

Efficacy of Abdominal Control Feedback and Scapula Stabilization Exercises in Participants With Forward Head, Round Shoulder Postures and Neck Movement Impairment

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Background: Signs and symptoms of impaired function of the musculoskeletal system may be targeted by treating dysfunction located elsewhere.

Hypothesis: Abdominal control feedback and scapular stabilization exercise interventions would result in positive changes in pain intensity, strength, electromyography, and flexion-relaxation phenomena in women with forward head and round shoulder postures and neck movement impairment.

Study Design: Pretest-posttest intervention.

Level of Evidence: Level 1.

Methods: A total of 135 women (aged 27.23 ± 1.9 years) with forward head and round shoulder postures were randomized to 3 groups. Group 1 received 6-week scapular stabilization exercises with abdominal control feedback ($n = 45$), group 2 received 6-week scapular stabilization exercises without abdominal control feedback ($n = 45$), and group 3 received active self-exercise as a control group ($n = 45$). Posture, pain, proprioception, strength, and electromyography were assessed before and after the interventions.

Results: There were significant between-group differences in pain, proprioception, strength, and electromyography favoring group 1. There were significant within-group changes in posture, pain, proprioception, strength, and electromyography in both groups 1 and 2. No significant change was observed for muscle strength.

Conclusion: The addition of abdominal control feedback to the scapular stabilization exercises was shown to be superior to the scapular stabilization exercises alone for decreasing neck pain and restoring proper proprioception, strength, and electromyography in females with forward head and round shoulder postures and neck movement impairment.

Clinical Relevance: The addition of abdominal control feedback to scapular stabilization exercises is superior to scapular stabilization exercises alone on the neck for improving electromyography, strength, and function in females with forward head and round shoulder postures and neck movement impairment.

Keywords: exercise therapy; posture; pain; electromyography

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The forward head posture (FHP) and round shoulder posture (RSP) are very common postural disorders.^{4,28} The FHP could cause RSP on the sagittal plane, disrupting the upper body ideal posture.²⁸ The FHP and RSP are often observed simultaneously in affected individuals demonstrating a forward head and round shoulder (FHRS) posture.³ The FHRS is commonly seen in office workers and involves a combination of lower cervical flexion, upper cervical extension, protracted scapula, and internally rotated shoulders.⁴

The FHP leads to an increase in gravity forces exerted on the head, which could lead to degenerative changes in the cervical spine.²⁵ Previous studies have shown that head and shoulder abnormalities are mainly caused by the dysfunction of flexion-relaxation phenomenon (FRP).⁴ The FRP is a normal and physiologic pattern that refers to the reduction or silence of myoelectric activity of the lumbar erector spinae (ES) muscle during full-trunk flexion.⁴

The FHRS may be corrected through manual therapy, motor learning, kinesiotaping, orthoses, and therapeutic exercises.²⁸ Stretching plus resistance exercises¹⁶ and the combination of stabilization and chin-tuck exercises^{14,25} could improve FHP.^{14,25} Neurofeedback exercises are also effective in improving cervical pain and scapulothoracic alignment in daily activities.¹⁹ Considering the positive effects of scapular stabilization exercises (SSEs) and abdominal control feedback (ACF), as well as the dysfunction of FRP in FHRS posture, this research aimed to compare the effect of SSE with and without ACF on the electromyography (activation onset, root mean square [RMS], and FRP), posture, pain, strength, proprioception, and movement control impairment in patients with FHRS and neck movement impairment (NMI).

MATERIALS AND METHODS

The protocol (number: IR.MODARES.REC.1397.046, website: ethics.research.ac.ir) was approved by the local ethics committee, in the Tarbiat Modares University of Medical Sciences, Tehran, Iran. This study was registered at UMIN-CTR website, and the unique trial number is UMIN000033225.

Participants

Females, aged 20 to 30 years, with FHRS were recruited by orthopaedic physicians via flyers displayed at the hospitals in July and August 2017 (Figure 1).

