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Effect of Scapular Upward Rotation Exercises on Scapular Neuromuscular Tenderness in Subjects with Depressed Scapular Alignment

Doha H. Al-Afify
Assistant Lecturer, Basic Sciences Department, Faculty of Physical Therapy, Badr University in Cairo, Egypt

Ragia Kamel
Professor, Basic Sciences Department, Faculty of Physical Therapy, Cairo University, Egypt

Amr S. Shalaby
Lecturer, Basic Sciences Department, Faculty of Physical Therapy, Cairo University, Egypt

***Abstract*---**Among the numerous scapular mal-alignments, scapular downward rotation (SDR) presents with depression, abduction and scapular tilt, attributed to upper trapezius elongation and levator scapulae stiffness, which consequently impacts scapular upward rotation. Scapular upward rotation exercise (SURE) that increase scapular upward rotators' strength and stretch scapular downward rotator, provide the SDR patient with optimum muscle conditions in terms length and strength. This study was carried out to investigate the impact of upward rotation exercises on scapular muscles tenderness in subjects with scapular downward rotation alignment. Setting the p value at $p < 0.001$, the six weeks of intervention significantly improved pressure pain threshold (PPT) post-treatment of median, ulnar, radial nerves, upper trapezius, and upper and lower cervical facet joints (C2/C3 and C5/C6 zygapophyseal joints) compared to those of pre-treatment, with a percent of increase of 81.85%, 93.38%, 92.68%, 87.54%, 76.32% and 69.66 % respectively. These results suggest that scapular upward rotation exercises regain optimal scapular function and posture that reduces neuromuscular tenderness in subjects with SDR.

***Keywords*---**scapular downward rotation, pressure pain threshold, scapular upward rotation exercises.

Corresponding author: *Al-Afify, D.H.; Email: Doha.h.afifi@gmail.com*
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Introduction

Abnormal scapular alignment is a common clinical problem that could be explained as or referred to muscular imbalance or alteration in resting muscles' length at rest (Caldwell et al., 2007 and Lim et al., 2015). One of the well-known causative factors of impairment in scapular alignment is muscle imbalance (Choi et al., 2015). Scapular downward rotation (SDR) may result in imbalance in scapular upward rotators; upper trapezius (UT), serratus anterior (SA), and lower trapezius (LT). SDR as a scapular mal-alignment is commonly encountered in patients referred with shoulder and/or cervical pain. Shoulder impingement may be caused by alteration in alignment of the scapula which affect the glenohumeral joint biomechanics bychanging tension at the cervico-scapular muscle (Van Dillen, 2007; Kim & Lim, 2016). Moreover, alteration in scapular and clavicular alignment may possibly affect the shoulder region's biomechanics by changing tension at the cervico-scapular muscle length, which might reduce scapular upward rotation, as well as glenohumeral joint instability during arm elevation (Ha et al., 2016).

Scapular downward rotation (SDR) is expressed in the form of depression, abduction and scapular tilt, which is one of the forms of scapular mal-alignments caused by increased length of UT muscle and stiffness of levator scapulae muscle, that consequently lead to deficiently scapular upward rotation (Lee et al., 2016). Observationally, when medial scapular border loses parallelism with the spine and the inferior scapular angle is apparently closer to the spine than the root of scapular spine, SDR is typically identified. The inferior scapular border is also directed more medially than the superior border, moreover the acromial end of the shoulder is dropped downward (Ha et al., 2011).

Scapular downward rotation can add sustained compressive load on the cervical spine by transferring the weight of the upper quadrants to the cervical region through the interconnecting peri-scapular muscles; upper trapezius and levator scapulae (Kim & Lee, 2015). According to Ha et al. (2011), SDR impact cervical ROM and increases the vertical stress acting on cervical vertebrae, owing to increased length-related tension of the upper trapezius.

Any scapular postural deviation from normal, would eventually result in shoulder pain syndromes that inevitably interferes with scapulohumeral rhythm during arm movement, and neck-shoulder pain (Choi et al., 2015) which negatively impacts the stability of glenohumeral joint (Azevedo et al., 2007; Reinold et al., 2009; Ha et al., 2016). The incidence of shoulder joint pathologies; glenohumeral instability, and rotator cuff injuries increases in individuals showing scapular mal-alignments. Furthermore, scapular dysfunction is linked to the pathological condition of neck pain (Seok & Kim, 2020).

