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REVIEW ARTICLE

Risk factors for shoulder injury in professional male handball players: A systematic review

Damjan Jakšić[1], Stefan Maričić[1], Mila Vukadinović Jurišić[1], and Marijana Čavala[2]

[1]University of Novi Sad, Faculty of Sport and Physical Education, Novi Sad, Serbia

[2]University of Split, Faculty of Kinesiology, Split, Croatia

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Abstract

Handball is a globally popular and physically demanding sport that requires high-intensity intermittent activities, with a particular emphasis on frequent ball throwing or shooting. The primary aim of this systematic review was to identify the risk factors for shoulder injuries in professional male handball players. The secondary aim is to propose preventive measures for reducing shoulder injuries in professional or elite handball players. This study followed the guidelines provided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Web of Science, PubMed, Science Direct, and Google Scholar were used to identify relevant studies. Only 8 studies met the eligibility requirements and were incorporated into the review. The Physiotherapy Evidence Database (PEDro) was assessed for the methodological quality of studies. Seven of the total eight studies were considered moderate quality, however, only one study was considered low quality. Based on this review findings, the following risk factors for shoulder injury are prominent among professional and elite male handball players. The primary factors for eventual shoulder injury are shoulder muscle imbalances, range of motion (ROM) discrepancies, glenohumeral internal rotation deficit (GIRD), and scapular dyskinesis. Also, in one study authors specified player position as a potential risk factor.

Keywords: rotator cuff · strength imbalances · range of motion · prevention strategies

Correspondence:
Damjan Jakšić
damjan.jaksic@fsfvns.edu.rs

Introduction

Handball is an intermittent high-intensity body-contact team sport that requires a combination of aerobic and anaerobic fitness to perform well-coordinated activities (Chelly et al., 2011). Additionally, team handball heavily emphasizes running, sprinting, jumping, and throwing (Gorostiaga et al., 2005). Throwing frequency is a fundamental element of handball and can be performed overhead or from the side (Skejø et al., 2019). Also, handball players make contact with their bodies during or upon the completion of the throwing action (Laver et al., 2018). Contact with the opponent is a potential cause of trauma, where a player may be pushed, resulting in an unexpected and unprepared fall, or the shooter's arm may be pulled during the throwing action or dual situation. Because of that, professional handball ranks among the sports with the most prevalent occurrence of injuries at the Tokyo 2020 Summer Olympics (Soligard et al., 2023). Previous studies (Mónaco et al., 2019; Vila et al., 2022) have shown that the most common injuries among handball players occur in the lower limb (specifically the knee and ankle), and the shoulder in the upper limbs. According to research by Raia-Gonzalez et al. (2021), professional handball players miss two to three weeks of training (1.000 hours) and more than 1.500 days of play due to injury. Luig et al. (2020) recorded that direct contact between players may induce approximately 70.2% injury of the shoulder and indirect contact about 27.7%. In more detail, direct contact between players, such as frequent and unexpected confrontation or blocking leads to acute injuries of the shoulder (throwing arm) in the form of microtrauma on the capsulolabral structures (Laver et al., 2018.). Other shoulder injuries in handball players are most often caused by shoulder overload when throwing from different positions, and the authors (Giroto et al., 2017; Ventura et al., 2023) point out that that can lead to potential injuries of the shoulder. Handball players performed almost 50000 throws during the year (Langevoort, 1996). During the game, male handball players (15.1±0.6 years), on average, performed 100.9 passes and 10.1 shots (Chelly et al., 2011). A novel systematic review (García-Sánchez et al., 2023) shows that back elite handball players performed more throws (9.9±4.1) than pivots and wings (6.6 ± 2.8 and 5.7 ± 2.4, respectively). At the European Men's Handball Championship 2020, authors (Pueo et al., 2023) analyzed more than 6000 throws, where 80% of the throws were at high (80-100 km/h) or very high (>100km/h) speeds, where back and wings have extremely quick throws. Because of the frequent and high-speed throwing in handball, players in particular positions are predisposed to shoulder problems and injuries (Liaghat et al., 2020). However, it's important to note that the frequency and high level of throwing (training load of the upper extremities) in handball players in different positions (player position) are not the only factors predisposing them to overuse shoulder injuries. Achenbach et al. (2020) reported that in elite youth handball (14.1±0.8), deficits in external rotation (ER) strength are a risk factor for overuse shoulder injury for both sexes and glenohumeral internal rotation deficit (GIRD) are the only risk factors for girls. On the other side, Andersson et al. (2018) noted that none of the risk factors (GIRD and ER range of motion (ROM), isometric IR and ER strength, and scapular dyskinesis) were related to overuse shoulder injuries in a youth (average 14 years) male and female elite handball players. A systematic review of Hadjisavvas et al. (2022) analyzed risk factors for developing shoulder injury through all age categories and both genders. Based on the above, it can be noticed that previous studies analyzed risk factors for shoulder injuries in young female and male handball players. Because of that, authors noticed that there is a gap in the literature, and that would be beneficial to analyze the reasons for the formation of shoulder injuries among professional or elite handball players.

