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Risk Factors for, and Prevention of, Overuse Shoulder Injuries Among Elite Handball Players: A Systematic Review

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Abstract
This systematic review aims to evaluate the available research on the causes of overuse shoulder injuries in elite handball players, as well as the available preventive measures. An extensive search was conducted using EBSCO Host from 2013 to December 2023 for studies that investigated the risk factors or prevention strategies of overuse shoulder injuries among elite handball players. The Modified Downs and Black tool (9) was used to assess the methodological quality of the included RCT and non-RCT studies. Thirteen studies were included after screening and quality assessment using the Modified Downs and Black checklist (9). Despite limitations in study methodologies and definitions of injury, evidence synthesis revealed multifactorial causative factors, including muscle strength imbalances, scapular dyskinesis, glenohumeral range of motion (ROM), training load, injury history, sex, and player positions. Strong evidence was found for female sex and weakness of the external rotator cuff muscles as risk factors. Moderate evidence supported associations with glenohumeral ROM imbalances, improper training load dosage, prior injury, player position, and playing level. Due to the high frequency of overuse shoulder injuries, particularly in female players, there is a need for further research to develop tailored preventative measures. This review underscores the complexity of injury prevention in handball and emphasizes the importance of customized interventions to mitigate the specific challenges posed by the sport and protect athletes' health.

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Key Words
Elite handball players, handball, risk factors, prevention, athletes

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INTRODUCTION

Millions of people worldwide participate in the all-time favorite team sport of handball[1]. Intense physical activity and repeated overhead movements, which put a lot of strain on the upper limbs and especially the shoulder joint, are some of the key features of this sport[2]. Handball players frequently sustain injuries of the shoulder, especially overuse injuries, which can have a negative impact on both player performance and general health[3].

Due to the high intensity and regular playing of handball games and competition, injuries of the overused shoulders are a subset of injuries that affect the shoulder joint repeatedly[4]. These injuries can range in severity from minor inflammation to serious rotator cuff tears that may necessitate surgery[5]. Based on the competition level and the age of the players, it is estimated that the occurrence of overused shoulder injuries in handball ranges from 10 to 40%[6].

The efficacy of injury prevention techniques in reducing the incidence of injuries of the overused shoulder in handball players has also been the subject of vast research. These preventative measures include general strength and conditioning programs, shoulder-specific strengthening exercises, technique modification, and rule changes specific to a particular sport[7]. Whether these interventions will be effective in reducing the frequency of injuries of the shoulder among professional handball players is unknown at this time.

This systematic review aims to offer a critical evaluation of the most recent research regarding the causes of injuries of the overused shoulder in professional handball players, as well as helpful preventative measures. This review can assist in the fundamental growth of evidence-based injury prevention programs for professional handball players by identifying the most important causative factors and practical prevention methods. In the end, decreasing the prevalence of injuries of the overused shoulder in handball can enhance player health and performance, adding to the sport's general success.

MATERIALS AND METHODS

A thorough review of the literature on the causative factors and prevention of injuries of the shoulder due to overuse in professional handball players was conducted. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were followed during the review[8]. The study selection criteria that specifically refer to PICO are shown in Table 1.

The databases Google Scholar, PubMed, MEDLINE, SPORTDiscus, and CINAHL were used for a thorough search. The search was done using a combination of "handball, shoulder injuries, risk factors, and prevention-related Medical Subject Headings (MeSH) terms and keywords." The titles and abstracts of all found studies were screened for relevance. Full-text articles were then retrieved and assessed for eligibility. Data were extracted from eligible studies using a predefined data extraction form. The extracted data included the design of the study, sample size, population characteristics, outcome measures, and main findings.

The quality of the included research papers was then evaluated using the Modified Downs and Black checklist[9]. The quality of each study and any discrepancies were resolved through discussion with supervisors.

RESULTS

A total of 13 articles were covered in the review. Selection of eligible articles is displayed in PRISMA[10] Fig 1.

