CRITICALLY APPRAISED TOPIC

FOCUSED CLINICAL QUESTION

For overhead athletes (ideally but not limited to tennis players) (P), do specific interventions (I) reduce the risk of shoulder injury (O) compared to standard training (C)?

AUTHOR

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CLINICAL SCENARIO

A 20-year old female that played Division 1 college-tennis, specifically in the top positions of both singles and doubles, was experiencing mild shoulder pain during the off-season. During the pre-season these symptoms progressed to more severe shoulder pain, including limitations in shoulder strength and shoulder fatigue following serving practice. The player was working with the team's athletic trainer, primarily to manage pain, in order to continue playing. She also took some time off during the off-season, which demonstrated some improvements in her symptoms, however, these symptoms quickly came back once she resumed training.

The player competed at the beginning of the season but about mid-season her symptoms were so severe that she was pulled from the singles and doubles line-up. She experienced severe pain when performing any stroke and was limited in active shoulder elevation and external rotation range of motion secondary to pain and stiffness. She was referred to an orthopaedic sports medicine surgeon and was diagnosed with internal impingement, with magnetic resonance imaging revealing a partial-thickness posterior supraspinatus tendon tear as well. The player was unable to compete in the remainder of the season.

There is a plethora of evidence in the literature that identifies common risk factors for shoulder injury in overhead athletes, with the 3 main ones being: glenohumeral internal rotation deficit (GIRD), weakness of the external rotator muscles and scapular dyskinesia.[1-3] Nonetheless, there is limited evidence in the evaluation of the effectiveness of preventive interventions that target these risk factors in overhead athletes, especially in tennis players. Sports physical therapists (PTs) play a vital role in the rehabilitation and prevention of injuries. Together with coaches, they are often the first line of defence for identifying risk factors and implementing prevention strategies. Thus, additional evidence that substantiates the benefits of shoulder prevention programs will aid in increasing their implementation across a wide range of overhead sports, in order to prevent injury and ultimately enhance performance.

SUMMARY OF SEARCH

[Best evidence appraised and key findings]

- Eight research studies were identified that met the inclusion/exclusion criteria, including 3 systematic reviews, 1 systematic review and meta-analysis, 2 randomized controlled trials and 2 quasi-experimental designs.
- A prevention program that includes exercises and stretches that aim at increasing internal rotation range of motion, external rotation and scapular muscle strength, as well as thoracic mobility is effective in reducing the prevalence of shoulder problems/pain and minor shoulder injuries in overhead athletes, however, may not be as effective in reducing the prevalence of severe shoulder injuries, compared to standard training alone.
- A prevention program only utilizing stretching, specifically the sleeper stretch that aims at increasing internal rotation range of motion, performed daily for 5 repetitions of 60 seconds, is effective in preventing mild to severe shoulder injuries, in overhead athletes, compared to standard training.
- Increasing compliance of the prevention program is a challenge in sports teams, which negatively affects the risk of experiencing moderate to severe shoulder injuries in overhead athletes.

CLINICAL BOTTOM LINE

A prevention program that aims at increasing internal rotation range of motion, external rotation and scapular muscle strength, can prevent shoulder injury in overhead athletes, compared to standard training. Evidence suggests that such a program can aid in preventing a wide range of shoulder symptoms, as well as reducing the severity of the shoulder symptoms and/or injury. Additionally, athletes with or without shoulder symptoms can benefit from preventive interventions, thus the training program of an overhead athlete should include preventive shoulder exercises.

This critically appraised topic has been individually prepared as part of a course requirement and has been peer-reviewed by one other independent course instructor

The above information should fit onto the first page of your CAT

SEARCH STRATEGY

Terms used to guide the search strategy			
Patient/Client Group	**I**ntervention (or Assessment)	**C**omparison	**O**utcome(s)
"Overhead athletes" Tennis players Baseball players Volleyball players	"Prevention exercises" "Prevention program" Strengthening program Stretching program Musculoskeletal screening "Biomechanical analysis" "Stroke analysis"	"Standard training" Practice	"Injury rate" "Rate of injury" "Risk of injury"

Final search strategy (history):

Show your final search strategy (full history) from PubMed. Indicate which "line" you chose as the final search strategy.

1. "overhead athlete*"
2. "tennis player*"
3. "baseball player*"
4. "volleyball player*"

5. "prevent* exercise*"
6. "prevent* program*"
7. prevention
8. "strength* program"
9. "strength* training"
10. "stretching program"
11. stretch*
12. strength*
13. "musculoskeletal screening"
14. "biomechanical analysis"
15. "stroke analysis"

16. "standard training"
17. training
18. practice

19. "shoulder injury"
20. "shoulder injury rate"
21. "shoulder rate of injury"
22. "risk of injury"

Final strategy: #1 AND #7 AND #19

In the table below, show how many results you got from your search from each database you searched.