Therefore, the primary aim of this study was to highlight the contributing factors for the formation of shoulder injuries in professional male handball players. As a secondary aim, the authors wanted to propose preventive measures for reducing shoulder injuries in professional or elite handball players.

Method

Literature search strategy

This paper was prepared and written based on Preferred Reporting Items for Systematic Review Analyses and Meta-Analyses (PRISMA) recommendations (Moher et al., 2009). The authors defined inclusion criteria through the PICO question model (Table 1). It consists of population, intervention, comparison, and outcomes questions.

The search process was conducted between February and April 2024. The search strategy was designed to be as broad as possible to identify all potentially relevant literature published in the last ten years. The year of publication was set because of the contemporary methodology. Earlier publications may used different approaches.

Published articles up to April 2024. were checked for relevance for this systematic review. This systematic review included available data from the four following scientific databases: Web of Science, PubMed, ScienceDirect, and Google Scholar. Additionally, more possible relevant studies were searched manually by checking reference lists of selected studies.

During the search process, the following string was used: "shoulder pain" AND "handball" OR "team handball"; "shoulder injury" AND "handball", "shoulder injuries" AND "handball", "rotator cuff injury" AND "handball", "rotator cuff injuries" AND "handball". Also, all of the mentioned keywords were combined with "team handball", a more used term in other parts of the world, particularly in the American Continent.

Inclusion and exclusion criteria

To ensure clearly defined boundaries for identification the relevant literature inclusion and exclusion criteria were used. To be a part of this review study, journal articles had to fulfill the following inclusion criteria: a) original scientific studies published in English, b) published in peer-reviewed high-quality journals, c) not be older than 10 years, published after 2013, d) include only male handball players older than 18 years, e) playing handball at a professional or elite level.

Formats of publications such as conference proceedings, case studies, abstracts, letters, editorials, and systematic reviews with meta-analyses were not considered in this review. Also, articles "in press", and with early access were not considered. Only original scientific studies published in high-quality peer-reviewed journals were considered for this review.

Table 1. PICO question model

PICO components	Review article components
Population	Male handball players older than 18 years competing at high level of handball (elite or professional)
Intervention	Shoulder injury or pain
Comparison	Subject or players without shoulder injuries
Outcome	Factors related to shoulder injury

Data extraction

Identified studies were uploaded into Mendeley's desktop software application. The citation information included the authors, year of publication, title of the paper, journal name, volume, and issue number, page numbers, DOI number, keyword, and the abstract. All duplicates were eliminated from the Mendeley database. The whole process of elimination is described in Figure 1, in the flow diagram.

Methodological quality of studies and risk of bias assessment

The methodological quality of studies was evaluated utilizing the Physiotherapy Evidence Database (PEDro) as recommended by Maher et al. (2003). The PEDro scale, comprising 10 methodological criteria, was employed to evaluate the included studies on a scale of 0-10. This scale has been established as a valid measure of clinical trial quality (De Morton, 2009). According to the characteristics of this review and included studies, it was anticipated that blinding participants, therapists, or assessors to the intervention would be difficult to conduct, thus a maximum score of 7 was projected. Studies achieving scores of 6 or 7 were considered as "high" methodological quality, while those scoring between 4 or 5 were considered as "moderate" quality. Studies scoring less than 4 were classified as "poor" quality and were consequently excluded from the review.

Quality assessment was independently conducted by two authors (SM and MVJ). Possible disagreements firstly were discussed, seeking consensus. If a consensus isn't reached, then the third author (DJ) or the fourth (MČ) was included in the discussion and helped to get the final decision.

