



Exercise therapy may affect scapular position and motion in individuals with scapular dyskinesis: a systematic review of clinical trials

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Background: Therapeutic exercise for scapular muscles is suggested to be effective in reducing shoulder pain in patients with rotator cuff disorders, whereas its effectiveness on scapular position and motion has remained unclear. Therefore, the aim of this systematic review was to investigate whether exercise therapy improves scapular position and motion in individuals with scapular dyskinesis.

Methods: This study is a wide systematic review including any type of clinical trial in which the effect of any type of therapeutic exercise, including scapular muscle strengthening, stretching, and scapular stabilization exercise, is investigated in adult participants.

Results: Twenty studies were included in this systematic review. Studies were categorized on the basis of the techniques they used to measure scapular position and motion and the included participants. Methodologic quality of the studies was assessed by the Cochrane tool of assessing the risk of bias. Eight studies used 3-dimensional techniques for measuring scapular motions. Among them, 5 studies showed significant effects of exercise on scapular motion, of which 3 studies investigated individuals with subacromial impingement syndrome (SIS). The other 12 studies used 2-dimensional measurement techniques, of which 8 studies reported significant effects of exercise on scapular position and motion both in SIS patients and in asymptomatic individuals. However, their methodologic quality was debatable. Therefore, there was conflicting evidence for the effect of exercise on scapular dyskinesis.

Conclusion: There is a lack of evidence for beneficial effects of exercise in improving scapular position and motion in individuals with scapular dyskinesis. However, exercise is beneficial in reducing pain and disability in individuals with SIS.

Level of evidence: Level IV; Systematic Review

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Keywords: Exercise therapy; scapula; dyskinesis; motion; systematic review; scapular position

The Research Ethics Committee, University of Social Welfare and Rehabilitation Sciences, approved this study. All participants gave written informed consent before data collection began.

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Optimal scapular position and motion are essential in normal shoulder function. Scapular upward rotation, posterior tilt, and external rotation avoid impingement of the subacromial space contents during shoulder elevation.^{25,26} Indeed, scapular dyskinesis is characterized by a prominent scapular medial border and an inferior angle, early scapular elevation, or inadequate scapular upward and downward rotation during arm lifting or lowering.^{15,16} Previous studies have claimed that 33%-100% of the patients with various shoulder disorders, like subacromial impingement syndrome (SIS), show scapular dyskinesis^{4,33}; however, it is frequently observed in asymptomatic individuals.³³ Preziosi Standoli et al,³⁴ in their recent study, reported scapular dyskinesis in 8.5% of asymptomatic elite young swimmers.

Scapular muscles are one of the essential contributors to scapular positioning both at rest and during shoulder motion.¹⁴ Alterations in scapular muscle activity, including trapezius, serratus anterior, and rhomboid muscles, as well as tightness of soft tissues have been reported to be associated with scapular dyskinesis.^{14,23} In this regard, increased activity of upper trapezius with inhibited activity of lower trapezius and serratus anterior has been suggested to be related to altered scapular kinematics, such as decreased upward rotation, decreased scapular posterior tipping, and external rotation.^{14,16,23} Several authors have emphasized the role of exercise therapy in restoring normal scapular kinematics.^{7,16} Thus, scapula-focused exercise therapy is considered an important physiotherapy intervention in individuals with SIS and scapular dyskinesis.³⁵ Several systematic reviews evaluated the effectiveness of exercise therapy on pain and function in individuals with SIS.^{1,8,9,11,19,35} Their results showed moderate to strong evidence that exercise therapy decreased pain and improved function at short-term follow-up in patients with SIS.^{1,8,9,11,19,35} However, there is considerable uncertainty concerning the effectiveness of such approaches in restoring normal scapular kinematics. Bury et al,⁵ in their systematic review, suggested that scapular muscle therapeutic exercise is effective in reducing shoulder pain in patients with rotator cuff disorders, whereas its effectiveness (from 4 included studies) on scapular position and motion remained unclear. Nevertheless, in the systematic review by Bury et al,⁵ the effect of scapular exercise on scapular position and motion was a secondary objective. In addition, they did not include gray literature and studies of asymptomatic individuals with scapular dyskinesis. Therefore, there would be a probability of missing some related studies. Accordingly, because the effect of recommended scapular dyskinesis interventions on correcting scapular position and motion is not clear yet, this systematic review aimed to investigate whether exercise therapy is effective on scapular position and motion in individuals with scapular dyskinesis and whether there is any

improvement in pain and disability accompanied by advancement in scapular position and motion.