Databases and Sites Searched	**Number of results**	**Limits applied, revised number of results (if applicable)**
PubMed	**67**	**42** – Applied filter: publication dates – 10 years
Embase	**16**	**9** – Applied filter: publication years – since 2010
CINAHL	**23**	**18** – Applied filter: publication dates – since 2010; Academic journals

INCLUSION and EXCLUSION CRITERIA

Inclusion Criteria
• Specifically addresses overhead athletes at any competition level (professional, college, high school or middle school, or amateur) • Prevention exercises or programs must include strengthening and/or stretching • Contain data regarding injury incidence or injury rate of overhead athletes • Systematic reviews • Meta-analysis • Meta-synthesis • Randomized control trials • Full text articles published in a peer reviewed journal
Exclusion Criteria
• Published more than 10 years ago • Narrative review • Case series and case studies • Quasi-experimental studies • Qualitative studies • Book reports • Poster presentations • Papers written in a language other than English

RESULTS OF SEARCH

Summary of articles retrieved that met inclusion and exclusion criteria

For each article being considered for inclusion in the CAT, score for methodological quality on an appropriate scale, categorize the level of evidence, indicate whether the relevance of the study PICO to your PICO is high/mod/low, and note the study design (e.g., RCT, systematic review, case study).

Author (Year)	Risk of bias (quality score)*	Level of Evidence**	Relevance	Study design
Andersson et al. (2017)[4]	Jadad scale: 3/5	2b	High	RCT
Mugele et al. (2018)[5]	AMSTAR: 4/11	2a	Moderate	Systematic Review
Sommervold et al. (2017)[6]	Jadad scale: 3/5	1b	Moderate	RCT
Shitara et al. (2017)[7]	Downs and Black checklist: 18/29	2b	High	Quasi-experimental design
Bullock et al. (2018)[8]	AMSTAR: 6/11	2a	Low	Systematic Review and Meta-analysis
Mine et al. (2017)[9]	AMSTAR: 6/11	1a	Low	Systematic Review
Niederbracht et al. (2008)[10]	Downs and Black checklist: 15/29	2b	Low	Quasi-experimental design
Asker et al. (2018)[11]	AMSTAR: 6/11	3a	High	Systematic Review

*Indicate tool name and score

**Use Portney & Watkins Table 16.1 (2009); if downgraded, indicate reason why

BEST EVIDENCE

The following 2 studies were identified as the 'best' evidence and selected for critical appraisal. Rationale for selecting these studies were:

- **Andersson et al. (2017)[4]**

  This randomized controlled trial provides level 2b evidence and has high relevance to the clinical question identified. It compares the effects of a specific prevention program that aims at increasing shoulder internal rotation, external rotation strength, scapular muscle strength and thoracic mobility, to standard training (control group), in the prevalence of shoulder problems and/or injuries. Interventions and outcome measures utilized both directly relate to my clinical question. The population evaluated are elite male and female handball players. Handball is considered an overhead sport, with similar mechanics to the overhead athlete of different sports, including tennis, thus results can be generalized.[1] The study includes randomization of participants and ensures allocation of concealment, which increased internal validity. However, it was rated of moderate to low risk of bias as it lacks blinding of participants and examiners.

- **Shitara et al. (2017)[7]**

  This is a quasi-experimental study with a 2b level of evidence that is of high relevance to my clinical question. It compares preventive measures, including strength training and stretching, to standard training (control group). The participants involved in the study are high school baseball pitchers, which is an overhead sport such as tennis. Evidence suggests that baseball overhead pitching consists of very similar biomechanics to the tennis serve, thus results can confidently be generalized to my clinical question and scenario.[12] Additionally, a log-rank test is utilized to identify incidence of shoulder/elbow injury, which is the primary outcome measure used and directly relates to my clinical question. It was rated with moderate risk of bias on the Downs and Black checklist due to the lack of blinding and randomization, as the athletes were instructed to choose the group they wanted to participate in. Even though this study may include some selection bias, the participants did not receive any information regarding the injury prevention aspect of the program.

I selected these two studies because they were two of the three articles that I reported to have 'high' relevance

to my clinical question. In addition, they are of moderate level of evidence and moderate methodological quality, which indicates that they have good enough strength and quality of their results to be utilized in practice. I did not choose the article by Asker et al., that I reported as having 'high' relevance to my clinical question, because even though it included what I mentioned above regarding the other two high relevance studies, in addition to preventive interventions it also analysed risk factors.[11] Reading and appraising the article and the studies it included I found that most studies targeted risk factors rather than preventive interventions.[11]

SUMMARY OF BEST EVIDENCE

(1) Description and appraisal of (Shoulder Stretching Intervention Reduces the Incidence of Shoulder and Elbow Injuries in High School Baseball Players: a Time-to-Event Analysis) by (Shitara er al., 2017)[7]

Aim/Objective of the Study/Systematic Review:

The aim of this quasi-experimental design, is to evaluate the effect of a prevention program that includes strength training and stretching, compared to standard training, on the incidence rate of shoulder and/or elbow injuries in high school baseball pitchers.

Study Design

[e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]

Note: For systematic review, use headings 'search strategy', 'selection criteria', 'methods' etc. For qualitative studies, identify data collection/analyses methods.

