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Prevention and Rehabilitation

Evaluation of scapular mobilization and comparison to pectoralis minor stretching in individuals with rounded shoulder posture: A randomized controlled trial

Maedeh Fani, PhD [a, b, *], Samaneh Ebrahimi, PhD [a, b], Ali Ghanbari, PhD [a, b]

[a] Physical Therapy Department, School of Rehabilitation Sciences, Shiraz University of Medical Sciences, Shiraz, Iran
[b] Rehabilitation Sciences Research Center, Shiraz University of Medical Sciences, Shiraz, Iran

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ABSTRACT

Background: Rounded shoulder posture (RSP) is a common postural condition which can alter scapular position. Although, there is no consensus on the relationship between posture and musculoskeletal dysfunction, some evidence suggests a significant relationship between RSP and shoulder dysfunction. Therefore, treatment of this postural condition is important. Various treatment methods are used to correct RSP. However, the effectiveness of scapular mobilization, (SM) as a method which can alter scapular kinematics, has not been investigated.
Objective: To evaluate the effects of SM on scapular resting position in individuals with RSP, and to compare this technique to pectoralis minor self-stretching (PMS), and combined SM + PMS.
Methods: 52 healthy students (18 men and 34 women; mean age 23.67 ± 6.73 years) with RSP were randomly assigned to four groups (SM, PMS, combined SM + PMS, control). The mobilization group received SM, the stretching group performed self-PMS, and the combined group received SM + PMS. The control group received no treatment. Kinematics data to measure scapular protraction (cm), anterior tilt (°), internal rotation (°), and downward rotation (°) were captured with a motion analysis system before and after 5 sessions of group intervention.
Results: All variables decreased significantly post-intervention compared to baseline values ($P < 0.05$). Internal rotation and downward rotation decreased significantly in the intervention groups compared to the control group ($P < 0.05$). No significant differences were observed between the intervention groups.
Conclusion: SM appears to be an effective technique to change scapular resting position in individuals with RSP. However, this technique was not superior to PMS or a combination of SM + PMS.

1. Introduction

Rounded shoulder posture (RSP) is a common postural condition characterized by downward rotation, protraction, anterior tilt and internal rotation of the scapula (Lukasiewicz et al., 1999; Neumann, 2010). It is considered an intrinsic risk factor in individuals with shoulder pain (Szeto et al., 2002), with an incidence of approximately 60% in the general population (Griegel-Morris et al., 1992). RSP is associated with bad postural habit, repetitive overhead activities, backpack carriage, mouth breathing, computer use, and prolonged periods of study (Singla and Veqar, 2017). It has been reported that 78% of people with work-related pain have protracted shoulders (Pascarelli and Hsu, 2001).

RSP may induce alterations in scapular position, kinematics and surrounding muscle activities (Borstad and Ludewig, 2005; Thigpen et al., 2010; Kwon et al., 2015). Appropriate scapular position is an important factor in optimal shoulder joint function since it provides centering of the humeral head in the glenoid fossa, thus creating a stable base for shoulder movements (Ludewig et al., 2009). Altered scapular kinematics and muscle imbalance increase stress on the shoulder, leading to shoulder pain, dysfunction and neuromuscular symptoms (Ludewig and Reynolds, 2009; Thigpen et al., 2010; Kibler et al., 2012; Timmons et al., 2012; Kwon et al., 2015). Previous research has shown a significant relationship between RSP and shoulder impingement syndrome (Borstad, 2006;

* Corresponding author. School of Rehabilitation Sciences, Shiraz University of Medical Sciences, Abiverdi 1 Ave., Chamran Blvd, Shiraz, Fars, Iran.
E-mail addresses: maedeh.fani@gmail.com (M. Fani), ebrahimis@sums.ac.ir (S. Ebrahimi), Ali_ghanbari@yahoo.com (A. Ghanbari).

