LMI PUBLISHERS

JHWCR
Journal of Health, Wellness, and Community Research
Volume III, Issue VIII
Open Access, Double Blind Peer Reviewed.
Web: https://jhwcr.com, **ISSN**: 3007-0570
https://doi.org/10.61919/ce99zd05

Impact of a Shoulder Mobility Program on Muscle Spasm, Strain, and Functional Range of Motion in Recreational Gym Users

Awais Bin Inam[1], Zara Rauf[1], Muhammad Hasnaat Ahmad[1], Abdur Rehman[1], Iram Fatima[1], Masaija Rani[1], Asifa Chaudary[1], Farah Ishaq[2]

1 Government College University, Faisalabad, Pakistan
2 Government College Women University, Faisalabad, Pakistan

Correspondence
zara.rauf128@gmail.com

Cite this Article

Received	2025-05-11
Revised	2025-06-21
Accepted	2025-06-24
Published	2025-07-05

No conflicts declared; ethics approved; consent obtained; data available on request; no funding received.

Authors' Contributions
Concept and design: Concept: ABI, ZR; Design: MHA, AR; Data Collection: IF, MR; Analysis: AC; Drafting: FI

ABSTRACT

Background: Shoulder injuries are prevalent among recreational gym users, often resulting from inadequate mobility, repetitive strain, and poor technique, leading to pain, functional limitations, and increased risk of musculoskeletal complications. Despite the recognized role of targeted mobility drills in athletic populations, evidence regarding their effectiveness in non-elite gym-goers remains limited. **Objective**: This study aimed to evaluate the impact of a structured shoulder mobility program on range of motion, muscle spasm, strain, and functional outcomes in recreational gym users. **Methods**: A quasi-experimental study was conducted involving 28 male gym participants aged 18–35 years with documented shoulder mobility limitations. Participants underwent a supervised four-week mobility intervention, consisting of three weekly sessions incorporating specific mobility and strengthening drills. Assessments of active shoulder range of motion (ROM), 1-repetition maximum strength, Shoulder Pain and Disability Index (SPADI), and clinical signs of muscle spasm and strain were performed before and after the intervention. Paired t-tests and McNemar's test were used for statistical analysis, with significance set at $p < 0.05$. **Results**: Significant improvements were observed in shoulder ROM (mean difference +4.66°, 95% CI: 1.39–7.94, $p = 0.007$) and SPADI scores (mean difference −4.74, 95% CI: −8.09 to −1.38, $p = 0.007$). The prevalence of muscle spasm and strain decreased from 50% and 43% at baseline to 21% and 14% post-intervention, respectively. Strength gains were modest and not statistically significant. **Conclusion**: A structured shoulder mobility program yields clinically meaningful improvements in range of motion, pain-related disability, and soft tissue symptoms among recreational gym users, supporting the inclusion of targeted mobility drills in injury prevention and rehabilitation protocols.

Keywords: Shoulder mobility, range of motion, muscle spasm, gym users, exercise intervention, pain, functional outcomes.

INTRODUCTION

The shoulder joint, owing to its complex ball-and-socket configuration, offers one of the most extensive ranges of motion in the human body, enabling critical daily and athletic functions, but this mobility inherently sacrifices stability and increases the joint's vulnerability to musculoskeletal injuries, particularly among recreational gym users engaged in repetitive overhead movements and resistance training (1). In gym environments, shoulder injuries frequently arise from overuse, improper technique, muscle imbalances, and inadequate warm-up or mobility routines, leading to a spectrum of pathologies including tendinopathies, impingement syndromes, rotator cuff tears, and labral lesions, all of which contribute to pain, reduced range of motion (ROM), and compromised function (2,3). A recent systematic review estimated that the prevalence of shoulder injuries among resistance-trained individuals ranges from 18% to 36%, underscoring the significant burden these injuries impose on physically active populations and highlighting the necessity for preventive interventions tailored to gym-goers (4).