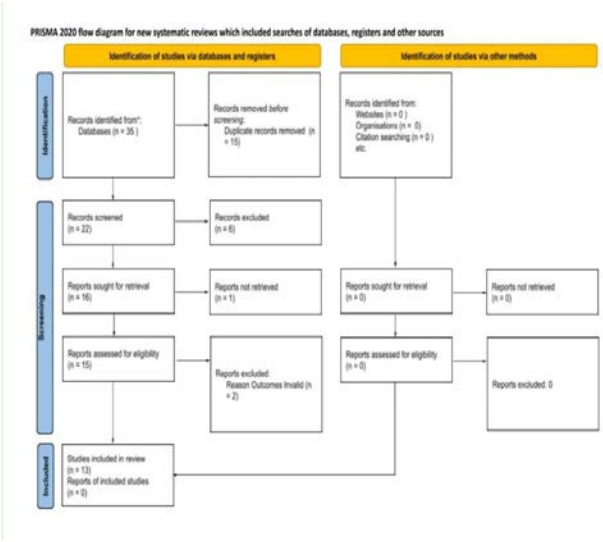

Fig. 1. PRISMA

The reviewer assessed the eligible studies' methodology independently using the Modified Downs and Black checklist. The combined average score of all RCT studies for this SR was 24 and for non-RCTs, the mean average score was 13.27 on the scale. There were 2 separate tables created; one for RCTs and one for Non-RCTs, as not all checklist points were applicable to non-RCTs. A few questionnaire questions were excluded as they seemed inappropriate for this particular SR. For non-RCT studies, questions 1, 2, 3, 4, 6, 7, 10, 11, 12, 15, 17, 19, 20, 22, and 25, were included only as they refer to aims, methods, study outcomes, external validity, and internal validity, respectively. The same modification was applied earlier in an SR investigating risk factors associated with injuries of the shoulder in handball[3].

Table 1: PICO Study selection criteria

Criterion	Inclusion Criteria	Exclusion Criteria
Shoulder	Elite handball players aged 18 years or older	Recreational handball players or individuals with pre-existing shoulder conditions
Intervention/Exposure	Studies investigating causative factors and prevention strategies for injuries of the overused shoulder	Studies focusing solely on acute injuries of the shoulder
Outcome	Studies reporting the incidence, prevalence, or severity of injuries from overused shoulder	Studies focusing on other reporting outcomes of other types of injuries or conditions
Risk factors	**Intrinsic:** age, sex, body composition, and previous injuries	Acute accidents and traumas
-	**Extrinsic:** training load, playing position, and match intensity	
Preventive measure	**General Injury** Prevention Strategies such as strength and conditioning programs	Steroid intake
-	**Sport-specific** interventions such as technique modification and match rule changes	
Study Design	**Observational studies** (cohort, case-control, cross-sectional) to study causative factors	Case reports, review articles, editorial articles, conference abstracts, and non-peer-reviewed articles
	Randomized controlled trials to study prevention strategies	
Language	Articles published in the English language	Articles published in languages other than English
Publication Date	Studies published between 2013 and 2023	Studies published before 2013

Study Characteristics: Ten studies compared the risk of injuries of the shoulder between competition and training. The risk of injury to the shoulder was compared between men and women in seven research articles[4, 11-16]. The predisposing factors for injuries of the shoulder in handball sport discussed in the included research papers were strength imbalances[4, 5, 7, 11, 15, 17], glenohumeral ROM imbalances[4, 11, 7, 15, 18], scapular dyskinesis[4, 7, 15, 17] inappropriate dosage of training load[4,17], history of injury[17], gender[14,16], player's position, school grade, level of playing[14] and modified shoulder joint position sense[15]. Three studies presented a prevention program for overuse shoulder injuries.

