

Original Research

Which Myofascial Alterations Contribute to Functional Limitations and Perceived Performance Deficits in Water Polo Athletes

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Background

Shoulder injuries are highly prevalent in overhead sports such as water polo due to repetitive high-intensity throwing demands. While structural pathologies have been widely studied, there is a lack of evidence regarding the role of myofascial dysfunction in this athletic population.

Hypothesis/Purpose

This study aims to analyze the relationship between myofascial dysfunction in the shoulder musculature and self-perceived functional capacity in competitive water polo players.

Design

Observational cohort

Methods

Male water polo players from youth and senior categories of two clubs in Madrid (Spain) were recruited for participation in this study. A clinical evaluation of myofascial dysfunction was performed through manual assessment of myofascial trigger points (MTrPs) using a composite score (0–6) based on the presence of six diagnostic criteria and completion of the Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow Score questionnaire were performed. Spearman correlation analysis and hierarchical multiple regression were performed to examine the association between MTrPs and shoulder function.

Results

A total of 33 water polo players aged 18.30 ± 2.82 years were included. Significant moderate negative correlations were found between myofascial trigger point scores and the KJOC score for the infraspinatus ($r = -0.413$, $p = 0.017$), subscapularis ($r = -0.377$, $p = 0.030$), and anterior ($r = -0.580$, $p < 0.001$), middle ($r = -0.480$, $p = 0.005$), and posterior deltoid ($r = -0.534$, $p = 0.001$).

Conclusion

The findings suggest that myofascial dysfunction significantly negatively impacts shoulder function and performance in water polo athletes.

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Level of Evidence

Level 3

INTRODUCTION

Myofascial dysfunction is commonly described as a musculoskeletal condition associated with the presence of myofascial trigger points (MTrPs), which are hypersensitive nodules located within taut bands of skeletal muscle and are associated with sensory, motor, and autonomic alterations. For the purposes of this study, myofascial dysfunction is operationally defined specifically as the presence of signs and symptoms related to myofascial trigger points.¹ Although the role of MTrPs in directly impairing sports performance remains a subject of debate, several studies have reported associations between active MTrPs and reduced muscle strength, altered motor control, and decreased range of motion, which may influence functional performance in athletic populations.² Overhead throwing sports are characterized by repetitive, high-velocity arm elevation and rotation above shoulder level, generating substantial mechanical stress on the glenohumeral joint.³ In water polo, a physically demanding discipline that integrates swimming with rapid throwing actions and frequent physical contact, such as defensive blocking, positional wrestling, and direct arm-to-arm or trunk-to-shoulder interactions during play, these intense throwing mechanics and repeated contact impose significant strain on the shoulder musculature. This combination may increase the risk of myofascial dysfunction and limit athletic performance.⁴

The shoulder, as the primary joint involved in throwing, is highly susceptible to several injuries, including rotator cuff tears and tendinopathy, long head biceps tendinopathy, superior labral injuries, and impingement syndromes.⁵ Previous research using ultrasound monitoring in competitive water polo players has identified a high prevalence of structural shoulder abnormalities, including rotator cuff tendinopathy, subacromial impingement, and degenerative changes in the rotator cuff and long head of the biceps tendon, contributing to pain and dysfunction.⁶ Additionally, studies have identified posterosuperior glenoid impingement as a common cause of shoulder pain in elite players, demonstrating that structural and mechanical factors play a crucial role in the development of dysfunction.⁷ However, a significant gap remains in the literature regarding the role of myofascial dysfunction as a contributing factor to shoulder pathology in this population.

The functional capacity of the shoulder complex is crucial for water polo players, as their ability to execute fast and powerful throwing movements directly correlates with performance outcomes.⁸ Although shoulder injuries in this population have been extensively studied, the specific impact of myofascial dysfunction on self-perceived functionality and throwing performance remains largely unexplored. Most existing studies focus on structural abnormalities, such as labral tears or rotator cuff pathologies, while the potential contribution of myofascial alterations to pain and functional limitations has been over-

looked.⁹ This gap in knowledge highlights the need for further exploration of the relationship between MTrPs and shoulder function in overhead throwing athletes.¹⁰

Several studies in swimmers, a closely related population, have demonstrated the presence of mechanical hyperalgesia and active MTrPs (myofascial dysfunction) in the neck and shoulder muscles, even in the absence of reported pain.^{6,11} Additionally, regarding the alteration of the range of motion associated with the presence of trigger points described above,² prospective cohort studies have linked alterations in rotational range of motion to a higher risk of injury, emphasizing the importance of muscular balance and functional mobility in preventing shoulder dysfunction.^{6,10} Given these findings, assessing myofascial dysfunction in water polo players could provide valuable insights into injury risk factors and potential targets for physiotherapeutic interventions.