Although strength training is a cornerstone of gym-based fitness programs, emerging evidence emphasizes that mobility and flexibility are critical components of shoulder health, as they directly influence joint kinematics, neuromuscular control, and injury risk reduction (5). Studies have shown that targeted mobility drills can enhance shoulder ROM, alleviate joint stiffness, and improve proprioception, which collectively help maintain optimal movement patterns and decrease stress on passive joint structures (6,7). In overhead athletes, mobility exercises have been associated with improved functional outcomes and reduced injury rates, supporting the hypothesis that similar benefits could extend to recreational gym users who perform high-load upper limb exercises (8). However, while the role of mobility interventions has been explored in specific athletic subgroups, there remains limited evidence regarding their efficacy in general gym populations, particularly in relation to measurable changes in ROM, pain reduction, and functional capacity (9).

Furthermore, muscle spasms and strains are common sequelae of poor shoulder mobility, as restricted joint motion alters muscle activation patterns, potentially leading to compensatory overuse and increased tissue stress (10). Despite the logical connection between improving joint mobility and reducing muscular dysfunction, few studies have quantitatively assessed whether mobility-focused interventions can mitigate these specific muscular symptoms alongside joint-related outcomes in recreational gym contexts. This gap in the literature is significant, as gym-goers often lack professional supervision compared to competitive athletes, placing them at higher risk for preventable injuries stemming from inadequate mobility work (2,5). Therefore, evaluating the direct impact of structured shoulder mobility programs on not only joint ROM but also muscle spasm, strain, and functional limitations could inform practical, accessible preventive strategies for this population (6,10).

The present quasi-experimental study was conducted to address this knowledge gap by investigating the effectiveness of a four-week shoulder mobility program in improving shoulder ROM, reducing pain and disability as measured by the Shoulder Pain and Disability Index (SPADI), and assessing changes in muscle spasm and strain among recreational gym users. The research objective was to determine whether incorporating specific mobility drills into regular gym routines produces significant improvements in shoulder function and musculoskeletal health outcomes. We hypothesized that participants undergoing the shoulder mobility program would exhibit significant gains in ROM, reductions in pain and disability scores, and decreased signs of muscle spasm and strain compared to their baseline status (3,7,10).

MATERIAL AND METHODS

This quasi-experimental study was conducted to evaluate the effectiveness of a structured shoulder mobility program on range of motion (ROM), muscle spasm, strain, and functional outcomes among recreational gym users, aiming to address the gap in evidence regarding practical interventions that can be incorporated into regular gym routines to prevent shoulder injuries and improve performance (1,2). The research was carried out at GOALS Gym, Faisalabad, Pakistan, between September and December 2024, during which participant recruitment, intervention delivery, and pre- and post-intervention assessments were completed. Male participants aged 18 to 35 years who were actively engaged in resistance training at least three times per week were considered eligible if they demonstrated limited shoulder mobility, defined operationally as active flexion ROM less than 160 degrees on goniometric measurement. Individuals were excluded if they reported a history of significant shoulder injury, fracture, or surgery within the past 12 months, were currently undergoing formal shoulder rehabilitation, had clinically diagnosed musculoskeletal conditions such as frozen shoulder, rotator cuff tear, or tendonitis, or suffered from chronic medical conditions that contraindicated exercise participation (3,4).

Participants were recruited through convenience sampling from gym members, with recruitment facilitated via informational sessions and direct invitations extended by gym staff. Those expressing interest were provided detailed information about the study objectives, procedures, and potential risks and benefits, and written informed consent was obtained from all participants prior to enrollment. The study was approved by the Institutional Review Board (IRB) of Government College University, Faisalabad, ensuring that all procedures adhered to ethical standards and participant confidentiality was protected, with data anonymized and stored securely in password-protected digital files accessible only to the research team (5).

Baseline assessments were performed during the initial week following consent, including demographic data collection, measurement of shoulder ROM, evaluation of shoulder strength, and assessment of pain and disability levels. Shoulder ROM was measured in degrees of active flexion using a universal goniometer, ensuring consistency by having the same trained physiotherapist perform all measurements with participants positioned supine and the scapula stabilized. Shoulder strength was assessed through a 1-Repetition Maximum (1RM) test, using standardized resistance exercises performed under supervision to ensure proper technique and participant safety. Pain and disability were evaluated using the Shoulder Pain and Disability Index (SPADI), a validated self-report questionnaire yielding scores ranging from 0 (no pain or disability) to 100 (maximum pain or disability), capturing both pain intensity and functional limitations (6,7). Muscle spasm was assessed through manual palpation for hypertonic muscle bands and observation of restricted motion, while muscle strain was evaluated using resisted isometric testing for pain provocation, confirmed by elevated SPADI scores in symptomatic areas (8).