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Thigpen et al., 2010), although some studies found no difference in scapular resting position between healthy persons and individuals with subacromial impingement syndrome (Struyf et al., 2011; Ratcliffe et al., 2014). However, given the high incidence of RSP and that it is probably a risk factor for upper extremity pain, treating RSP may improve shoulder mechanics and decrease the risk of developing shoulder pathology or dysfunction.

Various treatments have been used to correct RSP (Wang et al., 1999; Jain et al., 2004; Borstad and Ludewig, 2005; Kluemper et al., 2006; Wong et al., 2010; Han et al., 2015; Lee et al., 2015; Kim et al., 2016). Treatment protocols evaluated to date include teaching the correct position (Braun, 1991; Jain et al., 2004), pectoralis minor stretching (Wang et al., 1999; Borstad and Ludewig, 2005; Kluemper et al., 2006; Wong et al., 2010; Lee et al., 2015), strengthening exercises (Wang et al., 1999; Ludewig et al., 2004; Kluemper et al., 2006), use of a shoulder brace (Cole et al., 2013; Lee et al., 2015), kinesiology taping (Han et al., 2015), elastic band exercises (Kim et al., 2016), McKenzie and Kendall exercises (Kim et al., 2017), and pectoralis minor soft tissue mobilization (Wong et al., 2010). Among the different methods proposed to improve RSP, the effectiveness of scapular mobilization (SM) is not well documented. Surenkok et al. (2009) examined the initial effects of SM on shoulder range of motion (ROM) and scapular upward rotation in participants with painful limitation of shoulder movement. They found significant improvements in shoulder ROM and scapular upward rotation after SM (Surenkok et al., 2009). In another study, Yang et al. (2012) evaluated the effectiveness of end-range mobilization and scapular mobilization treatment approach in improving shoulder complex kinematics in individuals with frozen shoulder. They found that this approach was more effective than a standardized physical therapy program (Yang et al., 2012). However, Aytar et al. (2015) demonstrated that scapular mobilization had no significant advantage for ROM compared with sham or supervised exercise in patients with subacromial impingement syndrome (Aytar et al., 2015). Although some studies reported changes in scapular kinematics after SM, to the best of our knowledge, there are no published studies on the effectiveness of SM in changing scapular resting position in individuals with RSP.

SM can restore scapular mobility, decrease stiffness and reinforce proprioceptive position sense (Maitland et al., 2005). Furthermore**,** sustained forces induced by mobilization techniques can stretch contracted, fibrotic or shortened muscle tissues around the joint (Maitland et al., 2005). We hypothesized that this passive method might be an alternative intervention to correct scapular resting position in individuals with RSP, especially those unable to participate actively in correcting this postural condition. Therefore, the aims of this study were to evaluate the effects of SM on scapular resting position in individuals with RSP, and to compare this technique to pectoralis minor self-stretching (PMS), i.e. the conventional treatment for RSP, and combined SM + PMS.

2. Methods

2.1. Study design

In this randomized controlled clinical trial (clinical trial registration number: IRCT201206162708N6), volunteers with RSP from Shiraz University of Medical Sciences were recruited through an advertisement and by the word of mouth. Before data collection, all of the participants were informed about the nature of the study and signed a consent form. The study was approved by the Ethics Committee of Shiraz University of Medical Sciences (Ethics Committee number: CT-90-5982). Since no publications based on the same treatment method were available, the estimated sample size was based on the previous "Acute effects of scapular mobilization in shoulder dysfunction: A double-blind randomized placebo-controlled trial" study (Surenkok et al., 2009). For a power level of 80% and a confidence level of 0.95, 52 participants were included in the study. A block randomization method was used to allocate participants to one of four groups: SM (n = 13), PMS (n = 13), combined SM + PMS (n = 13), and a control group (n = 13). Scapular resting position kinematics data were collected with a motion capture system.

