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Research Article

Effectiveness of Modified Sleeper Stretch Combined with Modified Cross-Body Adduction in Alleviating Shoulder Stiffness Among Overhead Throwing Athletes: A Retrospective Cohort Study

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Abstract

Introduction: Overhead-throwing athletes frequently experience shoulder joint issues, specifically reduced internal rotation and posterior capsule tightness. This study aimed to compare the effects of two interventions on shoulder internal rotation, pain, and joint function: one involving a combination of modified sleeper stretch and cross-body adduction and the other, conventional physiotherapy.

Methods: This retrospective cohort study compared two groups of overhead-throwing athletes: one undergoing conventional physiotherapy from 2016 to 2019 and another receiving a combination of modified sleeper stretch and cross-body adduction exercises from 2020 to 2021. The conventional physiotherapy cohort focused on Codman's exercises, while the later cohort received modified sleeper stretch combined with cross-body adduction exercise. Outcome measures included pain intensity (visual analog scale), glen humeral internal rotation (GHIR), and shoulder function (Constant Score).

Results: The study enrolled 160 patients, equally divided into two cohorts. Both cohorts showed similar baseline characteristics regarding age, sex, VAS score, GHIR degree, and Constant Score, with no statistically significant differences. Post-treatment, the second cohort (sleeper stretch and cross-body adduction) exhibited more significant improvements: GHIR increased from 49.0 ± 6.4 to 71.0 ± 5.8 degrees compared to 48.0 ± 5.2 to 59.2 ± 5.4 degrees in the first cohort. VAS scores decreased more significantly in the second cohort, from 4.5 ± 1.2 to 0.9 ± 0.8, compared to 4.8 ± 1.0 to 2.6 ± 0.8 in the first cohort. Similarly, Constant Scores improved more in the second cohort, from 49.0 ± 6.4 to 88.0 ± 4.0, in contrast to 48.0 ± 5.2 to 79.2 ± 3.8 in the first cohort.

Conclusion: These findings indicate the superior effectiveness of posterior shoulder stretching exercises in enhancing shoulder function and reducing pain among overhead-throwing athletes compared to conventional physiotherapy.

Keywords: Shoulder rehabilitation, stretching techniques, Overhead-throwing athletes, Sports injuries, Shoulder stiffness.

Introduction

Shoulder injuries, accounting for about 30% of all sports-related injuries, are particularly prevalent among overhead-throwing athletes in sports such as volleyball, baseball, and tennis.[1] These sports place high stress on the shoulder, often leading to chronic stress-related changes like posterior shoulder tightness (PST), which

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can reduce internal rotation (IR) and increase external rotation (ER).[2] Glenohumeral internal rotation deficit (GIRD) is defined as a significant (>20-degree) discrepancy in IR between the shoulders.[3] In most cases, this decrease in IR is accompanied by an increase in ER, so the total ROM (TROM) does not change significantly compared to the contralateral shoulder.[4] According to a study by Wilk et al., if this difference in TROM is more than 5 degrees between the shoulders, it can be associated with shoulder injuries.[5] The altered IR is often due to the shortening of posterior shoulder muscles, such as the posterior deltoid, infraspinatus, and teres minor muscles.6 Additionally, there is a thickening of the posterior glenohumeral capsule resulting from repetitive microtrauma during the deceleration phase of throwing.7 Bony changes, such as increased humeral retroversion, can contribute to this alteration by decreasing IR and increasing ER in these athletes.[8]

To manage GIRD, enhance ROM, alleviate muscle soreness, and reduce shoulder injury risk, posterior shoulder stretching has been identified as a key approach.8 Cross-body or horizontal adduction and the sleeper stretch are notable among the various techniques.[9] Both methods had their limitations despite their successes. Salamh et al. showed that cross-body adduction, which was performed upright, did not stabilize the scapula, which prevented the stretching from focusing on the posterior structures of the glenohumeral joint.[2,10] Sleeper stretching also caused significant discomfort for patients because they had to lie directly on the affected shoulder. Therefore, modifications were introduced for both methods to address these limitations.[11] To overcome these drawbacks, modified versions of these two techniques were introduced in the side-lying position on the affected shoulder with 20 to 30 degrees rolling towards the posterior.[2] This position not only decreases the direct pressure on the shoulder, reduces the patient's discomfort, stabilizes the scapula, and focuses the stretching forces on the posterior glenohumeral structures.[12]