Females aged 20 to 30 years were included in the study with body mass index 20 to 25 kg/m², “worst pain over the past 24 hours” between 3 and 8 using the visual analogue scale (VAS), round shoulder angle of greater than 52° and forward head angle of greater than 46°, and at least 2 impairments in Patroncini et al²⁰ neck tests.

The movement control impairment NMI tests are reliable and valid and are easy and efficient for use in clinical practice.²⁰ The exclusion criteria were acute neck pain lasting less than 3 months, a previous history of neck or back surgery, neurological signs, rheumatoid arthritis affecting the neck or back, current

use of a muscle relaxer and engagement in regular weekly physical activities, or being professional athlete.³⁰

Study Design

This study was an assessor-blinded, 3-arm, randomized controlled trial. Participants were informed about the study procedure and signed the consent form before being enrolled in the study.

The dimension of the sample was calculated to be at least equal to 135 patients (45 per group) based on a 0.95 confidence level, a 0.8 statistical power, and a 0.6 Cohen *d* effect size coefficient. Effect sizes were 1.0 for the Neck Pain and Disability Scale, 0.6 for the Numeric Rating Scale, and 0.7 for the VAS.⁷ To balance potential dropouts, the current sample size of 135 was finally determined.

The participants were allocated to each group by concealed envelopes with an independent person. The size of each group was as follows: SSE group (group 1) (*n* = 45), SSE + ACF group (group 2) (*n* = 45), and no intervention group (control group) (*n* = 45).

Outcomes

All participants were asked to fill out a questionnaire that comprised age, gender, height, and weight and to limit their weekly exercise to the study intervention (see Table 1). Pain, strength, proprioception, and electromyography (activation onset, RMS and FRP) were measured before and after the 8-week program. A physical therapist with a PhD and 25 years of clinical experience examined the participants.

Pain Intensity

After the pain scale was explained to them, the participants marked their current pain level by choosing a number from 0 (no pain at all) to 10 (unbearable pain), all 10 of which were displayed along a 10-cm horizontal line. This scale is widely used in clinical settings, as it best reflects pain level and has been used as a valuable tool to assess effectiveness of pain treatment.^{6,13,30}

Shoulder Proprioception

To measure the shoulder proprioception by a goniometer, the participant sat on a chair next to the therapeutic bed, with 1 arm on the bed at 45° of abduction and 90° of elbow flexion.³ The participant completed a total internal rotation to external rotation 3 times. The mean was recorded as the external rotation motion. Fifty percent of this range was considered the target angle.³ For keeping the angle in mind, the individual put her arm at this angle 3 times for 5 to 10 seconds with the guidance of the tester. The angular active reconstruction test was repeated 3 times, with the participant being asked to take the limb slowly to the desired angle. The mean error was recorded as absolute repositioning error.³

Electromyography

After being filtered, electromyography (EMG) data were normalized in terms of maximum voluntary contraction. For this purpose, the average of the maximum, filtered, 1-way voluntary

