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RESEARCH

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"Investigating the combined effects of scapular-focused training and Mulligan mobilization on shoulder impingement syndrome" a three-arm pilot randomized controlled trial

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Abstract

Objectives To assess whether the combination of scapular-focused training and mulligan mobilization (SFTMM) improves pain and proprioception compared to scapular-focused training (SFT) and a control group in female rock climbers with shoulder impingement syndrome (SIS).

Design Three-arm randomized controlled trial (RCT).

Setting Outpatient setting.

Subjects Individuals were randomly assigned to SFTMM, SFT alone, and control group.

Interventions 8 weeks of SFTMM and SFT.

Main measures Outcome measures were pain and proprioception.

Results The results revealed significant differences in pain scores and proprioception among female rock climbers with SIS who participated in SFTMM, SFT, and a control group ($F(2, 32) = 81.01$, $p = 0.001$, $\eta2 = 0.83$ for pain scores; $F(2, 32) = 178.2$, $p = 0.001$, $\eta2 = 0.91$ for proprioception scores). Post-hoc tests via the Bonferroni test indicated that both SFTMM and SFT significantly reduced pain levels ($p = 0.001$) and improved proprioception levels ($p = 0.001$) compared with the control group. There was no significant difference in pain scores and proprioception between the SFTMM group and the SFT group ($p > 0.05$).

Conclusions In conclusion, the study indicates that SFTMM significantly reduces pain and improves proprioception in female rock climbers with SIS, as shown by notable changes compared to the control group. However, no statistically significant difference was found between the SFTMM (combined intervention) and SFT alone. Therefore, while the incorporation of SFT and MM shows promise; further research is needed to fully understand its long-term benefits and clinical implications.

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Keywords Joint position sense, Pain, Proprioception, Rock climbing

Background

Shoulder impingement syndrome (SIS) is characterized by the compression of subacromial structures between the humeral head and coracoacromial arch [3], particularly prevalent among overhead athletes [1, 4]. The primary clinical features of SIS include pain, a restricted range of motion (ROM), and diminished strength in the arm [5, 6].Contributing factors to shoulder impingement include mechanical compression of the rotator cuff structures (6), improper scapular stabilization [7], weakness of the rotator cuff muscles, acromial morphology, muscle imbalances, joint capsule laxity or tightness, dysfunctional glenohumeral and scapulothoracic kinematics, as well as degeneration and inflammation of the tendons or bursa [8].The implications of SIS for athletic performance are significant, as it can lead to altered proprioception [9, 10], muscle imbalances, impaired motor control [11], and disruptive movement patterns [12].

Given the various etiological and pathomechanical pathways associated with SIS, numerous treatment strategies have been suggested for its management, with each approach designed to address specific mechanical pathways [13, 14]. Treatment modalities include electrotherapy, exercise therapy, massage, joint mobilization, extracorporeal shockwave treatment, ultrasound therapy, laser treatment, and sling exercise treatment [15, 16]. Systematic reviews have assessed the effectiveness of these approaches in managing shoulder disorders, with current evidence highlighting that exercise yields both statistically and clinically significant improvements in pain reduction and functional enhancement [17, 18]. Literature indicates that exercise [19–21] and joint mobilization [22, 23] are effective interventions for managing SIS.

Studies have consistently highlighted the positive impact of Scapular-Focused Training (SFT) on individuals with SIS, particularly due to its emphasis on neuromuscular control and muscle-strengthening exercises. SFT programs are designed to target the muscles surrounding the scapula, aiming to restore proper biomechanics, improve shoulder stability, and optimize movement patterns [10, 24–26].

Research investigating manual therapy techniques independently has indicated that manual therapy is effective in alleviating pain, addressing hypomobility, and enhancing muscle strength [27–29]. Joint mobilization is frequently employed to address hypomobility and enhance shoulder function while alleviating pain [30, 31]. Mulligan Mobilization (MM) involves performing joint movements in a weight-bearing position through continuous gliding and active movement [20, 25]. This technique is believed to address key factors associated with SIS, including enhancing subacromial space, improving ROM, releasing adhesions, muscle tension, and joint compression [2].