Conventional physiotherapy of patients with shoulder injury mainly includes the Codman exercises.[13] The Codman's exercises, also known as pendulum exercises, require the patient to stand with their trunk bent forward and the affected arm hanging down. Using the momentum generated from trunk movements, the arm is swung without engaging the shoulder girdle muscles. This method allows the arm to move in various directions: forward and backward, side to side, or in a circular motion.[13,14] Research shows that Codman exercises may be beneficial in improving the early stretching of the upper limb, but in long-term, this method has limitations in restoring the passive shoulder ROM.[14]

Several studies have investigated these two posterior shoulder stretching methods, and most of them have evaluated and compared the results of each method individually.[15,16] While most of these studies reported positive effects of both methods on ROM and shoulder discomfort in throwing athletes, they typically involved smaller sample sizes.[16,17] On the other hand, the effect of combining both of these methods on GIRD and its comparison with conventional physiotherapy has yet to be studied in the literature.[18] Therefore, this study aimed to retrospectively investigate the effect of the simultaneous application of these two methods on a more significant number of overhead-throwing athletes with PST and GIRD following shoulder injury caused by overhead-throwing sports.

Methods

Study design

Study design and population

This research was conducted as a retrospective cohort study at the 5th Azar Hospital in Gorgan, Golestan, Iran. It included two distinct patient groups, differentiated based on a change in our center's rehabilitation protocol implemented in 2019 based on the experts' opinions and updated literature and evidence in the field. The first group consisted of patients who received the conventional physiotherapy protocol from 2016 to 2019. The second group was individuals treated with modified sleeper stretch and cross-body adduction exercises from 2020 to 2021. The participants were included, and their treatment outcomes were assessed based on a comprehensive review of existing medical records, allowing for a comparative analysis between the two rehabilitation approaches.

Inclusion and exclusion criteria

The study included participants actively engaged in overhead throwing activities, performing these at least

three times a week, with each session lasting at least 30 minutes. Additionally, eligibility was contingent upon the experience of shoulder pain and a demonstrable reduction in internal rotation. This reduction was quantitatively defined as an internal rotation discrepancy exceeding 20 degrees compared to the unaffected shoulder, with the shoulder 90 degrees abducted. Conversely, participants were excluded if they had a history of upper extremity trauma or surgery within the preceding two years or if they had sustained any fractures or dislocations involving upper extremity joints. In addition, patients whose medical records were incomplete for measuring the study variables were excluded.

Physiotherapy protocols

The initial patient cohort underwent a conventional physiotherapy protocol focused on enhancing shoulder mobility and pain using Codman's exercises and a hot pack.14 In this method, an orthopedic surgeon instructs patients to perform the exercises for 30 minutes, three days a week, for four weeks.

In contrast, the subsequent cohort followed a protocol incorporating modified sleeper stretch and cross-body adduction exercises. These exercises were performed three times daily, thrice a week, for four weeks. An orthopedic surgeon provided detailed guidance for each exercise and also conducted regular follow-up assessments for both cohorts.

The modified sleeper stretch involved patients lying on the side of their affected shoulder with a 30° posterior trunk tilt, positioning the shoulder and elbow at 90 degrees' flexion. Passive internal rotation was achieved by applying force through the distal forearm, with a towel placed under the arm to intensify posterior element stretching [Figures 1 and 2]. The shoulder was maintained in maximum internal rotation for 30 seconds, then returned to the starting position. This exercise was repeated for ten consecutive cycles, three times daily, thrice a week, across four weeks.

For the modified cross-body adduction exercise, patients lie in the same position as they do for the modified sleeper method. The uninvolved hand performed passive adduction, holding the shoulder in the maximum adduction position for 30 seconds before returning to the start position [Figure 3]. Like the modified sleeper stretch, this exercise was repeated ten times in succession, three times daily, for four weeks.