A sum of 3820 (men=2124, women=1557) study members, of which 3639 were categorized as handball players. One study[5] had the smallest sample (sixteen participants) of handball players. The sample of the other research papers ranged from one hundred and eight to six hundred and seventy-nine handball players. Five research articles studied only men or women athletes[5,17-20]. The average age of the study members varied between fourteen and twenty-four years old. Four research papers enrolled young handball game players[4, 11, 14, 15]. The handball sports experience of the professionals in 4 research papers[4,5,7,16] varied between 8.2-14 years while other research papers didn't document the experience of their participants. Two studies[11, 16] didn't report the player's position.

The research articles employed various definitions for injuries of the shoulder excluding 2 research papers[7,17]. There was only one study that mainly focused on overuse shoulder injuries[7]. "Any pain, ache, stiffness, instability, weakness, or other symptoms related to the shoulder, impacting the player's participation, training load, and performance, as well as the existence of pain over the last week" is the definition of shoulder overuse problems in the actively affected arm, which were the prime focus of this study. Significantly, they did not include recent wounds. In a prior study[17], the same group used the same operational definition to calculate the incidences of shoulder pain in both upper limbs, and only those with moderate to severe limitations on training, performance, or participation were included in the analysis. The authors employed the same definition of "problems leading to moderate or severe reductions in training load, sports performance, or disability to participate in sport" for significant shoulder problems as Clarsen *et al*. (2014). Any new injury of the shoulder in the dominant arm was evaluated by Moller *et al*. (2017) and was "described as any handball-related problem of the shoulder irrespective of the requirement for time loss or medical attention." When the athelte came in contact with the national team physician and "failed to do complete participation in handball activity or match play at least 1 day beyond the day of injury," the shoulder injury was documented in the Edouard *et al*. (2013) study. Every type of injury-traumatic, acute, and overuse-was examined. Different criteria were applied by Giroto *et al*.[16] for new injuries, prior injuries, overuse injuries, injuries without contact, injury severity, and recurrent injuries. A key component of their analysis involved comparing three groups: professionals who reported a new injury due to trauma, professionals who reported a new injury due to an overuse problem, and athletes who were not injured (reference group). The Achenbach *et al*.[11] study used "injuries that occurred at the same location on the body within two months of the initial injury and injuries without a clear traumatic event, respectively," as criteria for injuries of the overuse shoulder and re-injuries in the analysis. According to Asker *et al*.[16], a shoulder injury occurs when the dominant shoulder reports an OSTRC questionnaire score of 40 or higher at any time during the season. Additionally, the OSTRC

overuse injury questionnaire had to be changed by the authors in order to gather data regarding shoulder issues from the previous season and the previous two months (the original questionnaire only gathered information from the previous week).

Five of the ten risk factor investigating research articles employed the OSRTC overuse injury questionnaire[7,14,15,17,20] to document injuries of the shoulder in handball. In one study[11], the Western Ontario Shoulder Indexch (WOSI) and an online questionnaire were used to assess overuse injuries that occurred during a handball practice or match. A weekly injury questionnaire was used in one study[16] to collect data on the date, circumstances, and nature of the injury during training or play. Moller *et al*. (2017) employed the Sports Injury Surveillance (SPEx) system in their research paper. Lastly, in the Edouard *et al*. (2013) study, the national team physician documented all new shoulder injuries in young athletes when an athlete conferred him or her for ache or injury, or by conducting a monthly medical interview. In the assessment of risk factors, four studies[7,11,16,17] used the odds ratios (O.R), two studies[4,15] the hazard rate ratios (H.R), and one study[5] the relative risk ratio (R.R).

All 3 intervention studies had different protocols for measuring the outcomes. The study by Asker, Hägglund, Waldén, Källberg, and Skillgate[18] held weekly surveys including the OSTRC-O and extra queries on handball exposure (match and training hours), handball injuries and the amount of strength and conditioning training, including both school and club training. While Andersson, Bahr, Olsen, and Myklebust[13] recorded questionnaire responses using online survey software (Questback V. 9692, Questback AS). Asker, Holm, Källberg, Waldén, and Skillgate[14] used the OSTRC Overuse Injury Questionnaire to measure the research outcomes.

