



Original Research

Effect of the scapula-setting exercise on acromio-humeral distance and scapula muscle activity in patients with subacromial impingement syndrome

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ABSTRACT

Objectives: The aim of present study was to investigate the effect of the scapula setting exercise on acromio-humeral distance (AHD) and the activity of scapula muscles in patients with subacromial impingement syndrome (SIS).

Study design: Cross sectional study.

Setting: Pusan National University Yangsan Hospital in South Korea.

Participants: Twenty-eight patients with SIS.

Main outcome measures: We measured AHD by ultrasound and muscle activation of the serratus anterior (SA), upper trapezius (UT), middle trapezius (MT), and lower trapezius (LT) by surface electromyography and compared outcome measures between patients with and without the SSE. The SSE involved maintaining the scapula in upward rotation with posterior tilting in the resting position, and passive shoulder elevation at 60° in the scapula plane.

Results: The AHD (rest and 60°: $P < 0.001$), as well as muscle activity of SA (rest: $P = 0.001$, 60°: $P = 0.004$), MT (rest: $P < 0.001$, 60°: $P = 0.001$), and LT (rest: $P = 0.001$, 60°: $P < 0.001$), was significantly increased by SSE with the arm at rest and with passive 60° shoulder elevation.

Conclusions: These findings suggest that the SSE could be used to increase the AHD and activity of the serratus anterior, middle trapezius, and lower trapezius muscles in patients with SIS.

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1. Introduction

Subacromial impingement syndrome (SIS) is the most common shoulder disorder (Millar, Jasheway, Eaton, & Christensen, 2006), accounting for 44–60% of all complaints of shoulder pain (Ludewig & Cook, 2000). SIS occurs due to intrinsic factors related to the joint itself, such as morphological changes in the acromion, and extrinsic factors, including altered scapula muscle activity and scapula kinematics (Mackenzie, Herrington, Hurlsey, & Cool, 2015; Michener,

McClure, & Karduna, 2003). In clinical practice, it is important to address these issues as therapists mediate problems related to extrinsic factors. Patients with SIS have decreased serratus anterior (SA) and lower trapezius (LT) muscle activity and increased upper trapezius (UT) muscle activity during shoulder elevation compared with normal subjects (Borstad & Ludewig, 2005; Smith, Sparkes, Busse, & Enright, 2009). Altered scapula muscle such as SA, LT, and UT activity may result in a reduction of scapula upward rotation and posterior tilt during shoulder elevation (Endo, Lkata, Katoh, & Takeda, 2001; Ludewig & Cook, 2000; Lukasiewicz, Cook, Michener, Pratt, & Sennett, 1999; Su, Johnson, Gracely, & Karduna, 2004). Altered scapula muscle activity and scapula kinematics is associated with a reduced acromio-humeral distance (AHD) (Hébert, Moffet, McFadyen, & Dionne, 2002; Michener et al., 2003), which may result in recurrence of SIS. Therefore, interventions should aim to increase SA and LT activity, as well as

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scapula upward rotation and posterior tilt, to increase the AHD and thus facilitate rehabilitation of patients with SIS.

The scapula-setting exercise (SSE) can be used to increase SA and LT activity and scapula upward rotation and posterior tilt (Mottram, Woledge, & Morrissey, 2009; Worsley et al., 2013) and to maintain a normal scapula position by isometric contraction of the scapula muscle (Mottram, 1997). Because upward rotation and posterior tilt movements are reduced to achieve the scapula location in patients with SIS (Hébert et al., 2002; Ludewig & Cook, 2000; Lukaszewicz et al., 1999) SSE is performed to maintain upward rotation and posterior tilt (Mottram et al., 2009). Activity of the SA and LT muscles is required to maintain this position, as these muscles have the largest lever arm for upward rotation and posterior tilt (Huang, Lin, Guo, Wang, & Chen, 2012; Ludewig & Cook, 2000). Mottram et al. (2009) reported that SSE increased the scapula upward rotation, posterior tilt angle, and trapezius muscle activity in healthy subjects. Motor control retraining via a 10-week SSE program improved pain, function, and SA and LT activation in SIS patients, and increased the scapula upward rotation and posterior tilt angle (Worsley et al., 2013). Increased muscle activation in these muscles has been reported to increase scapular upward rotation and posterior tilt (Kibler, 1998), which is associated with increased AHD (Michener et al., 2003; Solem-Bertoft, Thuomas, & Westerberg, 1993). Increased activation of SA and LT by neuromuscular electrical stimulation has been reported to increase AHD (Bdaiwi, Mackenzie, Herrington, Horsley, & Cool, 2015).