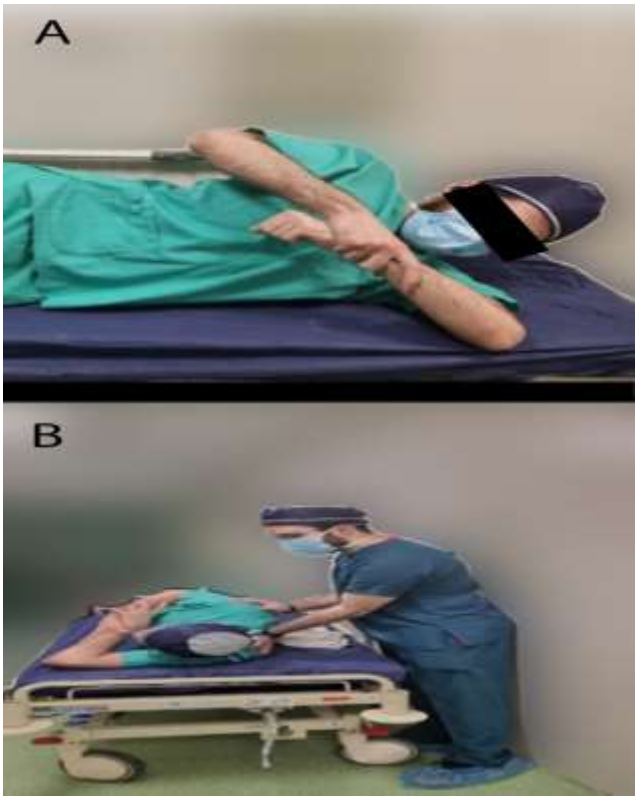

Figure 1: Modified Sleeper Stretch Technique; This image demonstrates the patient positioned in posterior rotation between 20° and 30°, which aids in stabilizing the scapula while preventing subacromial impingement.

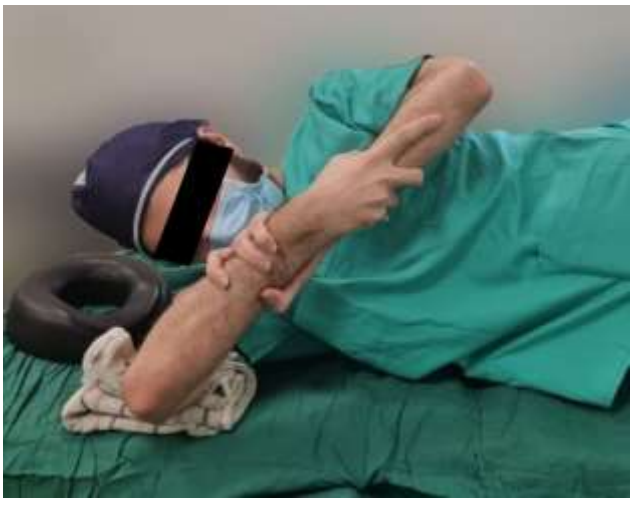

Figure 2: Enhanced Effectiveness of the Modified Sleeper Stretch; Illustrates how the placement of a towel under the arm intensifies the stretch in the posterior shoulder region.

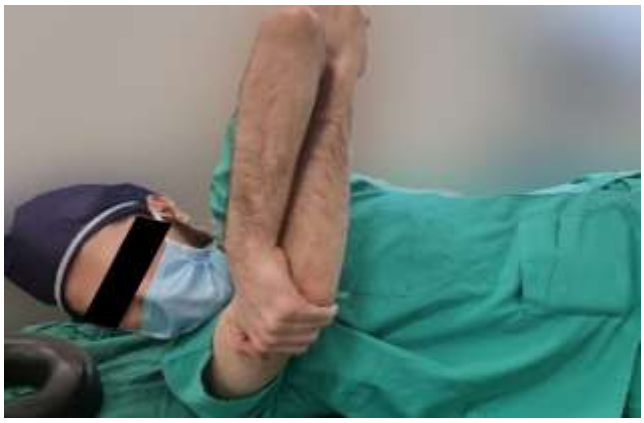

Figure 3: Modified Cross-Body Adduction; Depicts the posture and technique involved in the modified cross-body adduction exercise.

Outcome measures

The study employed the visual analog scale (VAS) to quantify the current pain intensity, with a scale ranging from 0 (no pain) to 10 (maximum pain). Additionally, both cohorts underwent assessments for glenohumeral internal rotation (GHIR) in a supine position. This involved positioning the shoulder at a 90-degree abduction, aligned with the plane of the body. The examiner applied downward pressure to stabilize the scapula against the examination table during this assessment. Active internal rotation measurements were precisely conducted using a goniometer. Furthermore, the functionality of each patient's shoulder was evaluated using the Constant score (CS), which provides a comprehensive assessment of shoulder capability and health.19,20 The study variables were measured once before the start of the treatment protocols in both groups and once again on the first working day after the end of the protocols by an orthopedic surgeon.