2.2. Participants

Fifty-two college student volunteers (18 men and 34 women, mean age 23.67 ± 6.73 years, height 166.04 ± 10.27 cm, weight 56 ± 9.77 kg) participated in this study. Participants were included if they had RSP, were within an age range of 18–30 years, and were asymptomatic for any musculoskeletal dysfunction. The presence of RSP was determined with a plumb line. A distance more than 1 cm from the posterior angle of the acromion to the plumb line in a standing position was considered to indicate RSP (Griegel-Morris et al., 1992). The anthropometric characteristics of the participants in each group are shown in Table 1.

Volunteers were excluded from the study if they reported acute neck or shoulder girdle pain, a history of major trauma to the neck or shoulder, shoulder fracture or surgery, cardiorespiratory problems, or systemic disorders that influenced the muscles, connective tissues or joints.

2.3. Procedures

A pilot study was done in 12 individuals to determine the intra-rater reliability of marker placement and measurements with the motion analysis system. The same physiotherapist carried out the whole procedure in 12 participants twice, with a 7-day interval between examinations. The two sets of measurements were used to calculate intraclass correlation coefficients (ICC).

To define scapular position, scapular resting position kinematics data were collected with a six-camera motion capture system (Proreflex, Qualisys®, Gothenburg, Sweden) at a sampling rate of 100 Hz. Scapular kinematics data were used to calculate the measures of scapular resting position variables (protraction, downward rotation, anterior tilt and internal rotation) with MATLAB.

To record posture in a reproducible manner, the participants were asked to walk through the measurement space (15 m), roll their shoulders three times, nod their head and neck five times and then inhale and exhale deeply (Greenfield et al., 1989). Then, they sat on a chair in a comfortable position, with their arms relaxed at the sides; their trunk was erect and their hips and knees were bent at 90°. They looked at a sign fixed at eye level on the wall in front of them. The same physiotherapist attached 4 light-reflecting markers (10 mm in diameter) to the flat bony surfaces of the medial side of the scapular spine, posterior part of the acromion angle, inferior angle of the scapula and the C7 spinous process. Three trials, each lasting 3 s, were recorded in this position with the Qualisys® motion capture system. All evaluations were performed by a physiotherapist who was blind to the allocation of participants to the control or different intervention groups.

Although there are international guidelines for reporting scapular position, we opted to evaluate the position of the scapula as described by Wang and colleagues (Wang et al., 1999). Scapular orientation was defined by a plane formed by imaginary lines connecting the medial root of the scapular spine, the posterior part of the inferior scapular angle and the acromion angle. The angles between this plane and the frontal or transverse plane represented, respectively, scapular internal rotation and anterior tilt. The angle between a line from the root of the scapular spine and inferior

Table 1
Anthropometric characteristics of the participants (mean ± SD).

	Mobilization Group (n = 13)	Stretching Group (n = 13)	Combined Group (n = 13)	Control Group (n = 13)	P-value*
Age (Years)	26.46 ± 12.66	22.46 ± 2.5	22.85 ± 2.44	22.92 ± 3.01	0.400
Height (cm)	164.73 ± 7.82	166.03 ± 11.79	166.57 ± 12.08	166.84 ± 9.97	0.958
Weight (kg)	55.25 ± 5.95	57.86 ± 12.17	56.2 ± 11.08	58.34 ± 9.63	0.847

* Significant at $P < 0.05$.

angle and the sagittal plane represented scapular upward rotation. The distance from the scapular center of gravity to a line passing from C7 to the transverse plan indicated the amount of scapular protraction (Wang et al., 1999). The location of the markers is shown in Fig. 1.

After calculating the scapular resting position variables, participants in the SM group lay on their left side near the edge of the bed, with their head on a pillow and their hips and knees bent. Another physiotherapist stood facing the patient's hip with her left armpit resting on the patient's right iliac crest, and applied sustained grade IV SM toward retraction, upward rotation and distraction. These maneuvers consisted of three sets of 10 repetitions with rest intervals of 30 s between sets (Surenkok et al., 2009).