Previous studies indicated that increased SA and LT muscle activation may be associated with increased AHD. However, few studies have investigated the effect of SSE on scapula muscle activity in patients with SIS. The effect of SSE on the AHD is also unclear.

Therefore, we investigated the effect of SSE on the AHD and scapula muscle activity in patients with SIS, with the arm at rest and with passive 60° shoulder elevation in the scapula plane. We hypothesized that applying the SSE would increase the AHD, as well as the activities of the SA, middle trapezius (MT), and LT muscles to a greater extent than non-application of the SSE.

2. Methods

2.1. Participants

This was a cross-sectional study involving 28 patients with physician-diagnosed SIS. The physician made a diagnosis of SIS in patients positive for pain during shoulder elevation (60°–120°), rotator cuff tendinitis on ultrasonography, Neer impingement sign, and Hawkins sign. The participants' characteristics are shown in Table 1. Participants were included if they had a visual analogue scale (VAS) shoulder pain score greater than 3, a positive scapula assist test (Seitz, McClure, Lynch, Ketchum, & Michener, 2012), and positive findings for at least three of the following: Neer impingement sign, Hawkins sign, painful arch during arm elevation, and

empty can test (Magee, 2014). Participants were excluded if they had undergone shoulder surgery, or showed cervical symptoms, adhesive capsulitis, shoulder dislocation, or shoulder fracture based on an interview, X-ray findings, and the results of ultrasonography. All participants read and signed an informed consent form approved by the Institutional Research Review Committee of INJE University (INJE 2017-09-017-001).

The number of subjects was determined by power analysis was performed using G*Power 3 software based on a previous report (Savoie, Mercier, Desmeules, Frémont, & Roy, 2015) of a significantly greater AHD. For a power of 0.95, effect size of 0.74, and α level of 0.05, the required number of participants was calculated to be 26.

2.2. Procedure

This study was divided into measurement of changes in AHD and scapula muscle activity during the application of the SSE, and measurement of the reliability of the outcome measurements. Prior to completing the SSE, patients provided baseline information on pain intensity, pain duration, and shoulder pain, and completed a disability index (Shoulder Pain and Disability Index).

To assess changes in AHD and the activity of the trapezius and SA during application of the SSE, the therapist (with a PhD and who has been performing manual and exercise therapy in patients with musculoskeletal injuries for 15 years) applied the SSE to the patients. While performing the SSE, the therapist measured the AHD and the examiner (with a PhD and who has been evaluating EMG in patients with musculoskeletal injuries for 7 years) conducted an electromyography (EMG) assessment of scapular muscle activity.

To determine the reliability of the test, patients were evaluated twice with 1 week between sessions, at the same time of day to assess the reliability of the tests.

2.2.1. Scapula-setting exercise

Prior to the experiment, each patient practiced the SSE with therapist for 10 min. In the pilot test the participants were unable to maintain the scapula position during active shoulder elevation by themselves. The SSE was therefore performed with passive shoulder elevation and the therapist placed the scapula in the required position. The SSE was performed with the shoulder in the resting position and passively elevated to 60° in the scapula plane. The participants were asked to sit with a neutral spine position. Therapist placed one hand on the medial border and inferior angle and the other hand on the coracoid process. In this position, the medial border of the scapula was rotated laterally upwards, and posterior tilt was induced by rotating the coracoid process backward and the inferior angle forward (Mottram et al., 2009). The SSE involved maintaining the following (Worsley et al., 2013): the acromion was higher than the superior angle of the scapula; the inferior angle was located lateral the superior angle, the spine of the scapula was rotated 15–25° in the frontal plane, and the scapula medial border and inferior angle were in contact with the chest wall (Fig. 1). The subject was asked to maintain this scapula position during measurement of SA and trapezius muscle activity and the AHD. The SSE was performed three times for seven seconds each with a 1-min rest between measurements. In the pilot study, maintenance of the SSE scapula position for seven seconds was found to minimize error in the AHD measurement, and the position was easily maintained; therefore, the holding time was set to seven seconds. During the SSE, the examiner checked the scapula position visually and by palpation, and also determined whether the patient had any pain. Collection of EMG and AHD data was stopped if the participant experienced pain during the SSE and could no longer maintain