Treatment hence, depends on correcting and/or modifying the root cause of such mal-alignment through restoring appropriate muscle length and strength of peri-scapular muscles is SDR subjects, and hence emerged the scapular upward rotation exercises (SURE) as an effective approach to enhance scapular upward rotators' strength, while stretching the downward rotators (Ha et al., 2016). The upward shrug exercise, a modification of the standard shrug exercise, has proved to be superior to the standard shrug exercise as it generates greater muscle activity in the upper trapezius and better facilitates upward rotation (Watson et al., 2009; Pizzari et al., 2014). The upward shrug exercise, compared to the traditional shrug, entails finishing the exercise in 30° shoulder abduction, which promotes the beginning of upward rotation and has the benefit of promoting serratus anterior involvement (Pizzari et al., 2014). Also, according to Lee et al. (2016), modifying the shrug exercise increased the muscle activity in the upward rotation angle.

Evidence has shown a relationship between a patient's complaint of neck pain and an improper scapular posture and/or scapular motion, such as scapular dyskinesis (Cools et al., 2014). Neck and arm pain, associated with scapular depression position, impose multitude of changes in the cervical spine in terms of changed proprioception, reduced ROM, and increased UT irritability evidenced as reduced pressure pain threshold (PPT) (Van Dillen, 2007; Ha et al., 2011; Sahrmann, 2011; Lee et al., 2015). Furthermore, either manually (Van Dillen, 2007; Ha et al., 2011), or through a taping technique (Lee & Yoo, 2012), passive elevation of the scapula improved these functional limitations and pain. SDR treatment has previously been proposed to involve passive brace correction and exercise programs (Ha et al., 2011; Kang et al., 2015; Ha et al., 2016; Lee et al., 2016). In patients complaining of neck-pain and showing signs of bilateral scapular downward rotation syndrome, Ha et al. (2011), suggested that passively correcting the downward rotation of scapular position reduced neck pain reduction and improved proprioception as well as active neck rotation. Ha et al. (2016), recently proposed that a 6-weeks scapular upward rotation involving non-resistive and resistive exercises of the upper extremity, could be used to restore scapular alignment and increase the power of the scapular upward rotators.

There are a multitude of subjective methods for assessment of pain including self-rating scale both verbal and numerical and visual analogue scales (Wagemakers et al., 2019), behavioural observation scales, and physiological responses, as well as objective tools as measuring pain threshold and tolerance using pressure algometer (Salian & Tulsankar, 2017). Sensitive tender muscular spots observed in muscular and soft tissue pathologies were measured objectively using pressure algometer, which is considered a pain diagnostic tool (Aboodarda et al., 2015). In addition to that, it has the ability to quantitively test pressure sensitivity in tissues in different settings and conditions, both healthy individuals and in patients (Polianskis et al., 2001). As clinical practice is currently seeking objectivity in assessment as well as treatment, we used the pressure algometer to objectively measure PPT of upper trapezius and peripheral nerves of the upper limb. The current study was designed to examine the effect of scapular upward rotation exercises (SURE) on scapular neuromuscular tenderness in subjects with depressed scapular alignment.

Methods
Design of the study

In the current study a pre-test/post-test experimental design was implemented. Participants were all enrolled in one group treatment study. The study was conducted in the Faculty of Physical Therapy, Badr University, Cairo, Egypt from March 2021 to June 2021. Before starting the study, the participants were given all information relevant to the study, instructions and signed the consent form. The current study was approved by the Research Ethical Committee, Faculty of Physical Therapy, Cairo University, with approval no. P.T.R.E.C/012/002640, dated February 9th, 2020.This trial was registered in the Clinical Trial.gov PRS No (NCT04775251).