Methods

The protocol of this systematic review was prepared and published according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist (PROSPERO registration number: CRD42017053923).³⁰

Identification and selection of the studies

This systematic review included any type of clinical trial, such as randomized clinical trials (RCTs), RCTs with or without blindness, and before-and-after clinical trials without a concurrent control group. Studies evaluating adult participants (athletes and nonathletes), asymptomatic individuals diagnosed with scapular dyskinesis, or individuals with rotator cuff tendinopathy and SIS in which scapular position or motion was considered one of the measured variables were included. The studies without clinical measures for scapular dyskinesis and case studies were excluded.

Types of interventions

All types of therapeutic exercises, such as scapular strengthening exercise, scapular stabilization exercise, and shoulder girdle muscle stretching, with the aims of changing scapular position and movement (scapular dyskinesis) and addressing the pain and disability found with scapular dyskinesis were included. The other types of interventions on scapular kinematics, such as manual therapy and taping, and studies in which therapeutic exercise was a component of a multimodal approach were excluded.

Types of outcome measures

A study was included if it assessed at least 1 scapular kinematics outcome according to any method to identify scapular dyskinesis (3-dimensional [3D] digitizer, visual observation, linear measurements), such as lateral scapular slide test (LSST), measurements of scapular upward/downward rotation, scapular anterior/posterior tilt, and scapular medial/lateral tilt. Pain and disability were considered the secondary outcomes.

Search methods

The following databases were electronically searched up to August 2017: PubMed, Scopus, Web of Science, Elsevier, Ovid, ProQuest, Physiotherapy Evidence Database, and the Cochrane Library. The keywords related to scapular dyskinesis and exercise therapy were included. The reference lists of the included articles, other reviews, gray literature, and key journals were also screened. All the studies meeting the inclusion criteria were entered without any time limit or language and publication type restrictions. [Table I](#) shows the suggested PubMed search strategy.

Table I Suggested PubMed keywords and syntax

Keywords		
1. Scapular dyskinesis	2. Scapular orientation	3. Scapular position
4. Scapular winging	5. Scapular protraction	6. Scapular malposition
7. SICK scapula	8. SICK scapular syndrome	9. Scapula* dyskines*
10. Scapular posterior tilt	11. Scapular posterior tipping	12. Scapular anterior tilt
13. Scapular anterior tipping	14. Scapular upward rotation	15. Scapular downward rotation syndrome
16. Scapulothoracic*	17. Scapulothoracic rhythm	18. Scapular kinematics
19. Scapular dysrhythmia	20. Rotator cuff tendinopathy	21. Shoulder impingement syndrome
22. Subacromial impingement syndrome	23. Scapula* exercise*	24. Scapular stabilization exercises
25. Scapula* stabili*	26. Shoulder rehab*[tiab]	27. Shoulder stretch*
28. Shoulder strengthen*[tiab]	29. Shoulder exercise*[tiab]	30. Scapular approaches
31. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22		
32. 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30		
33. 31 AND 32		

Data collection and analysis

Two authors screened the titles and abstracts of all the articles independently and categorized them as eligible, noneligible, or maybe eligible. The full text of the papers was reviewed for the final decision. Any disagreement concerning inclusion of a study was discussed, and the decision was made by the whole team. Data collection was performed through a data extraction form by 2 authors independently. Information was collected on the study characteristics, participants' characteristics, methods and tools for scapular dyskinesis diagnosis, intervention characteristics, scapular outcome measurements, and pain and disability outcome measures.