Table 1
Demographic characteristics of the participants.

| Parameters | Values |
|------------------------|---------------|
| Age (years) | 39.71 ± 8.81 |
| Weight (kg) | 62.50 ± 11.95 |
| Height (cm) | 165.53 ± 9.47 |
| VAS | 5.64 ± 0.86 |
| Pain duration (months) | 10.35 ± 3.62 |
| SPADI | 73.00 ± 7.59 |

Values are means ± SD.

SPADI, shoulder pain and disability index; VAS, visual analogue scale.

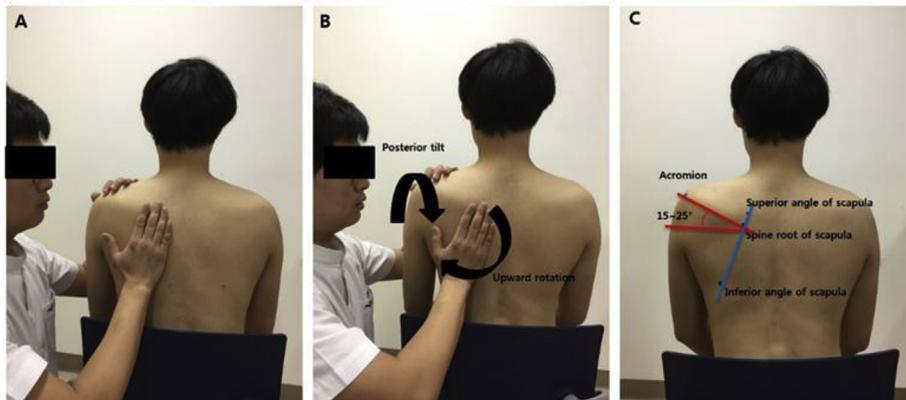


Fig. 1. The scapula-setting exercise (SSE). A: Starting position; B, Scapula upward rotation and posterior tilt; C, Scapula position during the SSE.

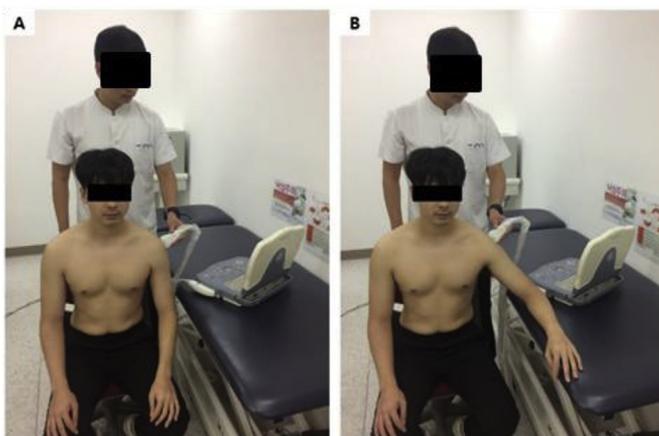


Fig. 2. Measurement of the acromio-humeral distance (AHD). A, Neutral position; B, passive shoulder elevation of 60°.