Participants

Through screening test for downward rotation alignment of the scapula among students and employees of the faculty of Physical Therapy, Badr University, forty subjects matched the study's inclusion criteria and were hence recruited in the current study. Subjects' inclusion criteria in the current study, as per the literature, is the presence of scapular downward rotation (Caldwell, 2007; Kiernan & Lin, 2012), conformed by visual scapular inspection showing one of the three main confirmative signs; 1) the distance between spine and inferior angle of the scapula is less than that at the level of the root of the scapular spine, 2) horizontally oriented clavicle or if the acromioclavicular joint appears to be at a level inferior to that of sternoclavicular joint by visual observation, or 3) reduced scapula-spinal distance to less than 3 inches using tape measurement. Any subject showing or having one of the following criteria was excluded from the study; 1) previous cervical spinal fractures, 2) reduce neck-rotation to less than 20º, 3) pain radiation to one of the upper extremities, 4) polyneuropathy, 5) myofascial pain syndrome, 6) fibromyalgia, 7) thoracic scoliosis, 8) leg length discrepancy, 9) current unresolved cancer patient, 10) diabetes mellitus, and 11) any other scapular mal-alignments other than SDR (Ha et al., 2016). Among subjects meeting the inclusion criteria, three subjects declined, and seven missed more than two consecutive sessions and were hence excluded from the current study. So, thirty subjects with scapular downward rotation syndrome with mean age of 24.5±4.27 years, were thus enrolled in the current study, and received the full exercise program course. The subjects in this study were four males (13.3%) and 26 females (86.7%) with 23 subjects (77%) had the right hand dominant, and 7 subjects (23%) had the left hand dominant. In all recruited subjects the dominant side was the affected side. All patients were examined clinically pre- and post-test using pressure algometer over the upper limb's peripheral nerves, UT muscle and cervical facet joints.

Procedures
Evaluation procedures:

All participants were first checked to see if they were matching the inclusion and exclusion criteria. The scapular static posture assessment was next carried out with the subjects in standing erect posture and arms adducted. A demographic pen was used to identify three anatomical sites by the examiner and given abbreviations: 1) the superior scapular angle “SAS”, 2) the lateral acromial border “A”, and 3) second thoracic spinal vertebral process, “ST2” (Figure 1). The screened subjects showed one of the three following conditions; 1) If “SAS” and “A” are in straight line above the level of ST2, the scapular alignment was classified as “normal,” and the subject was excluded from the study, and 2) if “SAS” and “A” are lower than STS, the subject is identified as SDR and was enrolled in the study (Figure 2) (Azevedo et al., 2008; Andrade et al., 2008). 3) Any other combination of these points was identified as other scapular mal-alignment and necessitates exclusion of this subject from the current study. Palpation of these reference points of spine and scapula is proven as valid by Lewis et al., (2005). Good inter-rater reliability (Greenfield et al., 1995), and intra-rater reliability are as well documented (DiVeta et al., 1990; Greenfield et al., 1995), for these reference points palpation to determine scapular position. Meeting the criteria of depressed scapular position, would make the subject eligible for study recruitment and completion of other examination procedures that included PPT over peripheral nerve trunks of the upper limb, UT muscle, and cervical zygapophyseal joints.

Figure 1. Subject with neutral vertical alignment of the scapula, Adopted from (Seok & Kim, 2020)

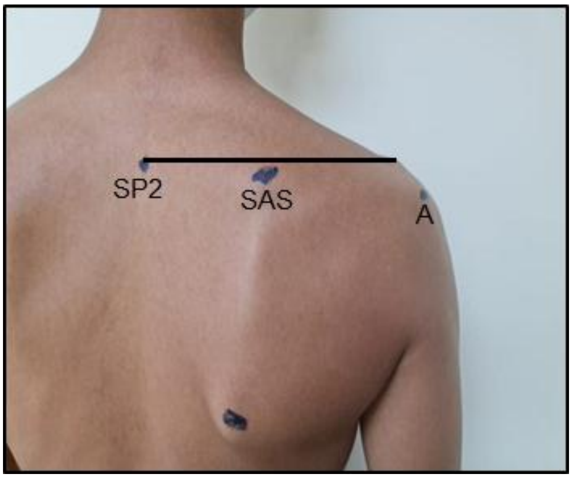

Figure 2. Subject with depressed scapular alignment

Measurement of Pressure Pain Thresholds (PPT):

