

Electromyographic Assessment of Professional Soccer Goalkeepers Experiencing Shoulder Pain During a Functional Activity

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ABSTRACT

Purpose: Shoulder pain is a common complaint among professional goalkeepers. The aim of the study was to examine and compare the electromyographic (EMG) activity of some shoulder girdle muscles between professional goalkeepers with and without Shoulder pain. For the comparison, we relied on a standardised, low-load functional task for the upper limb.

Methods: Fourteen professional male goalkeepers with unilateral mechanical shoulder pain participated; 14 pain-free players served as controls. All came from first- or second-division clubs, matched by age, anthropometrics, playing level. Surface EMG recorded activity in seven muscles : the upper trapezius (UT), middle trapezius (MT), lower trapezius (LT), serratus anterior (SA), middle deltoid (MD), latissimus dorsi (LD) and sternocleidomastoid (SCM). Players performed a validated low-load task. EMG amplitude was expressed as root mean square values referred to maximal voluntary contraction (%MVC). Group differences were examined with MANOVA and Bonferroni correction.

Results: Goalkeepers with shoulder pain showed significantly higher activation in UT (28 ± 10 vs 13 ± 6 %MVC, $p < 0.001$), SA (24.35 ± 11.20 vs 14.10 ± 7.02 %MVC, $p = 0.008$), and LD (24.08 ± 10.02 vs 8.10 ± 5.93 %MVC, $p < 0.001$). No differences emerged for MT, LT, MD, or SCM.

Conclusion: A scapulothoracic activation pattern that leans differently appears linked with shoulder pain in goalkeepers. Upper trapezius and latissimus dorsi take on greater roles, serratus anterior increases as well, yet the rise seems compensatory and probably falls short. Similar profiles have turned up among swimmers and overhead athletes in general. These observations suggest adding targeted scapular-stabiliser retraining to programs aimed at goalkeeper rehabilitation and injury prevention.

Keywords

EMG, Goalkeepers, Shoulder pain.

Introduction

The glenohumeral joint relies on a delicate balance between its main muscle groups, like the deltoid and pectoralis major, and stabilizing muscles, especially the serratus anterior and trapezius. This balance is crucial for maintaining a consistent center of rotation during repetitive overhead activities and diving. For football goalkeepers, the position presents unique challenges. They make overarm throws, catch, and block quickly, which all

require strong eccentric control. Additionally, they often fall and dive, putting stress on their shoulders during extreme abduction and external rotation, or when hitting the ground.

Epidemiological studies indicate that goalkeepers may have a higher injury rate compared to outfield players. A major video study in German professional football showed a significantly greater relative risk of shoulder dislocation in goalkeepers compared to others. Most injuries resulted from falls. Similarly, a large cohort study in Brazilian professional football found that goalkeepers had more than double the risk of shoulder injuries

compared to attacking players, involving both glenohumeral and acromioclavicular joints. Research on youth goalkeepers also revealed common features of “disabled throwing shoulder”. This is understandable since the goalkeeper's arm acts like a throwing arm in baseball, handball, or water polo but includes unique falling and impact elements.

Despite this known risk, there’s a lack of EMG-based studies on how goalkeepers with shoulder pain activate important muscles. Prevention programs aimed at this group, like the FIFA 11+ Shoulder program, have mainly drawn on exercise evidence from different throwing sports rather than goalkeeper-specific EMG data. Collecting reliable EMG data during vigorous movements is difficult. Factors like fatigue, pain-related muscle inhibition, daily fluctuations, and practical issues with standardization complicate the process. Therefore, using low-load, pain-free functional tasks is a sensible approach. Such tasks have been successful in studying muscle activation in individuals with neck and shoulder pain and have been applied to elite swimmers with similar injuries. They provide a viable way to compare muscle use in goalkeepers with and without symptoms.

This study aimed to compare the activation of seven shoulder-girdle muscles: upper, middle, and lower trapezius, serratus anterior, middle deltoid, latissimus dorsi, and sternocleidomastoid. This was done between professional goalkeepers with shoulder pain and those without during a standard low-load functional upper-limb task. The hypothesis was that those in pain would show a different activation pattern, particularly higher activity in the upper trapezius and latissimus dorsi, consistent with patterns seen in other overhead athletes.