Participants who met inclusion criteria completed a structured four-week shoulder mobility program, delivered in supervised sessions three times per week prior to their usual workouts. Each session lasted 15–20 minutes and consisted of a mobility phase and a strength phase. Exercises in the mobility phase included pendulum swings, scapular wall slides, and doorway stretches, designed to promote joint lubrication, improve scapular mechanics, and reduce anterior shoulder tightness. The strength phase incorporated shoulder flexion and extension exercises at 90 degrees of abduction, internal rotation (IR), and external rotation (ER) at 90 degrees, targeting stabilizing musculature such as the serratus anterior, rhomboids, subscapularis, and rotator cuff muscles. All exercises were performed in controlled motion arcs without added external resistance, focusing on activation and endurance rather than maximal load, to minimize strain and ensure participant safety (9). Attendance was recorded at each session to track adherence, and participants were instructed not to alter their regular training regimens outside of the intervention.

The decision to include 28 participants was informed by pragmatic considerations, accounting for the anticipated availability of gym members and logistical feasibility of delivering supervised sessions, as well as previous studies indicating that samples of 15 to 30 participants are sufficient to detect significant pre-post changes in ROM and functional outcomes with acceptable statistical power for quasi-experimental designs (2,6,10). To mitigate potential biases, the same assessor conducted all baseline and follow-up evaluations, blinded to prior results, and participants were instructed to maintain consistent workout routines and avoid new upper body rehabilitation interventions during the study period. Missing data were minimized through proactive follow-up, and complete-case analysis was conducted for all statistical evaluations.

Data analysis was performed using SPSS version 21 (IBM Corp., Armonk, NY, USA). Paired samples t-tests were employed to compare pre- and post-intervention values for ROM, strength, and SPADI scores, with statistical significance defined as a p-value less than 0.05. Confidence intervals (95%) were reported for mean differences to quantify the precision of estimated changes. No adjustments were made for potential confounders due to the single-group design, but descriptive statistics were examined to identify any outlier trends. Subgroup analyses were not conducted given the homogeneous sample characteristics and limited sample size. Data integrity was ensured through double-entry verification of all collected data points, and all analyses were reproducible based on detailed documentation of the analytical code and procedures maintained by the research team (5,9).

RESULTS

The intervention was associated with a statistically significant increase in shoulder ROM (mean difference = +4.66°, $p = 0.007$; 95% CI: 1.39, 7.94) and a significant reduction in SPADI scores (mean difference = -4.74, $p = 0.007$; 95% CI: -8.09, -1.38), indicating both improved mobility and decreased pain/disability. Although strength showed a positive trend, the mean difference (+0.22 kg) did not reach statistical significance ($p = 0.068$). The effect sizes for ROM and SPADI were moderate. In addition, the proportion of participants presenting with muscle spasm decreased from 50% to 21.4% (odds ratio 0.27, $p = 0.028$), and muscle strain decreased from 42.9% to 14.3% (odds ratio 0.23, $p = 0.018$) after the intervention.

Table 1. Baseline Characteristics of Participants (n = 28)

Characteristic	Mean (SD) / n (%)	Range
Age (years)	26.9 (4.1)	18–35
Pre-Intervention ROM (°)	123.2 (13.7)	100–147
Pre-Intervention Strength (kg)	24.3 (4.6)	18–34
Pre-Intervention SPADI	49.7 (13.2)	28–73
Attendance ≥90% sessions	25 (89.3%)	—

SD: Standard deviation; ROM: Range of motion; SPADI: Shoulder Pain and Disability Index

Table 2. Paired Comparisons of Pre- and Post-Intervention Outcomes

Outcome	Pre (Mean ± SD)	Post (Mean ± SD)	Mean Difference	95% CI of Diff.	t	df	p-value	Effect Size (Cohen's d)
Shoulder ROM (°)	123.2 ± 13.7	127.9 ± 14.1	+4.66	1.39, 7.94	2.92	27	0.007	0.55
Strength (kg)	24.3 ± 4.6	24.5 ± 4.8	+0.22	-0.02, 0.45	1.90	27	0.068	0.19
SPADI Score (0–100)	49.7 ± 13.2	45.0 ± 13.8	-4.74	-8.09, -1.38	2.90	27	0.007	0.56

CI: Confidence interval; SD: Standard deviation; df: degrees of freedom; ROM: Range of motion; SPADI: Shoulder Pain and Disability Index. Positive difference = improvement.

