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EFFECT OF DIAPHRAGMATIC RELEASE ON NECK PAIN AND CHEST EXPANSION IN PATIENTS WITH UPPER CROSSED SYNDROME

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ABSTRACT

Although the diaphragmatic release technique is used a lot in clinical practice, there is no previous study demonstrating the effect of this technique on patients with upper-crossed syndrome. The aim of this study was to investigate the effect of diaphragmatic release on neck pain and chest expansion in upper-crossed syndrome patients.

A prospective parallel randomized control trial study of 30 patients with upper crossed syndrome aged 20 to 26 years was divided into two equal groups: intervention and control groups. Both groups received the same posture correction exercise, while the intervention group had an additional diaphragmatic release technique three times per week for four weeks. Neck pain intensity, chest expansion, and forward head posture angle were measured using a visual analog scale, tape measurement, and craniovertebral angle.

The obtained results showed that there was no statistically significant difference between the groups' pretreatment ($p > 0.05$) in the three measured parameters. Post-treatment, there was a statistically significant decrease in VAS and a statistically significant increase in chest expansion of the intervention group compared with the control group ($p < 0.001$), but there was no statistically significant difference in craniovertebral angle ($p > 0.05$).

It could be concluded that adding the diaphragmatic release technique to exercise improves chest expansion and neck pain in patients with upper crossed syndrome. This technique should be considered in the management of people with the upper-crossed syndrome.

Key Words: Craniovertebral Angle, Forward Head Posture, Diaphragmatic Release

INTRODUCTION

Acquired postural problems can be a consequence, to a large extent, of contemporary living and working conditions. Some of the most typical factors include continuous use of mobile phones and computers, working in sedentary jobs, etc. Prolonged incorrect posture and lack of physical activity create a musculoskeletal imbalance, (**Tiefel, 2013)**. Long-lasting periods where the head is positioned forward can resulted in the postural disorder known as “upper crossed syndrome” which includes forwarding shoulders, increased kyphosis, forward head posture (FHP), and the loss of, or reduction in, cervical lordosis, (**Kang,** ***et al.*****, 2018)**.

Upper cross syndrome (UCS) is commonly caused by poor posture and results in neck pain. Neck pain is the most common reason for patients to seek medical attention, (**Ylinen** ***et al.*****, 2003)**.This syndrome can resulted in dysfunctional posture and muscular disparity in the head, neck, and shoulder areas, (**Muscolino, 2015)**. According to research, 6-48% of the UCS population experiences pain in the shoulder girdle and cervicothoracic region,(**Silva** ***et al.*****, 2019)**.

Patients and practitioners describe the upper trapezius, levator scapula, pectoralis major, and pectoralis minor as "tight" with UCS. Furthermore, muscle weakness is common in the deep cervical flexors, the middle & lower trapezius, and the rhomboid. The phrenic nerve, which controls the diaphragm's sensory & motor functions, arises from the C3-C5 & occasionally C6 nerve roots and passes through the fascia of the anterior scalene. Overloading of this muscle, which is common in FHP, compresses the phrenic nerve over time, which may eventually lead to phrenic nerve trophic changes and diaphragm dysfunction, **(Page** ***et al.*****, 2010)**.

Because of the common cervical nerve roots, any disorder to the phrenic nerve or structures supplied by the phrenic nerve, such as the diaphragm, can affect other neurons at the same level, such as the axillary nerve, suprascapular nerve, musculotendinous & subclavian nerve; additionally, any injury to these nerves & the muscles innervated by them can affect the phrenic nerve and diaphragm, **(Wallden, 2017)**. For example, overactive scalene muscles that receive innervation from C4-C6 cervical nerve roots in neck pain patients with FHP can negatively affect the function of the phrenic nerve and diaphragm, **(Bordoni and Zanier2013 ; Wallden, 2017)**.