Shitara et al., is a quasi-experimental design, time-to-event analysis, that evaluates the effects of a prevention program on the incidence of shoulder/elbow injury in high-school baseball pitchers, in a prospective manner, over 150 days. This study lacked blinding of examiners and participants and lacked randomization to the groups, as participants were instructed to select the group they wanted to participate in. Nonetheless, the participants did not receive any information regarding the injury prevention aspect of the program. Examiners were only blinded to the participants' hand dominance during the medical-checkup that was performed at baseline to evaluate the athlete's preseason condition of their shoulders and elbows. The primary outcome measure utilized was incidence of shoulder/elbow injury. Participants were instructed to fill out a daily questionnaire regarding the adherence to their intervention program, shoulder/elbow pain and limitations in pitching, which was sent to the examiners every month. Shoulder/elbow injury was identified when a participant was disabled for 8 or more days. Additionally, the examiners called the participants 1-2 times per month to confirm they were completing their daily questionnaire, encourage participation in the intervention program and consult with them regarding their condition.

SAS 9.4 (SAS Institute Inc., Cary, NC) USA was utilized for statistical analyses, with a P=0.05 significance level. A one-way ANOVA was utilized to evaluate group differences, the Kaplan-Meier method was utilized to obtain time-to-event curves, multi-variate Cox regression models were utilized to identify the incidence of injury and a log-rank test was utilized to compare the survival distributions in the groups.

Setting

[e.g., locations such as hospital, community; rural; metropolitan; country]

High-school, however, the location and name of the high-school the baseball pitchers were from is not provided in the article. The 'Institutional Review Board of Gunma University Hospital' is the hospital identified that approved the study.

Participants

[N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]

Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article.

One hundred and thirty-two male high-school baseball pitchers participated in a yearly preseason medical check-up. Of those 92 agreed to participate, aged 15-17 years old. All 92 participants were followed till the end of the study with no drop-outs. 14 pitchers were included in the standard training group (control), 32 in the stretching exercise only group, and 46 in the stretching and strengthening exercise group; no pitchers selected to participate in the strengthening group only. Baseline characteristics including: baseball experience, body height, weight, abduction and internal rotation range of motion (ROM), horizontal adduction ROM, elbow flexion and extension ROM, and prone internal rotation and external rotation strength had no significant between-group differences, indicating that all players had the same risk of experiencing a shoulder injury during the season.

Intervention Investigated

[Provide details of methods, who provided treatment, when and where, how many hours of treatment provided]

Control

The control group (N-group) received no intervention, performing neither strengthening or stretching preventive exercises, but their standard training program. Participants were instructed to complete a daily self-recorded questionnaire that included presence of shoulder/elbow pain and any pitching limitations, that was sent to the examiners monthly. The examiners called the participants 1-2 times per month to assure they were completing the questionnaire and consult with them regarding their condition.

Experimental

The intervention groups included were: stretching exercise only group (S-group), strengthening exercise only group (M-group) and stretching and strengthening exercise group (SM-group). No participants elected to participate in the strengthening only group. During the preseason each participant received 30 minutes of one-on-one instruction by a physical therapist (PT) that focused on correct technique of the exercise. Additionally, an illustrated brochure was provided that included their specific exercise and key compensatory motions that they should avoid. The S-group independently performed the "sleeper stretch" on the throwing shoulder, daily for 5 repetitions of 60 second holds. The examiners instructed participants to perform the stretch following daily baseball practice rather than during their warm-up, in order to decrease variability in stretching performance. The SM-group performed the "sleeper stretch" described above, in addition to prone external rotation, with the throwing shoulder abducted 90° and elbow flexed 90°, while holding a plastic bottle filled with water (~500g). The PT instructed the participants to externally rotate their throwing shoulder for 1 second and then return to the starting position over 1 second, and to repeat that movement for 20 repetitions of 3 sets, with a short break in between sets. As the S-group, they were also instructed to independently perform their preventive stretching and strengthening exercises after daily baseball practice.

Outcome Measures

[Give details of each measure, maximum possible score and range for each measure, administered by whom, where]

The outcome measure utilized was incidence of injury, that was obtained using a self-recorded questionnaire that participants completed daily and was sent to the examiners on a monthly basis. Shoulder/elbow injury was identified when the pitcher was disabled for 8 or more days; any injury that occurred from another mechanism was excluded from the statistical analyses.

Main Findings

[Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable. You may summarize results in a table but you must explain the results with some narrative.]

<u>Incidence and median time to shoulder and/or elbow injury in the 3 groups evaluated:</u>

	S-group	SM-group	N-group
Incidence of shoulder/elbow injury	8 (25%)	16 (35%)	8 (57%)

Median survival times (days)	89	92	29.5

Based on the N-group, Kaplan-Meier analysis with a 95% confidence interval (CI), demonstrated hazard ratios of 0.36 and 0.47 in the S- and SM- group, respectively. Significance level was set at P=0.05 and when comparing groups via a log-rank test, it was found that injury incidence was significantly lower in the S-group compared to the N-group (p=0.04), however, there were no significant differences between the S- and SM-group (p=0.05) or between the SM- and N-group (p=0.06). Additionally, a post-hoc power analysis was performed, which identified the statistical powers between the N- and S-group, N- and SM-group and S- and SM-group as 0.85, 0.68 and 0.19, respectively. Thus, this indicates that only the comparison between the N- and S-group had high enough power, 85%, to detect a treatment effect when it occurs, with no more than 14% probability of making a Type II error. Whereas the other group comparisons identified had moderate to low power, indicating that a larger sample size was needed to detect a treatment effect and that there was a higher probability of making a Type II error.