Results

Studies selected

Four scientific databases were searched: Web of Science, PubMed, Science Direct, and Google Scholar. After the search process, 869 studies were identified. An additional 2 records were discovered through other sources. Duplicates were then removed using the Mendeley application, resulting in 650 studies for screening based on titles and abstracts. A total of 572 studies were excluded at

this stage. Subsequently, 70 studies were excluded after full-text reading. Exclusion reasons were various, from inappropriate samples to the publishing of articles after 2014. In the end, after the screening process, 8 studies were chosen to be part of this review study. The screening process was summarized in the PRISMA flowchart, as illustrated in Figure 1.

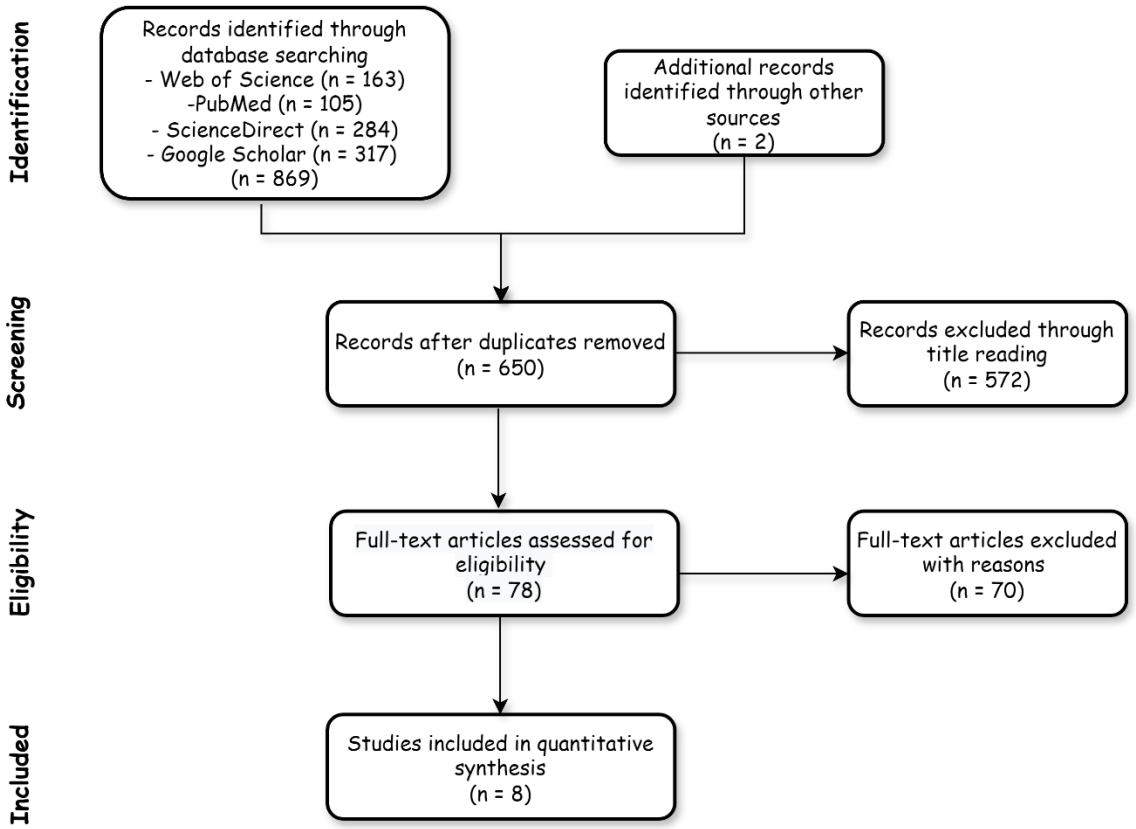

Figure 1. PRISMA flow chart

The included studies had PEDro scores ranging between 3 and 5. The majority of the studies were classified as "moderate" quality. Two selected studies had a score of 5, and five of them achieved a score of 4, which is also considered "moderate" methodological quality. Only one study had a "low" methodological quality. Even after achieving a low score, the authors agreed that that study still be in the consideration for review. The average PEDro score is above 4, and it means that the review could be considered as "moderate" quality. The results of the PEDro scale score are presented in Table 2.