Statistical analysis

Our analysis used descriptive statistics to report the mean ± standard deviation (SD) for quantitative outcome measures, including VAS score, CS, and GHIR degree. Categorical variables were summarized by their frequency and percentage. To verify the normal distribution of these data, we applied the Shapiro-Wilk and Kolmogorov-Smirnov tests. Paired samples T-tests were utilized to evaluate the changes in VAS score, CS, and GHIR degree before and after treatment. Additionally, independent samples T-tests were conducted to compare these outcome measures between the two study cohorts. We assessed the differences between the groups using P-values and 95% confidence intervals (CI), considering a P-value of less than 0.05 as statistically significant. All statistical analyses were performed using IBM SPSS Statistics, version 22 (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.). GraphPad Prism version 9 for Windows (GraphPad Software, Boston, Massachusetts, USA) was used for data visualization, facilitating a more explicit graphical representation of the study's findings.

Results

Study population characteristics

A total of 160 patients were included in this study. The first cohort, which received the conventional physiotherapy protocol, comprised 80 patients, including 32 females (40.0%) and 48 males (60.0%), with a mean age of 24.4 ± 4.5 years. The second cohort, treated with the modified sleeper stretch and cross-body adduction exercises, also consisted of 80 patients, 16 females (20.0%) and 64 males (80.0%), with a mean age of 22.6 ± 4.3 years. The baseline characteristics, age, and sex did not show statistically significant differences between the two cohorts, with P-values of 0.21 for age and 0.30 for sex distribution [Table 1].

Furthermore, the baseline values of the outcome measures were similarly comparable across both cohorts. The VAS score was 4.8 ± 1.0 in the first cohort and 4.5 ± 1.2 in the second cohort, with a mean of 4.7 ± 1.1 (P-value = 0.39). The GHIR degree recorded a mean of 48.0 ± 5.2 in the first cohort and 49.0 ± 6.4 in the second cohort, averaging 48.5 ± 5.8 overall (P-value = 0.59). The CS was consistent across both groups, with a mean of 69.8 ± 5.7 in the first cohort and 69.8 ± 6.2 in the second cohort, resulting in a combined mean of 69.8 ± 5.9 (P-value = 1.00) [Table 1].

Comparison of outcome measures before and after physiotherapy

In this study, both groups demonstrated notable improvements in GHIR degree, VAS scores, and CS following their respective treatments. The second cohort, which received the modified sleeper stretch and cross-body adduction exercises, exhibited more pronounced improvements than the first cohort, which underwent the conventional physiotherapy regimen. Specifically, regarding GHIR, the first cohort improved from a pre-treatment mean of 48.0 ± 5.2 degrees to 59.2 ± 5.4 degrees' post-treatment. In comparison, the second cohort improved from 49.0 ± 6.4 degrees to 71.0

± 5.8 degrees, with a 95% Confidence Interval (CI) difference between the groups post-treatment from 8.2 to 15.3.

Similarly, VAS scores decreased substantially in both groups, but more so in the second cohort, with a reduction from a pre-treatment mean of 4.8 ± 1.0 to 2.6 ± 0.8 in the first cohort, and from 4.5 ± 1.2 to 0.9 ± 0.8 in the second cohort. The 95% CI of the difference in VAS score reduction between the cohorts was between -2.2 and -1.2. Furthermore, the Constant score improvements were more significant in the second cohort than in the first, with the first cohort's score increasing from a pre-treatment mean of 48.0 ± 5.2 to 79.2 ± 3.8 post-treatment and the second cohort's score increasing from 49.0 ± 6.4 to 88.0 ± 4.0. The 95% CI of the difference in Constant score improvement was between 6.3 and 11.3 [Table 2 and Figure 4].

Table 1: patient characteristics

Variables		Substance abuser (n = 70)	Non-abuser (n = 222)	P value
Age (year)		38.7 ± 15	41.7 ± 18.7	0.427 [a]
Gender	Male	65 (92.9%)	152 (68.5%)	0.0001 [b]
	Female	5 (7.1%)	70 (31.5%)	
Marital Status	Married	25 (35.7%)	78 (35.1%)	0.903 [b]
	Single	45 (64.3%)	144 (64.9%)	
Education	Illiterate and Secondary	43 (61.4%)	100 (45%)	0.017 [b]
	Diploma and academic	27 (38.6%)	122 (55%)	
Occupation	Occupied	61 (87.1%)	140 (63.1%)	0.0001 [b]
	Non-occupied and housewifes	9 (12.9%)	82 (36.9%)	
Resident	Tehran	23 (32.9%)	105 (47.3%)	0.034 [b]
	Other provinces	47 (67.1%)	117 (52.7%)	
a: Man-Whitney-U test, b: Chi-square test				