Original Authors' Conclusions

[Paraphrase as required. If providing a direct quote, add page number]

The authors concluded that the utilization of the sleeper-stretch "significantly prevented baseball-related shoulder and elbow injuries and significantly prolonged pitching availability during the season" (p.4).[7] Thus, this further demonstrates the efficacy of an injury prevention program that includes self-stretching of the internal rotator muscles, specifically using the sleeper-stretch, in order to minimize the risk of shoulder/elbow injuries in high-school baseball pitchers.

Critical Appraisal

Validity

[Summarize the internal and external validity of the study. Highlight key strengths and weaknesses. Comment on the overall evidence quality provided by this study.]

Downs and Black checklist score: 18/29

Strengths:

The participants included in the study were all baseball pitchers from the same high-school, with no significant differences found in baseline characteristics that could have otherwise affected the results. This reduced variety in time-related factors, as all pitchers were participating in the same preseason and in-season, thus reducing the potential for negative effects in the time-to-event analysis.

The interventions for stretching and strengthening consisted of solely one exercise for each intervention, which limits the variables and allows the authors to more confidently determine an intervention/dose-response relationship. The interventions were performed post-baseball practice rather than during the athlete's warm-up, which reduced variability performed in stretching performance. Additionally, evidence suggests that the sleeper stretch is a very effective exercise to increase internal rotation, specifically as a preventive or return to sport intervention for overhead athletes.[1] Moreover, there is a plethora of evidence in the literature that demonstrates that glenohumeral internal rotation deficit (GIRD), weakness of the rotator cuff muscles, specifically the external rotators and scapular dyskinesis, are major risk factors for shoulder injury.[1-3]

Prior to the initiation of study, shoulder or elbow injury was defined and used uniformly across participants, that included the pitcher being disabled for 8 or more days, and all participants received the same instructions from the same PT regarding their intervention, including identical repetitions and sets for their specified intervention. Monthly phone calls to all participants were also provided, in order to increase compliance. Information regarding the prevention program was not provided to the participants, which aids in preventing selection bias and increasing internal validity.

Weaknesses:

There was no concealment or blinding of the participants or those measuring the main outcomes of the intervention, which increases bias. Participants were not randomized to intervention groups, as they had the freedom to choose which group they wanted to participate in, decreasing the internal validity and increasing self-selection bias that may have affected the results. Additionally, the study was low-powered secondary to a small sample size, which increases the likelihood of performing a Type II error. Sample sizes also differed between groups. Ultimately, this may account for the lack of statistical significance found between the S- and SM-group and between the SM- and N-group.

Data was collected from a single prefecture, which increases the likelihood of sample selection bias and decreases the external validity and generalizability of the results. Participants were 15-17 years of age, thus generalization to an older population may not be valid or reliable. Additionally, the authors fail to report

statistics regarding information on the injuries experienced (shoulder versus elbow). Therefore, we cannot confidently conclude if the positive effects are more beneficial in reducing one injury versus another.

Participants only received one-time instructions and feedback on the exercise they were prescribed, thus there is the potential that participants performed their preventive exercises incorrectly. While daily self-reported questionnaires were filled out, the authors fail to provide a statistical analysis regarding compliance level. Residual confounding factors could have also affected the validity of the results, and the authors had no control on whether the participants in the control group independently performed exercises/stretches similar to those in the intervention groups. In addition, the strength training protocol, including the load used, were identical for all the participants. This can be seen as a strength as it emphasizes uniformity but also as a weakness and the potential to have affected the results as each individual had different baseline external rotation strength. While there was no statistical difference in these baseline scores, it may still have impacted the results, as strength training programs are most effective when individualized to the athlete. Additionally, a strength training only group was not included in the study, thus strengthening cannot be excluded from a preventive program based on these results. Evidence also suggests that eccentric strengthening of the external rotators is most beneficial for decreasing risk of shoulder injury, thus an exercise emphasizing eccentric rather than concentric strength or instructions to emphasize the eccentric portion of the exercise provided would be a more effective preventive intervention.[1]

Interpretation of Results

[This is YOUR interpretation of the results taking into consideration the strengths and limitations as you discussed above. Please comment on clinical significance of effect size / study findings. Describe in your own words what the results mean.]

Daily self-stretching, utilizing the sleeper stretch (5 repetitions of 60 seconds) has statistically significant effects in reducing the incidence of shoulder and/or elbow injury in high-school baseball pitchers compared to a standard training. These statistically significant findings are due to the high power between the N- and S-groups, which demonstrates low probability of a Type II error occurring. Additionally, the small sample size and conservative p-value reduced the possibility of a Type I error occurring.

No statistical significance was found between the SM- and N-group, which is due to the moderate power between those groups, which ultimately increases the likelihood of a Type II error occurring. It is important to note that the S-group compared to the both the SM- and N-group had a higher sample size, which also likely affected the results. In addition, while no statistically significant difference was found in the SM-group compared to standard training (N-group), the incidence of injury was less in the SM-group (35%) compared to the N-group (57%).

In sum, increasing internal rotation range of motion using the sleeper-stretch is a vital component of an overhead athlete's prevention program and PTs should implement this strategy into practice. Further research is needed that evaluates strengthening of the external rotators in isolation to more accurately determine the effectiveness of this preventive intervention.