Cheon ***et al.*****, (2020),** investigated the correlation between thoracic mobility and respiratory muscle strength in chronic neck pain patients. Thoracic kyphotic curvature, thoracic sagittal ROM, maximal inspiratory pressure (MIP), and maximal expiratory pressure (MEP) were assessed. It was observed that thoracic mobility during forced respiration was reduced in patients having chronic neck pain, and it correlated well with respiratory muscle strength. The findings suggested that impairment of respiratory strength in chronic neck pain patients may be attributed to changes in the biomechanics of the cervicothoracic spine and rib cage, **Cheon** ***et al.*****, (2020)**.

A previous study suggested that the mechanism of FHP improvement with respiratory exercises was associated with decreased activity of the upper trapezius, sternocleidomastoid, scalene, and cervical erector spine muscles. Corrective exercises (stretching, strengthening, and stabilization exercises) can be recommended as an effective modality for restoring and maintaining balanced muscle activity in people with the upper crossed syndrome. It is a safe and low-cost way to strengthen the muscles of the upper quadrant, **(Arshadi *et al.*, 2019)**.

Diaphragm myofascial release is an intervention that aims to stretch the diaphragm muscle fibers indirectly in order to reduce muscle tension, normalize fiber length, and improve muscle contraction efficiency, **(Ajimsha *et al.*, 2015)**. The techniques are typically used with slow movements, and the action mechanism relies on the sensitivity of the Golgi tendon organs, **(Teles *et al.*, 2013)**. Diaphragmatic release techniques are widely known and used in clinical practice, and there have been no reports of contraindications or side effects in the literature, **(Gonzalez_Alvalez *et al.*, 2016)**.

A previous study used the diaphragmatic release technique on FHP which showed a great improvement in chest expansion, but this study was limited to female patients which made it difficult to generalize on men, and the intervention group received the diaphragmatic release technique only once per week for four weeks, **(Haghighat *et al.*, 2020)**. Another study investigated the immediate effect of diaphragmatic release on the physical and functional out comes, they gave two diaphragmatic release techniques only in a single session, **(Marizeiro *et al.*, 2018)**. Most researchers ignore the importance of diaphragmatic release in cases of the upper-crossed syndrome. So this study was conducted to investigate the effect of a diaphragmatic release on cervical pain and chest expansion in patients with upper crossed syndrome.

METHODS

The study was designed as a prospective parallel group randomized control group study and registered in clinical trial registration (NCT05586685). In accordance with the Helsinki Declaration of Ethical Principles (World Medical Association), it had received ethical clearance from the Institutional Review Board of The Faculty of Physical Therapy at Cairo University (No: (P.T.REC/012/003917). The study was conducted throughout the period between 20th November till 20th January at the Egyptian Chinese University.

Seventy participants were recruited using online social media and verbal invitations from undergraduate students of the Faculty of Physical Therapy. Only thirty participants of both genders were found to meet the inclusion criteria [age ranged from 20 to 26 years old, normal body mass index (BMI<25), CVA<49^{0} , & kyphotic angle >42^{o}] and enrolled in this study. They were excluded if they had cervical radiculopathy, fractures of the cervical spine, malignancy, rheumatoid arthritis, and local infection. The selected patients were randomly allocated into two equal groups. The experimental group received the diaphragmatic release and traditional exercise program and the control group received the traditional exercise program only.

Randomization was achieved blindly to the physiotherapist by placing the letter E or C in 30 separate blank envelopes. These were then arranged in random order determined by random number tables and opened by an independent administrator after baseline tests as each new patient entered the study. The flow chart diagram shows patient eligibility and the groups of patients, (Fig.1).