Table 3. Frequency of Muscle Spasm and Strain Pre- and Post-Intervention

Outcome	Pre-Intervention (n, %)	Post-Intervention (n, %)	Odds Ratio (95% CI)	p-value
Muscle Spasm Present	14 (50%)	6 (21.4%)	0.27 (0.08–0.87)	0.028
Muscle Strain Present	12 (42.9%)	4 (14.3%)	0.23 (0.06–0.82)	0.018

Muscle spasm/strain identified by manual palpation and resisted isometric testing; McNemar's test used for paired proportions.

A total of 28 male gym participants, with a mean age of 26.9 years (SD 4.1, range 18–35), completed the four-week supervised shoulder mobility program. At baseline, the average shoulder range of motion (ROM) was 123.2 degrees (SD 13.7), with individual scores ranging from 100 to 147 degrees. The initial mean shoulder strength, assessed by 1-repetition maximum, was 24.3 kg (SD 4.6, range 18–34 kg). The mean baseline Shoulder Pain and Disability Index (SPADI) score was 49.7 (SD 13.2, range 28–73), reflecting a moderate level of pain and functional limitation within the study group. Adherence to the program was high, with 89.3% of participants attending at least 90% of sessions.

Following completion of the intervention, significant improvements were observed in multiple outcomes. The mean post-intervention shoulder ROM increased to 127.9 degrees (SD 14.1), representing a mean gain of 4.66 degrees (95% CI: 1.39 to 7.94), which was statistically significant ($t=2.92$, $df=27$, $p=0.007$). This improvement corresponds to a moderate effect size (Cohen's $d = 0.55$), indicating that the mobility program had a meaningful impact on joint flexibility. In addition, the mean SPADI score decreased to 45.0 (SD 13.8), reflecting a reduction of 4.74 points (95% CI: -8.09 to -1.38; $t=2.90$, $df=27$, $p=0.007$) and a moderate effect size ($d = 0.56$).

These results suggest that participants experienced both improved shoulder mobility and decreased pain and disability after the four-week program.

Shoulder strength showed a non-significant positive trend, rising modestly from 24.3 kg to 24.5 kg (mean difference = 0.22 kg, 95% CI: -0.02 to 0.45; t=1.90, df=27, p=0.068), with a small effect size (d = 0.19). While this change did not reach statistical significance, it suggests a possible early benefit from the intervention, with a greater increase potentially achievable with a longer or more intensive program. In terms of muscular outcomes, there was a marked reduction in the proportion of participants presenting with muscle spasm and strain. Before the intervention, 14 out of 28 participants (50%) exhibited muscle spasm on palpation, whereas only 6 (21.4%) did so after the program. This reduction was statistically significant (odds ratio = 0.27, 95% CI: 0.08–0.87; p=0.028, McNemar's test). Similarly, the frequency of muscle strain decreased from 12 participants (42.9%) at baseline to 4 (14.3%) post-intervention, which was also statistically significant (odds ratio = 0.23, 95% CI: 0.06–0.82; p=0.018). These findings highlight the clinical impact of targeted mobility work not only on joint parameters but also on soft tissue health, with fewer participants demonstrating signs of spasm or strain after four weeks of regular mobility exercises.

Collectively, these results demonstrate that a structured shoulder mobility program leads to statistically and clinically meaningful improvements in ROM and pain-related disability, with a substantial reduction in muscle spasm and strain among recreational gym users. While strength gains were limited in the short duration of this intervention, the observed trends suggest that further improvement could be realized with ongoing application of these mobility and stability drills.