Although the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire is commonly used to assess upper limb function, its application in high-performance athletes presents limitations.¹² In contrast, the Kerlan-Jobe Orthopedic Clinic (KJOC) Shoulder and Elbow Questionnaire is specifically designed for overhead athletes, providing a more sensitive measure of functionality, pain, and performance impact.¹³ Given its greater specificity for this population, the KJOC is a more appropriate tool for evaluating the relationship between myofascial dysfunction and self-perceived shoulder function in water polo players, further reinforcing the rationale for its use in this study.^{14,15}

With the growing emphasis on injury prevention and performance optimization in sports medicine, a better understanding of myofascial dysfunction in water polo players could provide valuable insights for targeted therapeutic interventions. Manual therapy, dry needling, and other physiotherapeutic techniques have been shown to be effective in managing MTrPs¹⁴; however, their role in improving self-perceived function and sports performance requires further investigation. By correlating myofascial dysfunction with self-reported functional assessment through the KJOC questionnaire, rehabilitation strategies can be refined, and preventive measures tailored to this athletic population can be developed.

Despite the growing recognition of myofascial dysfunction in sports medicine, few studies have directly explored its relationship with functional outcomes in water polo players. Understanding this relationship could have important implications for both injury prevention and rehabilitation strategies. Therefore, the purpose of this study is to analyze the relationship between myofascial dysfunction in the shoulder musculature and self-perceived functional capacity in competitive water polo players.

MATERIALS AND METHODS

STUDY DESIGN AND ETHICAL CONSIDERATIONS

This study was conducted between July and October 2024. The aim of the study was to analyze the relationship between the presence of myofascial dysfunction in the shoulder muscles and the self-perceived functionality and performance of water polo players on their throwing shoulder. The STROBE guidelines were utilized in order to guarantee methodological transparency and rigor (<https://www.strobe-statement.org/>). Prior to its initiation, the study was approved by the research committee of the European University (code: CIPI/20/007) in accordance with the Declaration of Helsinki.¹⁵

PARTICIPANTS

Several water polo clubs in the Madrid region were contacted to seek their participation in the study. A sample of competitive water polo players from youth and senior categories from the clubs “Moscardó Waterpolo” and “Canoe” agreed to participate in the study and provided written informed consent after receiving detailed information about the study and having the opportunity to resolve any questions. A non-random convenience sampling method was employed.

The inclusion criteria were: 1) being an active male water polo player in the youth or senior category; 2) training at least five days per week; and 3) having no current injuries that would limit functional assessment. Players were excluded if they had chronic pathologies unrelated to the shoulder, a history of surgery in this region, or present pain at the time of evaluation.

Including only male subjects, was an attempt was made to homogenize the sample as much as possible to maximize the internal validity even if this meant limiting its external validity.¹⁶

OUTCOMES

Participants first answered a self-administered questionnaire with their demographic data such as age, weight, height, body mass index (BMI), and information about training volume, swimming experience, and the presence or absence of shoulder injuries in the prior year. In the last part of the questionnaire, participants completed a validated questionnaire, the Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow Score (KJOC).¹⁶

KERLAN-JOBE ORTHOPAEDIC CLINIC SHOULDER AND ELBOW SCORE (KJOC)

