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Original Research

Effects of an 8-week selective corrective exercises program on electromyography activity of scapular and neck muscles in persons with upper crossed syndrome: Randomized controlled trial

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A B S T R A C T

Objectives: Postural disorders disturb muscle activity and lead to joint dysfunction. This study aimed to evaluate the effects of an 8-week selective corrective exercises program on electromyography activity of scapular and neck muscles in persons with upper crossed syndrome (UCS).
Design: Randomized controlled trial.
Setting: Exercise evaluation was conducted in a laboratory setting.
Participant: Study recruited 30 healthy males with UCS from university students, who were then randomly divided into the control group (age = 20.14 ± 1.71 years; height = 176.86 ± 4.7 cm; BMI = 21.20 ± 1.96 kg/m^2) and the exercise group (age = 21.44 ± 2.06 years; height = 174.2 ± 4.0 cm; BMI = 20.62 ± 3.9 kg/m^2).
Main outcome measures: Electromyography activity of upper trapezius (UT), middle trapezius (MT), lower trapezius (LT), serratus anterior (SA), and sternocleidomastoid (SCM) was recorded before and after 8-week exercise program.
Results: T-test results revealed that baseline activity of SA ($P < 0.05$), had increased while UT ($P < 0.05$) and SCM ($P < 0.05$) activity as well as UT/SA ($P < 0.05$) and UT/LT ($P < 0.05$) ratios had decreased. In connection with these finding the effect sizes were large.
Conclusion: Eight week corrective exercises balance muscles activity and can be used to manage developing upper quadrant musculoskeletal disorders in person with UCS.

1. Introduction

In the age of the Internet, the constant use of mobile phones and other electronic devices has led to abnormal postures which have hit a large number of people from different walks of life (Park, Kang, Lee, & Jeon, 2017). One of the most commonly cited complications of today's mechanized life is upper crossed syndrome (UCS), which refers to a specific pattern of weak and strong muscles composition, and its postural appearance is the increase in cervical lordosis, forward head posture (FHP), rounded shoulders, and change in the scapular position (Clark & Lucett, 2010; Morris, Bonnefin, & Darville, 2015). Indeed, Janda described USC to introduce the effect of FHP on the muscles (Magee, 2013). FHP, round shoulder, and kyphosis are postural deviations including excessive neck protraction and thoracic spine flexion, anterior tilt, and downward rotation of scapula with an inclining tendency and internal rotation of shoulder (Frank, Page, & Lardner, 2009). FHP is related to thoracic kyphosis (Singla & Veqar, 2017). In addition, a relationship between the FHP and round shoulder as well as round shoulder and kyphosis has been reported (Singla & Veqar, 2017). However, it is not possible to determine which one is the cause and which one is the effect. In UCS, the head is laid in FHP (Clark & Lucett, 2010). This results in a reduction in the biomechanical efficiency of cervical non-contractile elements and causes neck muscles to increase their activity in order to provide cervical stability (Allia & Gorniak, 2006).

Altered position of the scapula in people with FHP and round shoulder may have altered the electromyography of the shoulder and scapula muscles and led to tissue overuse and injury of those muscles (Cole et al., 2013). It has been shown that in persons with

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FHP and round shoulder postures, the electromyography activity of upper trapezius (UT) increases, while electromyography activity of serratus anterior (SA) decreases (Ludewig & Cook, 2000). Decreased SA activity will be accompanied by a reduction in control of the scapula in static and dynamic states (Cricchio & Frazer, 2011). Reduced SA activity will be offset by the increased activity of the UT. This increase in the UT activity increases the anterior tilt of the scapula and elevates it, leading to a decrease in subacromial space, which increases the probability of shoulder pathology (Cricchio & Frazer, 2011).

Deep neck flexor (DNF) muscles play a key role in maintaining the neck's posture. These muscles are weak and prolonged in people with FHP and are not properly recruited (Kang, 2015). FHP reduces DNF activity and leads to muscle imbalance, postural changes and altered movement patterns of cervical spine (B.-B. Kim, Lee, Jeong, & Cynn, 2016). On the other hand, in FHP, the UT, SCM, and levator scapulae muscles are shortened (Ruivo, Carita, & Pezarat-Correia, 2016). Shortness of the levator scapulae may affect muscle coordination and increase shear force and compressive load in cervical spine (Jeong et al., 2017).