Some studies support integrating manual therapy as an adjunct to exercise, indicating that this combination may enhance outcomes by targeting both muscular and joint aspects of SIS [7, 32]. Techniques like joint mobilization are thought to amplify the benefits of exercise by improving acromiohumeral distance, thus facilitating more effective rehabilitation. However, other research questions the added value of manual therapy, suggesting that exercise alone may be equally effective in improving outcomes for SIS patients [33, 34].

Systematic reviews have emphasized the variability in study designs, intervention protocols, and patient populations, which likely contribute to the mixed findings [17, 33, 35]. While combining exercise with manual therapy shows potential, further research is needed to determine if this approach offers significant advantages over exercise alone [33, 34]. This study seeks to examine whether combining training with mobilization has a greater impact on pain and proprioception in athletes with SIS. We hypothesize that the integration of SFT and MM will result in significantly greater improvements in pain and proprioception compared to SFT alone or a control group.

Methods

Study design

This pilot randomized controlled trial (RCT) employed a three-arm parallel-group design to evaluate the feasibility and preliminary effects of two interventions compared to a control group in athletes with SIS. The study aimed to explore the impact of SFTMM and SFT on pain and proprioception in preparation for a larger, full-scale trial (Fig. 1).

Participants

A total of 36 female rock climbers with at least five years of experience were recruited from Tehran. Eligibility criteria for diagnosing SIS included: [3] shoulder pain persisting for over six weeks [1], a painful arc during shoulder flexion and abduction [4], a positive Hawkins-Kennedy test, and [5] pain during resisted external rotation, abduction, or Jobe's test [35]. Exclusion criteria included: [3] a history of surgical intervention, fractures,