Methods

Participants

Twenty-eight male goalkeepers from first and second division clubs participated in this study, conducted in the department of Physical and Rehabilitation Medicine of university hospital center of Ibn Rochd, Casablanca, Morocco. Fourteen reported ongoing unilateral mechanical shoulder pain in their throwing arm lasting three months or more, with above-average discomfort scores on the Cornell questionnaire. The other fourteen served as pain-free controls, matched by age and playing level. None of the controls had undergone shoulder surgeries, experienced dislocations, or had upper limb injuries in the past year. Demographic and anthropometric information is listed in Table 1, showing no significant differences in age, body mass, height, BMI, professional experience, or weekly throw volume estimates between the groups.

Surface electromyography

Surface EMG signals were recorded from seven muscles on the dominant throwing and diving side: upper trapezius, middle trapezius, lower trapezius, serratus anterior, middle deltoid, latissimus dorsi, and sternocleidomastoid. The electrodes were placed according to SENIAM and Hermens guidelines after skin preparation, with placement confirmed through manual testing. Maximal voluntary isometric contractions were measured for each

muscle in three five-second attempts, separated by thirty seconds of rest, and then averaged to normalize the data.

Table 1: Descriptive demographic and training-exposure data (M ± SD) for the pain and control groups.

Variable	Pain group (n = 14)	Control group (n = 14)	p-value
Age (years)	24.86 ± 3.42	24.21 ± 3.05	0.612
Body mass (kg)	82.14 ± 5.63	81.30 ± 6.10	0.712
Height (cm)	188.50 ± 4.71	187.90 ± 5.02	0.756
BMI (kg/m²)	23.11 ± 1.02	23.02 ± 1.14	0.831
Professional experience (years)	6.9 ± 2.8	6.4 ± 2.5	0.640
Weekly distribution throws (n)	215 ± 48	198 ± 40	0.318

Functional upper-limb task

A validated low-load functional task was implemented. Participants sat with their non-tested forearm resting on their lap and their tested elbow supported at table height. They used a pen to mark points inside three seventy-millimeter circles arranged in an equilateral triangle, with centers twenty-three centimeters apart, moving counterclockwise in time with a metronome set at eighty-eight beats per minute for one hundred fifty seconds. This task avoids the overhead movements that can trigger pain in affected goalkeepers, which helps reduce pain-related inhibition and technical variability often seen in high-speed EMG recordings.

Data analysis

Raw signals were passed through a 20 to 480 hertz band pass filter and sampled at 1000 hertz. The root mean square amplitude was calculated over six three-second segments from the middle of each trial, discarding the first and last 20 seconds. The data were then averaged and expressed as a percentage of maximum voluntary isometric contraction (MVIC). Differences between groups were analyzed using one-way MANOVA, followed by Bonferroni-adjusted pairwise tests. Partial eta squared values were used to report effect size: small between 0.05 and 0.10, moderate between 0.10 and 0.20, and large above 0.20. The alpha level was set at 0.05.

Results

A significant multivariate group effect on shoulder-girdle muscle activity was found in the overall MANOVA. When the results were broken down with univariate tests (Table 2), goalkeepers reporting shoulder pain showed clearly higher activation than pain-free controls in the upper trapezius, serratus anterior, and latissimus dorsi, and each difference was accompanied by a large effect size. Between groups, no significant differences were detected for the middle trapezius, lower trapezius, middle deltoid, or sternocleidomastoid. Even so, middle deltoid activation leaned higher in the pain group, though this did not reach significance and the effect size was moderate.

Table 2: Group comparison of normalised muscle activity (%MVC) during the functional task.

Muscle	Group	M ± SD (%MVC)	F	p	η ² p
Upper trapezius	Pain	28.00 ± 10.00	23.16	<0.001	0.471
	Control	13.00 ± 6.00			
Serratus anterior	Pain	24.35 ± 11.20	8.24	0.008	0.241
	Control	14.10 ± 7.02			
Latissimus dorsi	Pain	24.08 ± 10.02	26.35	<0.001	0.503
	Control	8.10 ± 5.93			
Middle trapezius	Pain	14.02 ± 7.05	3.03	0.094	0.104
	Control	10.04 ± 4.91			
Lower trapezius	Pain	12.03 ± 6.08	0.92	0.347	0.034
	Control	10.12 ± 5.20			
Middle deltoid	Pain	19.94 ± 10.02	6.91	0.014	0.210
	Control	11.04 ± 8.07			
Sternocleidomas- toid	Pain	6.07 ± 4.05	2.24	0.147	0.079
	Control	4.06 ± 2.98			