Risk Factors: One high-quality study looked at the relationship between previous injuries and recent injuries of the shoulder in handball players[16]. There was only a moderate amount of evidence linking the prior injury to a higher risk of injuries to the overused shoulder.

Two high-quality studies[11,18] and four moderate-quality studies[4,5,7,15] looked at muscle strength imbalances as a risk factor for injuries of the shoulder in handball professionals. Female handball players who have low concentric ER to concentric IR strength at 240°/s and high eccentric IR to concentric ER strength at 60°/s have a 2.5 times higher risk of overuse and acute shoulder injury, according to one moderate quality research article (limited evidence)[5]. Reduced ER isometric strength is associated with injuries of the overused shoulder in men[11,18] and females[11,15], according to three of the 4 high-quality research articles (strong evidence). There was no notable correlation between ER strength and injury of the overused shoulder, according to only one study[7]. Two high-quality studies[11,18] and three medium-quality studies[4,7,15] looked at the relationship between different glenohumeral ROM imbalances and shoulder injuries. A small body of research revealed a considerable correlation between increased internal rotation range of motion and overuse shoulder injuries[7]. According to Achenbach *et al*.[11], there was moderate evidence that a glenohumeral internal rotation deficit (GIRD) of more than 7.5° and an increased ER motion of more than 7.5° are causative factors for an injury of the overused shoulder in young women athletes.

Three moderate-quality studies[4,7,15] and two high-quality studies[11,18] looked at scapular dyskinesis. All things considered, 60% (3/5) of the research indicates that there is a notable correlation ($p = 0.02$) between scapular dyskinesis and shoulder injuries. Generally, the data on the contribution of scapular dyskinesis to injuries of the shoulder sustained during handball was inconsistent. Møller *et al*. (2017) found a limited amount of evidence suggesting that scapular dyskinesis worsened the correlation between elevated handball load and overuse or acute injury of the shoulder in professional adolescent handball athletes. One study of moderate quality looked at the relationship between joint position sense (JPS) and injuries of the shoulder[15]. There was insufficient data to conclude that JPS and injuries of the overuse shoulder in men and women athletes are unrelated.
Two studies, one of medium quality[4] and one of high quality[16], looked at match loads and excessive handball training. According to Giroto *et al*.[16], there was some evidence linking an increase in handball load with an extra match weekly to injuries of the overused shoulder. Furthermore, there was some evidence that a handball load increase of more than 60% was linked to a higher rate of shoulder injuries and that this link was stronger in athletes with lower ER strength. Only players with scapular dyskinesis or reduced ER strength are affected by little addition in handball load between twenty and sixty percent[4].

Prevention Strategies: Three intervention studies were identified through database searches. The two high-quality studies[12,13] concluded with positive results regarding the OSTRC Overuse Shoulder Injuries Prevention Program, while one moderate-quality study[18] evidenced the effectiveness of IPEPs on shoulder injuries.

Asker, Hägglund, Waldén, Källberg, and Skillgate[18] investigated the preventive effectiveness of

IPEPs on injuries of the knee as well as shoulder injuries in young professional handball athletes. It was determined that compared to players who carried on with their regular training, teenage elite handball players who participated in the Shoulder Control program had a decreased risk of injuries of the shoulder.

In order to prevent shoulder injuries in professional handball, Andersson, Bahr, Olsen, and Myklebust[13] looked at perspectives, assumptions, and present behaviour toward causative factors and shoulder injury prevention. They also looked into applying an exercise program during a CRCT. The findings indicate that there is potential for success in implementing the OSTRC SIPP in professional handball; the primary challenges to be addressed are the program's duration and the low motivation of players. Andersson, Bahr, Clarsen, and Myklebust[12] assessed the impact of a physical training program intended to lower the incidence of shoulder issues in professional handball athletes. In elite handball, shoulder issues were less common due to the implementation of the OSTRC SIPP.