Although there are various methods to stretch the pectoralis minor muscle, in this study we chose a pectoralis minor self-stretching method for the PMS group. The participants lay in the supine position with their knees bent and their legs rotated toward the floor in the direction opposite that of the target shoulder to be stretched. Then, the participants moved their arm in a circular motion overhead until they touched the floor with the dorsum of their hand, and maintained contact for 30 s. The full set of maneuvers consisted of 10 repetitions with a rest interval of 15 s (Fig. 2) (Wong et al., 2010).

Participants in the combined SM + PMS group initially received SM as described above for the SM group, and then performed PMS as described for the PMS group. Individuals allocated to the control group received no treatment throughout the study; however, all of them received PMS treatment after the end of the study.

The participants were blinded to their group allocation. All participants in the three intervention groups were treated with 5 sessions every other day. After 5 sessions of intervention, scapular resting position was determined again.

2.4. Statistical analysis

All statistical analyses were conducted using SPSS version 17 (SPSS Statistics for Windows, Version 17.0. Chicago: SPSS Inc.). The ICC was 0.841 (0.539–0.951) for scapular anterior tilt, 0.909

Fig. 2. Pectoralis minor self-stretching method.

(0.717–0.973) for internal rotation, 0.940 (0.805–0.982) for upward rotation, and 0.943 (0.814–0.983) for protraction.

The one-sample Kolmogorov–Smirnov test confirmed that all scapular resting position variables (protraction, downward rotation, anterior tilt and internal rotation) were distributed normally. All dependent variables were compared between groups with one-way analysis of variance (ANOVA). The Tukey-Kramer test was used for post-hoc analysis. To test treatment efficacy before and after treatment within groups, paired t-tests were used. The alpha level was set at 0.05.

3. Results

Data from 52 participants were analyzed (Fig. 3). The baseline (pre-intervention) analysis showed that there were no significant differences between the groups in any of the scapular resting position variables (protraction, downward rotation, anterior tilt and internal rotation) ($P > 0.05$) (Table 2).

Statistical analysis showed that after 5 sessions of SM, all variables examined (protraction, anterior tilt, internal rotation and

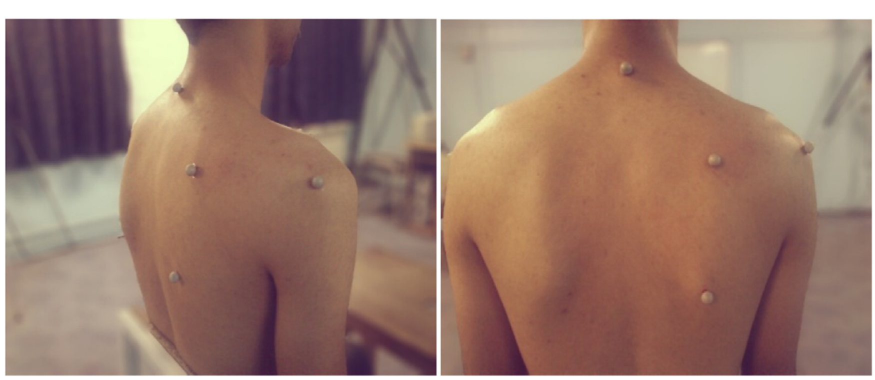

Fig. 1. Marker placement used to determine scapular resting position.