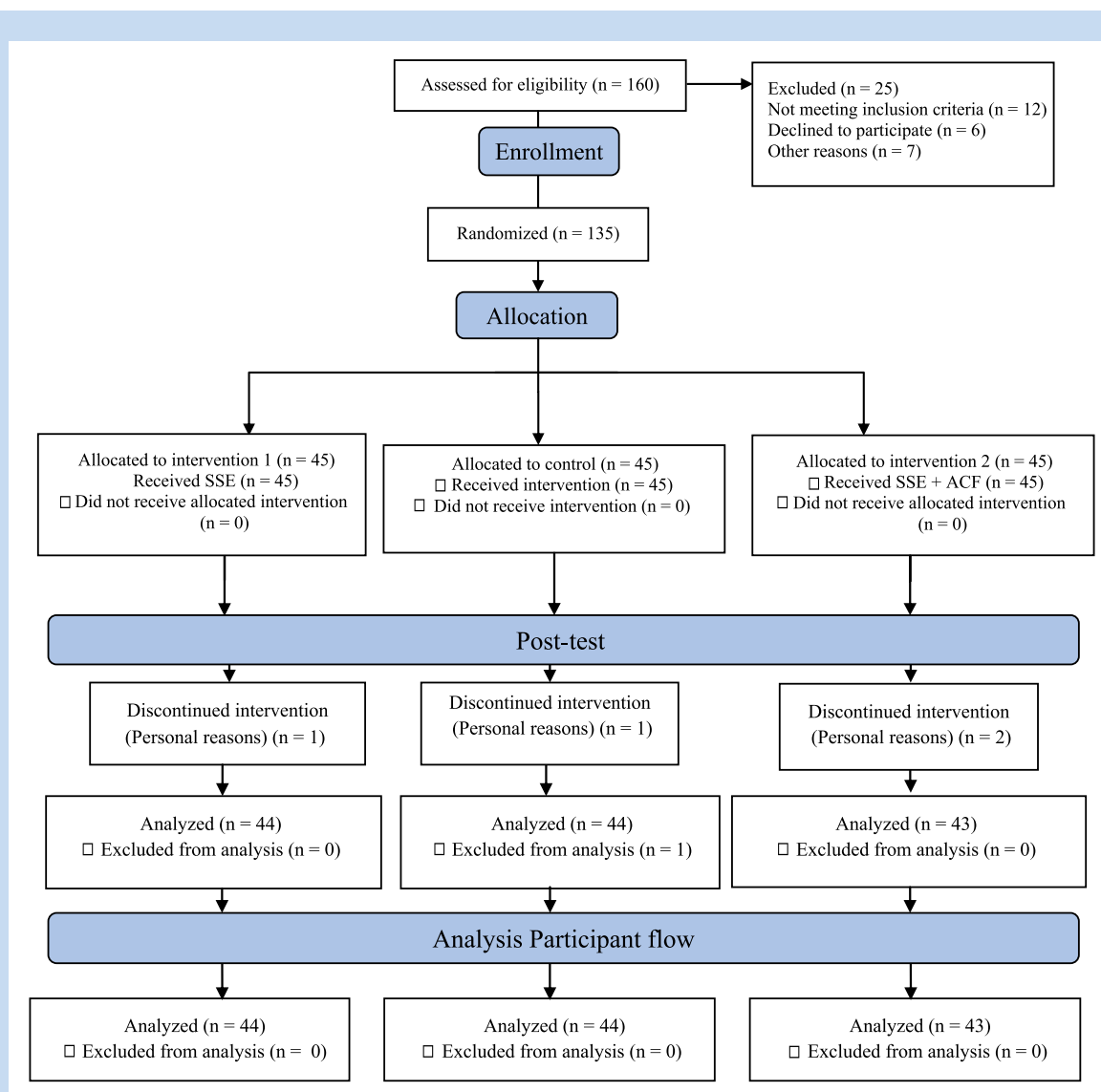


Figure 1. Study flowchart. ACF, abdominal control feedback; SSE, scapular stabilization exercise.

contraction of each muscle was calculated in the 200-ms window. Then, EMG data were displayed in each data point based on the relationship in percentage of maximum voluntary activity. In this regard, the beginning of muscle activity is marked as the mean + 2SD of the base activity of each muscle contraction lasting for 50 ms.^{7,12,15,18}

Muscle Strength

The maximal isometric strength of scapular upward rotators was measured using a handheld dynamometer (HHD) (Pelican, Case 1150 model) in newtons with good to excellent intra-trial and test-retest reliability.^{14,21}

The isometric strength testing of upper trapezius (UT), middle trapezius (MT), lower trapezius (LT), and serratus anterior (SA) muscles was performed as described by Kendal.⁷ After placing

the HHD at the desired place, the participant was instructed to “push up as hard as you can against my resistance.”¹⁴ As soon as force was applied to the device, it beeped and the participants had 5 seconds to produce their maximum strength while verbally encouraged. After 5 seconds, the device beeped a second time, and the maximum strength was recorded. In all positions, stabilizing the opposite shoulder and scapula was carried out by an assistant. The position of participants and order of testing were as follows: first, in sitting with the upper extremity relaxed for UT muscles, in supine for SA muscles, and finally in prone with the arm abducted 90° for MT and 120° for LT.⁷ The rest between each repetition was 30 seconds and the rest between each trial was 1 minute.^{5,14,23} All measurements were conducted 3 times, and the average was used as the final value.