Corrective exercises have been reported as one of the most effective methods for restoring function (Armijo-Olivo, 2018). To optimize muscle activity between force couples the selected exercise should emphasize not only muscle strength but also on providing proper ratio of muscle activity in relation to each other. In this context, using the results of electromyography studies could be helpful (Cricchio & Frazer, 2011).

To the best of our knowledge the research literature does not indicate clearly that neck abnormality is the cause of the scapular abnormalities or vice versa, it is not hoped that neck abnormalities would be corrected by rectifying abnormalities in the scapula. Therefore, in the treatment of abnormalities in this area, in addition to the need for a corrective program targeting motor defects and coordination of the scapular and neck region, it is necessary to validate these exercises with precise methods and tools such as electromyography.

Furthermore, much of previous studies have been done on people with pathology and pain symptoms (De Mey, Danneels, Cagnie, & Cools, 2012; Falla, Jull, Hodges, & Vicenzino, 2006; Falla, Jull, Russell, Vicenzino, & Hodges, 2007; Lynch, Thigpen, Mihalik, Prentice, & Padua, 2010; Sheikhhoseini, Shahrbanian, Sayyadi, & O'Sullivan, 2018). Due to the high variability of these statistical societies, the use of findings from these studies is subject to great constraints. Therefore, previous studies do not provide accurate information on the efficacy of these corrective exercises in asymptomatic healthy subjects. Accordingly, the present study aimed to study the effect of selected corrective exercises on restoring the balance of the muscles around the scapula and neck in young healthy subjects with UCS using electromyography.

2. Method

This study was randomized controlled trail with pre-test and post-test design. The entire research process, approved by the Ethics Committee of University of Isfahan was identified by IR.UI.REC.1396.044. Firstly, 264 students from University were screened. The sample size was calculated based on a pilot study using the following formula ($n = (Z_{1\_alpha/2} + Z_{1\_beta})^2 (S_1^2 + S_2^2) \div (M_1 - M_2)^2$) with an alpha level of 0.05, and power (1-β) of 0.80. Based on this formula, the number of participants needed for each group was 12. In order to overcome the probable potential loss of participants during research and availability of sufficient participants, 15 patients were included in the experimental group and 15 in the control group; total proses appeared in flow chart (Fig. 1). In addition to meeting the entry criteria, persons with the following characteristics were selected to participate in the study: the angles of craniocervical and forward shoulder - needed to be more than 46° and 52°, respectively. These angels was obtained by photogrammetry method (Thigpen et al., 2010); and the thoracic kyphosis angle needed to be greater than 42°, which measured by flexible ruler (Teixeira & Carvalho, 2007). Then, they were randomly divided into two groups of exercise and control. Having been informed of the conditions of the study, they filled out the informed consent form. Having a BMI greater than 29.9 kg/m^2, having a history of surgery and fracture in the upper limb and the spine during the past year, the presence of neurological disease, scoliosis, failing to attend pre- and post-test, and irregular attendance (up to 3 time absence) in training sessions were among the conditions leading to exclusion from the study; still, the participants were allowed to leave the study at any stage of the research process.

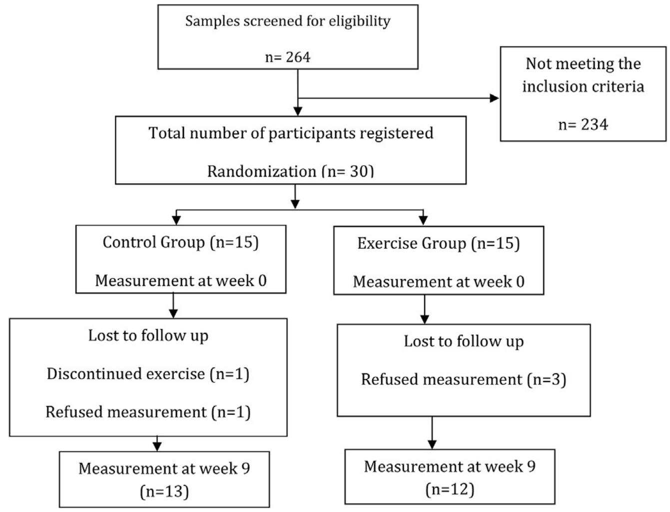

Fig. 1. Flow chart of the study.