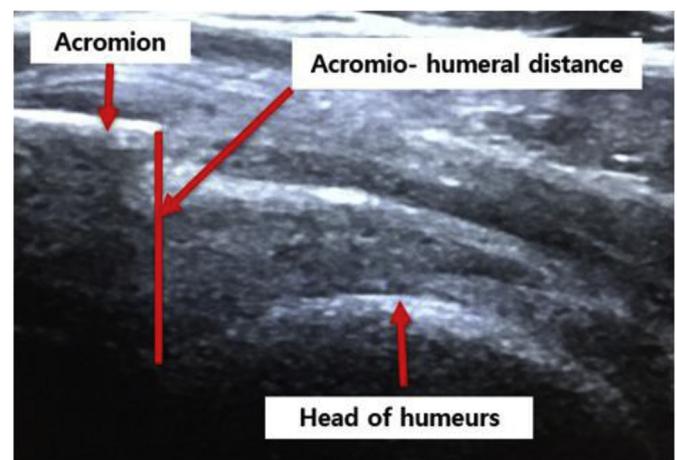


Fig. 3. The acromio-humeral distance.

the proper scapula position due to increased scapula elevation, downward rotation, anterior tilt, or winging. No patients showed pain during application of the SSE.

2.2.2. Measurement of acromio-humeral distance

To evaluate AHD the Sonosite M-Turbo ultrasound device, which is equipped with a linear-array transducer, was used. Ultrasound imaging was performed by a single investigator with advanced training in musculoskeletal ultrasound imaging. The AHD was measured with application of SSE and without application of SSE in two positions (resting position and passive shoulder elevation 60° in the scapula plane). Goniometer measurements were taken in the resting and passive 60° elevation positions. The resting position enabled the patient to relax their hand on their thigh, and passive elevation to 60° with the thumb held forward. Measurements were not taken with shoulder passive elevation above 60° due to the difficulty of capturing ultrasound images of the AHD (Leong, Tsui, Ng, & Fu, 2016; Navarro-Ledesma et al., 2017); furthermore, some patients experience pain with shoulder elevation greater 60°. Participants were requested to maintain a neutral spine position, with their hips and knees in contact with the ground with 90° of flexion and were asked to gaze at a single point at eye height and a distance of 3 m to maintain their posture. The examiner placed an ultrasound transducer on the lateral aspect of the acromion along the longitudinal axis of the humerus (Fig. 2). The AHD is defined as the shortest straight-line distance between the acromion inferior

aspect and the humeral head (Leong et al., 2016; Navarro-Ledesma et al., 2017) (Fig. 3). The AHD was measured in millimeters on the ultrasound screen using calipers. Three measurements were made; 1 min of rest was provided between measurements. In a previous study, reliability, standard error of the mean (SEM), and minimal detectable change (MDC) of ultrasound for AHD measurement were reported as 0.903–0.952, 0.04, and 0.11, respectively (Navarro-Ledesma et al., 2017).

2.2.3. Evaluation of scapula muscle activity

The wireless TeleMyo DTS instrument with Myo-Research Master Edition 1.06 XP software was used to collect and analyze EMG data (Noraxon Inc., Scottsdale, AZ, USA). This device is an eight-channel portable microcomputer with eight-channel A/D conversion (12-bit resolution). EMG data were collected on the affected side from the SA (intersection of the sixth rib and the midaxillary line parallel to the muscle), UT (midway between the spinous process of the seventh cervical vertebra and the acromion process), MT (midway between the spinous process of the third thoracic vertebra and the root of the spine of the scapula), and LT (midway along a line between the lateral side of the spinous process of the seventh thoracic vertebra and the intersection of the spine of the scapula) muscles. The electrode sites were shaved and rubbing alcohol was applied to minimize skin impedance. The surface electrode pairs had an inter-electrode distance of 2 cm (AG/AGCl) and a pre-gelled diameter of 10 mm. The electrodes were

attached parallel to the muscle fiber direction in the middle of each muscle belly. EMG signals were sampled at 1,000 Hz and root mean square (RMS) values were calculated using a 50 ms window. A band pass filter (20–450 Hz) and notch filter (60 Hz) were also used.

The EMG data were normalized by calculating the RMS of a five seconds reference voluntary isometric contraction (RVIC) against resistance at an arm elevation of 90° in the sagittal plane (Lopes, Timmons, Grover, Ciconelli, & Michener, 2015). The RVIC was used because it is less demanding and painful than maximal voluntary isometric contraction normalization tests. EMG data were measured for 3 s, and the first and last 1 s were discarded. The average RVIC value of the three measurements was calculated. The participants were allowed to rest for 3 min between measurements.