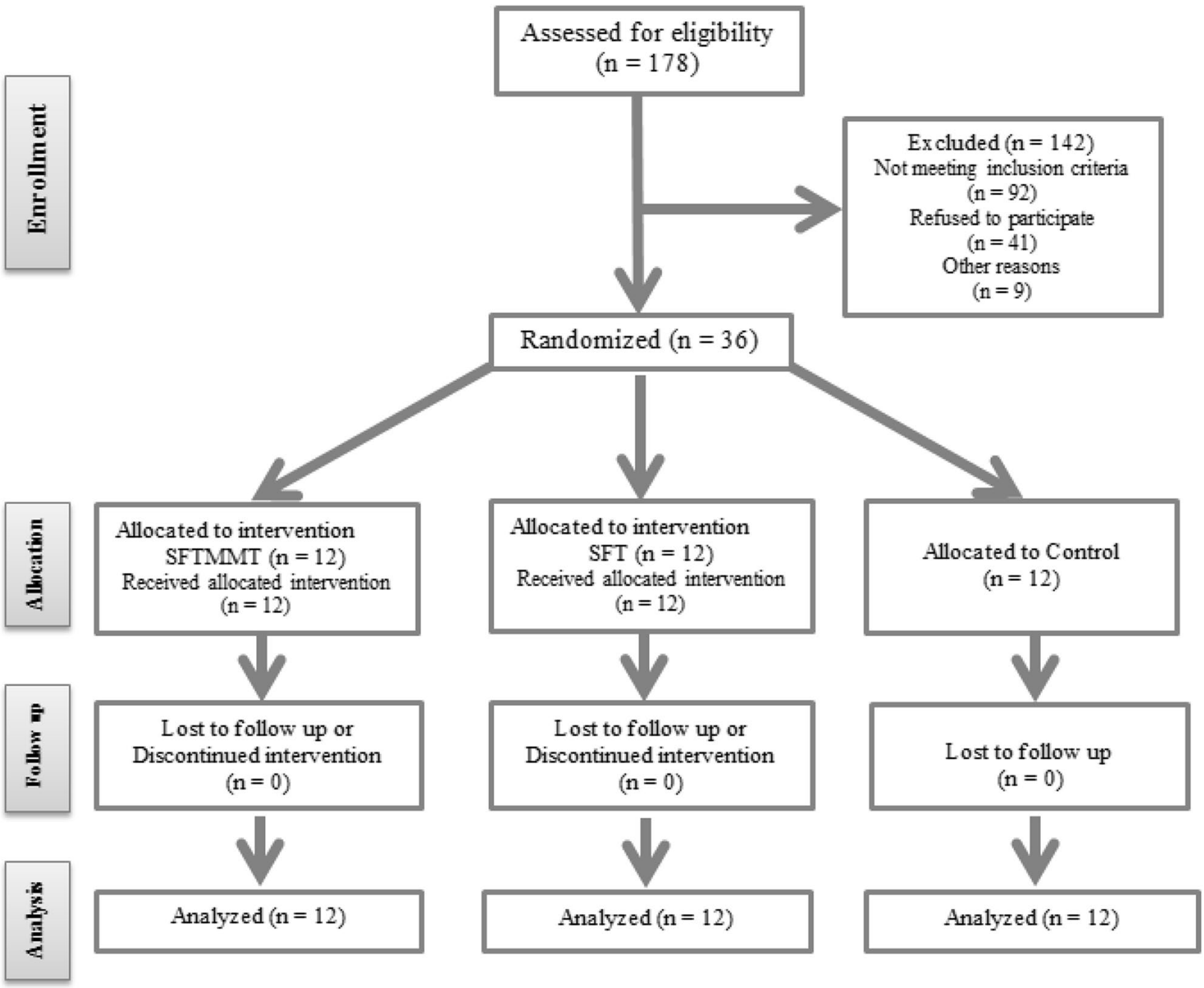

Fig. 1 Flow of study

traumatic onset of symptoms, massive rotator cuff tears, tears of the long head of the biceps tendon, or degenerative joint disorders of the shoulder; [1] pregnancy; and [4] steroid injections within the last six months [36]. Informed consent was obtained prior to participation, after which participants were randomly assigned to one of three groups: the SFTMM (n=12), the SFT (n=12), and the control (n=12).

Randomization was conducted using a concealed slot-drawing method to ensure unbiased group assignment. Opaque, sealed envelopes containing group designations were prepared, and participants were randomly assigned to groups after baseline assessments. The randomization process remained blinded to both participants and assessors throughout the trial. The allocation sequence was concealed until all baseline measurements were completed. A physiotherapist, with more than five years of clinical experience and blinded to group assignment, conducted the pre- and post-intervention assessments. These assessments were carried out within one week before the intervention (baseline) and immediately after the eight-week intervention period (post-intervention). Participants in both experimental groups received the assigned interventions for eight weeks, with assessments of primary outcomes (pain and proprioception) conducted before and after the intervention period. The control group did not receive any intervention during the study period but continued their usual daily activities. Participants in the control group were specifically advised to avoid activities that could potentially influence their shoulder pain or proprioception, including other forms of exercise, physical therapy treatments, and any new interventions for shoulder issues during the study period. This was done to minimize confounding factors that could impact the results and allow for a clearer comparison between the experimental groups and the control group. The control group was asked to keep a daily activity log to record any significant changes in their activity levels or any new treatments they may have sought during the study. This log allowed the research team to monitor adherence to the guidelines and ensure that no extraneous variables influenced the study outcomes.