Table 2. Methodological quality – PEDro scale

Study	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	Score
1. Castro et al. (2019)	-	-	+	X	X	X	+	+	+	+	5
2. Clarsen et al. (2014)	-	+	+	X	X	X	-	+	+	+	4
3. Fieseler et al. (2015) part II	-	-	-	X	X	X	+	+	+	+	4
4. Fieseler et al. (2015) part III	-	-	-	X	X	X	+	+	+	+	4
5. Forthomme et al. (2018)	-	-	+	X	X	X	+	-	+	+	4
6. Lubiatowski et al. (2018)	-	-	+	X	X	X	+	-	+	+	4
7. Raya-González et al. (2021)	-	-	+	X	X	X	-	-	+	+	3
8. Seabra et al. (2017)	+	-	+	X	X	X	+	+	+	-	5

1. Random allocation, 2. Concealed allocation, 3. Baseline comparability, 4. Blind subjects, 5. Blind therapist, 6. Blind assessors, 7. Adequate follow-up, 8. Intention-to-treat analysis, 9. Between-group comparison, 10. Point estimates & variability

Table 3. Characteristics of included studies

Authors and publication year	Study type	PEDro score	Measures	Outcomes
Castro et al. (2019)	Cross-sectional study	5 Moderate quality	Isokinetic concentric and eccentric shoulder IR and ER assessment at 60, 180, and 300°/s.	Shoulder ratios at high velocity of IR between upper limbs (dominant vs. non-dominant shoulder) Shoulder ratios in the dominant shoulder of handball players suggest an imbalance that might lead to rotator cuff fatigue increasing the risk of shoulder injuries
Clarsen et al. (2014)	Prospective cohort study	4 Moderate quality	IR ROM and ER ROM Isometric IR, ER, and abduction strength Assessment of scapular dyskinesis The Oslo Sports Trauma Research Center Overuse Injury Questionnaire.	Obvious scapular dyskinesis Reduced ER strength in the dominant shoulder ER strength to IR strength was lower for the dominant shoulder at 4% vs. 6% TROM more than 5° Dominant shoulder had less IR than their non-dominant shoulder (4° vs 3°) GIRD dominant shoulder >20°
Fieseler et al. (2015) part II		4 Moderate quality	Isometric rotational strength (hand-held dynamometer) Active ROM (goniometer) GIRD (difference between IR throwing shoulder and IR non-throwing shoulder as a comparable reduction in ROM, described in negative values)	The isometric strength in IR at the dominant shoulder (throwing shoulder) and non-throwing shoulder did not change. Reduced ER strength in dominant (throwing shoulder) and non-dominant shoulder. IR ROM at the dominant (throwing shoulder) was not significantly reduced. GIRD dominant shoulder =15±10°
Fieseler et al. (2015) part III		4 Moderate quality	Isometric rotational strength (hand-held dynamometer) Active ROM (goniometer).	IR ROM at the dominant (throwing shoulder) was significantly reduced. TROM at the throwing shoulder was significantly decreased

			GIRD (difference between IR throwing shoulder and IR non-throwing shoulder as a comparable reduction in ROM, described in negative values) ERG (difference in ER between limbs, describes in positive values)	Isometric strength for IR in the dominant shoulder (throwing shoulder) and non-dominant shoulder did not change. The eccentric strength improved in the non-dominant shoulder throughout the period of 40 weeks. The isometric strength in IR and ER is initially distinct between the dominant and non-dominant shoulder. After 40 weeks of training, ER strength in the non-dominant shoulder increased significantly. GIRD dominant shoulder=-15 ± 11° GIRD non-dominant shoulder= to -12 ± 9°) ERG=7 ± 7°
Forthomme et al. (2018)	Cross-sectional study	4 Moderate quality	Dominant- and nondominant-shoulder IRs and ERs (dynamometer) Questionnaire about any dominant-shoulder injury	IR strength was stronger on the dominant side for all isokinetic conditions. Preseason questionnaire, 51 of 108 (47%) participants reported a history of dominant-shoulder injury. The previous injury was not a risk factor for a new injury. Backcourt players faced 3.5 times the risk of injury compared to players in other positions, while defensive players experienced 8 times lower injury risk.
Lubiatowski et al. (2018)		4 Moderate quality	IR ROM ER ROM, Registration of existing throwing shoulder pain GIRD TROM Dominant- and non-dominant-shoulder	Decreased in IR ROM dominant shoulder Increased in ER ROM dominant shoulder Shoulder pain was associated with GIRD dominant shoulder GIRD > 20°–25°
Raya-González et al. (2021)	Prospective cohort study	3	Questionnaire about injury	The Second division group showed a higher injury burden related to the injuries suffered in the ankle, leg, knee, thigh, and wrist while only injuries in the head and shoulder generated a greater