EMG data are expressed as percentages of RVIC (%RVIC). SA, UT, MT, and LT EMG data were measured three times for seven seconds each, and the first and last 1 s were discarded. The mean %RVIC value was used for data analysis.

2.3. Statistical analysis

The mean \pm standard deviation of the SA, UT, MT, and LT activities, and the AHD, were calculated. The Kolmogorov–Smirnov test was used to assess the normality of the outcome variables. Differences in scapula muscle activity and the AHD were evaluated by one way repeated-measures analysis of variance (ANOVA). The reliability of scapula muscle activity and AHD measurements was estimated by calculating the intraclass correlation coefficient (ICC_{3,1}). We considered ICC values of >0.90 as excellent, 0.70–0.89 as high, and 0.50–0.69 as moderate (Munro, Visintainer, & Page, 1986). Absolute reliability is presented as the SEM and the MDC. SEM was calculated as follows: standard deviation $\times \sqrt{(1 - ICC)}$; and MDC was calculated as $1.96 \times SEM \times \sqrt{2}$ (using Microsoft Excel software; Microsoft Corp., Redmond, WA, USA). Statistical analyses were performed with SPSS for Windows software (ver. 20.0; SPSS Inc., Chicago, IL, USA), and statistical significance was set at $p < 0.05$.

3. Results

All of the outcome variables were normally distributed ($p > 0.05$). The AHD and EMG activity data of the scapula muscles are shown in Table 2. The AHD was significantly greater during performance of the SSE more than without application of SSE in the resting position and passive 60° of shoulder elevation (Table 2, $p < 0.05$). The SA, MT, and LT muscle activities were

significantly greater during SSE more than without application of SSE in the resting position and passive 60° of shoulder elevation (Table 2, $p < 0.05$). However, there is no difference in UT (Table 2, $p > 0.05$).

The relative reliability of the AHD measurement was excellent (0.90–0.96) and the absolute reliability of the AHD measurement was 0.2–0.5 mm and 0.7–1.3 mm for SEM and MDC, respectively (Table 3). The relative reliability of the SA activity SEM was excellent (0.90–0.94) without performance of the SSE and high (0.84–0.85) during performance of the SSE. The absolute reliability of the SA activity measurement ranged from 0.7 to 2.2% RVIC and from 2 to 6% RVIC for SEM and MDC, respectively (Table 3). The relative reliability of the UT activity measurement was excellent (0.91–0.97) during performance of the SSE and high (0.85–0.89) without performance of the SSE. The absolute reliability of the UT activity measurement ranged from 0.4 to 1% RVIC and from 1 to 2.8% RVIC for SEM and MDC, respectively (Table 3). The relative reliability of the MT activity measurement was excellent (0.96–0.97) without performance of the SSE and high (0.89) during performance of the SSE. The absolute reliability of the MT activity measurement ranged from 0.5% to 1.8% RVIC and from 1.3 to 5% RVIC for SEM and MDC, respectively (Table 3). The relative reliability of the LT activity measurement was excellent without

Table 3
Reliability of the AHD and scapula muscle activity measurements.

| L | ICC | | SEM | | MDC | |
|------------------|-------|------|-------|-----|-------|-----|
| | W-SSE | SSE | W-SSE | SSE | W-SSE | SSE |
| AHD | | | | | | |
| Rest position | 0.95 | 0.93 | 0.2 | 0.4 | 0.7 | 1.1 |
| Elevation 60° | 0.90 | 0.96 | 0.5 | 0.3 | 1.3 | 0.9 |
| Activation of SA | | | | | | |
| Rest position | 0.94 | 0.91 | 0.7 | 1.5 | 2 | 3.2 |
| Elevation 60° | 0.90 | 0.91 | 1.2 | 2.2 | 3.2 | 4.5 |
| Activation of MT | | | | | | |
| Rest position | 0.96 | 0.89 | 0.5 | 1.8 | 1.5 | 5 |
| Elevation 60° | 0.97 | 0.97 | 0.5 | 1.6 | 1.3 | 4.4 |
| Activation of LT | | | | | | |
| Rest position | 0.90 | 0.90 | 0.9 | 2.5 | 2.5 | 6.9 |
| Elevation 60° | 0.91 | 0.86 | 1.1 | 2.2 | 2.9 | 6.2 |
| Activation of UT | | | | | | |
| Rest position | 0.85 | 0.91 | 0.9 | 1 | 2.5 | 2.8 |
| Elevation 60° | 0.89 | 0.97 | 0.9 | 0.4 | 2.5 | 1 |