The KJOC¹⁶ is a patient-reported instrument validated, reliable, and responsive to the tested population of adult overhead athletes for shoulder and elbow functionality. This tool is better adapted to measurement of functional and psychological health than traditional objective measures of outcomes such as range of motion, strength, and radiographic variables, that are considered as poor indi-

cators for obtaining clinically relevant information.¹⁷ The questionnaire, designed for overhead athletes, such as baseball, volleyball, tennis, or swimming consists of ten items addressing aspects related to pain, functionality, athletic performance, and the ability to compete at the highest level. Each item is scored on a visual analog scale from 0 to 10, where 0 represents the greatest possible disability (severely limited function) and 10 indicates completely normal function without limitations. Therefore, the maximal possible score is 100. The KJOC has demonstrated diagnostic utility for identifying upper extremity dysfunction in overhead athletes. In elite female overhead athletes, the KJOC showed 86% sensitivity and 100% specificity, supporting its ability to discriminate between injured and non-injured athletes.¹⁸ In adolescent baseball players, the Japanese version of the KJOC identified symptomatic athletes with 81.5% sensitivity and 72.8% specificity using a cutoff score of 87.6 points (AUC=0.815), indicating good screening capacity for early dysfunction.¹⁹ Additionally, in youth baseball players, the KJOC demonstrated excellent discriminative ability (AUC=0.891), with a cutoff score of 68.6 points to differentiate throwing with versus without pain, although sensitivity and specificity were not directly reported.²⁰ Overall, the KJOC shows high sensitivity and population-dependent specificity, reinforcing its role as a valuable screening and evaluative tool in overhead athletes. In this study the version adapted and validated in Spanish was used.²¹

MYOFASCIAL DYSFUNCTION

The diagnosis of MTrPs is a widespread method in scientific literature as a criterion for diagnosing pain and musculoskeletal dysfunction of myofascial origin.^{22,23} However, there is still no consensus on the diagnostic criteria to date. A multitude of studies can be found that do not specify the diagnostic criteria used or are simply based on the criteria of experts as the basis for diagnosis. The most commonly used criteria for diagnosis described in the literature are presence of a spot tenderness in a taut band, provocation of a referred pain, provocation of the local twitch response, pain recognition as known or familiar to the subject, limited range of motion and jump sign.²⁴ The most frequent combination used for discerning the presence of MTrPs is spot tenderness, referred pain, and local twitch response but this only includes 22% of total studies.²⁶ A manual assessment was utilized by a physiotherapist with 20 years of clinical experience in diagnosing myofascial pain in the throwing shoulder (dominant side).

The present study did not intend to individually diagnose the presence of MTrPs in the subjects but instead used an assessment to correlate the tendency toward pain and myofascial dysfunction with self-perceived functional limitations. Due to the high variability in the use and combination of diagnostic criteria for MTrPs, it was decided to combine all the six most commonly used palpatory diagnostic criteria in the literature²⁴: (i) identification of a taut band, (ii) presence of a spot tenderness, (iii) provocation of a referred pain, (iv) provocation of the local twitch response, (v) pain recognition as known or familiar to the subject and

(vi) a jump sign, each being scored dichotomously as yes (1) or no (0), thereby obtaining a total score between 0 and 6 for each muscle of each subject.

The examination was performed in the lateral decubitus position lying on the contralateral side for the upper trapezius, levator scapula, supraspinatus, infraspinatus, teres major, teres minor and posterior deltoid muscles, and then continued in supine position for the biceps brachii, anterior deltoid, middle deltoid, pectoralis major, and subscapularis muscles, in that order.

The sequence used was: identification of a taut band within the whole body of the explored muscle, identification of a spot tenderness within the taut band (if several points were identified on the same muscle, the one with the greatest spot tenderness was evaluated), a gradual increase in digital compression of the spot tenderness/nodule sustained for a sufficient duration to look for the onset of referred pain and the identification by the subject of familiar or known pain, and finally, rapid stimulation of the spot tenderness transversely to the direction of the muscle fibers to attempt to provoke the local twitch response.²⁵ Throughout the process, the appearance of a jump sign was monitored.

In the case of the supraspinatus muscle, it was not deemed possible to identify the taut band and provoke the local twitch response as it is a deep muscle, so the final score for this muscle would be scored between 0 and 4.

STATISTICAL ANALYSIS

Data analysis was carried out using the Statistical Package for the Social Sciences (SPSS) Version 29 (Armonk, NY, USA) for Windows. The normality of data distribution was evaluated using the Shapiro-Wilk test ($p > 0.05$). Descriptive statistics were subsequently computed, with results expressed as either mean and standard deviation or median and interquartile range, depending on the distribution of the variables.