2.1. Recording electromyography data

Surface electromyography activity was recorded with a portable surface EMG device (DataLog p3X8, Biometrics, UK) and was analyzed with Datalink version 5.06 (Biometrics, Ltd). Before placing the electrodes, the skin was prepared as follows: it was shaved and cleaned by 70% isopropyl alcohol to reduce skin impedance below 10 Ω (Mendez-Rebolledo, Gatica-Rojas, Martinez-Valdes, & Xie, 2016). bipolar surface electrodes with a fixed 2 cm center-to-center electrode distance (SX230, Biometrics, UK) were applied over the body of flowing muscle using the die cut medical grade double sided adhesive tape (T350, Biometrics). For the UT, the electrode was placed between the 7th cervical vertebrae and the posterior aspect of the acromion along the trapezius muscle line. The electrode of the MT was located somewhere in the middle of the horizontal line that connects the root of the spine of the scapula and 3rd thoracic vertebrae; and the LT electrode was put obliquely along a line, which connects spinous process of the 7th thoracic vertebrae to the junction of medial border of scapula and spine of scapula. The SA electrode was placed below axilla region along muscle fibers, anterior to latissimus dorsi and posterior to pectoralis major muscle (Cools et al., 2007). SCM electrodes were attached to muscle belly of sternal portion (Kumar, Narayan, & Amell, 2001) (Fig. 2). The Earth's electrode (R206, Biometrics) was placed on styloid process of radius. Sample rate was set at 1000Hz and gain 1000, bandwidth was 20–450 Hz,. In all samples, the

Fig. 2. Electrode placement.

dominant side was tested.

The maximal voluntary isometric test (MVIC) was applied to normalize the surface EMG data. The MVIC test positions were taught to the participants by the examiner, and sufficient training was performed to obtain the correct test position and contraction before the measurement (Castelein, Cools, Parlevliet, & Cagnie, 2016). For this purpose, according to Kendall's recommendation, manual resistance was applied in each test position by the examiner (Weon et al., 2010). Each participant performed three 5-s MVIC for each muscle. The rest time was 30 seconds between each repetition and 2 min for next muscle testing. The middle 3 s of every 5 s trial used for analysis. Average of three trail applied for normalization. Verbal encouragements such as "strong and consistent" were given to the participants to boost maximal effort during MVIC. All MVIC tests were performed before elevation task (Castelein et al., 2016). After rectifying and smoothing signal, root mean square (RMS) was calculated at a time constant of 50 ms for 3 seconds. After five minutes of rest, each participant performed arm elevation in scapular plane during three phases including concentric, isometric and eccentric phases, each one lasting 3 seconds (De Mey et al., 2012). Scapular plane elevation of the arm was carried out according procedure as described by Wadsworth and Bullock-Saxton (Wadsworth & Bullock-Saxton, 1997). Prior to EMG data acquisition, arm elevation task was practiced by each participant to ensure that movement is performed reliably and at a required speed. The velocity of arm elevation was controled by stopwatch. Each participant performed arm elevation task five times with a three-second rest between each repetition. Arm elevation was performed without any load to ensure minimal basic resting level on the EMG acquisition (De Mey et al., 2012). Muscle mean RMS value was calculated from the middle three attempts out of five. In order to calculate the percentage of muscle activity, RMS mean divided with MVIC value, multiplied by 100.