AHD: acromial-humeral distance, LT: lower trapezius, MDC: minimal detectable change, MT: middle trapezius, SA: serratus anterior, SEM: standard error measurement, SSE: scapula setting exercise, UT: upper trapezius; W-SSE: without scapula setting exercise.

Table 2
Effect of SSE on the outcome variables.

| | Without SSE | With SSE | Mean difference | F | P |
|------------------|------------------|------------------|-----------------|-------|---------|
| AHD | | | | | |
| Rest position | 10.38 \pm 1.13 | 11.54 \pm 1.58 | 1.16 | 15.64 | <0.001* |
| Elevation 60° | 9.42 \pm 1.52 | 10.38 \pm 1.72 | 0.96 | 47.65 | <0.001* |
| Activation of SA | | | | | |
| Rest position | 6.21 \pm 2.91 | 8.22 \pm 4.00 | 2.01 | 12.98 | 0.001* |
| Elevation 60° | 7.20 \pm 3.83 | 9.27 \pm 5.43 | 2.07 | 9.694 | 0.004* |
| Activation of MT | | | | | |
| Rest position | 5.42 \pm 2.63 | 11.23 \pm 5.53 | 5.81 | 25.43 | <0.001* |
| Elevation 60° | 6.98 \pm 3.02 | 14.02 \pm 9.50 | 7.04 | 15.05 | 0.001* |
| Activation of LT | | | | | |
| Rest position | 7.61 \pm 2.89 | 12.93 \pm 7.83 | 5.32 | 14.09 | 0.001* |
| Elevation 60° | 8.70 \pm 3.65 | 13.72 \pm 6.10 | 5.02 | 24.35 | <0.001* |
| Activation of UT | | | | | |
| Rest position | 3.52 \pm 2.38 | 4.87 \pm 3.36 | 1.35 | 3.77 | 0.063 |
| Elevation 60° | 4.31 \pm 2.36 | 4.94 \pm 2.43 | 0.63 | 2.60 | 0.118 |

* $p < 0.05$.

AHD: acromial-humeral distance, MT: middle trapezius, LT: lower trapezius, SA: serratus anterior, SSE: scapula-setting exercise, UT: upper trapezius.

performance of the SSE (0.90–0.91) and high (0.86) during performance of the SSE. The absolute reliability of the LT activity measurement ranged from 0.9 to 2.5% RVIC and from 2.5 to 6.9% RVIC for SEM and MDC, respectively (Table 3).

4. Discussion

We investigated the effect of the SSE on the AHD and scapula muscle activity in patients with SIS. The SSE produced in a significant increase in the AHD, and the activities of the SA, MT, and LT muscles.

The SSE resulted in a significant increase in the AHD in the resting position and 60° of shoulder elevation. This may be due to an increase in scapula muscle activity. An increase in SA and LT activity may increase scapular upward rotation and posterior tilt, in turn increasing the AHD (Michener et al., 2003; Solem-Bertoft et al., 1993). Although there is no report of an altered AHD in patients with SIS due to SA and LT activity, Bdaiwi, Mackenzie, Herrington, Horsley, and Cools (2015) reported that neuromuscular electrical stimulation of the SA and LT significantly increased the AHD in healthy subjects. Thus, increased SA and LT activity leads to an increase in AHD. In addition, the MT acts to keep the scapula in place at the beginning of elevation (Wickham, Pizzari, Stansfeld, Burnside, & Watson, 2010), thus neutralizing the protraction effect of SA (Neumann, 2010). Because the SSE was performed in the resting position and 60° of shoulder elevation in this study, the resulting increase in MT activity may have increased the AHD. Second, the posture maintained during the SSE may have increased the AHD. In a previous study, a manual scapula assistance test (scapula upward rotation and posterior tilt) was performed in patients with SIS, with shoulder elevation of 0°, 45°, and 90° (Seitz et al., 2012), and resulted in upward rotation and posterior tilt of the scapula, as well as a significant increase in the AHD. Although we did not quantify changes in the scapula position, we confirmed the position of the scapula; *i.e.*, its upward rotation and posterior tilt, during the SSE, and AHD is considered to be increased because it is consistent with the scapula assistance test method except that the scapula position is actively maintained. Thus, our findings suggest that the SSE could be applied to increase the AHD in patients with SIS.