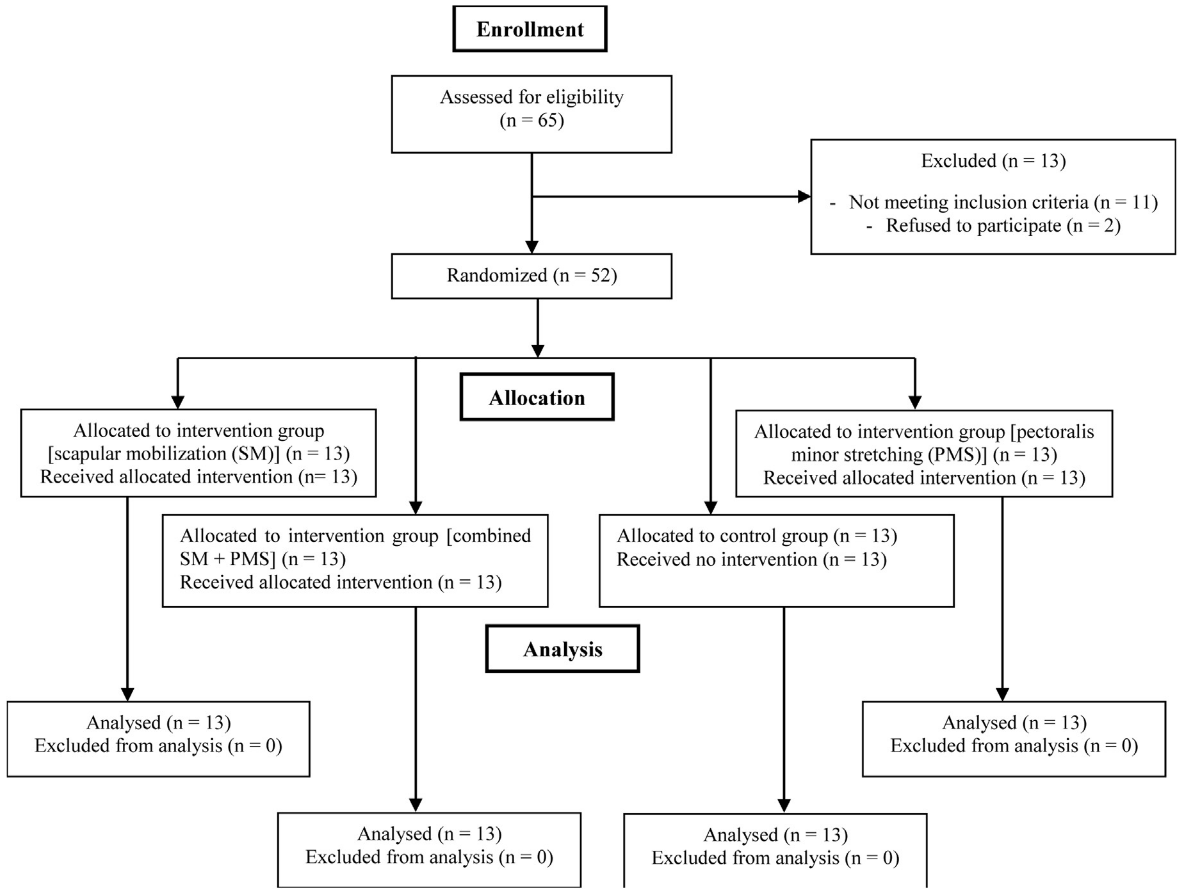

Fig. 3. CONSORT flowchart showing randomization of 52 participants.

Table 2
Within- and between-group comparisons of mean differences in scapular resting position (mean ± SD).

		Mobilization Group (n = 13)	Stretching Group (n = 13)	Combined Group (n = 13)	Control Group (n = 13)	Between-group Comparisons P-value
Internal rotation (°)	**B**	39.18 ± 5.43	38.49 ± 5.57	39.55 ± 5.14	42.33 ± 4.47	0.259
	A	34.01 ± 7.37	33.24 ± 4.40	34.70 ± 4.73	41.60 ± 4.83	0.001**[1]
	D	5.16 ± 3.45*	5.24 ± 4.38*	4.85 ± 5.05*	0.73 ± 1.44	0.01**[2]
Upward rotation (°)	**B**	0.87 ± 5.79	0.39 ± 4.62	1.39 ± 3.99	2.12 ± 5.26	0.831
	A	5.45 ± 4.95	4.19 ± 5.71	4.67 ± 3.56	2.27 ± 5.51	0.427
	D	−4.5 ± 3.53*	−3.54 ± 2.61*	−3.28 ± 1.38*	−0.14 ± 1.87	0.01**[2]
Anterior tipping (°)	**B**	18.26 ± 4.76	14.86 ± 4.93	18.70 ± 6.05	14.71 ± 5.02	0.101
	A	16.16 ± 3.67	12.13 ± 3.73	14.62 ± 6.95	14.54 ± 4.44	0.225
	D	2.10 ± 2.67*	2.73 ± 3.12*	4.08 ± 3.59*	0.17 ± 1.64	0.01**[3]
Protraction (cm)	**B**	12.57 ± 1.33	12.38 ± 1.40	12.05 ± 0.93	12.61 ± 1.24	0.631
	A	12.06 ± 1.15	11.9 ± 1.38	11.48 ± 1.26	12.59 ± 1.25	0.179
	D	0.51 ± 0.56*	0.48 ± 0.43*	0.57 ± 0.69*	0.04 ± 0.43	0.06