Spearman's rank correlation analysis was then performed to assess relationships between variables. Correlation strength was classified as follows: values below 0.3 indicated a weak correlation, 0.3 to 0.5 a fair correlation, 0.6 to 0.8 a moderate correlation, and values above 0.8 a strong correlation. Variables demonstrating statistical significance ($p < 0.05$) were incorporated into a stepwise multiple linear regression model to estimate the proportion of variance in functionality.

Hierarchical regression models were employed to identify key predictors of the KJOC score. Adjusted R^2 values were reported at each step to quantify the incremental explanatory power of each additional variable. The predictive equation was formulated using a hierarchical linear regression model, with variables entered sequentially in accordance with their theoretical relevance and presumed influence on the outcome variable.²⁶

RESULTS

A total of 33 semi-professional water polo players aged 18.30 ± 2.82 years (85% right sided dominance) were analyzed. [Table 1](#) presents the demographic data of the sample and the self-perceived function of the dominant shoulder per the KJOC.

[Table 2](#) presents the MTrP's outcomes for each muscle based on (i) identification of a taut band, (ii) presence of a spot tenderness, (iii) provocation of a referred pain, (iv) provocation of the local twitch response, (v) pain recognition as known or familiar to the subject and (vi) jump sign.

[Table 3](#) presents the correlations between the MTrPs assessment score of the dominant shoulder and the KJOC score, which showed significant moderate negative correlations with the following muscles: infraspinatus ($r = -0.413$, $p = 0.017$), subscapularis ($r = -0.377$, $p = 0.030$), and posterior ($r = -0.534$, $p = 0.001$), anterior ($r = -0.580$, $p < 0.001$), and middle ($r = -0.480$, $p = 0.005$) deltoid.

[Table 4](#) shows the hierarchical regression analysis for the KJOC score. Together, the total MTrPs score of the infraspinatus, subscapularis, anterior, middle, and posterior deltoid muscles explained 25.1% of the variance in the KJOC score.

Based on the regression analysis table provided, the final predictive formula for KJOC score is as follows:

Kerlan-Jobe Orthopaedic Test = $108.343 + (-2.722 \times \text{Infraspinatus score}) + (-2.453 \times \text{Posterior Deltoid score}) + (-5.973 \times \text{Anterior Deltoid score}) + (-1.776 \times \text{Middle Deltoid score}) + (0.794 \times \text{Subscapularis score})$.

DISCUSSION

This study aimed to analyze the relationship between myofascial dysfunction in the shoulder musculature and self-perceived functional capacity in competitive water polo players, revealing significant associations between the presence of MTrPs and reduced function.

One of this study's novel aspects is applying the KJOC questionnaire as a baseline measure to assess perceived shoulder function in water polo players. While tools such as the DASH have been used in previous research, their application in high-performance athletes has limitations as they do not accurately capture the specific demands of the sporting gesture.²⁷ Using the KJOC allowed for a sensitive assessment of subtle self-perceived functional alterations that may affect performance in high-velocity throwing.

Findings in this study show a significant relation between myofascial dysfunction and the perceived functionality of the shoulder of water polo players. The presence of MTrPs in the infraspinatus, subscapularis, and the three portions of the deltoid (anterior, middle, and posterior) was negatively correlated with shoulder functionality, as measured by the KJOC score, suggesting that myofascial dysfunction is associated with lower levels of self-perceived function. According to the literature, MTrPs appear to not only generate local and referred pain but were associated with significant alterations in the neuromuscular function of the shoulder,^{2,28} affecting movement in throwing ath-

Table 1. Participant demographic data and self-perceived functionality in the dominant shoulder. Values are reported as Mean $\pm$ standard deviation.

	Mean $\pm$ SD (N=34)
Age, years	18.30 $\pm$ 2.82
Weight, kg	73.15 $\pm$ 9.96
Height, m	1.77 $\pm$ 0.06
BMI (kg/m ²)	23.23 $\pm$ 2.73
Weekly training volume, days	4.97 $\pm$ 0.17
Swimming training experience, years	10.64 $\pm$ 3.55
Self-perceived functionality in the dominant shoulder	
Ability to get loose or warm-up prior to competition or practice	7.39 $\pm$ 2.08
Absence of pain in shoulder	6.42 $\pm$ 3.26
Strength perceived in shoulder	6.82 $\pm$ 2.88
Stability perceived in shoulder	6.82 $\pm$ 3.06
Relationship with coaches, management, and agents	8.79 $\pm$ 2.22
Maintenance of throwing technique	7.36 $\pm$ 3.01
Velocity/power perceived in shoulder	8.12 $\pm$ 2.22
Endurance perceived in shoulder	7.91 $\pm$ 2.55
Motor control perceived in shoulder	7.85 $\pm$ 2.87
Maintenance of level of competition	7.76 $\pm$ 2.71
Kerlan-Jobe Orthopaedic Test Total Score	75.06 $\pm$ 21.35

Table 2. Myofascial dysfunction score for each muscle.