Table 1. Demographic data of participants (mean \pm SD)

Variable	Group	Pretest	Posttest	P-value
Age, years	SSE	27.6 \pm 2.06	—	0.234
	SSE + ACF	26 \pm 1.65	—	
	Control	25.11 \pm 1.99	—	
Height, cm	SSE	160 \pm 3.47	—	0.159
	SSE + ACF	165 \pm 5.12	—	
	Control	161.2 \pm 6.44	—	
Weight, kg	SSE	62.7 \pm 6.00	—	0.214
	SSE + ACF	61.5 \pm 6.28	—	
	Control	63.22 \pm 5.75	—	
BMI (kg/m ²)	SSE	22.2 \pm 1.16	—	0.221
	SSE + ACF	21.1 \pm 2.27	—	
	Control	22.3 \pm 1.43	—	

ACF, abdominal control feedback; BMI, body mass index; SSE, scapula stabilization exercise.

After taking the test position, the HHD was placed on the acromion process of the scapula, the proximal lateral epicondyle of the humerus, and on the heel of the palm,¹⁴ testing UT,¹⁴ MT²³ and LT,^{5,9,23} and SA,^{5,9,14} respectively.

Intervention

The SSE protocol was taken from previous studies.^{6,30} The exercises include chin-tuck, overhead press, horizontal pull apart, chest press, serratus anterior punches, retraction plus external rotation, scapular protraction, XY, and TYW exercises. The protocol was performed 30 minutes each day for 6 weeks (3 sessions per week).

In group 2, in addition to SSE, ACF was performed.²⁹ The exercises included the inferior glide, isometric low row, and dynamic knee push-up, wall press, and wall slide exercises.

Statistical Analyses

All statistical analyses were performed using SPSS software (version 23). The Shapiro-Wilk test was used to assess normality. The FRP, posture, pain, strength, and proprioception outcomes were then subjected to separate 2×2 multivariate analyses of variance to determine the effect of group (SSE or SSE + ACF) and time (pretest or posttest). Independent analyses of variance were conducted for the outcomes because of weak intravariability correlations. Paired-samples *t* tests were used to assess differences in change scores within groups significantly. The alpha level was $P > 0.05$. Effect sizes and 95% CIs were then calculated to provide a measure of clinical meaningfulness. Between-group effect sizes were calculated and were

interpreted according to Cohen's *d* (small ≤ 0.4 , medium = 0.41–0.7, large ≥ 0.70).²⁴

RESULTS

No adverse effects were seen during the study.

Pain and Proprioception

Favoring group 2, there were significant differences between experimental groups in pain (0.58*, $P = 0.036$) and proprioception error (0.51*, $P = 0.034$) after 6 weeks. Both experimental groups demonstrated significant within-group decreases in pain (group 1, -3.8 ± 0.48 , $P = 0.021^*$ and group 2, -4.3 ± 0.23 , $P = 0.001^*$) and in proprioception error (group 1, -2.5 ± 0.2 , $P = 0.033^*$ and group 2, -3.3 ± 0.2 , $P = 0.002^*$). No significant changes were seen in pain (-0.2 ± 0.55 , $P = 0.098$) and in proprioception (-0.1 ± 0.2 , $P = 0.103$) in the control group (Table 2). (Asterisks indicate a significant difference.)

UT, MT, LT, and SA Strength

Changes were not significant in any groups from pre- to posttest. However, there were improvements in both experimental groups in all mentioned muscles, except LT (Table 3).

