EFFECT OF UPPER CROSSED SYNDROME IN CERVICOCEPHALIC KINESTHESIA AND ELECTROMYOGRAPHIC ACTIVITY OF SCAPULAR AND SHOULDER MUSCLES

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ABSTRACT

Background: *Upper crossed syndrome (UCS) posed a significant health concern in several developed countries. It was considered a work-related musculoskeletal disorder since it led to substantial days off and the associated costs for compensation and disability. purpose: to investigate the correlate between cervicocephalic kinesthesia and electromyographic activity of levator scapulae muscle and pectoralis major muscle in subjects with upper crossed syndrome.* ***Materials and Methods:*** *Thirty-six subjects with upper crossed syndrome recruited to participate in this study; their age ranged from 25 to 45. All subjects' evaluation included Cervicocephalic kinesthesia by Cervical Range of Motion Instrument (CROM), and Electromyography (EMG) for scapular and shoulder muscles activity. They were randomized into two groups, A and B. Group A included subjects with upper crossed syndrome, while group B included healthy matching subjects without upper crossed syndrome.* ***Results:*** *There was a significant decrease in craniovertebral angle (CVA) has been detected in UCS group in favor of healthy group. On the other hand, there was a significant increase in kyphosis, forward shoulder angle (FSA), flexion joint reposition error (JRE) and extension joint reposition error (JRE) in UCS group compared with healthy subjects ($p < 0.05$). There was a significant decrease in duration of right and left Levator scapulae muscles of subjects with UCS compared with healthy subjects ($p < 0.01$), while there was no significant difference in duration of Pectoralis major between groups ($p > 0.05$). There was a significant decrease in amplitude of right and left Levator scapulae muscles and right and left Pectoralis major muscles of subjects with UCS compared with healthy subjects ($p < 0.01$).* ***Conclusion:*** *In the current study it was be concluded that the cerviccephalic kinesthesia was affected in subjects with UCS and amplitude of levator scapulae and pectoralis major muscles was affected while only duration of levator scapulae muscle was affected.*

Keywords: *Cervical Range of Motion, Cervicocephalic Kinesthesia, Cranioverterbral Angle, Electromyographic activity, Upper Crossed Syndrome.*

INTRODUCTION

Upper crossed syndrome (UCS) is also referred to as proximal or shoulder girdle crossed syndrome. UCS is defined as a common postural dysfunctional pattern characterized by tight upper trapezius, levator scapulae on the dorsal side that crosses with tight pectoralis major and pectoralis minor paired with weak deep cervical flexors ventrally that crosses with the middle and lower trapezius. Upper Cross Syndrome is characterized by muscular imbalance of skeletal muscles activation and inhibition rather than just single muscle involvement. Any failure of activation between tonic and phasic muscles results in muscular insufficiencies [1].

Kinesthesia is defined as the ability to judge joint position, which is helpful in the coordinated movement of the head, trunk, and extremities. Dysfunction of the cervicocephalic kinesthetic sensibility can be characterized by movement and head relocation errors (HRE) and increased movement irregularities [2]. Cervicocephalic kinesthetic sense had shown to be affected in several musculoskeletal disorders like Forward Head Posture that is significantly associated with the severity of FHP and chronic neck disorders [3].

EMG recording and analysis are powerful neuro- physiological techniques that can be employed to identify the health status of the motor system. The method most used by researchers and clinicians was surface electromyography (SEMG). Parameters that can be studied by EMG are amplitude, timing, conduction velocity, fatigability, and characteristic frequencies/patterns [4].

Purpose of the study:

The purpose of the study was to investigate the effect of:

Upper crossed syndrome on cervicocephalic kinesthesia and electromyographic activity of levator scapular muscle.

Upper crossed syndrome on cervicocephalic kinesthesia and electromyographic activity of pectoralis major muscle.