Assessment of risk of bias in the included studies

Two authors independently assessed the risk of bias in each study based on the Cochrane Collaboration risk of bias.¹³ The methodologic quality of the studies was assessed according to the following items: selection of participants, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and methods and tools of scapular dyskinesis diagnosis (observational, 2-dimensional [2D], and 3D assessment methods). Each item was scored as low risk, high risk, and unclear risk. To solve any disagreement, a consensus procedure was used.

Results

Flow of studies through the review

The searching process of search engines initially generated a total of 6423 articles, including PubMed (n = 1577), Scopus (n = 966), Web of Science (n = 1224), Elsevier (n = 620), Ovid (n = 1261), and ProQuest (n = 775). The number was reduced to 6315 articles after removal of duplicates. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow chart in [Figure 1](#) presents the details of eligibility screening of the included articles.

Finally, a total of 18 articles and 2 dissertations were included for analysis (n = 20). Interventions other than exercise therapy, such as mobilization, taping, and electrotherapy, were not included for analysis.

Characteristics of studies

[Supplementary Table SI](#) presents the characteristics of the included articles.

Effect of interventions

The results of included studies were classified as 3D and 2D according to measurement methods of scapular motion and position.

3D studies

Scapular motion and position were measured in 8 studies using 3D tracking systems.^{6,12,22,28,37,42,45,46} Four studies evaluated scapular motion in individuals with SIS,^{6,28,42,46} of which 3 studies revealed significant effects of exercise on scapular motion.^{6,42,46} However, evaluation of the risk of bias showed high risk of bias in 3 studies in terms of participant selection and blinding. Hence, McClure et al²⁸ considered all risk of bias items except assessor blinding ([Table II](#)). The other 4 studies evaluated scapular motion in asymptomatic individuals.^{12,22,37,45} Two studies reported significant effect of exercise on scapular motion.^{12,45} On evaluation of their methodologic risk of bias, high risk was revealed in many aspects of bias assessment ([Table II](#)). On the other hand, Rosa et al³⁷ and Lin and Karduna²² reported no effect of exercise on scapular motion.

2D studies

The 2D scapular motion evaluation was performed in 12 studies.^{3,10,18,20,27,29,31,32,36,38-40} The LSST was used to measure scapular motions in 4 studies.^{3,20,32,38} Three

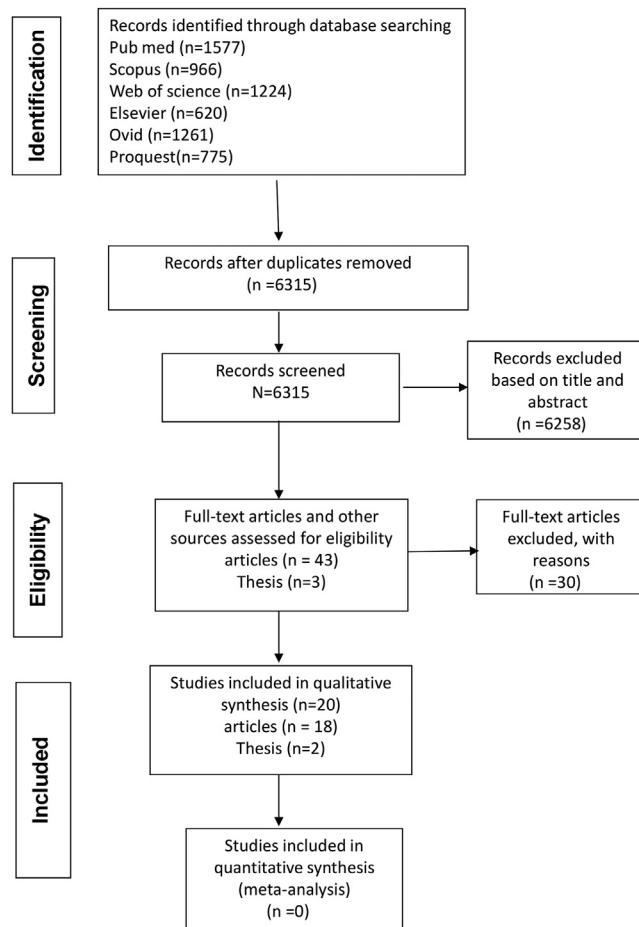


Figure 1 Flow chart of the clinical trials search and selection.