Interventions

The scapula-focused training (SFT)

The SFT consisted of 8 weeks, with 1-hour sessions conducted three times a week on nonconsecutive days. The participants were treated individually. The training protocol consisted of neuromuscular exercises and muscle-strengthening exercises. The neuromuscular exercises included towel slides, proprioceptive neuromuscular facilitation, inferior glides, and scapular clocks. The muscle-strengthening exercises included diagonal D1, push-up plus, full can, prone horizontal abduction with external rotation (90–135°), side-lying external rotation with abduction (0°), diagonal D2 eccentric, scapular punch, and horizontal rowing presented in Table 1.

Each one-hour session consisted of five exercises, including two neuromuscular control exercises and three muscle-strengthening exercises, which utilized dumbbells and elastic bands. The initial load was set at 60% of the one-repetition maximum and was increased to between 60% and 80% of the one-repetition maximum by the second week. During the first three weeks, three sets of 10 repetitions were performed for each exercise. In the fourth week, the exercises progressed to three sets of 12 repetitions, and in the fifth week, they progressed to three sets of 15 repetitions. The push-up plus exercise also underwent load progression, which was performed with the feet elevated on supports at heights of 20 cm and 40 cm. The neuromuscular exercises progressed through an incremental increase in repetitions. The therapist provided stimuli tailored to the individual needs of each participant, ensuring proper exercise execution. The repetition protocol was gradually increased over the 8-week training period, with 10 repetitions per exercise in the first three weeks, 12 repetitions per exercise in week four,

Table 1 SFT protocol

	Exercise	Execution	W-1	-2	W-3	-4	W-5	-6	W-7	W-8
1.	Towel Slide	Involves arm flexion and shoulder protraction, followed by extension and retraction.	3r with 15s	3r with 15s					3r with 30s	
2.	Scapular Proprioceptive Neuromuscular Facilitation	Focuses on protraction and retraction of the scapula along with lowering the scapula.			3R with 20s	3R with 20s			3R with 15s	
3.	Inferior Glide	Involves the retraction and lowering of the shoulder with the arm in 90-degree abduction.	3r with 15s	3r with 15s	3r with 20s	3r with 20s	3r with 25s	3r with 25s		
4.	Scapular Clock	Imaginary clock visualization on the shoulder, moving the "ball" to different positions.			3r with 20s		3r with 25s	3r with 25s	3r with 30s	3r with 30s
5.	Diagonal D1	Abduction with external rotation of the arm using an elastic band.	3r with 15s	3r with 15s		3r with 20s	3r with 25s	3r with 25s		3r with 30s
6.	Side Lying External Rotation	External rotation of the arm at a 90-degree angle of the elbow.	3r with 15s	3r with 15s	3r with 20s					3r with 30s
7.	Knee Push and Push-up Plus	Focuses on maximum protraction of the scapula in various positions.			3r with 15s		3r with 25s		3r with 30s	
8.	Diagonal D2 Eccentric	Adduction movement with internal rotation.			3r with 20s	3r with 20s		3r with 25s		
9.	Scapular Punch	Scapular protraction with lifting the shoulder from underneath.	3r with 15s	3r with 15s	3r with 20s	3r with 20s				3r with 30s
10.	Full Can	Involves movement of the elbow in the scapular plane using a dumbbell.					3r with 25s	3r with 25s	3r with 30s	3r with 25s
11.	Prone Horizontal Abduction with External Rotation of 90° to 135°	Horizontal abduction with external rotation of the arm within a specific angle range.				3r with 20s		3r with 25s	3r with 30s	3r with 25s
12.	Horizontal Rowing	Scapular retraction using an elastic arm band in 60-degree abduction.					3r with 25s		3r with 30s	3r with 25s

*r: repetition

*s: second

and 15 repetitions per exercise from week five to week eight [24–26].