Significance of the study:

Many researchers and therapists had only evaluated one of the affected regions in upper crossed syndrome, such as head, shoulders, or spine, separately and reported a degree of postural deviation regardless of other relevant malalignments and patterns of the muscle activation and related movement patterns, such as scapulohumeral rhythm. Most of these studies had focused on the cervical extensors and flexors in patients with neck pain. To our knowledge there are no available studies that examined the relationship between cervicocephalic kinesthesia and electromyographic activity of scapular/shoulder muscles in upper crossed syndrome. In this study, we would focus on scapular muscle group mainly leavator scapulae because there was little research focused on that muscle and shoulder muscles group mainly pectoralis major. A lot of research has been performed on the activity of the Trapezius and the Serratus Anterior during different movements in different population groups. Very little EMG data was available on the activity of the smaller and less superficial muscles that attach on the scapula, including the Levator Scapulae, Pectoralis Major and Rhomboids Major, despite the hypothesized importance of these muscles in shoulder and neck function. [5].

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MATERIALS AND METHODS

Study design:

A Cross Sectional Study was conducted at the outpatient clinic, at faculty of Physical Therapy, Horus University, New Damietta, Egypt in the period from September 2023 to March 2024. Prior to data collection, ethical approval was obtained (NO P.T.REC/012/004808).

Participants:

Thirty-six subjects from both genders with upper cross syndrome were recruited for the study. Sample size calculation was carried out using G Power and Sample Size Calculations software, type 3.0.11 for MS Windows (Walton D and William D. DuPont., Vanderbilt University, Tennessee, USA).

Subjects were allowed to get involved in the study if they had the subsequent criteria: Age ranges from 25 to 45 years from both genders, craniovertebral angle is equal or less than 53 ^{0} , rounded shoulder angle is equal or more than 52^{o} and excessive thoracic kyphosis angle is equal or more than 42^{0} [6]. Level of pain on VAS is more than 3. While subjects were excluded from the study if they exhibited one of the subsequent criteria: Past history of traumatic neck injuries, Rheumatic joint disease, Cervical spine fracture or dislocation and Severe osteoporosis and any neurological disorder like - Cervical spine disc protrusion, Cervical surgery and Vertebrobasilar insufficiency [٢]. Patients who met inclusion criteria were given a detailed information of the study objectives.

Subjects in the study groups was evaluated for Forward Head Posture for patient selection and inclusion using craniovertebral angle (CVA). Rounded Shoulder angle using forward shoulder angle (FSA). Thoracic kyphosis using two gravity dependent inclinometer. Outcome parameters were Mean Amplitude and duration of muscles by Electromyography (EMG), and cervicocephalic kinesthesia evaluated by Cervical Range of Motion (CROM).

Measurement Procedures:

Purposes of the study and methodology and were explained to every patient participated in the study and they agreed to share in this study. Informed consent was signed by each patient. Confidentiality was assured.

The demographic data was obtained by measuring weight and height then the body mass index (BMI) was calculated by dividing the subject’s weight in kilograms by the square of subjects’ height in meters2.

Assessment of FHP:

Craniovertebral angle (CVA) is used to detect FHP by taking pictures and analyzing them using the Kinovea software program. CVA is the angle formed by horizontal line passing through C7 and line from the tragus of the ear to spinous process of C7. The lateral view of the patient was photographed to determine the CVA. The camera's base was set to the shoulder height of the person and was fixed without rotation or tilt at a distance of one and a half meters from the participants. A self-balanced posture was maintained to standardize the head and neck position of the individual. To attain this position, the head and neck of the subject were moved through their full range of flexion and extension before pausing and maintaining a natural position. Participants were told to stand comfortably with their arms at their sides while being evaluated. They were instructed to focus their vision on a location on the wall directly in front of them. With a plastic marker, the skin above the spinous process of the C7 vertebra was marked, and the tragus of the ear was labeled with a sticker. After obtaining the image, it was uploaded to the Kinovea application. A horizontal line was drawn across the marker atop the C7 spinous process to determine the angle. Then, a second line was drawn on the image to determine the craniovertebral angle, extending from the marker above the C7 spinous process to the marker on the tragus [7].

Fig. (1): A plastic marker taped to the skin overlying the spinous process of the C7 vertebra.