2.2. Exercise protocol

The training program included stretching, strengthening, and stabilization exercises (Cools et al., 2007; Ishigaki et al., 2014; Kisner & Colby, 2009; Sahrmann, 2011) (Fig. 3). This eight-week training program was performed with three sessions per week, each lasting 50 min. In order to ensure sufficient achievement of the exercises, exercise variation was set according to the ACSM[1] recommendations (American-College-of-Sports-Medicine, 2009). At the beginning and at the end of each training session, standard warm-up and cool-down was done by each participant for five minute, respectively. The duration of the stretching exercises (Figures A to E, Fig. 3) was 30 seconds for the initial sessions, which were added five more seconds every two weeks (Clark & Lucett, 2010; Wang, McClure, Pratt, & Nobilini, 1999). Stabilization exercises consisted of movements that were done without any load in supine and quadruped positions (Figures F & G, Fig. 3); and progression in these movements was based on an increase in the repetition of correct movement, duration of holding given position, and the range of motion (Sahrmann, 2011). Stabilization exercises were used to craniocervical joint and deep neck flexor muscles. These exercise started with 6 repetitions of 2 second hold then, progressed to 10 repetition of 10 second hold (Falla et al., 2007). In this study, strengthening exercises were selected based on EMG studies aimed at restoring the strength balance of force couples around scapula (Fig. I, J, K, Fig. 3). Initial exercise loads were selected based on body weight, but they were individualized by calculating 10 repetition maximum (10RM) for each participant (Corporation, 2000). Since participants were beginners, the exercises began with three repetitions of 12 at 40% intensity of 10RM, increased by 10% every two weeks and ended with 70% intensity of 10RM in the final sessions (Prentice, 2011; stand., 2009).

Descriptive and inferential statistics were used to analyze the collected data. The Shapiro-Wilk test was used for evaluating normal distribution of data. Paired *t*-test was used to examine the within-group difference and independent *t*-test to examine the between-group difference. To estimate the effect size, Cohen's d was used and values were interpreted as follows less than 0.4 as small, from 0.41 to 0.8 as moderate, and greater than 0.81 as strong (Cohen, 1988). The data were analyzed at the level of 0.05 confidence with SPSS software IBM, Ver 21.

3. Results

The results of Shapiro-Wilk test showed that all variables had normal distribution ($P > 0.05$). The demographic details of the participants, including age, height, weight, and BMI, have been presented in Table 1. In connection with these variables, independent *t*-test showed no significant difference between control and exercise groups ($P > 0.05$). The within-group changes before and after the exercise were evaluated using paired *t*-test. Results revealed electromyography activity of SCM, UT, LT, SA; and the ratio of UT/LT and UT/SA of exercise group compared to the values of these variables before the exercise revealed significant changes ($P < 0.05$), (Table 2). Between-group changes were evaluated using independent *t*-test. The results of this test showed that there was a significant difference in electromyography activity of SCM, UT, SA and UT/LT and UT/SA ratios between the exercise group and control group in the post-test ($P < 0.05$) (Table 3).

4. Discussion

The present study examined the effect of 8-weeks of corrective exercises on electromyography activity of neck and scapula muscles. The findings revealed that the activity of the UT decreased relative to its lower portion. A similar trend was observed regarding the UT's activity relative to the SA. In other words, the present study provides evidence to confirm that the exercise protocol can provide an optimal ratio of muscle activity in the neck and scapula.

Present study showed SA activity was increased after corrective exercises. Magnitude of the observed effect size ($d_s = 0.9$) revealed

[1] American College of Sport Medicine.