Mulligan mobilization (MM)

The MM involves active accessory mobilizations of the humeral head, which are performed in various directions, including flexion, abduction, external rotation, and internal rotation [23]. To execute the technique, subjects were seated on a stretcher, while the physiotherapist stood opposite the affected upper extremity. The physiotherapist then stabilized the patient's shoulder girdle with their internal hand and used their thenar eminence to glide the humeral head. The direction of the glide was specifically chosen for treating shoulder limitations. The participant was instructed to flex the affected shoulder until pain was felt, at which point the physical therapist maintained the gliding force to the humeral head. The therapist aimed to maintain the glide at a 90-degree angle to the plane of movement throughout the entire range, while the participant performed an active movement. The participant was reminded that the treatment should be pain free and should be stopped immediately if any pain was experienced during the treatment. The MM lasted approximately 20 min and consisted of three sequences of 10 repetitions with a 30-second rest interval between each sequence.

Measurements and procedures

Pain assessment

The VAS scale measures the level of pain from 0 to 10 (Fig. 2). A score of 0 indicates no pain, whereas a score of 10 indicates uncontrollable pain. The participants were asked to choose their pain level from 0 to 10.

Proprioception assessment (joint position sense)

Joint position sense is a specific aspect of proprioception that refers to the ability to perceive and recreate specific joint angles or positions accurately. The Biodex Multi-joint System, manufactured in the USA, was used to assess shoulder proprioception [9]. Before the experiment, the subjects were trained to familiarize themselves with the device and its operation. The subjects were placed on the Biodex machine with their eyes closed and strapped to the chest to prevent trunk movement. The shoulder of the injured side was adjusted in the scapular plane at a speed of 5 degrees per second. The horizontal position of the dynamometer lever arm was set at an angle relative to 90 degrees. The subjects were asked to actively bring their shoulder to internal rotation at specified angles (45° and 90°) and hold each position for 10 s. The subjects were then asked to rest for 5 s before the process was repeated twice. The absolute value of the difference between the recorded angle and the target angle was recorded as an error (absolute angular error), and their average was used for statistical analysis [25].

Sample size and power calculations

The sample size for this study was determined using statistical power analysis to ensure the study could detect meaningful differences among the intervention groups [37]. A total of 36 participants were recruited and randomly assigned to one of three groups, with 12 participants in each group: Group 1, SFT; Group 2, SFTMM; and Group 3, Control (no intervention).The sample size was determined through a priori power analysis with the following parameters: a significance level (α) of 0.05, representing a 5% risk of a Type I error (incorrectly rejecting the null hypothesis); statistical power (1 – β) of 0.80, providing an 80% probability of detecting a true effect if it exists, thereby reducing the risk of a Type II error (failing to detect a true effect); an assumed moderate effect size (Cohen's d) of 0.5, based on previous studies involving SFT and MM for shoulder impingement syndrome; and a two-tailed test to account for potential differences in either direction between groups.

The following sample size formula for comparing independent groups was used:

$$n = \frac{2(Z_\alpha/2 + Z_\beta)^2 \cdot \sigma^2}{\Delta^2}$$

Where:

- $Z_{\alpha/2}$ is the z-score corresponding to the significance level (for α = 0.05, $Z_{\alpha/2} \approx 1.96$).
- Z_β is the z-score corresponding to the desired power (for 0.80 powers, $Z_\beta \approx 0.84$).
- σ is the estimated standard deviation of the outcome variable (such as shoulder pain or proprioception). This is often based on prior studies or pilot data.

Fig. 2 Pain scale

Table 2 The demographic information of the subjects

Group	Age	Height	Weight	BMI
SFTMM	24.69 ± 3.61	1.64 ± 0.03	58.50 ± 4.82	21.67 ± 0.90
SFT	25.09 ± 3.51	1.63 ± 0.03	58.22 ± 3.64	21.80 ± 0.60

SFTMM: Scapula-Focused Training with Mobilization

SFT: Scapula-Focused Training

- Δ is the minimum detectable difference (effect size) between the groups, expressed in standard deviation units (Cohen's d = 0.5 in this case).

