The effectiveness of exercise interventions to prevent shoulder injuries in athletes: a systematic review protocol

Johannes Jacobus Wessel Swart¹ • Benita Olivier¹ ²

¹Department of Physiotherapy, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa; ²The Wits-JBI Centre for Evidenced-Based Practice: A JBI Affiliated Group, Johannesburg, South Africa

ABSTRACT

Objective: This review aims to evaluate the effectiveness of exercise intervention versus no intervention or alternate intervention to prevent shoulder injuries in athletes.

Introduction: Injury-prevention research has proven the effectiveness of exercise in preventing sports injuries in general and in the lower limb specifically. However, the results have been extrapolated to sport-related shoulder injuries from limited evidence. Similar reviews have been faced with insufficient high-quality evidence and limited studies due to restrictive target populations, resulting in reduced generalizability.

Inclusion criteria: Peer-reviewed randomized controlled trials, with adequate control arms, investigating shoulder-injury events after exercise intervention in athletes, both training or competing in sports, will be included. Studies with substitute end points for injury events and non-self-propelled athletes, or vehicle assisted athletes, will be excluded.

Methods: A comprehensive search of multiple databases will be used to find relevant studies. The databases will be searched from inception to April 2021, with no language restrictions imposed. Keywords and derivatives of “sport,” “exercise intervention,” “prevention,” “shoulder injury,” and “randomized controlled trials” will be used. Sources will include Academic Search Ultimate (EBSCOhost); CINAHL Plus (EBSCOhost); Cochrane Central Register of Controlled Trials (Wiley); MasterFILE Premier (EBSCOhost); MEDLINE (PubMed); Physiotherapy Evidence Database (PEDro); ProQuest Health and Medical Complete and Nursing and Allied Health Source (ProQuest Complete); ScienceDirect (Elsevier); Scopus (Elsevier); SPORTDiscus (EBSCOhost); and Web of Science (Clarivate Analytics). Data extraction and synthesis will follow the JBI Manual for Evidence Synthesis guidance for systematic reviews of effectiveness.

Systematic review registration number: PROSPERO CRD42020204141

Keywords: exercise interventions; primary prevention; shoulder injury; systematic review


Introduction

Physical activity can significantly and positively enhance health, with injury being the only real adverse effect.¹ Upper limb injuries contribute up to 21.4% of all injuries sustained during practice in a variety of team sports.² The repetitive nature of some sports can result in higher incidences of shoulder injuries in individual sports, with an incidence of up to 91% of shoulder injuries occurring in elite swimmers.³ Shoulder injuries can cause significant dysfunction and disability in sports with high recurring upper-limb loads.⁴ The high loads from excessive repetitive shoulder rotary movements in sports like swimming, or the explosive shoulder actions found in primary throwing sports, can result in injury.⁵

The incidence of injury to the upper limb is lower than that of the lower limb, which can justify the disproportional amount of literature related to lower-limb injury prevention.⁶,⁷ However, this appears unjustified when comparing the evidence amassed in preventing a relatively rare condition,
such as an anterior cruciate ligament injury (ACL). An ACL injury has an incident rate of 2.10 per 10,000 athletic exposures for contact sports and 0.36 per 10,000 athletic exposures for non-contact sports; even in high-risk sports only one out of 80 athletes sustain an injury to the ACL. The limited research resources spend on shoulder-injury prevention seems unfounded. There exists a clear need for a specific review on shoulder-injury prevention.

Adult athletes experience an average burden of injury of two weeks per season. In 45% of youth athletes, more than a week’s loss of training is due to injury. A resultant 65% reduction in the achievement of their performance goals occurs in athletes who sustain more than one injury requiring a modification of more than 20% of their seasonal training weeks. The impact of an injury on an athlete produces a physical, psychological, performance, and financial fallout that requires management over several seasons. Prevention is better than cure in breaking the chain reaction that develops as a sequela of injury.

In order to prevent sporting injuries, contemporary research trends advocate primary-injury reduction strategies, such as rule adaptation, neuromuscular training, and equipment modification for at-risk populations, particularly active youths and adolescents. These recommendations were developed from a disproportional lower-limb research focus, ignoring the upper extremity’s unique characteristics. This intense lower-limb focus is consistently defended from a utilitarian perspective and appeals to the successful outcomes. Nevertheless, the risk and burden associated with shoulder injuries necessitate a more specific and rigorous investigation.