Applicability of Study Results

[Describe the relevance and applicability of the study to your clinical question and scenario. Consider the practicality and feasibility of the intervention in your discussion of the evidence applicability.]

This study has high relevance to my clinical question as it compared two different preventive interventions, strength training and stretching, to a standard training program. The primary outcome measure utilized was incidence of injury, which directly relates to my clinical question. Additionally, the participants included were baseball pitchers who are classified as overhead athletes. Even though the athletes evaluated were younger (high-school age) compared to the athlete in my clinical scenario (college age), evidence suggests a high similarity between the biomechanics and pathomechanics utilized in pitching and serving, making the results applicable to my clinical scenario.[12] Moreover, the study includes both shoulder and elbow injuries, whereas my clinical question and clinical scenario exclusively relates to shoulder injury.

The preventive interventions used in the study are very feasible, as the exercises utilized are safe, require no special equipment or extra space, are time-efficient and easy to perform independently, which increases the likelihood of utilization and compliance by sports teams and overhead athletes.

(2) Description and appraisal of (Preventing overuse shoulder injuries among throwing athletes: a cluster-randomised controlled trial in 660 elite handball players) by (Andersson et al., 2017)[4]

Aim/Objective of the Study/Systematic Review:

The aim of this randomized controlled trial is to evaluate the effect of the Oslo Sports Trauma Research Centre (OSTRC) Shoulder Injury Prevention Programme, which is an exercise program that aims at increasing shoulder internal rotation, external rotation strength, scapular muscle strength and thoracic mobility, compared to standard training, on the prevalence of overuse shoulder problems and injuries in elite handball players.

Study Design

[e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]

Note: For systematic review, use headings 'search strategy', 'selection criteria', 'methods' etc. For qualitative studies, identify data collection/analyses methods.

Andersson et al., is a two-armed cluster-randomized controlled trial that evaluates the effects of a prevention program on the prevalence of shoulder pain/problems in male and female elite handball players over 1 competitive season (7 months). This study included randomization by team to the intervention or control group, where a neutral, blinded individual performed and revealed the randomization, which ensured allocation concealment. A computer-generated list was utilized to randomize teams, in order to stratify for gender and competition level and further ensure that groups were comparable. Additionally, this study lacked blinding of participants and examiners. The primary outcome measure utilized was the prevalence of shoulder problems and substantial shoulder problems in the dominant side. This was measured six times during the season utilizing the OSTRC Overuse Injury Questionnaire that was sent via e-mail on the last Sunday of each month. The secondary outcome measure utilized was the severity score on the OSTRC Overuse Injury Questionnaire that was identified for all the athletes that reported a shoulder problem.

Statistical analyses were performed utilizing SPSS statistical software (SPSS V.21, IBM, New York, New York, USA). Generalized estimating equation (GEE) models were used to evaluate differences in the prevalence of shoulder problems and substantial shoulder problems between the two groups, with the significance level (α) set to 0.05. No confounding effects were identified, thus univariate analyses were performed.

Setting

[e.g., locations such as hospital, community; rural; metropolitan; country]

Two top divisions (elite level) of male and female handball teams in Norway.

Participants

[N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]

Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article.

The study included 22 teams (331 players, 160 females of average age of 22.5 years and 171 males of average age of 21.9 years) in the prevention group and 23 teams (329 players, 161 females of average age of 21.6 years and 168 males of average age of 23.5 years) in the control group. Following drop outs secondary to withdraw, retirement, pregnancy or acute injury, as well as participants with insufficient injury data, the participants included in the primary analysis consisted of 264 in the prevention group and 270 in the control group. In the prevention and control group, 139 and 146 players, respectively, had no shoulder problems at baseline and 125 and 124 players, respectively, had shoulder problems at baseline, as identified by the OSTRC Overuse Injury Questionnaire. No significant group differences were identified in the prevalence of shoulder pain/problems or in the prevalence of acute shoulder injuries or surgery that was reported at baseline. In addition, there were no significant differences in anthropometrics or demographics (gender, age, height, body mass) between the two groups, with the exception of the male participants in the intervention group being younger compared to the male participants in the control group, with an average of 21.9 years of age compared to 23.5 years of age, respectively. The average years the participants played handball was 14, the majority of the participants were right-handed (78%), with no statistical difference found in playing position or the average weekly time spent in handball training or match play. There was however, a statistically significant difference found in strength training, with the intervention group spending an average of 83 minutes per week on strength training compared to an average of 100 minutes per week by the control group ($p=0.004$).

Intervention Investigated

[Provide details of methods, who provided treatment, when and where, how many hours of treatment provided]

Control

The control group received no preventive interventions but were simply instructed to warm-up as they usually would and continued performing their stranded training program. The control group also received the OSTRC Overuse Injury Questionnaire by e-mail every month; a total of 6 times throughout the study.