Statistical analyses

Statistical analyses were conducted using SPSS software version 26, with a significance level set at 0.95 and an alpha threshold of less than 0.05. The Shapiro–Wilk test was utilized to evaluate the normality of the data distribution. To detect differences between groups, a one-way analysis of variance (ANCOVA) was performed, followed by post-hoc comparisons using the Bonferroni test. The effect size was represented using eta squared (η^2) to quantify the magnitude of the differences observed.

Results

The demographic information of the subjects is outlined in Table 2.

A Shapiro–Wilk test was conducted to assess the normality of the distribution for Age, Height, Weight, and BMI. The results indicated that the data were normally distributed for all variables ($p > 0.05$). A one-way ANOVA was conducted to compare the effect of different groups on Age, Height, Weight, and BMI. The results indicated that there were no statistically significant differences between groups on Age, (F [1] = 0.126, $p = 0.882$), Height, (F [1] = 0.652, $p = 0.528$), Weight, (F [1] = 0.065, $p = 0.937$), or BMI, (F [1] = 0.295, $p = 0.747$) (Table.3).

The results revealed a significant difference in pain scores and proprioception (joint position sense) among female rock climbers with SIS who participated in SFTMM, SFT, and a control group (F [1, 2] = 81.01, $p = 0.001$, $\eta 2 = 0.83$ for pain scores; F [1, 2] = 178.2, $p = 0.001$, $\eta 2 = 0.91$ for proprioception scores). Post-hoc tests via the Bonferroni test indicated that both SFTMM and SFT significantly reduced pain levels ($p = 0.001$) and improved proprioception levels ($p = 0.001$) compared with the control group. There was no significant difference in pain scores and proprioception between the SFTMM group and the SFT group ($p > 0.05$).

Discussion

This study investigated the effects of adding MM to SFT on pain and proprioception in athletes diagnosed with SIS. The results indicated that SFTMM led to a significant reduction in pain and better proprioception (JPS) than did the baseline and control interventions. The effect sizes for pain scores and proprioception demonstrated large effects ($\eta^2 = 0.83$ and $\eta^2 = 0.91$, respectively), indicating substantial differences between the intervention groups and the control group.

The results regarding the positive effects of SFTMM and SFT in reducing pain and improving proprioception in individuals with SIS are in line with those of previous studies [18–20, 22–24, 29, 38]. The findings of this study underscore the significance of SFT in the rehabilitation of female rock climbers with SIS. A critical aspect of shoulder function is the scapulohumeral rhythm, which refers to the coordinated movement of the scapula and humerus during arm elevation. Disruptions in this rhythm can lead to altered biomechanics, resulting in increased stress on the shoulder joint and contributing to symptoms of SIS [39]. SFTMM aimed to enhance the strength and control of the scapular stabilizing muscles, thereby facilitating proper scapulohumeral rhythm. Our results demonstrated significant improvements in pain and proprioception, which can be attributed to the restoration of this rhythm. As the scapula functions optimally, it allows for better alignment and movement mechanics, ultimately reducing the risk of impingement and enhancing overall shoulder performance in athletes.

Abnormal movements are caused by pain, and on the contrary, pain can cause abnormal movements [40]. The reduction in pain may also be attributed to the specific design of the mobilization technique to reduce shoulder pain during active movement, as well as the ability to reduce pain with active movement. The mobilization technique has been shown to provide immediate pain relief in individuals with shoulder impingement by promoting proper alignment, and by targeting areas of restriction or stiffness, mobilization can help improve the

Table 3 The mean ± standard deviation for pain and proprioception (JPS)

Groups	Pain		Change (%)	JPS		Change (%)
	Pre-Test	Post-Test		Pre-Test	Post-Test	
SFTMM	5.64	2.86	49.29	3.96	2.29	42.17
SFT	5.84	2.94	49.66	3.77	2.48	34.22
Control	5.20	5.04	3.08	3.88	3.92	-1.03

SFTMM: Scapula-Focused Training with Mobilization

SFT: Scapula-Focused Training

overall ROM in the shoulder joint, reduce impingement and alleviate pain [22].