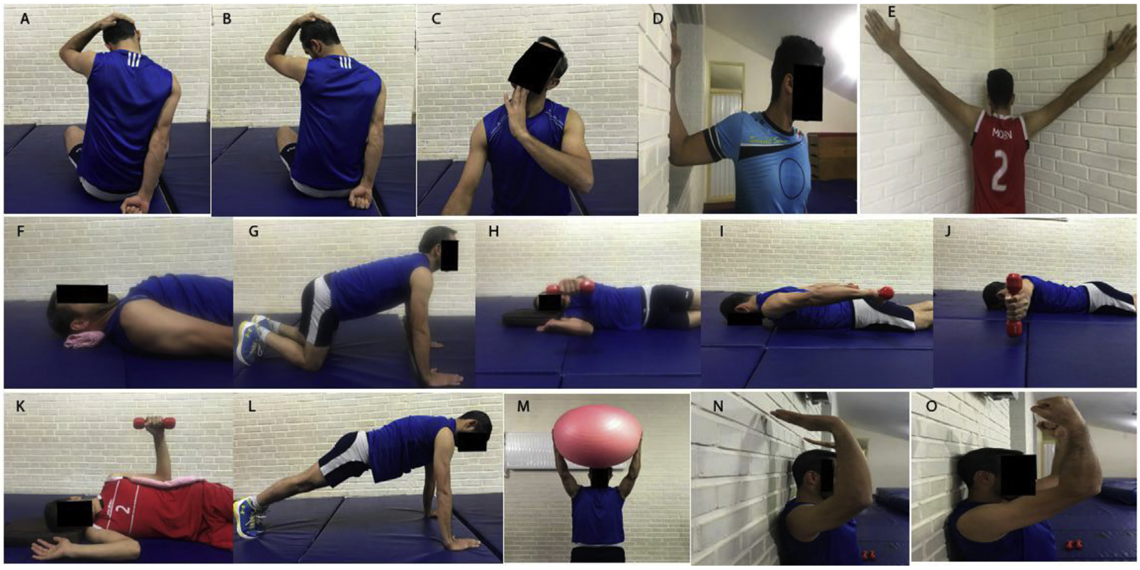

Fig. 3. Exercises used during 8week training, A: Levator scapula stretching, B: UT stretching, C: SCM stretching, D: Pectoralis minor stretching, E: Pectoralis major stretching, F: DNF stabilization, G: DNF stabilization in quadruped, H: Lying forward flexion, I: Prone extension, J: Abduction external rotation, K: Lying external rotation, L: Plush up plus, M: Flexball exercise, N: Abduction external rotation in sitting back to wall, O: Flexion in sitting back to wall.

Table 1
Participants' descriptive characteristics expressed as mean ± Standard deviation (M±SD), and normality distribution.

Measure	Group	M ± SD	t	P
Age (year)	Control	20.14 ± 1.71	1.94	0.163
	Exercise	21.44 ± 2.06		
Height (cm)	Control	176.9 ± 4.7	−1.70	0.099
	Exercise	174.20 ± 4.00		
Weight (kg)	Control	67.26 ± 8.4	−1.08	0.287
	Exercise	62.93 ± 12.99		
BMI (kg/m^2)	Control	21.20 ± 1.9	−0.482	0.633
	Exercise	20.62 ± 3.9		

that training intervention was effective in increasing SA activity. Evidence supports the effect of exercises on the change in posture and the reducibility of the activity of the overactive muscles of the scapula. Kim investigated the effect of exercise training on scapular muscle during six weeks of training and showed that the electromyography activity of UT and SA in people with FHP decreased and increased, respectively (E.-K. Kim, Kang, & Lee, 2016). Earlier, Lee, through cervical stabilization and scapula setting exercise during four weeks, increased electromyography activity of the SA and LT (S. Lee, Park, & Lee, 2013).

It has also been reported that LT activity has increased during stretching and posterior tilt exercises (J. H. Lee et al., 2015). Another study showed a decrease in the level of UT activity in all phases of hand movement during flexion-extension after six weeks of training, but this study failed to show a significant increase in the activity of the SA (De Mey et al., 2012). The findings of this study are consistent with previous reports regarding the decrease in electromyography activity of the UT (De Mey et al., 2012; E.-K.; Kim et al., 2016) and increase in the activity of the SA (E.-K. Kim et al., 2016; S. Lee et al., 2013), except for a study that could not show a change in SA activity (De Mey et al., 2012). The difference in the observed results can probably be attributed to the nature of the exercises used in the research exercise protocol and also to the

Table 2
Within-group differences in muscles activity and their relative activity compared to the trapezoid muscle in the control and exercise group.P < 0.05*, EMG = Electromyography, SCM = sternocleidomastoid, UT=Upper trapezius, MT = Middle trapezius, LT = Lower Trapezius, SA= Serrates anterior.