Experimental

The intervention group participated in the OSTRC Shoulder Injury Prevention Programme that consisted of five exercises, with each exercise having 2-3 different variations or levels that the participants would alternate or progress every 6 weeks, with specified parameters identified for each exercise. These exercises aimed at increasing shoulder internal rotation range of motion, external rotation strength, scapular muscle strength and kinetic chain and thoracic mobility, as evidence suggests that there are major risk factors to shoulder injury in overhead athletes.[1-3] The exercises were to be performed 3 times per week during the player's warm-up, prior to throwing activity. The coaches, team captains and team medical staff received training on the protocol and performance of the program, as they were responsible for delivering the exercises, however, details of what that entailed are not provided. Teams were provided with the equipment needed to complete the program (resistance bands, weighted/unweighted balls, weights), as well as a poster with details regarding the exercises/stretches. The team's medical staff was instructed to be present for at least one session per week for the first 4 weeks and every second week for the remainder of the season, in order to ensure proper technique and that the correct parameters and load was utilized. A PT was recruited if a team did not have their own medical staff.

In addition, the examiners performed follow-up visits to all the teams in the intervention group at some point during the middle of the season, in order to ensure good quality of the exercises/stretches and increase compliance. As the control group, the OSTRC Overuse Injury Questionnaire was sent to all the participants on a monthly basis via e-mail. Reminders via e-mail and SMS were sent automatically to participants who failed to respond after 3 and 7 days. The team's medical staff was also responsible of reporting acute shoulder injuries by mail, on a monthly basis, in order to prevent risk of recording an acute shoulder injury as an overuse injury.

Outcome Measures

[Give details of each measure, maximum possible score and range for each measure, administered by whom, where]

The primary outcome measure used was the prevalence of shoulder problems and substantial shoulder problems in the player's throwing arm, that was measured using the OSTRC Overuse Injury Questionnaire, which was administered once per month, totalling six times throughout the program. This was administered as a self-repot questionnaire via an online software. Shoulder problems was defined as: "any pain, ache, stiffness, instability, looseness or other symptoms related to their shoulder" (p.1075).[4] Substantial shoulder problems were defined as "shoulder problems leading to moderate or severe reductions in training or performance, or a total inability to participate" (p.1075).[4] The OSTRC Overuse Injury Questionnaire consists of four questions with each question having 4 possible answer choices.[13] The participant is considered to have an overuse injury, or in this case a shoulder problem, if they report anything but the lowest response to all four questions.[13]

The secondary outcome measure used was severity score of the shoulder problems that were reported. This was calculated from the participants' responses in the OSTRC Overuse Injury Questionnaire. All responses were allocated a numerical value from 0 to 25, where the sum of the responses of each of the four questions gave a severity score of 0 to 100.[13] Questions 1 and 4 were scored 0-8-17-25, and questions 2 and 3 were scored 0-6-13-19-25.[13]

Along with the questionnaire the participants in the intervention group also self-reported their compliance to the prevention program. This one done by reporting their compliance in the last 7 days.

Main Findings

[Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable. Use a table to summarize results if possible.]

The average prevalence of overuse shoulder problems and substantial shoulder problems between the intervention and control group during the season demonstrated a 6% and 3% mean difference, respectively,

which is further presented in the table below.

Prevalence of shoulder problems and substantial shoulder problems during the season in the intervention and control group:

	Prevalence of shoulder problems (95% CI)	Prevalence of substantial shoulder problems (95% CI)
Intervention group	17% (16-19)	5% (4-6)
Control group	23% (21-26)	8% (7-9)

The GEE model was utilized to find a 28% lower risk of experiencing shoulder problems over time in the intervention group versus the control group, which is a statistically significant difference (OR: 0.72, 95% CI: 0.52-0.98, p=0.038). However, no statistically significant difference was identified in the risk of experiencing substantial shoulder problems over time between the two groups (OR: 0.78, 95% CI: 0.53-1.16, p=0.23).

Analyses of severity scores identified an average severity score of 29 (95% CI: 28-32) in the intervention group compared to 35 (95% CI: 28-31) in the control group, which yields a mean difference of 5. Thus, the intervention group had a 64% lower relative impact of shoulder problems compared to the control group.

The authors also examined the influence of compliance of the prevention program on the risk of shoulder problems, which is demonstrated in more detail in the two tables below. Compliance within the intervention group did not influence the risk of experiencing a shoulder problem, as no statistically significant differences were found, however, it did influence the risk of experiencing a substantial shoulder problem. Additionally, there was a 69% lower risk of experiencing substantial shoulder problems in participants within the intervention group reporting an average compliance of 0.1 sessions per week compared to participants reporting zero compliance (n=16; OR: 0.31, 95% CI: 0.15-0.67, p=0.003).

The effect of compliance on the risk of shoulder problems:

Compliance group (sessions/week)	n	OR	95% CI	p Value
0.1-1.2	77	0.49	0.20-1.21	0.125
1.1-2.0	88	0.69	0.27-1.75	0.435
>2.0	83	0.58	0.22-1.52	0.271

The effect of compliance on the risk of substantial shoulder problems:

Compliance group (sessions/week)	n	OR	95% CI	p Value
0.1-1.2	77	0.36	0.16-0.82	0.02
1.1-2.0	88	0.25	0.10-0.60	0.005
>2.0	83	0.35	0.15-0.82	0.02

The GEE model was further utilized to analyse statistics of only players with shoulder problems at baseline. The intervention group was found to have a 35% lower risk of experiencing shoulder problems compared to the control group (OR: 0.65, 95% CI: 0.43-0.98, p=0.04), which is a statistically significant difference. However, there was no statistically significant difference identified in the risk of experiencing substantial shoulder problems between the groups (OR: 0.86, 95% CI: 0.51-1.45, p=0.58). When analysing only players without shoulder problems at baseline, there were no statistically significant differences in the risk of experiencing shoulder problems (OR:0.80, 95% CI: 0.47-1.37, p=0.42) or substantial shoulder problems (OR: 0.68, 95% CI: 0.36-1.31, p=0.25).