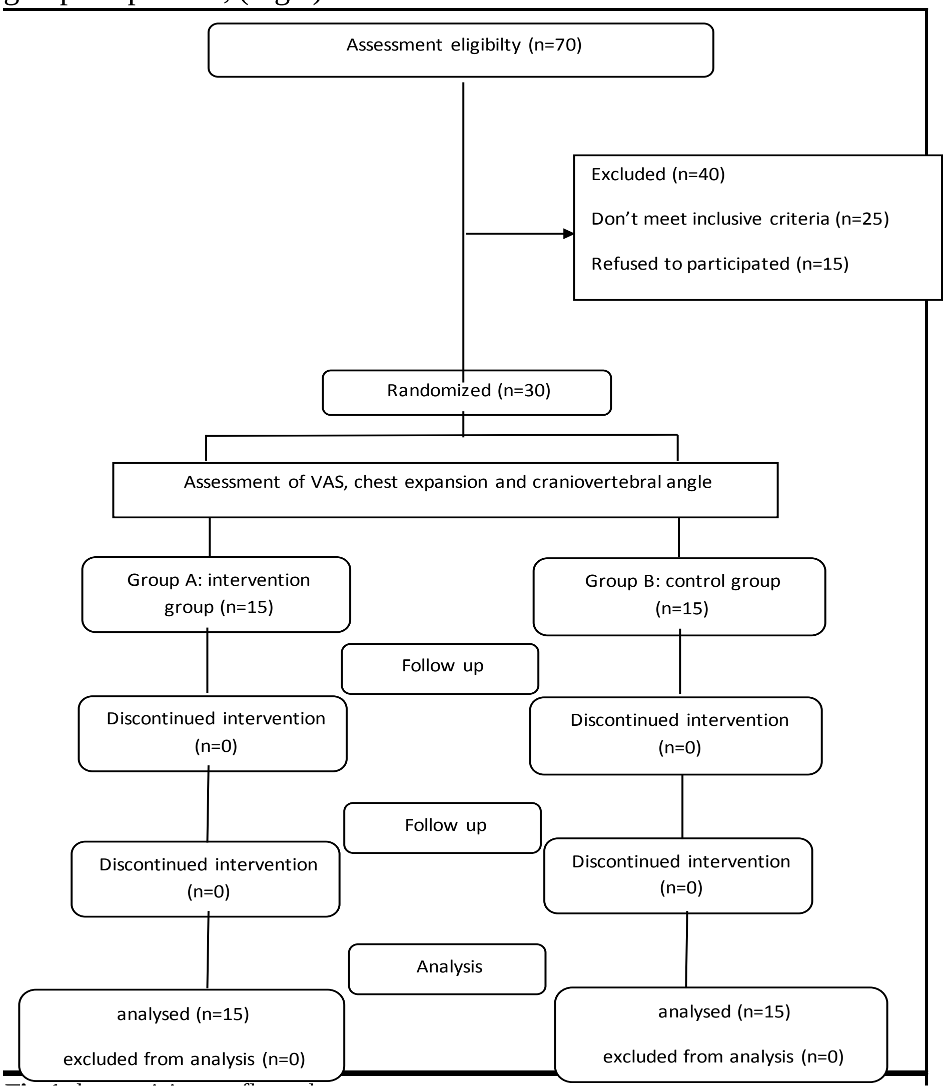

Fig 1: The participants flow chart

Procedure

The participants signed the consent form before starting the study, and the procedures to be used, & the health hazards & risks of the study had been fully explained to each of them verbally and in writing. They were medically screened for any history of respiratory problems. The weight and height of the subjects were taken by digital weight-height scale then calculate the BMI as the ratio of weight (kg) over height (m) squared. Explain to the patients the instruction about the measurement and then the intervention**.** Pain intensity, craniovertebral angle, and chest expansion were measured before intervention and after four weeks at the end of the last session for all patients. Measurements and treatment were performed by the same therapist.

Measurement of pain intensity

The visual analogue scale was used, which consists of a line, usually 10 cm long, ranging from no pain or discomfort (zero) to the worst pain imaginable, **(Debouche *et al.*, 2016)**. In this system, total scores range from 0 to 100, with a higher score indicating more severe pain, based on measuring the distance in millimeters from the left end bar to the mark made by the patient on the 10 cm line. While VAS is regarded as a valid and reliable method of assessing neck pain, **(Debouche *et al.*, 2016)**.

Measurement the craniovertebral angle (CVA)

The CVA was measured using the photogrammetric method to determine the FHP. The intra and interrater reliability of photogrammetry findings of the cervical spine standing sagittal posture was discovered, **(Do Rosário, 2014)**. The CVA is defined as the distance between a horizontal line passing through the spinous process of the 7th cervical vertebrae and a line passing through the tragus of the ear. It was evaluated while the subject was standing, and a lateral view photograph was taken from the dominant side with a digital camera, **(Ruivo *et al.*, 2015)**. Panasonic, Lumix, DMC-FZ5, Panasonic Inc., Japan, with a 35-mm lens and × 12 optical zooms and a built-in flash] that was placed on a tripod 1.5m away from the subject and its base was adjusted at the subject's shoulder level. Three measurements were taken; then the average angle was taken, **(Kim and Kim, 2016)**. The photos were analyzed by autocade software.