A preliminary search of PROSPERO, MEDLINE, the Cochrane Database of Systematic Reviews, and JBI Evidence Synthesis was conducted and no similar systematic review on the topic was identified. A systematic review from 2014 performed an analysis on which components of exercise-prevention programs prevented lower-limb injuries. Out of the 25 studies included, eight investigated “all injuries”; however, no included study focused on the shoulder specifically, and very few contained specific upper-limb exercises. Additional evidence is required to endorse the generalizability of exercise effectiveness to reduce shoulder injuries, as inferred in the studies evaluating “all injuries.”

The shoulder was explicitly targeted in a 2018 systematic review. This review investigated shoulder injury risk factors and prevention in overhead sports. The study limited the inclusion population to overhead athletes. The primary aim was to identify and categorize the risk factors for sustaining shoulder injuries. The secondary objective was to synthesize the evidence for the prevention of shoulder injury in overhead athletes. One relevant study matched the pre-planned inclusion criteria.

Potentially collatable studies investigating or including shoulder injuries have recently been published for baseball, cricket pace bowlers, football, handball, tennis, and volleyball. Relevant articles can be included from specific sporting codes, which are regularly excluded due to limitations on the population or injury method.

The recent influx of studies provides a persuasive argument to investigate the feasibility of producing a systematic review on shoulder injuries in sport.

High-quality systematic reviews propose strength training as superior or at least essential compared to all other components of injury-prevention programs for injuries in general, and to the lower limb specifically. The literature on whether or not exercise interventions can reduce shoulder injuries and, if so, which specific elements of the program produce the proposed effect, is unclear. Current research extrapolation has substituted specific investigation into shoulder-injury prevention, resulting in some studies reporting diverse findings when interventions are applied.

This review will have four aims. The main aim will be to summarize the available evidence on shoulder-injury prevention in sport. The second aim will be to provide estimates of acute injury versus overuse. The third aim will be to describe and categorize the different types of exercise interventions found in the injury-prevention programs. Exercises will be categorized into strength, stretching, and flexibility, mobility, plyometrics, balance and proprioception, or multiple components.

Furthermore, the final aim will be to describe and categorize the components of shoulder-exercise-intervention programs into open kinematic chain exercises versus closed kinematic chain exercises. To the authors’ knowledge, no meta-analysis on the effectiveness of exercise to prevent shoulder injury exists. Producing a meta-analysis will enable...
new and thought-provoking information, furthering recommendations for prospective studies in the field.

**Review question**

What is the effectiveness of exercise intervention versus no intervention or alternate intervention in the prevention of shoulder injury in athletes?

**Inclusion criteria**

**Participants**

This review will consider all studies that include human athletes participating in any sports forms, irrespective of sex, age, ethnicity, setting, geographical location, or level of skill. Study participants are typically healthy and free of injury at the start of injury-prevention studies; however, in order to investigate acute injury versus overuse (chronic) data, the inclusion of both injured and uninjured participants is necessary. An athlete with an overuse index injury regularly continues to participate and can partake in exercise interventions to prevent secondary injuries, which can be either recurring or subsequent injuries during a season. Non-self-propelled or vehicle-assisted sports will be excluded due to the high levels of damage sustained from collisions. Collision injuries have no bearing on the biomechanical and neuromuscular adaptations that exercise intervention is purported to facilitate.

Sport will be defined according to PubMed’s medical subject headings (MeSH): “Activities or games, usually involving physical effort or skill. Reasons for engagement in sports include pleasure, competition, or financial reward.” As athletes compete in sport, the definition will provide absolute clarity if the definition of sport is ambiguous. A summary definition from the literature is presented for an athlete: An athlete must train to improve performance and results; participate actively in competitions while formally registered; and devote a considerable amount of time to the endeavor.

**Interventions**

This study will consider literature that assesses the effectiveness of all exercise interventions aimed at preventing injury to the shoulder. All types of exercise intervention will be included and grouped primarily into six categories: i) strength, ii) stretching and flexibility, iii) mobility, iv) plyometrics, v) balance and proprioception, or vi) multiple components of exercise.