Original Authors' Conclusions

[Paraphrase as required. If providing a direct quote, add page number]

The authors concluded that the OSTRC Shoulder Injury Prevention Programme demonstrates a statistically significant decrease in the prevalence of overuse shoulder problems and injuries in elite handball players, compared to standard training alone. Thus, an exercise program that aims at increasing shoulder internal rotation range of motion, external rotation strength, scapular strength and kinetic chain and thoracic mobility is an effective preventive intervention that can be added to an overhead athlete's and/or team's warm-up to prevent shoulder injury.

Critical Appraisal

Validity

[Summarize the internal and external validity of the study. Highlight key strengths and weaknesses. Comment on the overall evidence quality provided by this study.]

Jadad scale: 3/5

Strengths: The study included a large sample size, which aids in increasing the power of the study and decreasing the likelihood of a Type II error. Use of cluster randomization of all teams decreased the risk of cross over effects between the two groups and the risk of confounding effects, and increased internal validity. Concealment of allocation was ensured as a neutral, blinded individual performed the randomization utilizing a computer-generated list to randomize teams. Stratification for gender and competition level was also performed, which ensured that the groups were comparable to yield accurate results. Additionally, there were 48 elite male and female hockey teams in Norway and 46 of those agreed to participate, which decreases risk of bias and improves generalizability. The same exercise program was assigned to all participants in the intervention group and all participants were evaluated utilizing the same outcome measures. The exercise program was very comprehensive and aimed at increasing internal rotation range of motion, external rotation strength and scapular muscle strength, which are all evidence-based interventions for preventing shoulder injuries in the overhead athlete.[1]

Furthermore, this study unlike most studies, included players with shoulder injuries at baseline, which prevented the risk of having a biased population. This also more accurately encompassed the population of overhead athletes, as the majority of overuse shoulder injuries are chronic in nature. Additionally, the biomechanics and pathomechanics of other throwing sports or sports with overhead throwing motion are similar, which also increases external validity and generalizability.[1]

Weaknesses: The study lacked blinding of participants and examiners measuring the outcomes, which increases bias. There was lack of control between teams on the overall performance of the prevention program, since it was up to the coaches and team captains to deliver the program and assure that it was being performed. Different coaches may have emphasized and encouraged performance of the program more or less than others, which may have affected the compliance and performance of the exercises/stretches. On average the participants in the intervention group completed the prevention program 1.6 times per week, which is 53% of the three times that was instructed per week, which is a limitation in the study. On the other hand, participants in the control group may have independently performed preventive exercises that the authors had no control over, which would also have affected the results. In addition, repetitions and sets are identified in the program for each exercise but the load utilized is dependent on the player and assigned independently by the player/coach/team medical staff. While this can be seen as a strength as it promotes individuality, the authors cannot control that this was done effectively across all the players.

Another weakness of the study is that the authors failed to conduct baseline and post-intervention testing, such as internal rotation range of motion and external rotation strength measures, to evaluate how effective the prevention program was on improving the risk factors identified. In addition, the participants self-reported their exposure to hand-ball training, match play and strength training, and their compliance with the prevention program. Compliance was also self-reported as the sessions performed during the past 7 days. Ultimately, both these methods greatly increase risk of recall bias. Moreover, the definition of shoulder problems identified includes a very broad range of physical symptoms, thus, generalization to a specific injury is not possible.

Regarding external validity, results can be generalized to elite overhead adult athletes but not to children/teenagers or athletes of amateur level, as there may be a safety issue involved.

Interpretation of Results

[This is YOUR interpretation of the results taking into consideration the strengths and limitations as you discussed above. Please comment on clinical significance of effect size / study findings. Describe in your own words what the results mean.]

The OSTRC Shoulder Injury Prevention Programme, that aims at increasing shoulder internal rotation, external rotation strength, scapular muscle strength and thoracic mobility, has statistically significant effects in lowering the risk of shoulder problems but not substantial shoulder problems in elite handball players, compared to standard training. Additionally, a conservative p-value was utilized that reduced the possibility of performing a Type I error.

There was a statistically significant decrease in the intervention group versus the control group in the risk of experiencing shoulder problems during the season, when evaluating only players with shoulder problems at baseline. However, no statistically significant decrease was found between the groups when evaluating players without shoulder problems at baseline. It is important to note that no statistically significant difference was found in baseline characteristics or sample number of players with and without shoulder problems at baseline in the intervention and control group that could have affected the results. Thus, this indicates that the prevention program is more effective when utilized by athletes with past or baseline shoulder problems/pain, which are typically the athletes that exhibit risk factors for shoulder injury. Further, this implies that such a program has the potential to be used as a return to sport guideline for overhead athletes with shoulder injury, however, further research is needed.

