficit; HA, horizontal adduction; IR, internal rotation; ROM, range of motion; SMS, short message service (text); US, ultrasound.
[a]Significant risk factor.

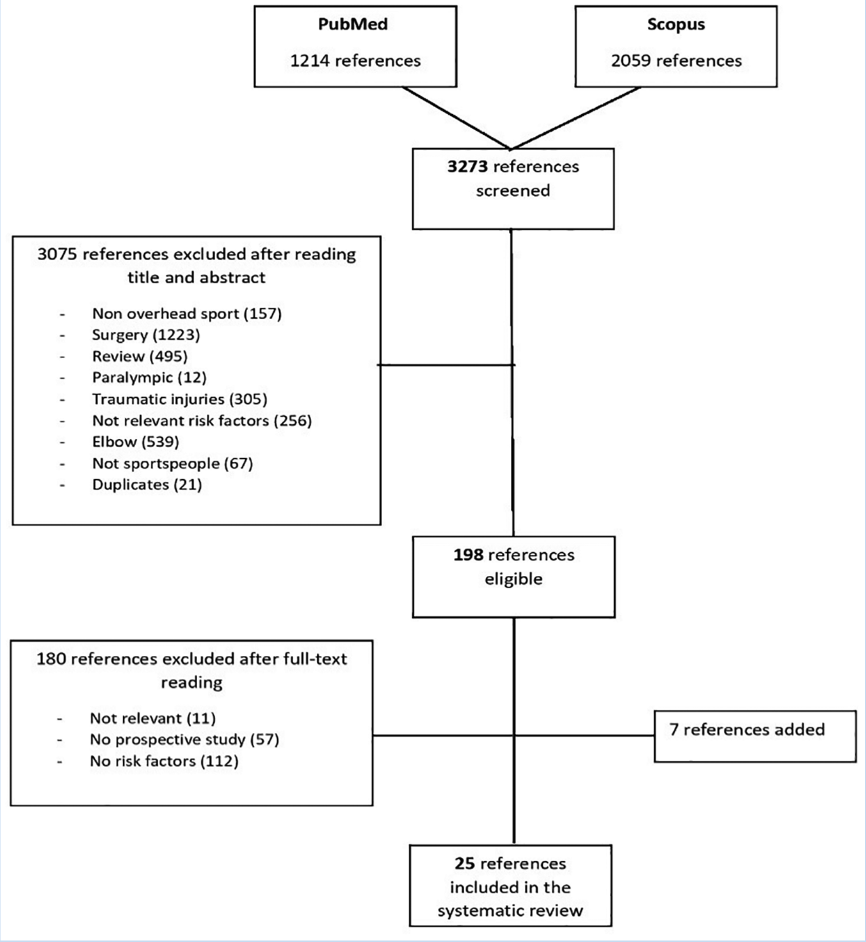

Figure 1. Research strategy using the PRISMA (Preferred Reporting Items for Systematic Meta-Analyses) guidelines.

Data Extraction and Quality Assessment

The studies in this systematic review included participants from 6 different sports: baseball (n = 11), handball (n = 6), swimming (n = 3), volleyball (n = 2), tennis (n = 1), and basketball (n = 1). Additionally, 1 study included recreational overhead athletes without distinction between sports. Participant age ranged between 7 and 36.6 years. A total of 17 studies included male athletes, 7 included both male and female athletes, and 1 included only female athletes. The duration of follow-up was quite variable, ranging from 31 weeks to 10 years, with a mean (±SD) follow-up period of 2.23 ± 2.4 years. The standard deviation is larger than the mean, which shows an important interstudy variability in the length of follow-up.

The level of evidence of the included articles was between 1 and 3, but it was not specified in 10 articles. The quality score of the articles was calculated as the average of the scores from the 2 investigators. Statistical analysis showed a very good interrater agreement both for *t* test ($P = 0.752$) and for intraclass correlation coefficient (0.981; range, 0.958-0.992). The scores varied between 21 and 43 of a total of 64, with a mean score of 30.4 ± 6.00. The score assigned to each article can be found in Table 1. The score provided is the mean score from the 2 investigators.

Risk Factors for Shoulder Injuries

The different risk factors of shoulder injuries identified in the studies are summarized in Table 2 (intrinsic factors) and Table 3 (extrinsic factors).