An exercise intervention will be included if it conforms with and corresponds to the definition of exercise. Exercise will be defined as: “a potential disruption to homeostasis by muscle activity that is either exclusively, or in combination, concentric, eccentric or isometric.” Exercise interventions include bodily activity meant to improve health, and typically consist of strength, stretching, mobility, plyometrics, balance, or multimodal exercise components.

**Comparator**

This review will consider studies that compare the intervention to either a pure passive control group receiving no interventions (eg, regular training, usual practice, or no additional training) or an active control arm receiving alternate forms of intervention (eg, other programs, technique feedback, supplementation, equipment inclusion, or adaptation of assistive devices).

**Outcomes**

The primary outcome measure of interest is shoulder injury or pain, as defined by the authors. Similarly, the definitions provided for the outcome measures in each individual study will be applied. In circumstances where the injury definition is ambiguous, this study will define an injury according to the definition of the International Olympic Committee: “Injury is tissue damage or other derangement of normal physical function due to participation in sports, resulting from the rapid or repetitive transfer of kinetic energy.”

The injury rates and relative risk (RR) will be calculated using the number of injuries, odds ratios (OR), rate ratios (rr), hazard ratios (HR), and incident rate ratio (IRR) reported in the studies or calculated using STATISTICA (Statsoft, Tulsa, OK), based on raw data provided in the included studies. An injury of the shoulder area will include injuries of the rotator cuff, clavicle, scapula, and the proximal biceps tendon. Research in injury prevention regularly reports injuries in an upper- and lower-extremity split. A subgroup analysis of upper-extremity injuries will be performed in addition if the data permits.

Secondary outcomes will include providing acute versus overuse data (according to each study’s
definition) estimates, if feasible. An overuse injury is defined as repetitive micro-trauma over multiple events that may have either a gradual or sudden onset, while a singular sudden traumatic event results in acute injuries. Secondly, the aim will be to describe and categorize the different types of exercise interventions found in injury-prevention programs, mainly: strength, stretching and flexibility, mobility, plyometrics, balance and proprioception, or multiple components of exercise. Thirdly, we will describe and categorize the components of the intervention program’s shoulder-specific exercises into a closed or open kinematic chain, in order to establish an overview of current prevention programs for the sporting shoulder.

Types of studies
All randomized controlled trials (RCTs) will be eligible for consideration. Published and unpublished literature in all languages will be considered, and the relevant articles in other languages will be translated. Studies measuring controlled clinical outcomes (eg, shoulder strength) will be excluded. Quasi-experimental studies and observational studies will only be included in the absence of RCTs on the subject matter. The decision to include only RCTs is based on the concern that studies with a high risk of bias can intensify bias if pooled rather than reduce it.

Methods
A priori registration in PROSPERO (CRD42020204141) has been completed. JBI methodology will be followed for conducting a systematic review of effectiveness. The design will incorporate the framework as per the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. Protocol amendments will be dated, will include an explanation of the alteration, and will provide a rationale.

Search strategy
A three-step sequential strategy will be used to discover the relevant studies. The search process will be designed and implemented to uncover published and unpublished studies. Firstly, a restricted investigative search in MEDLINE (PubMed) will be performed using the keywords “shoulder injury,” “primary prevention,” and “exercise intervention.” The initial search will enable the investigation into which text words and index terms are required to develop a comprehensive search strategy for MEDLINE (PubMed).

The literature search will be designed to include both MeSH terms and text words. Search terms from similar reviews will be screened to determine the completeness of the strategy. The second search will be expansive and employ all the identified keywords and index terms contained in a fully developed search strategy with the adaptations required by each specific database. The search procedure for MEDLINE (PubMed) is attached (Appendix I). Thirdly, the bibliography of critically appraised articles selected for inclusion will be scrutinized for further studies.

All databases will be searched from inception to April 2021, with an updated search to be performed near the end of the review. All RCTs contained in the previous reviews will be included if they comply with the inclusion criteria. The databases to be searched from inception up until April 2021 include: CINAHL Complete (EBSCOhost); Cochrane Central Register of Controlled Trials (Wiley); MEDLINE (PubMed); Physiotherapy Evidence Database (PEDro); ProQuest Health and Medical Complete and Nursing and Allied Health Source (ProQuest Complete); ScienceDirect (Elsevier); Scopus (Elsevier); SPORTDiscus (EBSCOhost); and Web of Science (Clarivate Analytics). Source of unpublished studies and gray literature will include Academic Search Ultimate (EBSCOhost) and MasterFILE Premier (EBSCOhost).