Major Findings Regarding the Design of Intervention Studies: Experimental studies were mainly performed in handball clubs; experimental groups were especially randomized by teams. However, there were no significant differences in the particular intervention, as 2 studies[12,13] used the same OSTRC overuse injury prevention program, and only 1 study[18] followed the Swedish Control Programme.

DISCUSSIONS

This systematic review set out to look into overuse shoulder injury risk factors and preventative measures for professional handball players. There are fewer research articles examining handball than other overhead sports (such as baseball, volleyball, softball, and tennis). This review examined two RCTs[12,18] and eleven prospective cohort studies[4,5,11,13,14, 16-18]. These studies examined several potential risk factors and preventive measures. Strong evidence, however, was only discovered for the female sex and the weakness of the external rotator cuff muscles, which both increase the risk of injury to the shoulder in handball athletes.

In addition to the lack of available data, practitioners must decide whether to evaluate shoulder variables from the perspective of performance or return to play as opposed to injury prevention[3].

Risk Factors: Reduced isometric shoulder ER muscle strength is strongly associated with overuse injuries of the shoulder in handball players, according to two of the three high methodological quality studies[11,15, 17]. The outcome appears to be unaffected by the evaluation technique or sample variation among the studies that yielded positive results[3].

According to Forthomme *et al*.[19], the rotator cuff muscle's power production capacity increased at 90 degrees of shoulder abduction as opposed to 45 degrees of abduction. Rotational power was higher at 70 degrees of shoulder ABD in the Lin *et al*.[21] study when the ratios of IR and ER muscle strength were assessed at various ABD angles. The muscle strength of the rotator cuff is assessed in some studies when the shoulder is positioned below 90 degrees, but ball throwing typically occurs at or near 90 degrees of abduction. Consequently, it was recommended that the assessment of rotator cuff strength be more tailored to a particular sport at 90 degrees of abduction[3].

Edouard *et al*.[5] evidenced no correlation between isokinetic ER or IR strength and injury in female youth handball players. Nonetheless, there was an increased chance of injury for players with low concentric ER to concentric IR strength ratios and high eccentric IR to concentric ER strength ratios. Since the strength was measured using a different technique, their findings cannot be directly compared to the research by Clarsen, Bahr, Andersson, Munk, and Myklebust[17]. However, the two studies' conclusions are similar in that they raise the possibility of the value of ER-strengthening exercises in injury prevention programs.

Five studies[4,7,11,14,17] looked into the possibility of glenohumeral ROM imbalances as a risk factor for injuries of the shoulder in handball athletes. Many of the research articles in this SR did not support the role of TROM and ROM imbalances in injuries of the shoulder. A follow-up research article by the same group using the same methodology in a bigger sample of men and women athletes were not able to verify this conclusion and proposed that only higher IR ROM was associated with shoulder overuse injuries[7]. Clarsen *et al*.[17] proposed that absolute TROM values rather than TROM differences were notably linked with overuse problems of the shoulder in professional men players. The only research to find a significant correlation between injuries of the overused shoulder in sport women and higher external rotation and GIRD in the dominant shoulder was conducted by Achenbach *et al*.[11].

According to three of the five studies included in this analysis, handball players who have scapular dyskinesis have a significantly increased risk of suffering a shoulder injury[4,15,17]. Just two of the studies that were included in this review assessed how training load affected injuries of the shoulder in handball players[4,16]. According to the Giroto *et al*.[16] study,

there is a significant correlation between overuse shoulder injuries and the addition of one official match weekly. Athletes who added to their weekly handball training load by sixty percent or more had twice as high a risk of overuse injuries as athletes who increased their training load by twenty percent, according to a research article by Moller *et al*.[4].