Flexion-Relaxation Phenomenon

Favoring group 2, there were significant differences between experimental groups in posttest FRP (P [start of eccentric contraction] = 0.043, P [start of concentric contraction] = 0.009,

Table 2. Between- and within-group differences for pain and proprioception (mean \pm SD)

	Group	Pretest	Posttest	Within-Group Difference (Paired <i>t</i> Test)	Difference Between Groups (Covariance)			Effect Size (95% CI)
					Groups 1 and 3	Groups 2 and 3	Groups 1 and 2	
Pain, VAS (range)	1	6.9 \pm 0.56 (4.8-6.14)	3.1 \pm 1.04 (2.3-4.17)	-3.8 \pm 0.48, <i>P</i> = 0.021*	3.61*, <i>P</i> = 0.004*	4.1*, <i>P</i> = 0.001*	0.58*, <i>P</i> = 0.036*	0.71 (0.5-1.42)
	2	6.4 \pm 0.82 (5.1-6.9)	2.1 \pm 0.72 (1.1-2.8)	-4.3 \pm 0.23, <i>P</i> = 0.001*				
	Control	6.2 \pm 0.68 (4.3-6.9)	6 \pm 1.23 (4.7-7.3)	-0.2 \pm 0.55, <i>P</i> = 0.098				
Pro- prioception, degree (range)	1	5.6 \pm 0.5 (5.1-6.1)	3.01 \pm 0.3 (2.8-3.5)	-2.5 \pm 0.2, <i>P</i> = 0.033*	2.42*, <i>P</i> = 0.002*	2.9*, <i>P</i> = 0.001*	0.51*, <i>P</i> = 0.034*	0.69 (0.4-1.03)
	2	5 \pm 0.6 (4.4-5.7)	2 \pm 0.4 (1.5-2.4)	-3 \pm 0.2, <i>P</i> = 0.002*				
	Control	5 \pm 0.5 (4.6-5.5)	5 \pm 0.62 (4.3-5.6)	-0.1 \pm 0.2, <i>P</i> = 0.103				

VAS, visual analogue scale.

*The mean difference is significant at the *P* < 0.05 (group 1, SSE [scapular stabilization exercises]; group 2, SSE + ACF [abdominal control feedback]; group 3, control).

and *P*[end of concentric contraction] = 0.044), but no significant changes were seen between experimental groups in posttest FRP (end of eccentric contraction) (*P* = 0.737) after 6 weeks. Both experimental groups demonstrated significant within-group decreases in FRP. No significant changes were seen in the control group.

There were between-group differences in FRP (start of eccentric contraction) favoring the intervention groups 1 (4.1*, *P* = 0.021*) and 2 (5.5*, *P* = 0.016*) against the control group. There were between-group differences in FRP (start of concentric contraction) favoring the intervention groups 1 (0.9*, *P* = 0.047*) and 2 (11.6*, *P* = 0.005*) against the control group. There were between-group differences in FRP (end of concentric contraction) favoring the intervention groups 1 (4.5*, *P* = 0.021*) and 2 (5.5*, *P* = 0.013*) against the control groups. There were between-group differences in FRP (end of eccentric contraction) favoring the intervention groups 1 (7*, *P* = 0.019*) and 2 (7.1*, *P* = 0.016*) against the control group (Appendix Table A1, available in the online version of this article).

RMS of UT, Sternocleidomastoid, and Levator Scapulae Muscles

Favoring group 2, there were significant between-group differences in the experimental groups in RMS of P_{UT} = 0.042, P_{SCM} = 0.041, P_{LS} = 0.037, and P_{ES} = 0.008, after 6 weeks.

Both experimental groups demonstrated significant within-group changes in RMS of all muscles.

No significant changes were seen in the control group.

There were between-group differences in RMS of UT, SCM, LS, and ES, favoring the intervention groups 1 and 2 against the control group (Appendix Table A2, available online).

Activation Onset of the UT, SCM, and LS Muscles

Favoring group 2, there were significant between-group differences in the experimental groups in activation onset of P_{UT} = 0.009, P_{SCM} = 0.018, P_{LS} = 0.002, and P_{ES} = 0.001 after 6 weeks.

Both experimental groups demonstrated significant within-group decreases in activation onset.

No significant changes were seen in the control group (Appendix Table A2).