studies revealed significant effects of exercise therapy on LSST measures,^{3,20,38} of which 2 studies^{3,38} investigated SIS individuals, whereas Pekyavas and Ergun³² reported no significant effect of exercise on LSST. Two other studies used total scapular distance (TSD) as the measurement method for scapular position.^{27,36} The result of the study of Lynch et al²⁷ showed no significant effect of exercise on TSD, whereas Roddey et al³⁶ reported a significant effect of exercise on TSD. Both of these studies investigated asymptomatic individuals. Ha et al¹⁰ measured the distance between scapular superior angle, medial border, and inferior angle with their identical thoracic spines using radiography. They reported significant effects of exercise on the outcome measures in asymptomatic individuals. Two studies used an inclinometer to measure scapular upward rotation at different angles of arm elevation, 1 in asymptomatic individuals³¹ and 1 in SIS patients.³⁹ They did not report any significant changes in scapular motion by therapeutic exercises,^{31,39} except for a significant increase in left scapular upward rotation at 90° of left arm elevation in asymptomatic individuals reported by Paulson et al.³¹ Klawiter¹⁸ used McClure's classification system to investigate effects of exercise on scapular dyskinesis in

asymptomatic individuals. The results indicated a significant improvement of scapular dyskinesis after therapeutic exercises. Moezy et al²⁹ introduced a new index to measure the scapular position based on the retraction and protraction plane and found a significant effect of exercise on scapular protraction in individuals with SIS.

Pain

Ten studies evaluated pain before and after exercise interventions.^{3,6,28,29,32,37-39,41,46} Four studies measured pain using the visual analog scale; in 3 of these studies, significant effects of therapeutic exercise on pain were reported.^{3,6,29} Although Struyf et al³⁹ reported no change in resting pain after exercise therapy, they reported a significant reduction of pain during movement ($P < .004$) at the end of the exercise program. Four studies used the Shoulder Pain and Disability Index to report pain. All 4 studies showed a significant decrease in pain after therapeutic interventions.^{32,38,42,46} Only 1 study used the Penn Shoulder Score to measure and to report pain intensity, demonstrating a significant improvement in pain.²⁸ Rosa et al³⁷ reported a significant decrease in pain; however, they did not report how they evaluated it.

Disability

Disability was measured by the Shoulder Pain and Disability Index in 4 studies,^{32,38,42,46} Disabilities of the Arm, Shoulder, and Hand in 3 studies,^{6,37,46} Shoulder Disability Questionnaire in 1 study,³⁹ and Penn Shoulder Score in 1 study.²⁸ All the studies revealed significant effects of therapeutic exercise on decreasing disability.

Discussion

SIS is a common musculoskeletal condition with various causes, including muscle imbalances and biomechanical factors⁴³ that in some cases may result in disability, reduced quality of life, and impaired function.³ Scapula-oriented exercises are frequently recommended to people with SIS who are diagnosed with scapular muscle imbalance to correct the faulty scapular position and to improve function.^{6,35} In this systematic review, 20 RCTs were evaluated to identify the effect of exercise therapy on scapular motion and position, pain, and disability in individuals with scapular dyskinesis. The results showed conflicting evidence⁴⁴ for the efficacy of therapeutic exercises on scapular position and motion. However, the results of evaluated studies on the effectiveness of therapeutic exercise on shoulder pain and disability showed moderate evidence.^{13,44}

There are some inconsistencies in the results for efficacy of therapeutic exercises on scapular kinematics. Methodologic heterogeneity could be a reason for the conflicting results. There were 8 studies among the 20 included papers in which 3D techniques were used to evaluate effects of

Table II The risk of bias in included studies (n = 20)