Correcting Postural changes [10], and abnormal muscle tension and joint alignment may also contribute for reducing shoulder pain [6]. The subacromial space is critical in preventing shoulder impingement, as it contains the rotator cuff tendons and the subacromial bursa. A decrease in this space can lead to friction and inflammation of the surrounding tissues. Strengthening the muscles surrounding the shoulder joint is fundamentally crucial for both injury prevention and rehabilitation. The protocol is meticulously designed to incorporate a variety of targeted muscle-strengthening exercises, such as Full Can and Prone Horizontal Abduction with External Rotation. These exercises are specifically aimed at enhancing the stability and functional capacity of key shoulder musculature, particularly the rotator cuff and scapular stabilizers.Enhanced muscular strength directly correlates with improved control over shoulder movements, which is vital for maintaining proper joint alignment throughout a wide range of activities [24]. This control not only optimizes movement efficiency but also significantly contributes to the maintenance of adequate subacromial space, thereby reducing the likelihood of impingement and associated discomfort. In this training protocol, Exercises that promote proper joint mechanics, like Inferior Glides and Diagonal D1 and D2 patterns, facilitate enhanced mobility and positioning of the shoulder joint, thereby maintaining adequate subacromial space. By effectively expanding this space through improved alignment and mobility, the risk of impingement can be significantly reduced, leading to decreased pain and enhanced function.The neuromuscular exercises included in this protocol, such as Towel Slides and Scapular Clocks, aimed to enhance scapular positioning and promote optimal shoulder alignment. These exercises are crucial for ensuring that the glenohumeral joint is positioned correctly within the socket, minimizing the risk of impingement during arm movements. Also, improving.

ROM and flexibility is a critical component of this protocol. Restricted ROM in the shoulder can exacerbate dysfunction and contribute to impingement. Techniques included in the protocol, such as PNF stretches and Towel Slides, are designed to enhance flexibility and facilitate greater ROM in the shoulder joint. An increased ROM allows for more fluid movement patterns, reducing compensatory strategies that can lead to pain. Enhanced flexibility of the shoulder girdle also supports better alignment and function during activities.

Muscle imbalances [41], and overuse [42] can cause chronic shoulder pain. Muscle balance around the shoulder is vital for stabilizing the joint and ensuring proper movement patterns. Imbalances, such as overactivity in the internal rotators relative to the external rotators, can lead to altered shoulder mechanics and an increased risk of injury. The protocol included targeted strengthening exercises such as Side-Lying External Rotation and Push-Up Plus, which focus on developing strength in the external rotators and other stabilizing muscles. By promoting balanced muscle development, this protocol aimed to create a more stable shoulder joint, which is essential for maintaining proper alignment and reducing impingement.

The combination of SFT and MM with potential to optimize movement patterns in the shoulder joint, promoting proper alignment and mechanics during shoulder movements [43] revealed significant result for pain and proprioception in individuals with SIS. The same mechanisms could be referred to justify the outcome as noted. Adding MM specifically targets the glenohumeral joint to reduce mechanical stress on the surrounding tissues. By applying specific mobilization techniques, it can reposition the humeral head in the glenoid cavity, thus increasing the subacromial space. A greater subacromial space can alleviate pressure on the rotator cuff tendons and subacromial bursa, inflammation in affected structures by promoting blood flow and lymphatic drainage [44] which can help decrease pain associated with SIS and facilitate the healing process. The technique involves mobilization while the athlete actively participates in movement. This combination can trigger a neurological response that helps modulate pain perception through the gate control theory, potentially reducing the nociceptive input to the central nervous system.

Therefore, Pain reduction can improve joint position sense in participants with SIS by enhancing sensory feedback, proprioception, and neuromuscular control [45]. Pain can disrupt sensory feedback from the affected shoulder, leading to impaired perception of joint position [9]. When pain is reduced, proprioceptive input from the shoulder joint is better preserved, enabling individuals to have a more precise perception of joint position and movement.