Pain pressure thresholds were measured using a digital pressure algometer (Wagner FDX 100, Force Ten Handheld Digital Force Gage) with the tip of the algometer applied perpendicular on the skin surface except for the zygapophyseal joint of the cervical spine, in which it was applied with a 45° angle. The algometer tip was applied with a rate of 1 $Kg/cm^2/s$. Three distinctive measures were obtained for each site with an intersecting period of 30 seconds between measurements and mean value was calculated and considered (Martínez-Merinero et al., 2017). The formal measurements were preceded by a familiarisation phase in which participants were informed on the process and the examiner used the same approach on patients at a remote location, namely the forearm. In concordance with the definition of PPT, and after giving the participants standardised instructions, they were instructed to report when pressure shifted to pain. They were repeatedly, strictly and clearly notified that they are expected to record the first sensation of pain not pain tolerance. The order of measuring the PPT for the upper limb was median nerve, ulnar nerve, radial nerve, upper trapezius muscle, and C2/C3 and C5/C6 zygapophyseal joints.

To apply the PPT test, specific points on the peripheral nerve trunks of the tested upper limb nerves were identified through manual palpation, being easily accessible by the probe of the algometer and as they are commonly used sites of peripheral nerves' palpation with moderate inter-tester reliability (Schmid et al., 2009). The supine lying posture was assumed to test median and ulnar nerves, while sitting posture was the choice for radial nerve, and UT. Median nerve was located and tested in the antebrachial fossa just medial to the biceps brachii tendon. Throughout the testing procedure, the subject's limb was maintained in external rotation shoulder and elbow extension. Ulnar was tested in the cubital tunnel between humeral medial epicondyle and olecranon process, with the arm in 90° shoulder abduction as well as external rotation, and elbow flexion. Radial nerve palpation point lies between the middle and lower thirds of the humerus, as it pierces the lateral intermuscular septum between the medial and lateral heads of triceps brachii (Sterling et al., 2000). PPT of the UT muscle was measured at the midpoint of the muscle between lateral acromial border and C7 spinous process. Unlike all previous PPT measurements, PPT of chosen cervical zygapophyseal joints, were performed with the subject in prone lying position. the subject was positioned in prone.

Figure 3. Placement of pressure algometer for recording pressure pain threshold in median nerve

Intervention

Scapular Upward Rotation Exercise (SURE):

Performing SURE involves instructions to the recruited subjects to keep standing posture with their back against the wall, maintaining full torso contact with the wall, and feet kept apart at shoulder-width. The exercise conduction starts with assuming a 90° shoulder abduction and a 90° elbow flexion posture with keeping the lateral borders of both the forearms and arms in direct contact with the wall. To excute the exercise the subject was instructed to slide their arms up the wall, till the shoulder strikes the 180° shoulder abduction, while maintaining full wall contact. To ensure proper performance of the SURE, the subjects were asked to touch their earlobes with their shoulders and maintain this position for ten seconds (Figure. 4). As the exercise is expected to induce muscle fatigue, not shoulder pain, the subjects were instructed of so and requested to report any signs of shoulder pain induction. SURE's frequency was set at thrice per week for six weeks, with dividing the full program span into two sections; non–resistive SURE during first three weeks and resistive SURE using a theraband during the next three weeks (Fig.4). The SURE program is gradually progressed in term of repetition as in case with the resistance. The repetition of SURE program is stage dependent, so, the first and fourth weeks involves performing three sets of 10 repetitions each, second and fifth weeks include three sets of 15 repetitions each and lastly third and sixth weeks involve three sets of 20 repetitions each (Fig. 5). Theraband tension was controlled in a low level by a concentric exercise phase to eliminate excessive activated muscle loading and joint pain. Theraband tension level was increased by shortening the length of the theraband to suit subject's tolerance without discomfort or pain. At each session, the length of the theraband was modified. The theraband strength was selected for each subject before applying SURE by changing the theraband colour. Subjects who can execute 20 repetitions of the SURE, could change the colours and length of theraband. Subjects were requested to elongate the theraband if pain or discomfort arises during the resistive SURE utilizing theraband (Ha et al., 2016).