Author (year)	Selection of participants	Allocation concealment	Blinding of participants	Assessor blinding	Incomplete data	Selective reporting	Other bias
Baskurt ³ (2011)	U	U	U	U	L	L	H
Camargo ⁶ (2015)	L	L	L	H	L	L	L
Ha ¹⁰ (2016)	H	H	H	H	L	L	H
Hibberd ¹² (2012)	U	H	H	H	H	L	L
Klawiter ¹⁸ (2017)	H	H	H	H	L	L	H
Kumar ²⁰ (2017)	L	L	U	L	L	L	H
Lin ²² (2016)	H	H	H	H	L	L	L
Lynch ²⁷ (2010)	H	L	H	H	L	L	H
Roddey ³⁶ (2002)	H	H	U	L	L	L	H
McClure ²⁸ (2004)	H	H	H	H	H	L	L
Moezy ²⁹ (2014)	H	L	H	H	H	L	H
Paulson ³¹ (2017)	H	H	L	L	L	L	H
Pekyavas ³² (2017)	H	U	H	H	L	L	H
Rosa ³⁷ (2017)	U	H	H	H	L	L	L
Shankar ³⁸ (2016)	H	H	H	H	L	L	H
Struyf ³⁹ (2013)	L	L	U	L	L	L	H
Thakur ⁴⁰ (2016)	H	H	H	H	L	L	H
Turgut ⁴² (2017)	H	L	U	H	L	L	L
Wang ⁴⁵ (1999)	H	H	H	H	L	L	L
Worsley ⁴⁶ (2013)	H	H	H	H	L	L	L

L, low risk of bias; U, unknown risk of bias; H, High risk of bias.

therapeutic exercises on scapular kinematics^{6,12,22,28,37,42,45,46}; the other 12 studies used 2D techniques to record scapular motions.^{3,10,18,20,27,29,31,32,36,38-40} In addition, in 3D or 2D techniques, each researcher chose different devices and setups to record the scapular motion. Considering the fact that the reliability of measurements with different devices varies widely, controversy in the results of the studies seems reasonable. It is because some techniques, like Kibler measurements, have shown challenging reliability.¹⁷

Furthermore, on the basis of this review, it is difficult to reach a conclusion as several variables and measurements were administered to record scapular kinematics. Some authors measured scapular internal/external rotation, anterior/posterior tilt, and upward/downward rotation. Among them, some studies measured all 6 scapular motions, whereas some considered 3 motions in 3 planes. Therefore, there was a lack of consistency between the evaluated variables in included studies so that the meta-analysis was not included. There were also different exercise regimens prescribed in each study; some studies prescribed scapula-focused exercises, whereas other studies recommended strengthening exercises or just simple stretching workouts. As a result, we could not conclude which exercises can be efficient in improving scapular kinematics. The finding of this systematic review is in agreement with the previous systematic review that did not report a robust conclusion for the efficacy of scapula-focused exercise on scapular kinematics in individuals with SIS.³⁵ However, in this review, we included studies of SIS patients and asymptomatic individuals with scapular dyskinesis to recognize and to

distinguish the apparent differences between SIS patients and asymptomatic individuals.

There were 12 studies in which 2D techniques were used to investigate effects of exercise on scapular position and motion.^{3,10,18,20,27,29,31,32,36,38-40} The findings revealed that regardless of the challenging reliability of the measurement technique, most studies showed significant sources of bias. For example, Roddey et al³⁶ reported a significant effect of pectoralis minor stretching on TSD. However, their study lacked allocation concealment, which is an extremely important source of bias.

Analysis of studies in which 3D techniques of measurement were employed showed controversial effects of exercise on scapular position and motion.^{6,12,22,28,37,42,45,46} Wang et al⁴⁵ investigated an exercise regimen of stretching and strengthening on scapular position and motion. The only changed scapular outcome measures were reduced scapular upward rotation and scapular superior tilt in 90° of scapular abduction, which does not seem a desirable improvement for scapular dyskinesis. McClure et al,²⁸ in a 3D investigation of scapular position and motion, reported that a combination of strengthening, flexibility, and postural exercise had no significant effect on improving scapular dyskinesis. Evaluation of their study quality revealed that they did not control most sources of bias, which might directly affect the results. In another study by Hibberd et al,¹² both strengthening and stretching exercises were found effective in increasing scapular internal rotation, elevation, and protraction during arm elevation. However, it was unclear