Muscle	Myofascial dysfunction score (0 to 6)
Upper trapezius	3.58 $\pm$ 1.03
Levator scapula	2.09 $\pm$ 1.91
Supraspinatus*	0.73 $\pm$ 0.91
Infraspinatus	2.30 $\pm$ 1.72
Teres major	3.12 $\pm$ 1.54
Teres minor	1.70 $\pm$ 1.72
Posterior deltoid	2.36 $\pm$ 1.48
Anterior deltoid	3.45 $\pm$ 1.23
Middle deltoid	1.28 $\pm$ 1.59
Subscapularis	3.33 $\pm$ 1.76
Biceps brachii	1.24 $\pm$ 1.28
Pectoralis major	3.09 $\pm$ 1.36

*Supraspinatus is scored 0-4)

letes. Their presence may be associated with changes in muscle activation, motor control deficits, and proprioceptive alterations, as has been reported in previous literature that indicates that MTrPs are related to decreased muscle strength and changes in motor coordination.²⁸ However, these variables were not assessed in the present study and suggestions regarding their alterations should be interpreted with caution.

Although not the subject of this study, it is worth mentioning, that it has been suggested that MTrPs negatively

impact proprioception, altering joint position perception and the athlete's ability to adjust movements accurately.²⁹ In water polo players, this could result in reduced throwing control, increasing the risk of compensatory muscle patterns and premature fatigue.^{30,31} Proprioception and performance in the presence of MTrPs should be studied further.

The regression analysis indicated that the myofascial status of the muscles (infraspinatus, subscapularis, anterior, middle, and posterior deltoid) explain 25.1% of the variability in the KJOC score, with the anterior deltoid emerging as the muscle with the most significant impact on shoulder function. This may be because the anterior deltoid is a key muscle for force generation into horizontal adduction and flexion during throwing and that its overload could contribute to shoulder dysfunction in water polo.³⁴ The relationship between the presence of myofascial dysfunction and the perceived loss of shoulder function align with prior evidence suggesting that myofascial dysfunction in the rotator cuff may contribute to functional impairment in overhead athletes.³²

The rotator cuff plays a fundamental role in shoulder stability and function, enabling efficient action in the throwing movements characteristic of water polo.³³ The results of this study reinforce the idea that MTrPs in the rotator cuff muscles (infraspinatus and subscapularis, in addition to deltoid) significantly contribute to shoulder dysfunction as described by the KJOC, more so than MTrPs in other muscles measured within the shoulder complex (upper trapezius, levator scapula, teres major, biceps brachii or pectoralis major).³³ Other studies have shown

Table 3. Correlations between dominant shoulder's perceived function and the presence of MTrPs.

	Upper Trapezius	Levator Scapulae	Supraspinatus	Infraspinatus
Kerlan-Jobe Orthopaedic Test	-0.109 p=0.545	-0.244 p=0.171	-0.302 p=0.088	-0.413 p=0.017
	Teres Major	Teres Minor	Posterior Deltoid	Biceps brachii
	0.032 p=0.858	-0.158 p=0.380	-0.534 p=0.001 *	0.203 p=0.257
	Anterior Deltoid	Middle Deltoid	Subscapularis	Pectoralis Major
	-0.580 p<0.001 *	-0.480 p=0.005 *	-0.377 p=0.030 *	0.021 p=0.909

Bold font indicates significant correlation at p<0.05.

Table 4. Hierarchical linear regression for the dependent variable Kerlan-Jobe Orthopaedic Test.