DISCUSSION

To expand treatment options, this randomized controlled trial investigated the efficacy of SSE with and without ACF in people with FHRS and neck movement impairment. The addition of ACF to a conservative SSE program for the cervical spine led to greater improvements in neck pain, posture, FRP, and strength.

Table 3. Between- and within-group differences for strength of scapular upward rotators (mean \pm SD)

	Group	Pretest	Posttest	Within-Group Difference (Paired <i>t</i> Test)	Difference Among Groups After 8-Week Intervention (Covariance)			Effect Size (95% CI)
					Groups 1 and 3	Groups 2 and 3	Groups 1 and 2	
UT ^a (kg)	1	1.76 \pm 0.74 (0.5-3.6)	1.93 \pm 0.73 (0.9-3.5)	0.17 \pm 0.93, <i>P</i> = 0.475	0.15, <i>P</i> = 0.501	0.19, <i>P</i> = 0.387	0.046, <i>P</i> = 0.835	0.23 (0.1-0.3)
	2	1.94 \pm 0.72 (0.8-3.5)	2.07 \pm 0.77 (0.9-3.5)	0.13 \pm 0.55, <i>P</i> = 0.358				
	Control	1.84 \pm 0.69 (0.7-2.9)	1.83 \pm 0.63 (0.8-2.8)	-0.01 \pm 0.46, <i>P</i> = 0.913				
MT ^a (kg)	1	1.24 \pm 0.45 (0.6-2.0)	1.44 \pm 0.39 (1.0-2.5)	0.21 \pm 0.49, <i>P</i> = 0.116	0.12, <i>P</i> = 0.516	0.15, <i>P</i> = 0.424	0.03, <i>P</i> = 0.881	0.17 (0.09-0.4)
	2	1.24 \pm 0.37 (0.9-2.0)	1.68 \pm 0.70 (0.7-3.1)	0.08 \pm 0.65, <i>P</i> = 0.633				
	Control	1.48 \pm 0.45 (0.6-2.0)	1.45 \pm 0.44 (0.7-2.4)	-0.03 \pm 0.53, <i>P</i> = 0.813				
LT ^a (kg)	1	1.42 \pm 0.44 (0.6-2.0)	1.19 \pm 0.39 (0.8-2.0)	-0.23 \pm 0.48, <i>P</i> = 0.071	0.045, <i>P</i> = 0.750	0.038, <i>P</i> = 0.793	0.83, <i>P</i> = 0.564	0.14 (0.08-0.2)
	2	1.24 \pm 0.48 (0.7-2.3)	1.21 \pm 0.50 (0.5-2.4)	-0.03 \pm 0.53, <i>P</i> = 0.847				
	Control	1.31 \pm 0.41 (0.5-2.0)	1.20 \pm 0.34 (0.5-1.7)	-0.13 \pm 0.45, <i>P</i> = 0.350				
SA ^a (kg)	1	2.66 \pm 0.91 (1.4-4.4)	2.83 \pm 1.04 (1.2-5.0)	0.17 \pm 0.91, <i>P</i> = 0.466	0.42, <i>P</i> = 0.154	0.25, <i>P</i> = 0.397	0.17, <i>P</i> = 0.564	0.22 (0.1-0.4)
	2	2.47 \pm 1.09 (0.6-5.0)	2.60 \pm 0.88 (1.5-4.5)	0.13 \pm 1.21, <i>P</i> = 0.697				
	Control	2.55 \pm 1.39 (0.6-5.8)	2.37 \pm 0.77 (1.5-4.1)	-0.18 \pm 1.1, <i>P</i> = 0.537				

Abbreviations: LT, lower trapezius; MT, middle trapezius; SA, serratus anterior; UT, upper trapezius.

^aUnit of measurement is kg.

Despite the combined intervention's being superior to the SSE intervention alone, the results demonstrate that SSE training is also effective in improving pain, FRP, and strength.