whether they controlled the participants' selection bias. In a more recent work, Worsley et al⁴⁶ found that 10-week scapula-oriented exercises could improve scapular upward rotation and posterior tilt in shoulder flexion and abduction, respectively. They were not successful in covering many sources of bias except for data reporting. Camargo et al⁶ found that 4-week stretching and strengthening exercises could be effective in increasing scapular internal rotation and upward rotation. There was a significant increase in scapular anterior tilt, which is not a desirable improvement in scapular dyskinesis.²¹ Reaching a conclusion on their results is debatable as they did not control assessor blinding, which is an extremely important source of bias. Lin et al²² found no significant effect of strengthening exercise on scapular position and motion. Their study did not cover sources of bias except for the attrition and reporting data. Turgut et al⁴² reported significant increases in scapular external rotation, upward rotation, and posterior tilt after 8 weeks of either scapular strengthening, stretching, and stabilizing exercises or scapular strengthening and stretching exercises, although the quality of their study is debatable because of not controlling assessor blinding. Finally, Rosa et al³⁷ reported no significant effect of pectoralis stretching on scapular kinematics. They did not control most sources of bias in their study.

The other evaluated outcome measures in this systematic review were pain and disability. There were 10 studies in which individuals with SIS participated and effects of exercise on their pain and disability were evaluated.^{3,6,28,29,32,37-39,42,46} All the studies showed significant effects of exercise on pain and disability regardless of the type of exercise. This is in line with a previous RCT by Bang and Deyle,² who reported a significant decrease in pain after exercise and manual therapy in patients with impingement syndrome. In addition, Ludewig and Borstad²⁴ reported improvement in pain and disability in workers suffering from shoulder pain after exercise. It is claimed that shortening of the surrounding connective tissue of the shoulder may be one of the reasons for pain in SIS.³⁷ Therefore, stretching exercise may decrease pain through increase of connective tissue extensibility.³⁷ It is also assumed that stretching exercise may affect muscle length and result in better muscle flexibility and activation pattern. Therefore, it would be reasonable to assume that stretching exercise decreases pain and disability indirectly by exercise-induced improved muscle function.³⁷ Furthermore, Ludewig and Cook²⁵ reported reduced activity of serratus anterior in addition to altered scapular kinematics in patients with SIS. Hence, strengthening or stabilization exercise can logically reduce pain and disability in individuals with SIS by improving muscle strength. Although the results of this systematic review do not reveal any association between reduction in pain and disability and improvement in scapular kinematics as

some studies reported improvement in all outcome measures, including pain disability and scapular kinematics,^{3,6,29,37,38,42,46} others observed reduced pain or disability but no effects of exercise on scapular kinematics.^{28,32,39}

Despite the fact that this review is the first review evaluating RCTs in which effects of exercise on scapular kinematics were investigated, there are some limitations. The participants in the included studies were both symptomatic SIS individuals and those asymptomatic individuals with scapular dyskinesis. Therefore, there was a kind of inconsistency between the evaluated participants. Second, the methodologic heterogeneity, including various employed devices and measured variables of the included studies, limited our conducting a meta-analysis on outcome measures and reaching a conclusive result. Therefore, there is a need for future studies conducted using standard, consistent, and reliable techniques.

Conclusion

Based on the results of this review, there is conflicting evidence for exercise therapy in improving scapular position and motion in SIS patients and asymptomatic individuals even in studies using highly reliable 3D measurement techniques of scapular dyskinesis. However, it seems that if scapula-oriented exercises were employed, we could expect a significant improvement in scapular position and motion. Furthermore, stretching alone could not be effective in correcting scapular dyskinesis. Thus, future high-quality clinical trials are warranted to investigate and to compare effects of scapula-oriented exercises on scapular position and motion.

Moreover, our review demonstrated that different types of exercise therapy, such as stretching, scapular-focused strengthening, and stabilization exercises, could reduce pain and disability in SIS patients. Therefore, we concluded that scapula-oriented exercises reduce pain and disability in individuals with SIS and may improve scapular position and motion both in SIS patients and in asymptomatic individuals. However, to clearly know which exercise is the most beneficial and how it affects scapular position and motion, future studies with standard, reliable, and valid measurement techniques are warranted.

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Supplementary data

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