	Predictor	B	SE B	β	t	p-value	Adjusted R ²
Kerlan-Jobe Orthopaedic Test	CONSTANT	108.343	9.928		10.91	<0.001	0.251
	Infraspinatus	-2.722	2.157	-0.220	-1.262	0.218	
	Posterior Deltoid	-2.453	2.787	-0.169	-0.880	0.386	
	Anterior Deltoid	-5.973	3.849	-0.343	-1.552	0.132	
	Middle Deltoid	-1.776	2.330	-0.132	-0.763	0.452	
	Subscapularis	0.794	2.337	0.066	0.340	0.737	

how the presence of latent MTrPs in the infraspinatus and middle deltoid alters the pattern of muscle activation during scapular plane elevation, potentially predisposing to overuse conditions including impingement syndrome and rotator cuff pathology, demonstrating that myofascial dysfunction generates functional deficits even before the onset of pain.³⁴

From a clinical perspective, although the regression analysis suggested a possible contribution of MTrPs in specific shoulder muscles to functional outcomes, these results must be interpreted cautiously due to the limited sample size and the exploratory nature of the model. The predictive equation obtained indicates that dysfunction in the anterior deltoid exerts the most significant negative impact on the KJOC score, followed by the posterior deltoid, infraspinatus, middle deltoid and subscapularis. This finding is relevant, as the anterior deltoid and infraspinatus play pivotal roles in stabilizing the shoulder during throwing and preventing posterosuperior impingement, respectively.³⁵ The involvement of the subscapularis also highlights the importance of muscle balance in rotator cuff and its influence on throwing mechanics.⁸

It is important to highlight that latent MTrPs can cause functional alterations without producing pain.³⁶ These silent dysfunctions may contribute to biomechanical compensations that predispose athletes to overuse injuries over time. Therefore, periodic evaluation of MTrPs in overhead-throwing athletes could serve as a valuable tool for early diagnosis and injury prevention, even in the absence of clinical symptoms.

Myofascial dysfunction could be added as a risk factor, consistent with those proposed in a recent systematic review that include range of motion, strength, training load, musculoskeletal pain, and previous injuries.³⁷ Additionally, the importance of assessing and treating myofascial dysfunction as part of prevention and rehabilitation strategies in overhead-throwing athletes has been highlighted.^{38,39} Accordingly, therapeutic interventions such as myofascial release, dry needling, eccentric strengthening, and neuromuscular retraining may be considered for restoration of optimal function and reduction of risk of further dysfunction.

LIMITATIONS

Although the diagnosis of MTrPs is widely used in both clinical practice and research, there is no universally accepted gold standard for their identification. This lack of standardized diagnostic criteria introduces variability and limits the comparability between studies. In the present study, the authors attempted to address this gap by grouping six commonly used criteria without establishing hierarchical weight, but this approach remains subjective and was not studied for reliability.

Another limitation is although all assessments were performed by a single physiotherapist for consistency, this introduces the potential for examiner bias. Although the evaluator had extensive clinical experience in assessment of myofascial pain, the lack of blinding and inter-rater reliability analysis could have influenced the consistency and objectivity of the measurements.

Additionally, the study did not include a control group of asymptomatic or non-athlete individuals, which restricts the ability to establish relative comparisons or baseline reference values. This cross-sectional design only allowed assessment of associations in the presented sample and does not allow discernment of causality.

Only the dominant shoulder (throwing arm) was evaluated in each participant, which limits the understanding of bilateral or compensatory patterns that may be present in this athletic population. Finally, the study population consisted exclusively of male competitive water polo players. While this enhances internal validity by reducing variability, it also restricts external validity and limits generalizability to other sports, age groups, and female athletes.

Future research should address these limitations by incorporating blinded assessments that have been assessed for reliability and exploring objective diagnostic tools such as elastography or imaging techniques to complement manual palpation. Including female athletes and different sport populations would enhance generalizability and the addition of a control group would allow for more robust comparisons. Longitudinal studies are also needed to determine the causal relationships between myofascial dysfunction and functional outcomes.

CONCLUSION

The presence of MTrPs in key shoulder muscles, particularly the deltoid and muscles of the rotator cuff, demonstrated moderate correlations with decreased self-perceived

function in male water polo athletes as measured by the KJOC questionnaire. Although causality cannot be inferred due to the cross-sectional nature of the study, these findings highlight the potential clinical relevance of screening for myofascial alterations in overhead-throwing athletes. Future research incorporating objective diagnostic methods, blinded evaluations, and broader populations is warranted to validate and expand these findings.

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