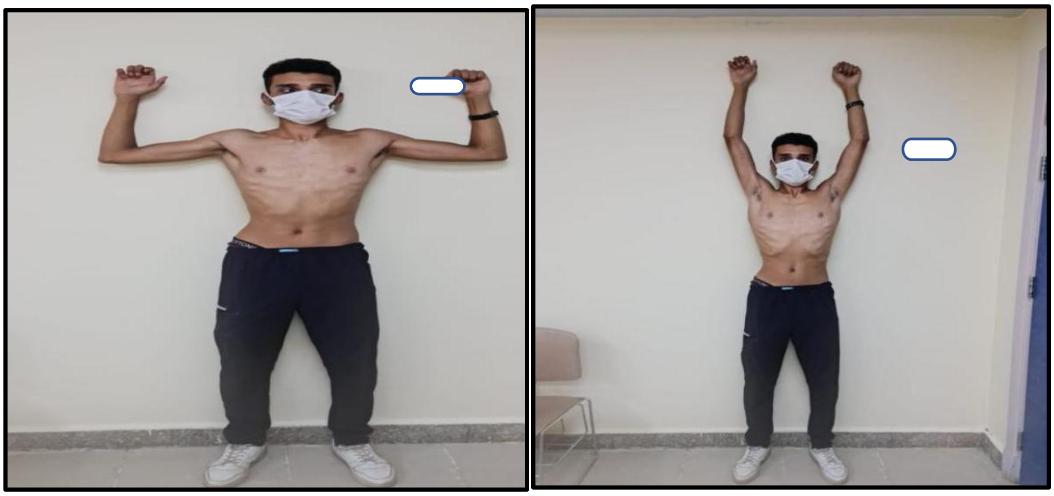

Figure 4. A) First stage of SURE; Non-resistive phase

B) Second stage of SURE; Theraband resistive phase

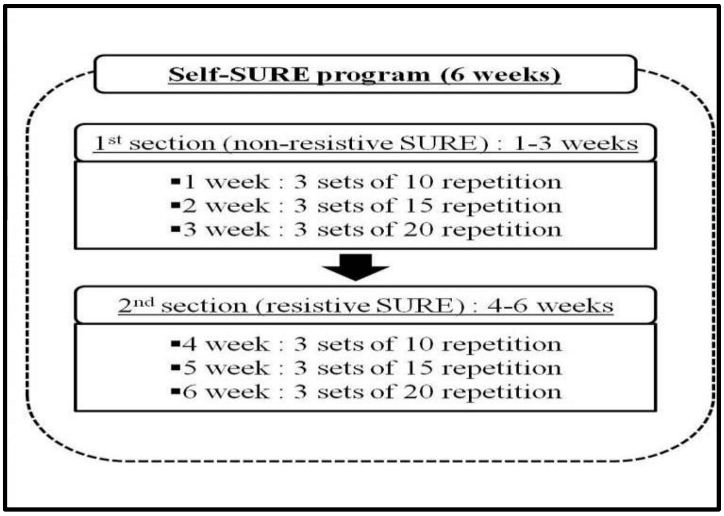

Figure 5. Scapular upward rotation exercise program progression, (Adopted from Ha et al., 2016).

Results

Subjects' characteristics in the study group were statistically analyzed and presented using descriptive statistics in terms of mean, standard deviation and frequency. PPT pre- and post-treatment mean values were compared using paired t-test, with setting ($p < 0.05$) as the level of significance for all statistical tests. All statistical measures were performed through the statistical package for social studies (SPSS) version 25 for windows.

Subjects' demographic characteristics

In the current study, thirty subjects with downward rotation of the scapula were recruited, with their mean age ± SD in the study group 24.5±4.27 years. The subjects in the current study were four males (13.3%) and 26 females (86.7%). Among recruited subjects right-handed subjects were 23 subjects (77%) and left-handed were 7 subjects (23%). The mean ± SD of subjects' weight (Kg), height (cm), and BMI (Kg/m²) were 65.41±8.78 Kg, 164.86±5.44 cm, and 24.04±2.83 (Kg/m²) respectively. Table 1 shows the subjects' demographic characteristics.

Table 1
Descriptive statistics (mean ± SD) of subjects' demographic data

	Mean ± SD	Minimum	Maximum
Age (years)	24.5 ± 4.27	19	31
Weight (Kg)	65.41 ± 8.78	54	88
Height (cm)	164.86 ± 5.44	156	176
BMI (Kg/m²)	24.04 ± 2.83	20.08	30.81

SD, standard deviation

Effect of treatment on PPT

In the study group, the PPT post-treatment showed significant increase compared to pre-treatment values for median, ulnar, radial nerves, upper trapezius, and C2/C3 and C5/C6 zygapophyseal joints ($p < 0.001$). The percent of increase in post-treatment PPT values were 81.85%, 93.38%, 92.68%, 87.54%, 76.32% and 69.66 % respectively. Table 2.