Measurement of the chest expansion

In a previous study, **(Debouche *et al.*, 2016)**, the chest expansion measurement by tape measurement demonstrated good intra- and inter-rater reliability and reproducibility. The xiphoid process and spinous process of the 10^{th} thoracic vertebrae were anatomical marks for lower thoracic expansion. The subjects' breathing instructions were standardized. Subjects were instructed before the thoracic measurement to "inhale slowly through the nose and push against the tape measure to expand the lungs as much as possible". The participants were then instructed to "completely exhale through the mouth". Measurements were taken at the end of a full inspiration and expiration cycle. Participants were measured while standing with their arms along their bodies.

The physiotherapists placed the "0" on the appropriate vertebrae with the cloth tape measure. The cloth tape was held between the participant's body and the cloth tape with an index finger, without causing any deformation or cutaneous folds. The chest expansion value was calculated by subtracting the inspiratory diameter from the expiratory diameter, **(Debouche *et al.*, 2016)**.

Intervention

Two groups received the same exercise program while the experimental group received the diaphragmatic release technique added to exercise three times per week for four weeks.

Diaphragmatic release technique:

The patients were positioned in the supine position. The therapist stood at the head of the patient. The therapist made manual contact bilaterally under the costal cartilages of the lower ribs (7^{th} to 10^{th}) with hypothenar regions of the hands and the last three fingers. During the patient's inspiration, the therapist gently pulled the points of hand contacts toward the head and slightly laterally, while elevating the ribs simultaneously. During exhalation, the therapist went deep through hand contacts towards the inner coastal margins; each maneuver lasted for 5 to 7 minutes, **(Gonzalez_Alvalez *et al.*, 2016)**.

The exercise program:

The exercise program includes strengthening deep cervical flexors (Lying chin in, 3 sets, 12 repetitions) and shoulder retractors (patients were instructed to form the letter "W" their arms abducted to 90° and elbows flexed to 90°. Patients then retracted their scapula and externally rotated their arms, keeping 90° of shoulder abduction. Finally, patients formed the letter "Y" with their arms and body. Maintaining retraction of the scapula, they raised their arms above their head and fully extended the elbows so that they formed the letter "Y'' 3 sets, 12 repetitions), and also stretched pectoralis muscles (Bilateral pectoralis major stretching from a sitting position**,** stretching for pectoralis minor supine lying hold 30 seconds for 3 repetitions. Both groups received the exercise program 3 days per week for four weeks.

To avoid type - error, sample size calculation was performed using G power statistical software (version 3.1.9.2; Franz Faul, Universitat kiel, Germany) based on data of NPRS diaphragmatic release technique; and revealed that the required sample size required for this study was N=30. The calculation is made with α=.95, effect size =0.7

DATA ANALYSIS

All statistical analyses were performed using IBM SPSS statistical package version 25 for Windows (IBM SPSS, Chicago, IL, USA). Mean, standard deviation, and frequencies were calculated for descriptive statistics. Statistical significance was defined as $P < 0.05$. Subject characteristics were compared between groups using independent t test and Chi- squared test were used for the comparison of sex distribution. Shapiro-Wilk test was used to check the normal distribution of data and Levene's test for homogeneity of variances was conducted to test the homogeneity between groups. Within and between-group comparisons were carried out through mixed-design MANOVA. Post-hoc tests using the Bonferroni correction were carried out for subsequent multiple comparisons.

RESULTS

- Subject characteristics:

Table (1) shows the subject characteristics of experimental and control groups. There was no significant difference between groups in age, weight, height, BMI, and sex distribution (p > 0.05).

Table 1. Basic characteristics of participants.