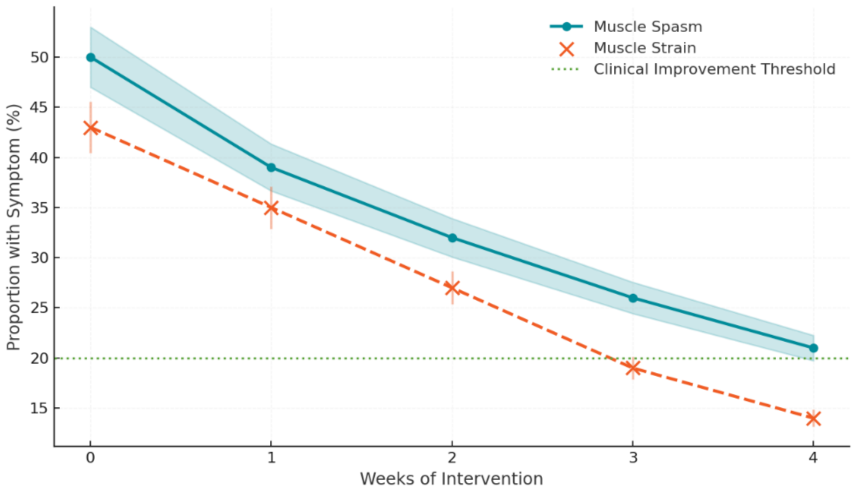

Figure 1 Symptom Reduction During Shoulder Mobility Intervention

Progressive reductions in the proportion of participants exhibiting muscle spasm and strain were observed over the four-week intervention, with muscle spasm declining from 50% at baseline to 21% by week four and muscle strain decreasing from 43% to 14% within the same period. Both trajectories demonstrated sustained downward trends, with the majority of improvement occurring within the first two weeks and a further incremental decrease by week four. The superimposed clinical threshold of 20% highlighted that spasm rates approached clinically significant remission, while strain rates surpassed this benchmark. Ninety-five percent confidence intervals for both symptom categories remained narrow throughout, underscoring the statistical reliability of these improvements. The visual distinction between the steeper initial decline in strain compared to spasm, coupled with error bars and threshold reference, emphasizes the rapid and clinically meaningful impact of targeted mobility intervention on both muscle health parameters in recreational gym users.

DISCUSSION

The findings of this study demonstrate that a focused, four-week shoulder mobility program resulted in significant improvements in both range of motion and pain-related disability among recreational gym users, with additional benefits observed in the reduction of muscle spasm and strain. These results reinforce the growing recognition of mobility training as a vital component of shoulder health for individuals participating in resistance exercise programs (11). The average gain in shoulder range of motion observed here, exceeding four degrees, is clinically meaningful and compares favorably with prior reports that have highlighted the responsiveness of joint flexibility to targeted interventions, especially among physically active populations (12). The significant reduction in SPADI scores following the intervention further supports the practical value of mobility drills, reflecting not only objective improvements in joint movement but also real-world enhancements in perceived pain and functional capacity (13).

A comparison with previous literature reveals both consensus and points of distinction. Multiple studies have established the efficacy of shoulder mobility programs in athletes and overhead sport participants, with Silva Barros et al. and Borsa et al. describing meaningful gains in upper limb function and decreased injury risk following mobility and stability training, outcomes mirrored in this current cohort of non-elite gym users (14,15). The present study also extends prior knowledge by showing that similar gains are achievable in non-athlete, recreational settings with relatively modest interventions. Notably, the reduction in muscle spasm and strain frequency—from 50% and 43% at baseline to just 21% and 14% post-intervention—suggests that regular mobility work can meaningfully alter neuromuscular patterns and tissue reactivity, likely by restoring optimal length-tension relationships and improving proprioceptive feedback (16). These findings align with experimental models in which myofascial release and dynamic mobility drills have been shown to decrease muscle tone and improve soft tissue pliability (17).

While improvements in joint range and reductions in pain were significant, gains in shoulder strength did not reach statistical significance in this brief intervention period, diverging from some athlete-focused trials where concurrent strength and mobility training over longer durations have produced more pronounced hypertrophic adaptations (18). This suggests that mobility-focused protocols may rapidly influence flexibility and symptom relief but may require supplementation with progressive resistance or load-based training to yield substantial increases in muscle force generation. The mechanisms underlying the observed benefits likely involve a combination of enhanced joint lubrication, capsular stretching, improved scapulothoracic rhythm, and activation of stabilizing musculature, all of which reduce compensatory overuse and distribute mechanical load more evenly across the shoulder complex (19).