I- Comparison of PPT between pre- and post-treatment:

Median nerve

The median nerve pre-treatment PPT mean ± SD was 3.03 ± 1.22 Kg and the post-treatment was 5.51 ± 1.67 Kg. The mean difference was -2.48 Kg with a percent of change of 81.85%. This shows a significant increase in post-treatment PPT values ($p = 0.0001$). (Table 2, figure2).

Ulnar nerve

The ulnar nerve pre-treatment PPT mean ± SD was 3.02 ± 1.67 Kg and the post-treatment was 5.84 ± 1.85 Kg. The mean difference was -2.82 Kg with a percent of change of 93.38%. This shows a significant increase in post-treatment PPT values ($p = 0.0001$). (Table 2, figure2).

Radial nerve

The radial nerve pre-treatment PPT mean ± SD was 3.28 ± 1.76 Kg and the post-treatment was 6.32 ± 2.06 Kg. The mean difference was -3.04 Kg with a percent of change of 92.68%. This shows a significant increase in post-treatment PPT values ($p = 0.0001$). (Table 2, figure2).

Upper trapezius

The upper trapezius pre-treatment PPT mean ± SD was 2.97 ± 1.13 Kg and the post-treatment was 5.57 ± 1.15 Kg. The mean difference was -2.6 Kg with a percent of change of 87.54%. This shows a significant increase in post-treatment PPT values ($p = 0.0001$). (Table 2, figure2).

C2/C3 zygapophyseal joints

The C2/C3 zygapophyseal joints pre-treatment PPT mean ± SD was 3.04 ± 1.19 Kg and the post-treatment was 5.36 ± 1.51 Kg. The mean difference was -2.32 Kg with a percent of change of 76.32%. This shows a significant increase in post-treatment PPT values ($p = 0.0001$). (Table 2, figure2).

C5/C6 zygapophyseal joints

The C5/C6 zygapophyseal joints pre-treatment PPT mean ± SD was 3.23 ± 1.01 Kg and the post-treatment was 5.48 ± 1.44 Kg. The mean difference was -2.25 Kg with a percent of change of 69.66%. This shows a significant increase in post-treatment PPT values ($p = 0.0001$). (Table 2, figure2).

Table 2
Comparison between pre- and post-treatment mean values of PPT of median nerve, ulnar nerve, radial nerve, upper trapezius, C2/C3 and C5/C6 zygapophyseal joints of the study group

PPT (kg)	Pre Mean ± SD	Post Mean ± SD	MD	% of change	t- value	p-value
Median nerve	3.03 ± 1.22	5.51 ± 1.67	-2.48	81.85	-13.54	0.001
Ulnar nerve	3.02 ± 1.67	5.84 ± 1.85	-2.82	93.38	-13.14	0.001
Radial nerve	3.28 ± 1.76	6.32 ± 2.06	-3.04	92.68	-13.30	0.001
Upper trapezius	2.97 ± 1.13	5.57 ± 1.15	-2.6	87.54	-19.99	0.001
C2/C3 zygapophyseal joints	3.04 ± 1.19	5.36 ± 1.51	-2.32	76.32	-12.65	0.001
C5/C6 zygapophyseal joints	3.23 ± 1.01	5.48 ± 1.44	-2.25	69.66	-12.33	0.001