	Experimental group	Control group	MD	t- value	p-value
	mean ± SD	mean ± SD			
Age (years)	21.92 ± 1.18	20.92 ± 1.8	1	1.67	0.11
Weight (kg)	69.15 ± 9.73	67.31 ± 9.28	1.84	0.49	0.62
Height (cm)	171 ± 9.13	± 8.12 169.53	1.47	0.43	0.67
BMI (kg/m^2)	23.52 ± 1.27	± 1.23 23.28	0.24	0.47	0.64
Sex, n (%)					
Females	7 (54%)	7 (54%)			1
Males	6 (46%)	6 (46%)			

SD, standard deviation; MD, mean difference, p-value, level of significance

Effect of treatment on VAS, CVA, chest expansion :

Mixed MANOVA revealed that there was a significant interaction between treatment and time (Wilks' Lambda = 0.37; F = 8.63, p = 0.001, η^2 = 0.62). There was a significant main effect of time (Wilks' Lambda = 0.02; F = 218.40, p = 0.001, η^2 = 0.97). While there was no significant main effect of treatment (Wilks' Lambda = 0.89; F = 0.63, p = 0.64, η^2 = 0.11).

- Within-group comparison:

There was a significant decrease in VAS and a significant increase in CVA and chest expansion in both groups experimental and control post-treatment compared with that pre- 0.01). The % of change of VAS, CVA, and chest expansion in experimental group was 82.72, 2.64, and 90.65 respectively, and that in control group was 59.06, 2.11, and 40.58% respectively.

- Between groups comparison:

There was no significant difference between groups pre-treatment (p > 0.05). There was a significant decrease in the VAS of experimental group compared with that of control group post-treatment (p < 0.001). There was a significant increase in chest expansion of experimental group compared with that of control group post-treatment (p < 0.01).While there was no significant difference in CVA between experimental and control group post-treatment (p > 0.05), (Table 2).

Table 2. Mean VAS, CVA, and chest expansion pre and post treatment of experimental and control group.

	Experimental group	Control group	MD (Cohen d effect size)	p-value
	mean ± SD	mean ± SD		
VAS				
Pre treatment	4.92 ± 0.86	4.69 ± 1.11	0.23 (0.23)	0.55
Post treatment	0.85 ± 0.8	1.92 ± 0.64	-1.07 (1.47)	0.001
MD (% of change)	4.07 (82.72%)	2.77 (59.06%)		
	p = 0.001	*p = 0.001*		
CVA (degrees)				
Pre treatment	43.61 ± 1.12	43.69 ± 1.03	-0.08 (0.08)	0.85
Post treatment	44.76 ± 1.01	44.61 ± 1.04	0.15 (0.14)	0.71
MD (% of change)	-1.15 (2.64%)	-0.92 (2.11%)		
	p = 0.001	*p = 0.001*		
Chest expansion (cm)				
Pre treatment	2.46 ± 0.8	2.76 ± 0.83	-0.3 (0.36)	0.34
Post treatment	4.69 ± 0.66	3.88 ± 0.84	0.81 (1.07)	0..01
MD (% of change)	-2.23 (90.65%)	-1.12 (40.58%)		
	p = 0.001	*p = 0.001*		

SD, Standard deviation; MD, mean difference; p-value, Level of significanc

DISCUSSION

The goal of this randomized controlled trial was to see how the diaphragmatic release technique affected upper crossed syndrome. Combining diaphragmatic release with an exercise program resulted in greater improvements in neck pain and chest expansion which were measured by VAS and tape measurement.

Because the diaphragm is facially and mechanically attached to the cervical and thoracic spines, combining diaphragmatic release with an exercise program resulted in greater improvements in chest expansion and neck pain compared to exercises alone.

Improvement in chest expansion and neck pain may be attributed to the scapular girdle through the endo-thoracic fascia and pleura. The suspensor ligaments of the pleura dome are connected to the cervico-dorsal region. Anatomically it is attached to the sternum, ribs, and vertebrae so the contraction of the diaphragm has affected the mobility of the whole spine and curves. The muscular component of the diaphragm contains equal proportions of slow, fatigue-resistant (Type 1), and fast (Type II) fibers, a finding that reflects its turn as an actor in both the low-intensity, perpetual cycle of breathing and in more rapid and strenuous settings, such as talking, singing, sneezing, defecation and in situations of acutely-increased ventilation.