Only one study with moderate methodological quality examined the association between shoulder injuries and reduced shoulder proprioception in handball athletes[15]. Several studies have examined and compared joint position sense and performance between throwers and non-throwers, with varying degrees of success[22,23]. However, there was no discernible link discovered between shoulder proprioception and injuries of the shoulder.

One of the most significant non-modifiable causative factors linked to a variety of sports injuries is likely a history of prior injuries. Only one excellent study examined the history of a prior injury as a potential causative factor for a subsequent injury of the shoulder in handball athletes in the current review[16]. According to Giroto *et al*.[16], one possible explanation for why a prior injury is a major causative factor for subsequent injuries is inadequate recovery from that prior injury.

Two studies with high methodological quality[14,16] agreed with the study by Hadjisavvas, Efstathiou, Malliou, Giannaki, and Stefanakis[3] that adolescent and mature female handball players are more likely than male players to sustain shoulder injuries. In the Asker, Holm, Källberg, Waldén, and Skillgate[14] study, the occurrences of both significant and any problems of the shoulder was significantly higher among sports women during the follow-up period. These findings are consistent with those of a previous research article on senior professional handball players in Norway, which found that sportswomen had an increased season occurrence of shoulder problems (26%) than men athletes (20%)[7].

Backcourt handball players and injuries of the shoulder were found to be significantly correlated in one study[14] with high methodological quality. The study by Asker, Holm, Källberg, Waldén, and Skillgate[14] found that in all classifications of problems of the shoulder, backcourt players had an importantly increased occurrence than wing and line players. Backcourt players are known to have a higher overall demand on their shoulders due to their increased frequency of high-velocity throwing and increased risk of being stopped by opponents during breakthroughs or blocked shots, both of which put the shoulder in danger[24]. The fact that backs demonstrate more passes and shots than other positions could be one reason[25]. The risk of injury may increase with these activities because they require a significant amount of acceleration and deceleration into abduction and external rotation[11].

Prevention Strategies: The 2 studies with high methodological quality agreed that the OSTRC SIPP is effective. According to Andersson, Bahr, Clarsen, and Myklebust[12], the OSTRC SIPP, a 10-minute exercise program, decreased the occurrences of shoulder issues and significant shoulder issues among professional handball athletes. The intervention group also had a twenty-eight percent decreased risk of reporting shoulder issues during the competitive season. Although similar findings were reported from a six-month pilot study with fifty-three women junior handball athletes (3 teams) in the experimental group[26], this is the first RCT examining an exercise program designed to reduce shoulder overuse injuries in professional throwing athletes[27]. They discovered that among players who performed particular shoulder-strengthening exercises, the occurrences of shoulder symptoms dramatically declined during the experimental period.

The OSTRC SIPP was implemented in the study by Andersson, Bahr, Olsen, and Myklebust[13]. The exercises were designed to improve thoracic mobility, the kinetic chain, and the glenohumeral internal range of motion. They also targeted to increase the strength of the scapular muscles and external rotation. According to Andersson, Bahr, Olsen, and Myklebust[13], there is a good chance that a shoulder injury prevention exercise program focusing on risk factors will lower the risk of shoulder injuries among players, as the majority of elite handball coaches and captains felt. The trial's recommendation to implement the OSTRC Shoulder Injury Prevention Programme was only followed by a small percentage of delivery agents, citing insufficient player motivation and an excessively time-consuming program as the primary barriers[13]. This implies that in order to be successful with widespread dissemination, initiatives to shorten the program and strategies to impact player motivation are required[13].

One moderate-quality study investigated the effectiveness of the Shoulder Control program[18]. This program focuses on trunk mobility, handball throwing load (frequency and velocity), and shoulder and trunk strength and control. It includes an extra partner exercise in addition to the five main exercises, each of which has four difficulty levels. It also encompasses a throwing program that is to be used in the pre-season and off-season (June to August). When compared to the non-experimental group, the effectiveness of Shoulder Control in lowering the incidence of injuries of the shoulder was less than half. In keeping with a prior study in which a shoulder IPEP decreased the occurrences of shoulder problems in senior professional athletes in Norway, Shoulder Control also decreased the occurrences of shoulder problems[7]. In

this trial, the weekly prevalence of shoulder problems was found to be lower than in our previous study on the same population[14].