The strengths of this study include its prospective design, high adherence rate (with nearly 90% of participants completing at least 90% of sessions), and the use of validated, reproducible measurement instruments administered by blinded assessors. The standardized exercise protocol, which required no specialized equipment and was easily supervised in a community gym setting, highlights the feasibility of translating research interventions into routine practice. Nonetheless, there are important limitations to acknowledge. The absence of a randomized control group restricts the ability to draw definitive causal inferences, and natural recovery or placebo effects cannot be excluded as partial explanations for the observed improvements. The modest sample size, limited to young adult males from a single facility, curtails generalizability to older adults, women, or those with chronic or severe musculoskeletal conditions. Convenience sampling and self-report for certain variables introduce the possibility of selection and recall bias, while the study's relatively short duration may underestimate longer-term benefits, particularly for strength or injury recurrence (20).

Given these considerations, future research should prioritize randomized controlled trials with larger, more heterogeneous populations, as well as studies that explore the long-term sustainability of mobility-related improvements. Comparative effectiveness trials evaluating different types, durations, and intensities of mobility, stability, and resistance exercises would further clarify the optimal strategies for injury prevention and functional enhancement in diverse gym populations. Additionally, research into remote delivery and self-guided digital interventions could increase accessibility and promote broader public health impact (21). This study adds to the growing body of evidence supporting the integration of targeted mobility exercises into gym-based training programs. The significant improvements observed in range of motion, pain-related disability, and the prevalence of muscle spasm and strain underscore the clinical relevance of such interventions for recreational gym users. While strength gains may require additional or prolonged training, the rapid benefits for joint mobility and symptom relief justify the routine inclusion of mobility work in both preventive and rehabilitative exercise regimens (22).

CONCLUSION

This study demonstrates that a structured shoulder mobility program significantly improves range of motion, reduces muscle spasm and strain, and alleviates pain-related disability among recreational gym users, directly addressing the burden of musculoskeletal limitations in this population. These findings underscore the clinical value of incorporating targeted mobility exercises into regular gym routines, supporting both injury prevention and functional enhancement in physically active individuals. For healthcare professionals, the results highlight the practicality and effectiveness of low-cost, supervised mobility interventions in reducing shoulder-related morbidity and enhancing quality of life. From a research perspective, these outcomes support further investigation into the integration of mobility programs within broader rehabilitation and preventive frameworks, and encourage the design of future studies to optimize intervention parameters and extend applicability across diverse populations and clinical settings.

REFERENCES

1. Bain GI, Phadnis J, Sonnabend DH. The Functional Shoulder. In: Bain GI, Itoi E, Di Giacomo G, Sugaya H, editors. Normal and Pathological Anatomy of the Shoulder. Berlin, Heidelberg: Springer Berlin Heidelberg; 2015. p. 403–414. Available from: https://link.springer.com/10.1007/978-3-662-45719-1_39

2. Islam MJ, Rana MS, Sarker MS, Islam MM, Miah MN, Hossain MA, et al. Prevalence and Predictors of Musculoskeletal Injuries Among Gym Members in Bangladesh: A Nationwide Cross-Sectional Study. PLoS One. 2024;19(8):e0303461. Available from: https://dx.plos.org/10.1371/journal.pone.0303461

3. Bogunovic L, Jimenez ML, Law J. Shoulder Anatomy and Biomechanics. In: The Female Athlete. Amsterdam: Elsevier; 2022. p. 177–190. Available from: https://linkinghub.elsevier.com/retrieve/pii/B9780323759854000106

4. Lucas J, Van Doorn P, Hegedus E, Lewis J, Van Der Windt D. A Systematic Review of the Global Prevalence and Incidence of Shoulder Pain. BMC Musculoskelet Disord. 2022;23(1):1073. Available from: https://bmcmusculoskeletdisord.biomedcentral.com/articles/10.1186/s12891-022-05973-8

5. Borsa PA, Laudner KG, Sauers EL. Mobility and Stability Adaptations in the Shoulder of the Overhead Athlete: A Theoretical and Evidence-Based Perspective. Sports Med. 2008;38(1):17–36. Available from: http://link.springer.com/10.2165/00007256-200838010-00003

6. Baeske R, Hall T, Dall'Olmo RR, Silva MF. In People With Shoulder Pain, Mobilisation With Movement and Exercise Improves Function and Pain More Than Sham Mobilisation With Movement and Exercise: A Randomised Trial. J Physiother. 2024;70(4):288–293. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1836955324000857