	Low quality		injury burden in the highest division group (First) with non-significant differences in abdomen and lumbar injuries.
Seabra et al. (2017)	5 Moderate quality	ROM measurements for dominant and non-dominant shoulder Measurements included: forward flexion (FF), external rotation with the shoulder in 90° of abduction (ABER), external rotation with the arm adducted (ADER), and internal rotation with the shoulder in 90° of abduction (IR).	Decreased IR (47° vs. 56°) Increased external rotation (ER) with the arm abducted (99° vs. 88°) in their dominant arm. Wings and pivots have a higher chance of developing a GIRD (13°) than backs and center becks 6°-7°.

Participant characteristics

The demographic characteristics of participants of the included studies are provided in Table 3. A total of 556 professional and elite handball players were analyzed in this systematic review. The average age of the handball players is 25.1±3.8 years. The number of elite or professional handball players ranged from 30 to 206 (Raya-González et al., 2021; Fieseler et al. 2015-part II, part III; Seabra et al., 2017; Lubiatowski et al., 2018; Forthomme et al., 2018; Clarsen et al., 2019), while the lowest number of handball players was 13 in one study (Castro et al., 2019). The athletes' handball experience ranged from 13.75 to 19.75 years in four studies, and the individuals' experience was not disclosed in five investigations.

Study characteristics

Table 3 presents the main outcomes of the included studies. The team of authors and publication years, study types, PEDro scores, measures, and outcomes are the main parts of this table.

All subjects were experienced male handball players, mostly playing handball at a professional or elite level. Seven of eight studies had achieved scores for moderate methodological quality, according to the PEDro scale.

The study on professional or elite handball players reveals significant findings regarding shoulder injuries and potential risks for them. Dominant shoulders exhibit decreased internal rotation and increased external rotation compared to non-dominant shoulders, indicating adaptations from repetitive and constant throwing. Also, notable imbalance in shoulder rations and reduced external rotation strength suggest an increased risk of rotator cuff fatigue and injuries. Different playing positions could be influential in developing shoulder injuries in handball players (Forthomme et al., 2018). For example, backcourt players face a 3.5 times higher risk of injury, while defensive players experience an 8 times lower risk of injury. Also, the level of playing handball can be influential. Raya-Gonzales et al. (2021) noticed that players playing in the Second division can suffer fewer injuries than players from the highest handball players.

Discussion

This systematic review aimed to determine shoulder injury risk factors among professional handball players. Furthermore, the secondary aim is to propose preventive measures for reducing shoulder injuries in professional or elite handball players. The review found eight appropriate articles reporting the risk factors for shoulder injuries in professional or elite male handball players. The study's findings showed that scapular dyskinesis, muscular strength imbalances, and ROM are possible risk factors for shoulder injuries in professional or elite handball players.

Muscle strength imbalances

The five studies (Clarsen et al., 2014; Fieseler et al., 2015 (part II); Fieseler et al., 2015 (part III); Forthomme et al., 2018; Castro et al., 2019) show that throwing shoulder (dominant shoulder) was weaker in ER strength compared with the non-dominant shoulder in professional male handball players. Three studies (Clarsen et al., 2014; Fieseler et al., 2015) (part III); Fieseler et al., 2015 (part II) show that isometric strength for IR in the throwing shoulder or dominant shoulder and non-dominant shoulder did not change (Clarsen et al., 2014). When analyzing throwing shoulders authors (Fieseler et al., 2015 (parts II and III) observed weak ER strength and strong IR strength during the season and after midseason in male professional handball players. The explanation for these differences (IR and ER strength in throwing shoulder) is likely to be found in the training program (resistance training) and the frequent throwing of the ball by professional handball players. Hadjisavvas et al. (2022), in their comprehensive study, noted that resistance training in professional handball players emphasizes the development of the IR muscles (teres major, pectoralis major, and latissimus dorsi) more than the ER muscles. This may be the explanation for an imbalance in strength between the internal and external muscle rotators in dominant arms. Moreover, the frequency of ball throws can bring to increase in the strength of IR muscles in the dominant shoulder. This increase in internal rotation strength allows the athlete to achieve faster ball speed, resulting in higher ball-throwing efficiency (Zapartidis et al., 2007). It seems that the shoulder girdle undergoes a significant change due to the inadequate load during strength training and also to sports activities that include throwing a ball.