The study's hypothesis that combining SFT with MM would result in significantly greater improvements in pain and proprioception compared to SFT alone was rejected based on the findings. Both interventions SFT with MM and SFT alone showed significant improvements in reducing pain and enhancing proprioception when compared to the control group. However, there was no statistically significant difference between the SFTMM group and the SFT group. Both SFT and MM target crucial aspects of SIS rehabilitation, particularly muscle strength, scapular control, and range of motion. It's possible that the core effects of these interventions overlap significantly, leading to similar outcomes. SFT improves scapular mechanics and muscular strength, which can directly address the biomechanical dysfunctions causing SIS. MM, on the other hand, works to increase joint mobility and alleviate pain, but these effects may not provide substantial additional benefits when SFT alone already addresses key impairments. Another potential explanation could be the ceiling effect, where patients in both intervention groups might have already achieved the maximum possible improvement in pain reduction and proprioception with SFT alone. This could make it difficult to detect additional improvements with the combined intervention (SFTMM), especially in a relatively short intervention period of 8 weeks.

Implications for clinical practice

This study suggests that SFT alone may be sufficient for many patients with SIS, particularly those who benefit from neuromuscular control and strength-based interventions. Given the similar outcomes in both the SFTMM and SFT groups, therapists may prioritize SFT as it significantly reduces pain and improves proprioception. The lack of a significant difference between the groups indicates that MM may not be necessary for all patients, though it could be beneficial for those with joint mobility restrictions or pain during movement. MM might be useful for patients with stiffness or limited range of motion that hinders effective scapular exercises. From a cost and time-efficiency standpoint, focusing on SFT as the primary intervention is practical, with MM reserved for more complex cases or as a supplement for patients whose symptoms persist despite exercise alone.

Limitations and future research

While this study provides valuable insights, several limitations should be considered: this is a pilot randomized control trial and the sample size of 36 participants definitely limits the generalizability of the findings. A larger sample size would enhance the statistical power of the study and allow for more robust conclusions about the effectiveness of the intervention. The study focused exclusively on female rock climbers, which may restrict the applicability of the findings to broader populations, including males and individuals involved in different sports or activities. Furthermore, the intervention period of 8 weeks may be insufficient to capture the long-term benefits of combining SFT and MM. SIS is a chronic condition, and extended interventions with long-term follow-up are necessary to assess sustained improvements and prevent recurrence of symptoms. We will highlight the need for studies with longer intervention periods and follow-up assessments to evaluate the durability of the treatment effects over time.

Conclusion

In conclusion, In conclusion, the study indicates that combining SFT with MM significantly reduces pain and improves proprioception in female rock climbers with shoulder impingement syndrome, as shown by significant changes compared to the control group. However, no statistically significant difference was found between the combined intervention and SFT alone. Therefore, while the incorporation of SFT and MM shows promise; further research is needed to fully understand its long-term benefits and clinical implications.

Abbreviations

BMI	Body Mass Index
JPS	Joint Position Sense
ROM	Range Of Motion
RTC	Randomized Control Trial
SFEMSFTMM	Scapula-Focused Training with Mulligan Mobilization
SFT	Scapula-Focused Training
VAS	Visual Analog Scale

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Author contributions

BZ, HA, and SS developed the idea, investigation and data gathering; BZ, HA, and SS conducted the research; All authors did quality appraisal of included studies as well as writing, reading, and approving the final draft manuscript; Supervision is done by SS.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The Ethics Committee affirmed the research protocol of Sport Sciences Research Institute (Code: IR.SSRC.REC.1402.170). In addition, before beginning the research process, all participants in this study provided informed consent.

Consent for publication

Not applicabale.

Competing interests

The authors declare no competing interests.

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