It is unclear which risk factor that the prevention program targeted was effective in reducing risk of injury, since all participants in the prevention group performed all the exercises. Ultimately this increased the variables and does not allow the authors to determine a specific intervention-response relationship. Additionally, baseline and post-intervention measures of the risk factors was not performed that may have also aided in determining the effects of each exercise/stretch.

Nonetheless, the prevention program as a whole is proven to effective in this study. Targeting the major risk factors that have been identified in the literature using exercises and stretches, 3 times per week, is a vital component of the overhead athletes' training program in order to minimize risk of shoulder problems and/or injury. The prevention program was reported to take only 10 minutes to perform, which is very convenient and efficient for the athlete and team, and can further help increase its use and its compliance.

Applicability of Study Results

[Describe the relevance and applicability of the study to your clinical question and scenario. Consider the practicality and feasibility of the intervention in your discussion of the evidence applicability.]

This study has high relevance to my clinical questions as it evaluates a prevention program that targets risk factors that are identified in the literature and demonstrate an association with risk of shoulder injuries in overhead athletes. Further, this prevention program is compared to standard training, which directly relates to my clinical question. The primary outcome measure utilized, prevalence of shoulder problems and/or injuries also directly relates to my clinical question and clinical scenario. While the participants included are not tennis players, handball players are shown to have similar biomechanics and pathomechanics to general overhead athletes thus generalizability is possible.[1] Additionally, the athletes included are male and female, of elite level and of mean age of 22 years, which correlates very well to my clinical scenario.

The prevention program utilized is feasible and time efficient, as it was reported to take approximately 10 minutes to complete. It was also performed during the team's warm up, thus does not take extra time from the athlete's regular program or the coaches' schedule, making it more efficient and feasible to use. While some equipment is required for the proper completion of the program, these include resistance bands, weighted balls and dumbbells, which are common items that almost all teams and athletes will have access to. Additionally, the program includes variations and progressions of exercises every 6 weeks, which can help increase variability, ultimately increasing compliance and motivation to participate.

SYNTHESIS AND CLINICAL IMPLICATIONS

[Synthesize the results, quality/validity, and applicability of the two studies reviewed for the CAT. Future implications for research should be addressed briefly. Limit: 1 page.]

The results of both studies reviewed provide good evidence to support the use of a prevention program in addition to or as part of standard training, to prevent and minimize the incidence of shoulder symptoms and injuries during the season in overhead athletes. Both studies included a control group for comparison that only performed standard training and assessed the incidence of shoulder injury as their primary outcome measure, which directly relates to my clinical question. The studies evaluated baseball pitchers and handball players, which are classified as overhead athletes.[1,2] Additionally, the biomechanics and pathomechanics of the overhead motion of those sports are very similar to that of a tennis player during the serving motion, allowing for generalizability of the results to my clinical scenario.[1,2,12] While both studies were of high relevance, they provided level 2b evidence with moderate methodological quality. Specifically, the study by Shitara et al., lacked randomization and blinding of participants and examiners, which increases its vulnerability to self-

selection bias, however, there were no loss of participants at follow-up.[7] The study by Andersson et al., included randomization of participants and allocation of concealment, ultimately increasing internal validity.[4]

The preventive interventions included in both studies were evidence based and targeted specific risk factors associated with risk of shoulder injury in overhead athletes, including GIRD, weakness of the external rotator muscles and scapular dyskinesia.[1-3] Neither of the studies conducted baseline and follow-up testing to evaluate the effects the preventive exercises on the different risk factors targeted.[4,7] Future studies should aim at evaluating these effects to determine a more valid intervention-response relationship and compare the significance and severity of the specific risk factor targeted in relation to the prevalence of shoulder injury. Nonetheless, the study by Shitara et al., demonstrated that stretching alone that aims at increasing internal rotation range of motion is effective in reducing risk of shoulder injury.[7] Additionally, several other studies evaluating the effectiveness of stretching, utilizing the sleeper stretch or cross-body stretch, demonstrated improvements in posterior shoulder tightness and GIRD in overhead athletes.[8,9] This further supports the implementation of stretching as part of a more comprehensive prevention program that targets all the major risk factors identified in the literature.

Benefits of preventive interventions have been found in athletes with and without shoulder symptoms, thus preventive programs should be utilized by all overhead athletes to prevent the risk of developing deficits associated with shoulder symptoms, ultimately preventing shoulder injury. In addition, compliance seems to be a major challenge in overhead sports teams, which negatively affects the risk of experiencing moderate to severe shoulder injuries in overhead athletes, as demonstrated in the study by Andersson et al.[4] Thus, it is important that prevention programs are time-efficient, do not require special equipment and extra space and exercises are easy to perform. Incorporating preventive exercises into the athlete's warm up is an effective way for the coach or the team's PT to ensure compliance and proper technique, while also not intruding in the athlete's or team's training schedule.

A sports PT plays a vital role in the rehabilitation and prevention of injuries in athletes. It is important that PTs are aware of the risk factors associated with shoulder injuries in overhead athletes, in order to educate coaches who are often the first line of defence and implement prevention program to enhance the athlete's success during the season. Additional, high-quality evidence, on a wider range of overhead sports, that evaluate the effectiveness of preventive interventions, both on the risk factors identified and on the risk of shoulder injury, are warranted, in order to increase awareness and implementation of preventive interventions in clinical practice.

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