Discussion

To the best of the authors' knowledge this is the first study to examine the activation patterns of the scapulothoracic and glenohumeral muscles in professional goalkeepers with shoulder pain. Moreover, a standard low-load functional task was investigated instead of the more common throwing or diving tasks. The results show higher activity of the upper trapezius, serratus anterior, latissimus dorsi, whilst no difference was found for the middle and lower trapezius, middle deltoid and sternocleidomastoid muscles. This pattern is similar to those previously reported in elite swimmers with shoulder pain. Additionally it has been reported in previous investigations in other overhead athletes and in patients diagnosed with subacromial pain syndrome [1,2]. The observed higher activity in the upper trapezius muscle is in line with its known response to repeated load during overhead lifting tasks [1,2]. This is especially the case for goalkeepers, who need shoulder mobility to lift the arms quickly from the guard position to catch or block a shot. It is not surprising that trauma-prevention protocols for goalkeepers traditionally involve the trapezius and serratus anterior muscles, as they contribute to maintain an optimal scapulohumeral rhythm and prevent scapular dyskinesis during repeated overhead reaching and diving actions [3]. The concomitant higher activity in serratus anterior may reflect an attempt to compensate for the higher upper trapezius activity but it is likely insufficient to maintain the scapular force couple described by Inman et al. [4]. This assumption is based on previous electromyography studies that demonstrate the necessity of co-activation of serratus anterior and lower trapezius to maintain scapula upwardly rotated and tilted during arm elevation [2]. Exercises that involve these two muscles and reduce upper trapezius activity are essential in the first phase of scapular rehabilitation [5]. The lack of similar increase in lower trapezius activity among goalkeepers (reflecting swimmer data) [6,7] implies that the force couple is partly maintained and the scapula remains at risk for dyskinesis during higher velocity, higher load actions that goalkeepers execute in match and training. The meaningful differences in latissimus dorsi muscle activation observed in this group may serve as a compensatory mechanism to stabilize the

humeral head during the low-load task, similar to those proposed in swimmers with painful shoulders [6,8]. Given the latissimus dorsi muscle's important role as humeral depressor, adductor and internal rotator it is likely to be heavily recruited during goalkeeper-specific tasks such as diving push-off, ball punching and deceleration following throwing [9,10].

Long-term over-activation may also exacerbate problems associated with the external rotation deficit [11] and compensatory changes in posture, which may not address the primary cause of impingement. The lack of differences in middle deltoid activity although favoring the pain group may reflect true variability, the relatively small sample size or a task-specific ceiling effect due to the low external load used. Similarly the lack of differences in sternocleidomastoid between groups is in agreement with previous studies in swimmers performing the same functional task [6,7]. These findings imply that changes may be specific to muscles involved in scapulothoracic relationships rather than a general effect related to the task affecting all cervicoscapular muscles. These findings have clinical implications and justify incorporating exercises to activate the serratus anterior and lower trapezius muscles, as well as treating the over-activity of the upper trapezius and latissimus dorsi muscles within goalkeeper-specific rehabilitation protocols and injury-prevention programs such as the Thrower's Ten [12,13] and the FIFA 11+ Shoulder framework [3]. Given that falls and direct ball impacts rather than throwing account for many goalkeeper shoulder injuries [9,10], future programs should include exercises to improve scapular control within fall-specific or diving-specific movement patterns in addition to traditional throwing exercises. Limitations of this study include the following. Whilst beneficial for pain-related inhibition and technical artifacts, the functional task does not reflect the high-velocity, high-load specific actions of goalkeeping and findings should be applied to on-field situations with caution. Cross-talk is known to occur with surface electromyography even with standardized electrode placement [14-16]. The sample size which is comparable to other electromyography studies in elite sport [6,7] may be of limited statistical power, especially for muscles with moderate but non-significant effects. Finally the design of this study was taken from a similar study in swimmers [6,7] and it does not take into account goalkeeper-specific factors such as falls, ball impacts and gloves which need further investigation.

Conclusion

Greater muscle activity of the upper trapezius, serratus anterior and latissimus dorsi was observed in professional goalkeepers during a standardised low-load functional test compared with goalkeepers without shoulder pain. No differences were found for the middle trapezius, middle deltoid and sternocleidomastoid muscles. These findings are in agreement with alterations observed in swimmers and other overhead athletes.

The present findings indicate that shoulder pain in goalkeepers may be related to a disturbed scapulothoracic force couple, rather than a general shift across the shoulder girdle. Consequently, the current findings provide support for including assessment and retraining of the scapular stabilisers in specific shoulder injury prevention

and rehabilitation programmes for goalkeepers.

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Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the authors used « Claud » in order to improve writing and language skills. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article

Written consents from participants was obtained by the authors

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