Table 2: The relationship between substance use with trauma and treatment factors

Variables		Substance abuser (n = 70)	Non-abuser (n = 222)	P value
Hospitalization (day)		9.73 ± 9.21	7.32 ± 9	0.006 [a]
Trauma	Positive	65 (92.9%)	181 (81.5%)	0.023 [b]
	Negative	5 (7.1%)	41 (18.5%)	
Trauma Type	Falling Down	16 (24.6%)	93 (51.4%)	0.0001 [b]
	Motorcycle accident	38 (58.5%)	27 (14.9%)	
	Pedestrian accident	8 (12.3%)	17 (9.4%)	
	Car accident	3 (4.6%)	-	
	Sport Injury	-	23 (12.7%)	
Surgical type	Fracture and dislocation	61 (87.1%)	131 (59%)	0.0001 [b]
	Other surgeries	9 (12.9%)	91 (41%)	
a: Man-Whitney-U test, b: Chi-square test				

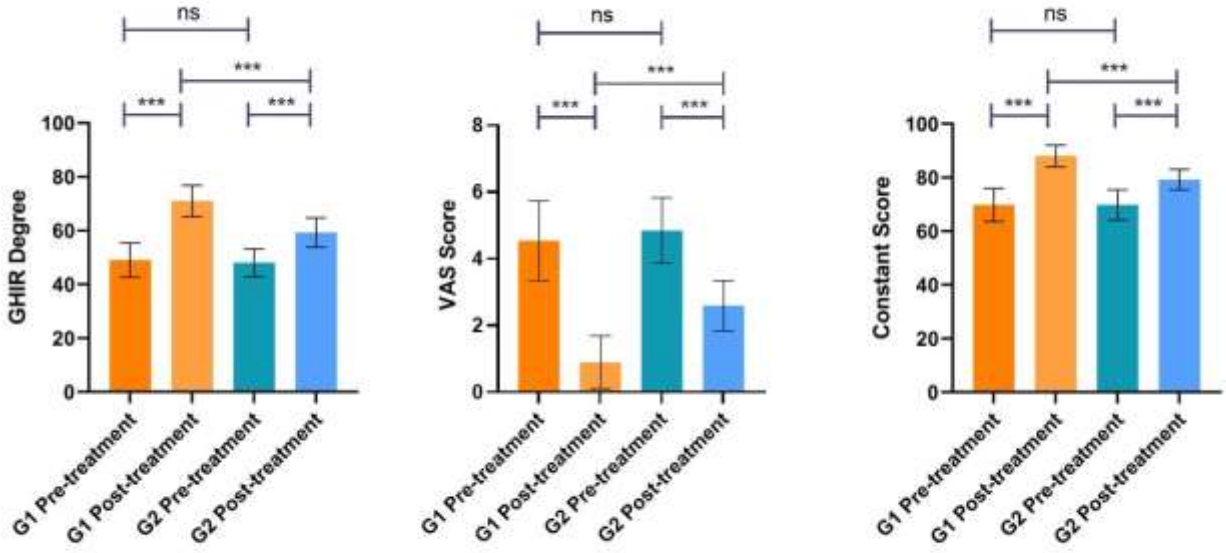

Figure 4: Comparative Outcomes of Sleeper Stretch and Conventional Physiotherapy; This bar chart compares the sleeper stretch combined with cross-adduction (Group 1) to routine physical therapy (Group 2) in terms of improvements in glenohumeral internal rotation (measured with a goniometer), pain relief (VAS score), and joint function (Constant score). Initially, both groups exhibited similar scores. Post-treatment, both interventions were effective, but sleeper stretch combined with cross-adduction resulted in more pronounced improvements across all measures. Error bars indicate standard deviation. Significance denoted as *** (P-value < 0.001), and ns for non-significant differences.

Discussion

In this study, we compared the combination of modified sleeper and cross-body adduction stretching methods with conventional physiotherapy approaches in treating GIRD in overhead throw athletes. The main findings of the current Research indicate substantial improvements in pain relief, internal rotation, and joint function, as reflected by changes in VAS score, GRID degree, and CS. These findings underscore the effectiveness of this combined stretching regimen for overhead-throwing athletes.