Groups	Variables	Mean ± SD		Percent of changes	t	p	d'Cohen
		Pre test	post test				
Control	SCM (%MVIC)	20.34 ± 14.19	17.23 ± 9.42	15.29	1.08	0.30	–
	UT (%MVIC)	49.36 ± 24.21	56.90 ± 18.98	15.27	0.20	0.84	–
	MT (%MVIC)	37.21 ± 18.47	31.37 ± 17.04	15.69	1.31	0.22	–
	LT (%MVIC)	46.28 ± 18.64	44.83 ± 18.02	3.13	0.97	0.35	–
	SA (%MVIC)	33.50 ± 16.60	32.89 ± 14.44	1.82	0.29	0.77	–
	UT/MT	1.66 ± 0.56	1.39 ± 0.45	16.26	2.27	0.07	–
	UT/LT	1.54 ± 1.29	1.76 ± 1.26	14.28	0.58	0.57	–
	UT/SA	2.54 ± 3.2	2.38 ± 2.06	6.2	1.13	0.28	–
Exercise	SCM (%MVIC)	43.64 ± 32.65	8.07 ± 6.21	81.15	3.90	0.00*	1.51
	UT (%MVIC)	58.55 ± 17.42	24.78 ± 14.41	57.67	6.97	0.00*	2.11
	MT (%MVIC)	29.19 ± 18.14	30.39 ± 16.80	4.1	−0.51	0.96	0.06
	LT (%MVIC)	33.52 ± 19.29	52.34 ± 21.74	56.14	−4.27	0.00*	0.91
	SA (%MVIC)	29.95 ± 2.60	46.30 ± 14.91	54.59	−3.68	0.03*	1.52
	UT/MT	2.14 ± 0.74	1.53 ± 1.21	28.50	1.8	0.09	0.68
	UT/LT	2.64 ± 1.98	0.52 ± 0.30	80.30	3.84	0.00*	1.49
	UT/SA	2.63 ± 2.65	0.85 ± .61	67.68	2.60	0.02*	0.94

Table 3
Between-group differences in muscles activity and their relative activity compared to the trapezoid muscle in the control and exercise group, $P < 0.05$. SCM = sterno-cleidomastoid, UT=Upper trapezius, MT = Middle trapezius, LT = Lower Trapezius, SA= Serrates anterior.

Variables	Pretest		Posttest		
	t	p	t	p	d'Cohen
SCM (% MVIC)	1.3	0.18	−2.7	0.01*	1.15
UT (% MVIC)	1.19	0.243	−4.6	0.000*	1.90
LT (% MVIC)	−1.8	0.08	0.91	0.37	–
SA (% MVIC)	−0.67	0.54	2.37	0.02*	0.91
UT/MT	1.9	0.06	0.35	0.76	–
UT/LT	1.6	0.10	−3.5	0.00*	1.35
UT/SA	0.08	0.93	−2.54	0.01*	1.00

differences in the duration of the exercise program. In De Mey et al., (2012) study (De Mey et al., 2012), four exercises were used to balance the relative activity of the muscle of the scapula within six weeks, while in the present study, which lasted eight weeks, in addition to the mentioned exercises, special exercises for activating SA in different body positions were used**.** FlexBall exercise and push-up plus minimizing UT activity produce high level of SA activity (Ishigaki et al., 2014; S. H.; Kim et al., 2014). Therefore, the exercises used in the present study probably modified the muscular recruitment pattern, and thereby reduced the activity of the UT and increased SA activity by removing the inhibition of that muscle. In order to explain the possible causes of increased activity of LT in the present study, consideration of the role of LT in the scapular movement can be helpful. The primary LT tilts lower angle of scapula posteriorly (J. H. Lee et al., 2015). With a decrease in LT activity and an increase in UT activity, posterior tilt of scapula decreases, which means increased anterior tilt of scapula (Ekstrom, Donatelli, & Soderberg, 2003)**.** In the previous section, the findings of this study showed that UT activity decreased. Probably a decrease in the activity of the UT provided more opportunity for increasing LT activity. On the other hand, the research protocol used the stretching exercises for lengthening muscles of pectoral region. After stretching exercises, the viscoelastic characteristics of pectoralis minor are altered and its passive tension is decreased. These changes allow the LT to be more active. Given the above points, the decrease in the activity of UT and restoring normal length of the pectoralis minor may provide the essential conditions for the increase of LT activity.