Assessment of Rounded Shoulders:

Forward Shoulder Angle (FSA) is used to detect Rounded Shoulders by taking pictures and analyzing them using the Kinovea software program. FSA is the angle formed by vertical line passing through C7 and line from the acromion process of the shoulder to spinous process of C7. The lateral view of the patient was photographed to determine the FSA. The camera's base was set to the shoulder height of the person and was fixed without rotation or tilt at a distance of one and a half meters from the participants. A self-balanced posture was maintained to standardize the head and neck position of the individual by asked to stand with natural posture and look ahead, raised, and lowered their arms over head, flex and extend head and neck and took deep breath for three times [8].

Assessment of Thoracic Hyperkhyphosis:

Two Gravity-Dependent (analogue) Bubble Inclinometer are used to measure the angle of thoracic hyperkhyosis through measuring differences between two angles. The subjects were instructed to leave their arms by their sides and face the wall'' which was approximately 1.5 m in front of them. The cephalic foot of the inclinometer was placed on the pencil mark already on the C7 spinous process. The caudal foot of the inclinometer placed on the pencil mark made for T12. Both inclinometer angles were recorded, taking care to minimize parallax error with each measurement by ensuring the recorder's eyes were on the same horizontal plane as the inclinometer [9].

Assessment of Cervicocephalic Kinesthesia by (CROM):

The subjects sat upright in a chair in a comfortable position and looked straight ahead, feet touch ground, trunk straight and were advised not to move their shoulders for the rest of the test. The CROM unit was secured on the head by Velcro straps. The magnetic yoke was placed on the patient shoulder with the arrow mark placed to the north. From this position, CROM was calibrated into neutral (zero). Their head was moved slowly to the predetermined target position, 50% of maximum range of motion. The speed of passive neck motion will be very slow as higher speeds have been associated with significant differences in vestibular function according to age. The head should be maintained in the target position for 3 seconds, and the subject will be asked to remember that position and the head was brought to neutral position and then the subject will be asked to reposition actively by moving the head to the target position. When the subjects reached the reference position the subject's relocation accuracy was measured in degrees with CROM device.

Three trials were undertaken in the direction of flexion and extension and the mean of these trials (mean error) should be used for analysis. No feedback about repositioning performance was given during the testing. The entire procedure took approximately 15 min for each subject [10].

Electromyographic Activity of Levator Scaplae and Pectoralis Major

Preparation: The subject's skin was prepared in a standard manner before electrode application to minimize electrical impedance. After the skin was cleaned and abraded, bipolar surface electrodes (Ag/AgCl) were placed over the Levator Scapulae (LS) and Pectoralis Major (PM) muscles consistent with established Surface Electromyography for the Non-Invasive Assessment of Muscle.

Electrode Placement:

For the LS, electrode was placed Two fingerbreadths cephalad to the medial angle of scapula and one fingerbreadth medial. The electrode will travel through the upper trapezius. A second electrode was placed 2 cm laterally on the same line, and the reference electrode was placed on the C7 spinous process [11].

For the PM, the electrodes were placed on the chest wall at an oblique angle to the clavicle approximately 2 cm (about 0.79 in) below it and parallel to the sternum. The first electrode of the adhesive array will be placed as close as possible to the clavicle and the reference electrode will position at the styloid process of the ulna [12].

Quantitative EMG:

Surface electrodes were placed over the LS and PM muscles as described above, where motor unit potentials MUPs were measured by EMG machine (true trace) software. Quantitative analysis was done with moderate muscle contraction to measure the MUPs amplitude: calculated from peak to peak, as well as the numbers of phases and turns. Interference pattern was measured too, which is defined as the recruitment pattern with maximal voluntary contraction. LS and PM MUP s amplitudes reflects the muscle power the higher the amplitude the higher the power, which is the cornerstone of the study.

Data analysis:

Unpaired t test was conducted for comparison of subject characteristics between groups. Normal distribution of data was checked using the Shapiro-Wilk test. Levene's test for homogeneity of variances was conducted to ensure the homogeneity between groups. Unpaired t test was conducted for comparison between groups. The level of significance for all statistical tests was set at $p < 0.05$. All statistical measures were performed through the statistical package for social sciences (SPSS) version 25 for windows.

RESULTS

***Subject characteristics*:**

Subjects' characteristics were demonstrated in table 1. There was no significant difference between groups in age, weight, height, BMI, sex and dominant hand distribution ($p > 0.05$).