The activities of the SA, MT, and LT muscles were significantly increased by the SSE. The SSE was performed to maintain upward rotation and posterior tilt of the scapula. The SA and LT increase the upward rotation and posterior tilt of the scapula (Dvir & Berme, 1978; Ludewig, Hoff, Osowski, Meschke, & Rundquist, 2004). This may explain the increased SA and LT activity seen during the SSE. In addition, the MT is activated before the movement to provide scapula stability and a stable base, from which the scapulothoracic muscles can generate force early in the movement (Wickham et al., 2010). Worsley et al. (2013) reported that motor control exercise using SSE significantly increased activation of SA and LT in patients with SIS. In this study, because the SSE was performed at 0° and 60° of shoulder elevation, the significant increase in MT activity served to increase the stability of the scapula. Thus, our findings suggest that the SSE could be applied to increase the AHD in patients with SIS. Thus, we propose that SSE contributed to increased activation of SA, MT and LT in patients with SIS.

However, there was no difference in UT activity during application of SSE more than without application of SSE. We have been instructed to avoid scapular elevation during the SSE. Although scapula elevation was not measured quantitatively, this may explain the lack of any change in UT activity. As patients with SIS can show excessive UT activity (Kamkar, Irrgang, & Whitney, 1993; Ludewig & Cook, 2000), the lack of change in UT activation during the SSE application may be meaningful.

In clinical practice, various exercise programs have been applied for SIS patients. Therapeutic exercise for SIS was reported to increase SA and LT activity (Cools et al., 2007; Ludewig et al., 2004), but few studies have investigated the effects of these changes on the AHD. In this study, application of the SSE to patients with SIS increased the AHD and SA, LT, and MT muscle activities without changing UT activation. Co-activation of scapula muscles, such as the SA, MT and LT without increasing of UT activation is important for rehabilitation in patients with SIS. AS the SSE increased SA, MT, and LT muscle activities without an increase in UT activity, our results are clinically meaningful. In addition, the SSE can be applied easily in clinical practice because it is a simple and pain-free exercise. Therefore, we recommend the SSE for patients with SIS to increase the AHD and selectively increase SA, MT, and LT activation, *i.e.*, without increasing UT activation. The outcome measurement in this study exceeded the MDC, which suggests a clinical meaningful result but could also be due to measurement error.

This study had several limitations. First, we confirmed scapula position during the SSE visually and by palpation, but did not quantify the effects of the position; effects of variation in posture among patients in the static position cannot be ruled out; Further studies are required to examine this issue. Second, the AHD is affected by other factors, such as rotator cuff muscle activity, alterations in glenohumeral joint capsule length, and the scapula muscle balance; however, these factors were not considered in this study. Third, this study used a crossover design. Further studies should investigate the long-term effects of the SSE on the AHD and activities of scapula muscles. Finally, SIS patients have dynamic problems with elevation above 90°. However, the SSE was performed in a static position with resting position and passive shoulder elevation 60°.

5. Conclusions

We investigated the effects of the SSE on the AHD and the activity of the scapula muscles. The results of this study demonstrated the AHD, SA, MT, and LT activity were significantly increased by the SSE. Therefore, the SSE is effective for increasing the AHD and muscle activity of the SA, MT, and LT in patients with SIS.

Source of support

None declared.

Conflicts of interest

None declared.

Funding statement

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Ethical statement

Our study was performed in accordance with the principles outlined in the Code of Ethics of the World Medical Association (Declaration of Helsinki). Ethical approval was given by the INJE University Ethics Committee for Human Investigations (INJE 2017-09-017-001) and all participants signed an informed consent form.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ptsp.2019.03.006>.

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