The findings of the present study showed that the activity of SCM reduced during arm elevation. The observed effect size ($d_s = 1.15$) was so large that the observed difference could be attributed to the efficacy of corrective exercises intervention in reducing SCM activity. Evidence suggests that SCM activity decreases following craniocervical flexion exercises (G. A. Jull, Falla, Vicenzino, & Hodges, 2009; B.-B. Kim et al., 2016). The results of this study are consistent with the findings of these studies regarding SCM activity. The DNF muscles maintain a neutral position in the neck. With FHP, the function of these muscles decreases; and if the DNF muscles do not work well, the SCM muscle will dominate (Kisner & Colby, 2009). Craniocervical flexion exercises lead to relearning of the muscle recruitment pattern and activates the DNF (Falla et al., 2007), and provide the proper interaction between the DNF and SCM and prevent the dominance of SCM over DNF muscles (G. A. Jull et al., 2009).

There is an inverse relationship between the activity of the SCM and DNF muscles, and the decrease in SCM activity is an indicator of increase in the activity of the DNF muscles (G. Jull & Falla, 2016). When neck flexor is activated, the neck is positioned in appropriate posture (Falla et al., 2007). In the exercise protocol of the present research, craniocervical flexion exercise was used to strengthen the neck muscles. These exercises may have activated deep neck muscle recruitment and thus reduced the activity of SCM.

Concerning the muscle activity ratio, the findings of this study showed that the UT/SA activity as well as of UT/LT activity decreased. Based on the observed considerable effect size for both UT/SA ($ds = 1.00$) and UT/LT ($ds = 1.35$), exercise played a significant role in decreasing muscles activity ratio. De Mey et al., showed that after training, trapezius muscle activity decreased relative to the SA, but they did not observe such a trend for reducing the ratio of electromyography activity of the UT relative to its other parts (De Mey et al., 2012). Part of their findings is consistent with the results of present study, while there is no such agreement on findings regarding the ratio of the UT to the LT. This inconsistency in the results can be attributed to the characteristics of their participants, who suffered from impingement syndrome. Also, the ratio of UT activity to the LT in the pre-test of their research was 1.9, indicating that this ratio was low in the pre-test results of their study. However, this ratio was 2.64 in the pre-test results of present study. Probably the low proportion of this ratio in their study has prevented observing significant changes.

The proper SA function is essential for the shoulder function, because in all three-dimensional movements of the scapula during arm elevation the SA plays a major role (Andersen et al., 2012). SA with UT forms a force couple. SA can play a role in upward rotation of the scapula in the event that it produces enough force against the UT (Thigpen et al., 2010). Changes in the posture of the neck affect the level of muscle activity; thus, electromyography activity increases in few muscles of the person who has musculoskeletal dysfunction such as UCS (Frank et al., 2009; Weon et al., 2010). Therefore, during flexion of shoulder in the person with FHP, the UT and SA activity increases and decreases accordingly. Reduction in the serratus activity decreases the upward rotation of scapula (De Mey et al., 2012), and reduced LT activity leads to reduced posterior tilt of scapula or increased anterior tilt of scapula (J. H. Lee et al., 2015). Changes in the scapular kinematics are due to muscle imbalance of scapula (Sahrmann, 2011). Therefore, in patients with muscle imbalance, the activation of weak muscle parts along with reduction in overactive parts of the muscle is emphasized to reduce muscle imbalance (Cools et al., 2007). To explain the findings of this section, which showed that the ratio of the UT to the LT as well as the SA was reduced, it can be argued that neural adaptation, improved neuromuscular control, and proprioceptive responses due to participating in corrective exercises may have led to a decrease in the ratio of muscle activity. Regarding the results of this study, it can be said that corrective exercise can balance muscle activity by decreasing the activity of overactive muscles and increasing the activity of inhibited muscles. This study has several limitations. Frist, static position of scapula was not assessed. Second, kinematic of scapula was not studied due to lack of access to motion analyser system.

5. Conclusion

Eight week corrective exercise succeeded in decreasing activity of SCM and UT muscles, UT/SA and UT/LT ratio, increasing activity of SA and LT. With regard to observing large effect size it can be stated corrective exercise (stretching, strengthening, and stabilization exercises) is a safe and low-cost way to optimize the muscles of the upper quadrant. Corrective exercises can be suggested as an effective modality to restore and maintain balanced muscle activity in people with UCS.

Conflicts of interest

None.

Ethical approval

The entire research process, approved by the Ethics Committee of University of Isfahan was identified by IR.UI.REC.1396.044.

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Appendix A. Supplementary data

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