B = before the intervention, A = after the intervention, D = difference between before and after the intervention.
* Significant (P < 0.05) pre-post intervention change (within-group comparison).
**[1] Significant post-intervention change between the three intervention groups and the control group.
**[2] Significant (P < 0.05) difference between the three intervention groups and the control group.
**[3] Significant (P < 0.05) difference between the combined SM + PMS group and the control group.

downward rotation) decreased significantly in comparison to baseline values as well as 5 sessions of PMS and combined SM + PMS (P < 0.05) (Table 2).

Between-group comparisons showed that after 5 sessions of treatment, internal rotation and downward rotation decreased significantly in comparison to the control group (P < 0.05). However, after 5 intervention sessions, no significant differences were observed between any of the intervention groups (P > 0.05). These results are summarized in Table 2.

4. Discussion

Various research findings suggest a move away from the idea that health depends on ideal posture (Lunghi et al., 2016). In the context of this new approach, some current evidence does not support scapular rehabilitation to optimize normal posture. For example, some studies have concluded that normal scapula position is part of normal variation in posture, and is not a contributing factor to subacromial impingement syndrome (Struyf et al., 2011; Ratcliffe et al., 2014). In contrast, there is evidence of a significant relationship between RSP and subacromial impingement syndrome (Borstad, 2006; Thigpen et al., 2010). Therefore, the relationship between scapular position and shoulder dysfunction remains equivocal. In the present study we hypothesized that the altered scapular position seen in RSP may contribute to future shoulder dysfunction. Therefore, this study aimed to elucidate the influence of rehabilitation intended to improve scapular position. We evaluated the effects of SM on scapula resting position in individuals with RSP and compared this technique to PMS, and combined SM + PMS.

The results showed that after 5 intervention sessions, anterior tilt, internal rotation, downward rotation and protraction decreased in the SM group. Given that these angles are increased in individuals with RSP (Neumann, 2010), these decreases probably represent effective changes in scapular resting position and shoulder girdle posture.

To the best of our knowledge, there are no published studies on the effectiveness of SM in modifying scapular resting position. However, some researchers reported changes in scapular kinematics after SM (Surenkok et al., 2009; Yang et al., 2012). The scapulothoracic joint is not a true synovial joint, but is an area of contact between the scapula and the posterior wall of the thorax, which is separated by muscles (Neumann, 2010). Therefore, the main effects of SM are likely to occur primarily in the muscles surrounding this joint. Maitland and colleagues claimed that SM may lengthen shortened or fibrous muscles, thereby releasing them (Maitland et al., 2005). In addition, previous work found relationships among shoulder posture, pectoralis minor muscle shortening and shoulder joint movement alterations (Borstad and Ludewig, 2006). The pectoralis minor is attached to the scapular coracoid process; therefore, sustained stretching induced by SM may lengthen this muscle and lead to changes in scapular resting position. Additionally, SM may enhance neural inputs and improve proprioceptive position sense (Maitland et al., 2005), and these changes in turn may also influence scapular resting position. It thus seems likely that SM can affect scapular resting position.