Addressing the challenges of GIRD and PST is crucial in sports medicine, especially for overhead-throwing athletes. These conditions significantly affect performance and can lead to shoulder pain and dysfunction.[21] The prevalence of shoulder issues, including pain and missed games among athletes, highlights the need to monitor overuse injuries during training and competitions.[22,23] So far, various treatments have been proposed for this injury. Although conventional physiotherapy methods such as Codman exercises have positively affected patient symptoms and shoulder ROM, Burkhart et al. have introduced new stretching methods focusing specifically on the posterior shoulder structures.[9,24] Stretching techniques focusing on posterior shoulder flexibility are commonly used to prevent and treat these conditions.5 The sleeper stretch and cross-body adduction exercises are popular choices but have disadvantages like scapular stabilization challenges and potential shoulder discomfort.[2] [Figure 5]

The literature proposes several modified stretching techniques to overcome these limitations.2,8 Research exploring the efficacy of these stretches has reported notable improvements in IR, horizontal adduction ROM, and pain relief.[11,25,26] However, stretching exercises alone may not comprehensively prevent overuse shoulder injuries. Studies indicate that a mix of glenohumeral stretching and rubber band strengthening exercises may not significantly reduce overuse shoulder

injuries or symptoms in amateur handball players, suggesting the necessity for a holistic approach to injury prevention and management.[27]

Figure 5: **Traditional Cross-Body Adduction**; Shows the traditional cross-body adduction exercise, highlighting the considerable amount of scapular abduction due to the lack of scapular stabilization.

The clinical implications of this study's findings can be interpreted considering several important aspects of patient care, such as patient compliance, athlete-specific considerations, the potential integration of these new methods into institutional rehabilitation protocols, cost-effectiveness, and long-term outcomes. A critical factor to consider is the long-term patient-reported outcome, which should be assessed over time and compared to the results of other modalities and rehabilitation methods, as this also affects patient compliance.[28] Regarding cost-effectiveness, this method imposes no additional costs to patients or healthcare systems since it is similar to conventional physiotherapy and can be performed in the same clinical settings without requiring additional resources. Integrating these methods into current rehabilitation protocols requires more evidence to convince experts and authorities through specific approval panels and discussions.[29]

With its retrospective cohort design, this study presents several inherent limitations that warrant consideration. The primary concern is that the two cohorts were not assessed during the same periods, introducing potential biases related to changes in clinical practice, patient demographics, and other external factors that might have influenced the outcomes. This temporal disparity could affect the comparability of the two groups, as advancements in medical knowledge or varying environmental factors over time could have impacted the results. Additionally, as a retrospective study, it relies on the accuracy and completeness of existing medical records, which can vary in detail and comprehensiveness. The lack of randomization and the potential for selection bias further limit the ability to establish causality between the interventions and outcomes.

Furthermore, the study did not control for potential confounding variables such as the athletes' training intensity, their sports field, duration of symptoms prior to intervention, or individual physiological differences, which could have influenced the treatment effectiveness. The Constant Score, being a multifactorial variable, cannot precisely determine the outcome of the treatment and provides only a general picture of the patient's function. Finally, as the study was conducted at a single center, the findings might need to be more generalizable to a broader population, limiting their applicability in different clinical settings or geographical locations. Acknowledging these limitations is essential for interpreting the study's findings and guiding future Research that could address these gaps.

Conclusion

Effectively managing GRID and posterior shoulder tightness is imperative for enhancing performance and minimizing the risk of overuse injuries in overhead-throwing athletes. Our findings suggest that modified stretching techniques are beneficial in improving flexibility and alleviating pain. However, while promising, these techniques should ideally be part of a broader, multifaceted approach incorporating additional preventive measures. Such a comprehensive strategy is essential to thoroughly address the complex challenges associated with shoulder issues in athletic populations.

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Conflict of Interest Disclosures

The authors declare no potential conflicts of interest regarding this article's research, authorship, and/or publication.

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Authors' Contributions

SK conceptualized and designed the study. SA and BH actively participated in the data collection process. SA performed the data analysis. AC and FAO took the lead in writing the initial draft of the manuscript. MB and GMS contributed significantly by revising the initial manuscript.

All authors contributed to the intellectual discussions and critically reviewed the manuscript at various stages. Their collective expertise and insights strengthened the research outcomes and conclusions. Finally, all authors carefully read and approved the final version of the manuscript, ensuring its accuracy and scholarly integrity.

Ethical Statement

The study protocol was conducted by the Declaration of Helsinki and reviewed and approved by the research ethics committee of the School of Medicine at Golestan University of Medical Sciences, Golestan, Iran (code: IR.GOUMS.REC.1401.063). All patients provided written informed consent forms prior to the participation.

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