DISCUSSION

The purpose of this systematic review is to identify risk factors of overuse shoulder injury in overhead athletes. Despite the important variability of the quality of the studies, several intrinsic and extrinsic risk factors have been highlighted among the 25 studies retained. All of these factors should be considered in managing overhead athletes, and the modifiable ones may be the subject of preventative strategies.[1,10,11]

Glenohumeral internal rotation deficit resulting from posterior shoulder stiffness[40,47] is frequently observed after practice.[2,9,20,23] Even though Burkhart et al[3] suggested that an internal rotation deficit less than 20° was acceptable, Shanley et al[42]

Table 2. Intrinsic risk factors of shoulder injuries

Intrinsic Risk Factors	Study	For (+) or Against (-)
History of shoulder pain, with or without shoulder injury	Meeuwisse et al, 2003	+
	Walker et al, 2012	+
	Hjelm et al, 2012	+
	Forthomme et al, 2013	+
	Chase et al, 2013	+
	Giroto et al, 2017	+
	Matsuura et al, 2017	+
Range of motion and shoulder flexibility	Shanley et al, 2012	+
	Tyler et al, 2014	–
	Shanley et al, 2015	+
	Wilk et al, 2015	–
Muscle weakness and agonist/antagonist imbalances	Byram et al, 2010	+
	Forthomme et al, 2013	+
	Tyler et al, 2014	+
	Clarsen et al, 2014	+
	Shitara et al, 2017	+
Scapular dyskinesis	McKenna et al, 2012	+
	Hjelm et al, 2012	–
	Myers et al, 2013	–
	Clarsen et al, 2014	+
	Struyf et al, 2014	+
Years of practice	Hjelm et al, 2012	+
	Chase et al, 2013	–
	Clarsen et al, 2014	–
Body mass index	McKenna et al, 2012	+
	Edouard et al, 2013	+
	Clarsen et al, 2014	–
Sex	Forthomme et al, 2013	+
	Giroto et al, 2017	+
Age	Clarsen et al, 2014	–
	Matsuura et al, 2017	–
Level of play	Seil et al, 1998	+
	Clarsen et al, 2014	–

Table 3. Extrinsic risk factors of shoulder injuries

Extrinsic Risk Factors	Study	For (+) or Against (-)
Field position	Seil et al, 1998	+
	Smith et al, 2015	+
	Matsuura et al, 2017	+
	Forthomme et al, 2018	+
Match or training	Seil et al, 1998	+
	Walker et al, 2012	+
Training load/frequency of the matches	Lyman et al, 2002	+
	Fleisig and Andrews, 2012	+
	Hjelm et al, 2012	+
	Tyler et al, 2014	+
	Matsuura et al, 2017	+
	Møller et al, 2017	+

demonstrated that, in baseball, a side-to-side difference of 13° still increased the risk of shoulder injuries by a factor of 6. The sleeper stretch can be performed regularly by athletes with glenohumeral internal rotation deficit to loosen the shoulder joint.[11,12] Moreover, an excess of external rotation range of motion, which can increase anteroinferior instability,[51] could be modified by proprioception and motor control exercises.[39]

Even if causes of scapular dysfunction are quite disparate, Kibler[26] recommend 2 different types of alterations: a lack of extensibility and an altered motor pattern. Pectoralis minor stretching could be done in association with TheraBand exercises to normalize scapular motor pattern.[25,31]

As demonstrated in this review, there should be a focus on strengthening the external (concentric and eccentric modes) and internal (eccentric mode only) rotators to provide stability to the humeral head during movement of the upper extremity in overhead athletes. Athletic equipment such as elastic bands and dumbbells can be used, even if the gold standard remains the isokinetic dynamometer, which can instantly adapt the resistance to the individual strength of the athlete.

The importance of optimal management of the training load must be emphasized. The frequency of sports matches and the intensity of training have an important influence on shoulder issues, thereby amplifying strain injuries caused by inadequate movement and lack of recovery time.[16,29,32] Coaches and trainers should be aware of the importance of quantifying training load and adapt it to each athlete.

This systematic review has several limitations. The first is the variability of the different studies included in this review. The level of evidence varied between 1 and 3 for each study. Moreover, the MCMS scores of the included articles are between 21 and 43 out of a total of 64. It is clear that there are differences between articles regarding methodology and quality. Additionally, the populations that were examined varied in age, number of athletes included, sport practiced, hours of training, level of play, and history, which may influence the results. Finally, the length of study varied, with athletes examined between a 0- and 10-year time span.

CONCLUSION

This systematic review highlights important risk factors for shoulder injuries in overhead athletes. Prevention is an existing topic, but the small numbers of prospective studies published on that topic in the literature and the important variability of the quality of the studies included in this systematic review show that risk factors of shoulder injuries in overhead sports are still not completely demonstrated. Biomechanics differs from one sport to another. Although there are 11 studies on baseball, there are other sports such as volleyball, tennis, and badminton that beg to be explored if prevention is to be mastered. The true efficiency of prevention programs to limit shoulder injuries in overhead athletes must also be further investigated.

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