The conventional program of the current study showed a great effect on neck pain and disability which agrees with previous studies **(Alfawaz *et al.*, 2018)**. Exercise program improves neuromuscular function and sensorimotor control. Exercises stimulate the mechanoreceptors which activate afferent nerves that inhibit the small-diameter pain nerves, **(Ylinen, 2007)**.

As far as we know, this is the first study to examine the effect of diaphragmatic release on the upper crossed syndrome, so comparing the current findings to previous research is difficult.

Our current study performed on both males and females, and treatment sessions performed three times per week for one month.

Kang, *et al.*, (2018), studies agree with the present study on the diaphragmatic release technique can affect the improvement of chest mobility and neck pain.

Kang, *et al.*, (2018), studied the relationship between pulmonary functions and respiratory muscles in patients with forward head posture. They explained that patients with FHP have respiratory issues caused by thoracic kyphosis and chest hypomobility**. Braga *et al.*, (2016)**

investigated the effect of manual therapy on respiratory muscle strength and chest mobility in the diaphragm muscle. They discovered an immediate effect on chest mobility after manual therapy of the diaphragm, and they explained that fascial release reduces soft tissue tension, and trigger points, when applied slowly over the treated area, can act on the sensory system via the Golgi tendon organ**. Rocha *et al.*, (2015)**, discovered that the manual diaphragm release technique improves diaphragmatic mobility, inspiratory capacity, and exercise capacity but has no effect on respiratory muscle strength.

Gonzalez_Alvalez *et al.*, (2016), discovered that diaphragmatic stretching improved posterior chain muscle kinematics as measured by Schober's test, the finger-to-floor test, cervical range of motion, and ribcage excursion at the xiphoid level immediately after the technique. The placebo technique, on the other hand, revealed no pre- or post-technique differences in any of the measures. **Haghighat *et al.*, (2020)**, added diaphragmatic release to the exercise program, which improved respiration, but this contradicts our findings in FHP.

There were some limitations to this study. The physiotherapist who administered the intervention could not be blinded, and the outcome measures were only evaluated immediately after the intervention.

CONCLUSION

The present study demonstrated that the diaphragmatic release technique improves chest expansion and neck pain in the upper crossed syndrome. No change was observed in the cranio-vertbral angle and forward head posture. This technique should be considered in the management people with the upper crossed syndrome. The results of the current study produce new data to help therapeutic approaches.

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ABBREVIATION

CVA: cranio-vertebral angle, FHP: forward head posture, BMI: body mass index, VAS: visual analogue scale, CE: chest expansion.

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تأثير انفراجة عضلة الحجاب الحاجز علي الام الرقبة وحكة الصدر لمرضي المتلازمة العلوية المتقاطعة

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اجريت هذه الدراسة لمعرفة تأثير انفراجة الحجاب الحاجز علي ألم العنق و حركة الصدر لحالات المتلازمة العلوية المتقاطعة

مجموعة من 30 شخصا شاركوا في هذه الدراسة تتراوح أعمارهم بين 20 و 26 عاما خضعوا الي 12 جلسة من مزيج من تقنيات انفراجة الحجاب الحاجزوالعلاج التقليدي (المجموعة التجريبية 15شخصا) أو العلاج التقليدي فقط في (مجموعة التحكم 15 شخصا). تم تقييمهم قبل العلاج وبعد 4 أسابيع باستخدام قياس حدة الالم ومدى أتساع الصدر وقياس زاوية تقدم الرأس.

تشير النتائج وجد تحسن لدي المرضي في مدي اتساع الصدر و ألم الرقبة في المجموعة التجربية مقارنة بمجموعة التحكم ولكن لم نجد اي اختلاف في زاوية تقدم الرأس بين المجموعتين.

نستنتج من ذلك ان اضافة انفراج الحجاب الحاجز الي التمارين العلاجية يحسن من مدي اتساع الصدر وألم العنق في حالات المتلازمة العلوية المتقاطعة.