SD, standard deviation; MD, mean difference; p value: Probability value

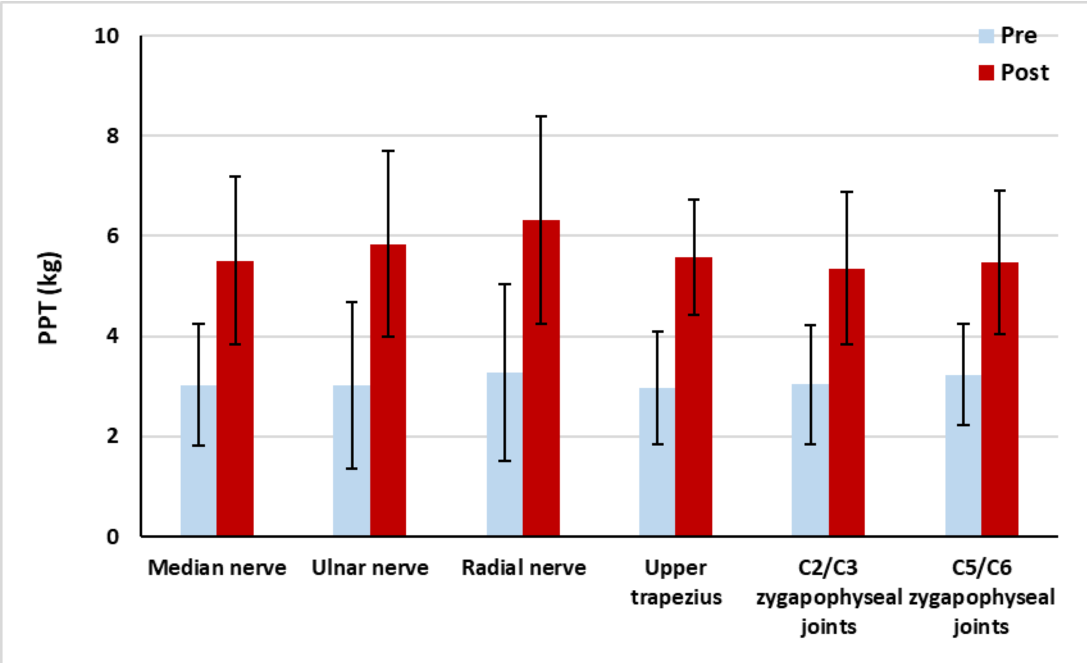

Figure 7. Mean PPT of median nerve, ulnar nerve, radial nerve, upper trapezius, C2/C3 and C5/C6 of the study group

Discussion

The current study was designed and conducted to investigate the impact of scapular upward rotation exercises on tenderness of scapular muscles in subjects with depressed alignment of the scapula. Our results showed a significant increase in post-treatment PPT of study group compared with that of pre-treatment. Our findings came in line with previous studies studying PPT and muscle activation time in normal subjects with normal scapular alignment and reported decreased PPT of the UT and middle trapezius (MT) muscles in healthy subjects with depressed scapular mal-alignment as well as delayed muscle activation timing as compared to same values in normal scapular alignment participants (Lee et al., 2015).

Our findings were in line with findings reported by Chesterton et al., (2003) and Azevedo et al. (2008), that participants with scapular depression posture had higher upper trapezius muscle excitability expressed as lower levels of PPT than participants with normal scapular position. As per their literature the upper trapezius muscle will remain elongated in case of a scapular depression position, thus creating undue tension. This strain may cause the affected area's peripheral nociceptive nerves to become sensitised, affecting the PPT. So, in the UT, a link is present between depressed scapular posture and lower PPT (Yoo, 2016).

Previous studies have reported increased UT pain sensitivity in young subjects with depressed scapular alignment, which is consistent with our results (Lee et al., 2015). The increased muscular tissue sensitivity of upper trapezius muscle was explained by the presence of continuous unrelieved strain on the upper trapezius, that is induced by putting the muscle in a lengthened position as a result of the depressed position of the scapula (Azevedo et al., 2008; Park et al., 2013). Moreover, researchers found a decrease in PPT of upper and lower cervical zygapophyseal joints in scapular depression group, that could be explained by the impact of depressed alignment of the scapula on neck function imposed by the cervico-scapular muscles attachments (Van Dillen, 2007; Ha et al., 2011). The noticed exaggerated tenderness over the facet joints of the cervical spine might be thus attributed to the constant strain applied in a downward direction on the cervical insertions of muscle connecting scapula to cervical spine as a result of the depressed scapular position (Ha et al., 2011). The relationship between scapular alignment and increased cervical zygapophyseal joints' pain sensitivity has been established and formulated by Lluch et al., (2014). Furthermore, active exercise program to correct scapular mal-alignment in patients complaining of persistent neck pain and scapular dyskinesis, has been rapidly reflected in the form of increased PPT measured at the most symptomatic cervical zygapophyseal joint (Lluch et al., 2014).