Limitations of the Study: There are various limitations to the studies that make up this review. There were differences in the operational definition of shoulder injury. Furthermore, a number of studies examined both overuse and general shoulder injuries, despite the critical need to concentrate on overuse injuries. Since risk factors for acute and overuse shoulder injuries may differ, even studies that examined all shoulder injuries were unable to distinguish between the two adequately. Regarding the precise diagnosis of the injuries included in each research article, there was either very little or no data available. The lack of a standardised approach for documenting new shoulder injuries across studies makes it difficult to compare the outcomes. Some studies have significant data loss (weekly, for example), which could lead to an underestimate of the actual number of injuries.

The generalizability of findings may be limited by the variations in study methodologies and definitions of injury. Standardised injury definitions and assessment procedures should be the focus of future research. Long-term prospective studies that monitor athletes over several seasons may offer a more thorough comprehension of the combined impact of risk factors on the frequency of shoulder injuries.

There were a number of other limitations to the research on preventative measures. Since only team captains were included in the study by Andersson, Bahr, Olsen, and Myklebust[13], it is unknown how much their attitudes, beliefs, and current behaviour reflect those of their teammates. Given the responsibilities of a team captain, it's probable that they are more committed to and aware of preventative measures. Furthermore, the authors are unable to generalise the findings to all head coaches at the highest level because different teams selected different candidates to represent their coaching staff. A limitation of the study by Andersson, Bahr, Clarsen, and Myklebust[12] is that they didn't perform baseline and follow-up testing to investigate the impact of the exercise program on the various risk factors targeted.

Implications: In particular, more research is required to determine the causative factors and preventative strategies for overuse injuries of the shoulder in professional handball players. Furthermore, more research on young and adult handball players at various skill levels should be done to explore modifiable causative factors for injuries of the shoulder and to prolong athletic careers. Future research on handball players should include both male and female participants in order to assess how prevention strategies differ in terms of risk and efficacy between the sexes. To generate reliable results and prevent misunderstandings, there should be agreement on both technical (for example, measurement position) and methodological (for example, injury definition, evaluation of scapular dyskinesis, injury surveillance technique) issues.

CONCLUSION

A detailed understanding of the causative factors and preventative strategies for injuries of the overused shoulder in professional handball athletes is delivered through this systematic review. A multifaceted approach is required due to the multifactorial nature of these injuries, taking into account factors such as muscle strength imbalances, scapular dyskinesis, glenohumeral ROM, proprioception, training load, injury history, sex, and player positions. Studying high-quality and moderate-quality research articles allowed for the identification of numerous causative factors for injuries of the shoulder in handball players. One modifiable risk factor (strength of external rotators) and one non-modifiable risk factor (women's gender) were found to have strong evidence. Glenohumeral ROM imbalances, improper training load dosage, prior injury, player position, and playing level all showed moderate evidence. Particularly, training load appears to have an association with shoulder injuries, both on its own and in combination with other variables like scapular dyskinesis and ER strength. Due to the high frequency of injuries of the overused shoulder among professional handball athletes, particularly in female players, more studies on shoulder injury causative factors and the development of preventative measures for handball players are necessary. These results also emphasise how important it is to regularly implement a clinical monitoring program and enhance the medical assistance provided to handball-focused secondary schools while taking gender-related factors into account. The evidence synthesis highlights the intricacy of injury prevention and calls for customised interventions to reduce the particular difficulties presented by the sport. A dynamic and comprehensive approach to handball shoulder injury prevention is still necessary to protect athletes' health as research on the subject grows.

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