Study selection
Following the search, all identified citations will be collated and uploaded into EndNote v.9.3 (Clarivate Analytics, PA, USA) and duplicates removed. Two independent reviewers will then screen the titles and the abstracts against the inclusion criteria for the review. Potentially relevant studies will be retrieved in full and their citation details imported into the JBI System for the Unified Management, Assessment and Review of Information (JBI SUMARI; JBI, Adelaide, Australia). The full text of selected citations will be assessed in detail against the inclusion criteria by two independent reviewers. Reasons for exclusion of full-text studies that do not meet the inclusion criteria will be recorded and reported in the systematic review. Any
disagreements between the reviewers at any stage of the study selection process will be resolved through discussion or via arbitration by a third reviewer. The results of the search will be reported in full in the final systematic review and presented in a Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram.³⁶

**Assessment of methodological quality**

Two independent reviewers will critically appraise the selected studies. The methodological quality will be assessed after review inclusion. The standardized JBI critical appraisal checklist for randomized controlled trials will be utilized for RCTs and the JBI critical appraisal checklist for quasi-experimental studies will be used if non-randomized experimental studies require inclusion. If a disagreement arises between the reviewers, a discussion will be held to resolve the dispute by consensus. If no agreement can be reached, the decision of a third independent reviewer will be final.

In the case of missing, incomplete, or ambiguous data, an open-ended email will be addressed to the corresponding author. The results of the critical appraisal will be reported in narrative form and a table. All studies, regardless of the results of their methodological quality, will undergo data extraction and synthesis.

**Data extraction**

A two-reviewer, independent data-extraction process will be applied, and a table based on the standardized data extraction tool from JBI-SUMARI will be used. The retrieved data will include the details relating to population demographics, type of intervention and characteristics, primary and secondary outcome measures, and the critical appraisal rating (Appendix II).

In the case of missing, incomplete, or ambiguous data, an open-ended email will be addressed to the corresponding author. Any disagreements between the reviewers will be resolved through discussion or by arbitration of a third reviewer.

**Data synthesis**

The rationale is to pool quantitative data for a statistical meta-analysis using JBI SUMARI. If pooling is not possible, a narrative method will be applied to represent the data using tables and graphs. Effect sizes for categorical data will be reported as RR and continuous data as standardized mean differences. Relative risk is intuitively interpreted and enables greater access for a layperson, as OR may be challenging to understand.³⁸,³⁹ The confidence intervals will be calculated at 95% for analysis of the effect sizes.

Sensitivity analysis will be performed to investigate the robustness of the results and the influence that variances in study design, statistical methods, and methodology have on the effect estimates. Analyses will be performed testing the inclusion of different cluster adjustment methods; performing synthesis utilizing different statistical models, methods, and effect measures; and assessing the inclusion of methodological quality of studies included. The testing will ascertain if similarity exists regarding the effect magnitude and direction.

The standard Cochran’s Q and its P value, together with the χ² statistical assessments, will identify statistical heterogeneity. The I² and τ² statistical tests will quantify the heterogeneity. The thresholds for heterogeneity will be classified as unimportant (0 to 40%), moderate (30% to 60%), substantial (50% to 90%), and considerable (75% to 100%).⁴⁰ The lower the P value of the heterogeneity, the more significant the clinical heterogeneity (keeping in mind that the P-value’s significance is set at 0.1 due to the statistical test’s low power).⁴¹

The performance of sub-group analysis will be executed as the broad topic is expected to produce high levels of inconsistency, requiring the identification of the clinical or methodological sources of heterogeneity.⁴² Subgroups will enable the comparison of the effects in the following pre-planned groups: shoulder injuries/upper-extremity injuries; acute/overuse shoulder injuries; shoulder specific/non-specific programs; upper/lower-extremity-dominant sports; and RCTs/cluster RCTs. Shoulder-specific programs are deemed such if the applicable study provides a statement to that effect or the program includes four or more shoulder-targeted exercises. Lower-extremity-dominant sports require the lower limb for the majority of sport-specific maneuvers and skills.