Our statistical analysis showed that during the study, scapular resting position remained unchanged in the control group (Table 2). Therefore, the possible effect of learning can be ruled out, because participants in the control group were unlikely to learn how to modify scapular resting position during the study period.

Our analysis showed that after 5 treatment sessions, scapular internal rotation and downward rotation in the three intervention groups decreased significantly compared to the control group. Moreover, scapular anterior tilt decreased significantly in the combined SM + PMS group compared to the control group. Although we found some differences in scapular protraction between the intervention and control groups, the P value was not significant ($P = 0.06$). It thus appears that the number of intervention sessions may be an additional factor that affected the post-intervention results.

Statistical analysis disclosed no significant differences between the three intervention groups. All interventions were effective in improving scapular resting position; however, no intervention was superior to any of the other two treatments. The absence of significant differences among the treatments compared here may reflect the fact that all interventions for RSP were based on the same mechanism. For example, SM may affect scapular resting position via pectoralis minor stretching through its attachment to the coracoid process. Therefore, the SM technique may acts on the scapula in the same basic way as the pectoralis minor stretching technique. If this is the case, combined SM + PMS would not be expected to have a greater effect on scapular resting position than either technique alone. On the other hand, in the present study the treatment protocol consisted of only 5 sessions of intervention. Longer intervention periods or more treatment sessions may yield statistically significant differences; therefore, further studies are recommended.

The results of this study demonstrated that both PMS and SM were effective in changing scapular resting position. Therefore, any of these methods can be used to change scapular position in individuals with RSP. It is cheaper to teach patients PMS once and re-evaluate them than to treat them consistently with SM and/or SM + PMS. However, PMS is an active method that can be used by individuals at home without supervision, whereas SM is a passive technique which can be used for those who are unable to participate actively in correcting RSP.

4.1. Limitations

Although this study is the first to use three-dimensional motion data to analyze the influence of SM on RSP, some limitations should be noted. First, we only measured scapular resting position. It was not possible to measure scapular kinematics with our method, because the skin markers cannot move in conjunction with the scapular bony landmarks during arm movements. Second, participants' understanding of the aims of the study may have influenced the follow-up measures of scapular posture. Third, our study involved asymptomatic participants, so our results may be different from those in individuals with symptoms. Fourth, in this study, based on a biomechanical approach, we assumed that poor scapular posture may contribute to future shoulder dysfunction. However, as noted above, the relationship between scapular position and shoulder dysfunction is equivocal; therefore, additional research is needed to establish the nature of this relationship.

Further studies are suggested to evaluate the effects of SM during follow-up, in order to compare this technique to other treatment techniques such as strengthening exercises and taping, and to determine the long-term clinical influence of scapular mobilization techniques on RSP.

4.2. Clinical relevance

- SM is an effective passive technique in changing scapular resting position in RSP.
- SM is as effective as PMS and/or SM + PMS in changing scapular resting position.
- SM is recommended in individuals unable to actively correct RSP and who therefore need passive interventions.

5. Conclusion

The current study evaluated the effects of SM on scapular resting position in individuals with RSP, and compared this technique to PMS, and combined SM + PMS. The results suggested that 5 sessions of SM appear to be an effective alternative technique to change scapular resting position in individuals with RSP. However, this technique was not superior to PMS or the combination of SM + PMS.

Credit author statement

Maedeh Fani: design of the study; measurement of laboratory parameters concerning scapular resting position; all authors: interpretation of the data, manuscript revision, reading and approval of the submitted version. Samaneh Ebrahimi:

performance of scapular mobilization and teaching of pectoralis minor self-stretching to participants; all authors: interpretation of the data, manuscript revision, reading and approval of the submitted version. Ali Ghanbari: design of the study; Data curation, Formal analysis, coordination of the study and analysis of the data; all authors: interpretation of the data, manuscript revision, reading and approval of the submitted version.

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Declaration of competing interest

The authors report no conflicts of interest.

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