There was a between-group difference in pain intensity of 2.53 on a 0- to 10-point scale. The improvements in pain in both experimental groups may be explained by research on mechanisms of pain reduction through exercise. Specifically, the intrafusal fibers may be reset with exercise, discontinuing the cycle of muscle tension and impaired circulation with metabolite accumulation and pain associated with myogenic (myofascial) pain.^{1,16,17}

SSE with ACF interventions significantly improved joint proprioception. Başkurt et al³ also showed that 6 weeks of SSE had a significant role in the shoulder proprioception in patients with anterior shoulder pain. Scapular stabilization can improve the accuracy of the movements through retraining of the motor pattern at the scapula.^{3,8,11,26,27}

Both experimental interventions were effective in reducing the activity of UT and SCM and increasing the activity of the SA. However, the SSE with ACF exercise was more effective in reducing the UT activation onset. SSEs are used to promote scapular stabilization, which has been very effective in maintaining the correct scapular positioning and reducing the associated pain and symptoms.^{6,29,30}

The SA and UT are the main scapular stabilizer during functional activities affecting the scapular positioning.⁴ Whereas, increasing hyperextension and cervical lordosis, the UT could produce FHP.⁴ This finding was consistent with other observations showing the increased activation of the UT with neck pain.¹⁵ In this regard, to correct FHP and reduce neck pain, the intervention should control excessive activity of the UT.²⁹ In other words, SSE with ACF may reduce the activity of the UT, resulting in improved scapulothoracic alignment and reestablished proper scapulothoracic rhythm.

In general, SSEs seem to reduce the tension of these muscles by modifying the relationship between length and tension after strengthening the scapular muscles and improving scapular positioning. The conscious activation of abdominal muscles increases the involvement of the SA muscle as one of the most important muscles responsible for maintaining the scapulothoracic alignment.²⁹ The SCM does not require much involvement in normal conditions, and its activity decreases significantly during such assignments. However, it appears that feedback exercises played a more major role in increasing trunk and pelvic stability, resulting in reduced activity of the SCM.^{8,22,29}

The results of this research indicated that SSE with ACF in individuals with FHRS did not affect the activity of the LS. The LS is one of the muscles responsible for supporting cervical lordosis and head flexion caused by head weight. This mechanism helps maintain the balance of the cervical vertebrae and better absorb the loads applied to the vertebrae.^{1,2} In the same vein, Jull et al¹² stated that the LS becomes hyperactive with FHP,¹² leading to pain.

The combined intervention may have decreased RMS through muscle coordination, increased motor unit recruitment, and an increased firing rate in each unit.

Based on previous research, the conscious use of abdominal muscles during feedback exercises increases the involvement of SA.²⁹

The current study has shown that the 6 weeks of corrective exercise intervention did not have a significant effect on scapular upward rotator muscle strength in women with FHRS postures. Although the strength change in these muscles was not significant, improvement has been observed in almost all muscles except the LT. In most previous studies of FHP patients, the focus was on improving strength and endurance¹⁴ to improve the position of the scapula. However, in the current study, the focus was on modifying cervical posture.²⁸ It is likely that gender is also an influential factor in the results, because women generally have a negative attitude toward resistance exercises.²²

The 6 weeks of SSE-ACF intervention did not have a significant effect on upward scapular rotator muscles strength in women with FHRS. However, there were strength improvements in all muscles except the LT. The combination of cervical-posture and breathing exercises could significantly reduce the electrical activity of the UT.¹⁰

The results indicate a medium (0.50) to large (1.00) effect size for the variables in this study, suggesting that adding ACF to an SSE protocol in a clinical setting may selectively improve the activation onset, FRP, and RMS of the neck superficial muscles.²⁴

There are several limitations to this study. The exercise program was 8 weeks long, so the long-term effects of the exercises are unknown. Further research is needed to validate and confirm the SSE-ACF intervention; identify the long-term effects of the intervention on pain, strength, and FRP; and determine the benefit of the intervention program in other groups with neck pain.

CONCLUSION

Scapular stabilization exercises with abdominal control feedback can increase the strength of muscles acting on the shoulder joint, improve the activation of the scapular and neck muscles, and the function of the ES. This study emphasized the greater impact of SSE with ACF on all variables as compared with SSE alone. SSE with ACF can return proper function and firing patterns to the neck and shoulder muscles.

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