ROM imbalances and GIRD

Professional male handball players had lower values of shoulder ratio dominant shoulder compared to the non-dominant shoulder (Castro et al., 2017). Dominant shoulder or throwing shoulder professional handball players had significantly less IR ROM than their non-dominant shoulder

(Clarsen et al., 2014; Seabra et al., 2017). During the season authors (Fieseler et al., 2015 part III) noted that IR ROM and TROM at the dominant shoulder (throwing shoulder) were significantly decreased in professional male handball players. In male handball players, these changes in the dominant shoulder precisely decreased TROM and were associated with shoulder pain (Lubiatowski et al., 2018). The male professional handball players had a greater ER ROM in dominant shoulder-throwing shoulder (Clarsen et al., 2014; Fieseler et al. 2015 part II; Lubiatowski et al., 2018; Seabra et al., 2017). Reductions in IR ROM and development in ER ROM in the dominant shoulder of non-injured overhead athletes are regarded as typical soft tissue adaptations to repeated throwing (Clarsen et al., 2014). The GIRD is a potential risk factor for shoulder injuries in elite and professional handball players investigated in (Fieseler et al., 2015, part II; Fieseler et al., 2015, part III; Lubiatowski et al., 2018). Lubiatowski et al. (2018) and Clarsen et al. (2014) noted that GIRD between 20°–25° are related to shoulder injuries in professional and elite male handball players. The changes in shoulder ratios noticed in handball players' dominant shoulders indicate an imbalance that could cause rotator cuff fatigue and raise the risk of shoulder injury (Ventura et al., 2023).

Scapular dyskinesis

One study (Clarsen et al., 2014) found that professional male handball players mostly have slight scapular dyskinesis in the dominant shoulder during flexion and abduction. It is crucial to understand this phenomenon because the majority of scapular problems observed in throwing athletes are caused by a loss of control during scapular movement and in the normal resting posture. This can lead to scapular protraction, which can result in increased loads, altered movements, and reduced muscle activations. These factors have been associated with lower performance and a higher chance of injury (Hickey et al., 2018). By understanding and addressing scapular dyskinesis, we can potentially improve motor performance and decrease injury risk in professional handball players.

Player position

One study (Forthomme et al., 2018) found a significant correlation between playing position and shoulder injuries. During the new season, the chance of a shoulder injury was 3.5 times higher for backcourt players than for players in other positions. Compared to offensive players, defensive players were eight times less to develop a shoulder injury during the following season (Forthomme et al., 2018). A possible explanation could be the player's position, as backs demonstrate a greater frequency of shots, passes, and one-on-one interactions than other positions.

This systematic review has several strengths. First of all, the study oriented only to professional and elite male handball players, unlike previous studies that examined the youth male and female handball players. Also, this review paper shows risk factors for injuries of the shoulder as one of the frequent injuries in handball. There are also some limitations. The methodological quality of the studies was moderate and low. The study involved only studies written in English. The following research could include female professional handball players or analyze other risk factors for knee injury and ankle.

Conclusions

Professional male handball players have many risk factors for shoulder injuries that have been discovered. In professional male handball players, there was moderate evidence of scapular dyskinesia, GIRD, ROM, and muscular strength abnormalities. It's crucial to observe that there was insufficient data to determine the precise risk factors for injuries among professional handball players and proposed recommendations for the prevention of shoulder injuries. Based on these findings, this systematic review proposes recommendations for the prevention of shoulder injuries for professional male handball players.

1) Professional male handball players should be measured with reliable measurement instruments (hand dynamometer, isokinetic dynamometer, scapular dyskinesis test) before and during the competition period how to identify any problem in their shoulders.
2) Resistance training should be individualized and specific.
3) As part of handball training, coaches should apply stretching exercises; it is even recommended to include at least one stability and mobility training of the shoulder belt, but also the whole body during the season.

Conflict of interest

The authors state that they do not have any conflicts of interest.

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