Depressed scapular alignment result in decreased PPT over UT muscle as well as putting the muscle in weakened and/or lengthened position (Sahrmann, 2002; Azevedo et al., 2008). When depressed scapular alignment subjects performed shoulder shrug exercise, Lee et al. (2015), noticed a decreased PPT in the UT and MT, and delayed UT muscle activation. Owing to scapular depressed posture, there was an increase in muscle elongation with depressed scapula, which result in cervical stiffness, pain and cervical myofascial tenderness (Helgadottir et al., 2011). Scapular alignment distortion into depression, set tension on upper cervical compartment, and hence affecting upper trunk and lateral cord of the brachial plexus and in turn the median nerve along its course extending from upper trunk of brachial plexus to the hand. The shoulder girdle can be elevated in this posture to relieve these strains and potentially "decompress" the thoracic outlet (Byl et al., 2002). The shoulder girdle elevation corrects and counteracts the impact of muscles connecting scapula and cervical spine, and thus relieving the persistent downward pull on the neck, so, the increased pain sensitivity over cervical facet joints could be increased (Azevedo et al., 2008). Depressed alignment of the scapula can put the brachial plexus in chronic and repetitive stress and strain, sensitizing nervous tissue, and eventually set the onset of manifestation of neck-arm pain. Our results are agreeing with Ha et al., (2011), who recommended that neck pain, neck active ROM, and cervical proprioception have been improved in patients complaining of neck-pain secondary to bilateral SDR, when passively correcting the downwardly rotated position.

A prior study investigated the effect of using elastic band for one month to apply pulling banding and shoulder support on scapular posture and neck pain in bilateral scapular depression patient and scapular dyskinesis. The results showed decreased distance of both acromion depression and scapular inferior downward, with increased PPT of the UT, leading to the conclusion that passively supporting the scapula is an important treatment for depressed scapular syndrome. The scapula rests in a downwardly rotated position due to the unopposed action of gravity on it when the upper trapezius is weak. Despite the fact that the link between scapular alignment and pain is not yet clearly known, mal-alignment constitutes a predisposing factor that contribute to the development of mechanical pain. In people with depressed shoulders, passively raising the scapula during upper extremity exercises is an efficient approach for minimizing trapezius symptoms and neck pain (Yoo, 2016).

According to the findings of (Martínez-Merinero et al., (2017), the onset and development of non-attributable arm-neck pain symptoms in healthy subjects could be easily connected to the cumulative trauma caused by long-lasting excessive and repetitive stress on the cervical spine and the affined neural tissue structures secondary to depressed scapular mal-alignment. So, Azevedo et al., (2008), built his hypothesis on the relation between chronic scapular depression and its over time contribution to cervical dysfunction. The design of the current study, cannot, however, provide a conclusion concerning whether patients with lower PPT values in the neck region and neural tissues of the upper limb will experience neck and/or arm problems in the future or not. The development of mechanical neck discomfort is influenced by a number of factors, including, but not restricted to, scapular alignment. Future research is looking into whether a depressed scapular posture in otherwise healthy people can contribute to the development of pathology in the neck-arm area.

Conclusion

These present study results present recommended that the application of scapular upward rotation exercises (SURE) regained normal and proper scapular alignment and hence have a significant impact on scapular muscles position, length and tone that eventually affect their tenderness in subjects with scapular depression by decreasing the constant elongation acting on the upper trapezius.

Conflict of Interests

The authors declare no conflict of interest.

Abbreviations

SDR: scapular downward rotation; SURE: scapular upward rotation exercises; PPT: pressure pain threshold; UT: Upper trapezius; LT: Lower trapezius; SA: Serratus anterior.

Authors' contributions

Ragia Kamel, Amr S. Shalaby and Doha H. Al-Afify conceived and designed the study and conducted the data collection. Doha H. Al-Afify and Amr S. Shalaby analyzed and interpreted the data in addition to reviewing the final results. Doha H. Al-Afify and Amr S. Shalaby provided logistical support and wrote the initial and final drafts of the article. Doha H. Al-Afify, Ragia Kamel and Amr S. Shalaby are responsible for the findings and have critically reviewed and approved the final draft of the article. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethical Committee of the Faculty of Physical Therapy, Cairo university (P.T.R.E.C/012/002640) on 9/2/ 2020.This trial was registered in the ClinicalTrial.gov PRS No (NCT04775251). All participants signed a written informed consent before starting the study.

Consent for publication

N/A

Competing interests

The authors declare that they have no competing interests.

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