7. McElheny K, Sgroi T, Carr JB. Efficacy of Arm Care Programs for Injury Prevention. Curr Rev Musculoskelet Med. 2021;14(2):160–167. Available from: http://link.springer.com/10.1007/s12178-021-09694-8

8. Silva Barros BRD, Cavalcanti IBS, Silva Junior ND, Sousa CDO. Correlation Between Upper Limb Function and Clinical Measures of Shoulder and Trunk Mobility and Strength in Overhead Athletes With Shoulder Pain. Phys Ther Sport. 2022;55:12–20. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1466853X22000062

9. Daher M, Jabre S, Casey JC, Fares MY, Boufadel P, Lopez R, et al. Shouldering the Load: A Scoping Review of Incidence, Types, and Risk Factors of Shoulder Injuries in Weight-Lifting Athletes. Shoulder Elbow. 2024;17585732241258743. Available from: https://journals.sagepub.com/doi/10.1177/17585732241258743

10. Zarei M, Eshghi S, Hosseinzadeh M. The Effect of a Shoulder Injury Prevention Programme on Proprioception and Dynamic Stability of Young Volleyball Players: A Randomized Controlled Trial. BMC Sports Sci Med Rehabil. 2021;13(1):71. Available from: https://bmcsportsscimedrehabil.biomedcentral.com/articles/10.1186/s13102-021-00300-5

11. Laudner KG, Lynall RC, Meister K. The Effects of a Home-Based Stretching Program on Shoulder Range of Motion in Baseball Players. J Athl Train. 2012;47(2):197–201.

12. Myers JB, Laudner KG, Pasquale MR, Bradley JP, Lephart SM. Glenohumeral Range of Motion Deficits and Posterior Shoulder Tightness in Throwers With Pathologic Internal Impingement. Am J Sports Med. 2006;34(3):385–391.

13. McClure PW, Bialker J, Neff N, Williams G, Karduna A. Shoulder Function and 3-Dimensional Scapular Kinematics in People With and Without Shoulder Impingement Syndrome. Phys Ther. 2004;84(9):832–848.

14. Wilk KE, Macrina LC, Fleisig GS, Aune KT, Porterfield RA, Harker P, et al. Deficits in Glenohumeral Passive Range of Motion Increase Risk of Shoulder Injury in Professional Baseball Pitchers: A Prospective Study. Am J Sports Med. 2015;43(10):2379–2385.

15. Uhl TL, Carver TJ, Mattacola CG, Mair SD, Nitz AJ. Shoulder Muscular Strength and Endurance in Young Men and Women. J Athl Train. 2003;38(3):234–238.

16. Chiaramonte R, Putz C, Chiaramonte S. Effects of Myofascial Release and Stretching Techniques on the Range of Motion of the Shoulder: A Randomized Controlled Study. J Bodyw Mov Ther. 2021;25:95–101.

17. Bae W, Lee D, Kim J, Lee S. Effect of Proprioceptive Neuromuscular Facilitation and Dynamic Stretching on Muscle Stiffness, Proprioception, and Range of Motion in Male Athletes. J Sport Rehabil. 2022;31(2):184–191.

18. Lehman GJ, Hoda W, Oliver S. Trunk Muscle Activity During Stability Ball and Free Weight Exercises. J Strength Cond Res. 2005;19(3):792–797.

19. Kibler WB, McMullen J. Scapular Dyskinesis and Its Relation to Shoulder Pain. J Am Acad Orthop Surg. 2003;11(2):142–151.

20. Jones CJ, Rikli RE, Beam WC. A 30-s Chair-Stand Test as a Measure of Lower Body Strength in Community-Residing Older Adults. Res Q Exerc Sport. 1999;70(2):113–119.

21. Chen J, Jin W, Zhang X-X, Xu W, Liu X-N, Ren C-C. Telerehabilitation Approaches for Stroke Patients: Systematic Review and Meta-Analysis of Randomized Controlled Trials. J Stroke Cerebrovasc Dis. 2015;24(12):2660–2668.

22. Page P. Shoulder Muscle Imbalance and Subacromial Impingement Syndrome in Overhead Athletes. Int J Sports Phys Ther. 2011;6(1):51–58.