Analytical examinations will be done using a fixed-effect model if there are less than five studies included and a random-effects model if there are five or more studies included.⁴³ A funnel plot will be created in STATA v.16 (StataCorp. 2019, LLC, Texas) to assess publication bias and tested by funnel
plot asymmetry where suitable, using the Egger, Begg, or Harbord statistical tests. A funnel plot will not be performed for less than 10 studies. A double-data-entry methodology will be utilized to reduce errors.

Assessing certainty in the findings
The Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) approach for grading the certainty of evidence will be followed. A Summary of Findings (SoF) will be created using GRADEPro (McMaster University, ON, Canada). The SoF will present the following information where appropriate: estimates of relative risk with injury incidence and a ranking of the quality of the evidence based on the risk of bias, directness, heterogeneity, precision, and risk of publication bias of the review results.

Acknowledgments
This review will contribute to a masters of science degree through the University of Witwatersrand for JS. The Faculty of Health Sciences has reviewed the protocol, and an ethical clearance waiver has been applied for from the University of the Witwatersrand’s Human Research Ethics Committee (HREC). NM is the second independent reviewer.

References


Appendix I: Search strategy

MEDLINE (PubMed)

Search conducted on 05/02/2021, retrieving 883 results

<table>
<thead>
<tr>
<th>Search</th>
<th>Query</th>
<th>Records retrieved</th>
</tr>
</thead>
</table>
### Search Query

<table>
<thead>
<tr>
<th>Search</th>
<th>Query</th>
<th>Records retrieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>#6</td>
<td>“randomized controlled trial””[Text word] OR “randomised controlled trial””[Text word] OR “randomized clinical trial””[Text Word] OR “randomised clinical trial””[Text Word] OR “randomized controlled trial”[Publication Type]</td>
<td>761,572</td>
</tr>
<tr>
<td>#7</td>
<td>#1 AND #2 AND #3 AND #4 AND #5 AND #6</td>
<td>883</td>
</tr>
</tbody>
</table>
Appendix II: Data extraction instrument

<table>
<thead>
<tr>
<th>First author’s last name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Publication year</td>
<td></td>
</tr>
<tr>
<td>Appraisal rating</td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td></td>
</tr>
<tr>
<td>Setting</td>
<td></td>
</tr>
<tr>
<td>• Sport</td>
<td></td>
</tr>
<tr>
<td>• Level</td>
<td></td>
</tr>
<tr>
<td>Participants</td>
<td></td>
</tr>
<tr>
<td>• Sex</td>
<td></td>
</tr>
<tr>
<td>• Age</td>
<td></td>
</tr>
<tr>
<td>Sample</td>
<td></td>
</tr>
<tr>
<td>• Sample size</td>
<td></td>
</tr>
<tr>
<td>• Drop-out rate</td>
<td></td>
</tr>
<tr>
<td>• Sample analyzed</td>
<td></td>
</tr>
<tr>
<td>• ITT/PP analysis</td>
<td></td>
</tr>
<tr>
<td>• Cluster adjusted</td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td></td>
</tr>
<tr>
<td>• Name or description</td>
<td></td>
</tr>
<tr>
<td>• Type</td>
<td></td>
</tr>
<tr>
<td>• Frequency</td>
<td></td>
</tr>
<tr>
<td>• Dose</td>
<td></td>
</tr>
<tr>
<td>• Compliance</td>
<td></td>
</tr>
<tr>
<td>• Categorisation</td>
<td></td>
</tr>
<tr>
<td>• OKC vs CKC</td>
<td></td>
</tr>
<tr>
<td>Outcome measures</td>
<td></td>
</tr>
<tr>
<td>• shoulder or upper extremity</td>
<td></td>
</tr>
<tr>
<td>• number of injuries (INV vs CON)</td>
<td></td>
</tr>
<tr>
<td>• acute versus overuse</td>
<td></td>
</tr>
<tr>
<td>• Primary outcome</td>
<td></td>
</tr>
<tr>
<td>Bias and main limitations</td>
<td></td>
</tr>
</tbody>
</table>

CKC, closed kinematic chain; CON, control group; INV, intervention group; ITT, intention to treat; OKC, open kinematic chain; PP, per protocol