Table 1. Basic characteristics of participants.

	Subjects with UCS	Healthy subjects			
	Mean ± SD	**Mean ± SD**	**MD**	**t- value**	**p-value**
Age (years)	29.84 ± 4.10	28.70 ± 3.82	1.14	1.23	0.22
Weight (kg)	77.76 ± 9.02	78.73 ± 6.72	-0.97	-0.52	0.60
Height (cm)	174.16 ± 7.14	175.70 ± 5.49	-1.54	-1.04	0.30
BMI (kg/m²)	25.70 ± 3.21	25.55 ± 2.37	0.15	0.23	0.82
Sex, n (%)					
Females	17 (45.95%)	17 (45.95%)			1
Males	20 (54.05%)	20 (54.05%)			
Dominant hand, n (%)					
Right	34 (92%)	34 (92%)			
Left	3 (8%)	3 (8%)			1

SD, standard deviation; p-value, level of significance

<u>Effect of UCS on CVA, kyphosis, FSA, flexion JPE and extension JPE:</u>

There was a significant decrease in CVA of subjects with UCS compared with healthy subjects ($p < 0.001$).

There was a significant increase in kyphosis, FSA, flexion JPE and extension JPE of subjects with UCS compared with healthy subjects ($p < 0.05$). (Table 2).

Table 2. Mean CVA, kyphosis, FSA, flexion JPE and extension JPE of subjects with UCS and healthy subjects:

	Subjects with UCS	Healthy subjects		95% CI			
	Mean ± SD	**Mean ± SD**	**MD**	**Lower**	**Upper**	**t- value**	**p value**
CVA (degrees)	47.03 ± 5.87	54.71 ± 4.41	-7.68	-10.09	-5.28	-6.35	0.001
Kyphosis (degrees)	44.92 ± 3.10	39.16 ± 4.14	5.76	4.06	7.45	6.77	0.001

FSA (degrees)	54.34 ± 10.03	41.38 ± 10.86	12.96	8.11	17.80	5.33	0.001
Flexion JPE	9.15 ± 4.13	6.69 ± 3.73	2.46	0.63	4.27	2.67	0.009
Extension JPE	5.97 ± 2.21	3.07 ± 1.96	2.9	1.93	3.87	5.97	0.001

SD, standard deviation; MD, mean difference; CI, Confidence interval; p-value, probability value

Effect of UCS on EMG duration and amplitude of Levator Scapulae and Pectoralis major:

There was a significant decrease in duration of right and left Levator scapulae muscles of subjects with UCS compared with healthy subjects ($p < 0.01$), while there was no significant difference in duration of Pectoralis major between groups ($p > 0.05$). (Table 3).

There was a significant decrease in amplitude of right and left Levator scapulae muscles and right and left Pectoralis major muscles of subjects with UCS compared with healthy subjects ($p < 0.01$). (Table 4).

Table 3. Mean duration of Levator Scapulae and Pectoralis major of subjects with UCS and healthy subjects:

Duration (ms)	Subjects with UCS	Healthy subjects		95% CI			
	Mean ± SD	Mean ± SD	MD	Lower	Upper	t- value	p value
Levator Scapulae							
Right	11.39 ± 1.35	12.15 ± 1.18	-0.76	-1.35	-0.17	-2.57	0.01
Left	11.15 ± 2.04	13.06 ± 2.61	-1.91	-3.00	-0.83	-3.52	0.001
Pectoralis major							
Right	13.06 ± 1.28	13.33 ± 1.64	-0.27	-0.96	0.41	-0.79	0.43
Left	14.01 ± 1.33	14.31 ± 1.50	-0.3	-0.95	0.36	-0.89	0.37

SD, standard deviation; MD, mean difference; CI, Confidence interval; p-value, probability value

Table 4. Mean amplitude of Levator Scapulae and Pectoralis major of subjects with UCS and healthy subjects:

Amplitude (uV)	Subjects with UCS	Healthy subjects		95% CI			
	Mean ± SD	Mean ± SD	MD	Lower	Upper	t-value	p value
Levator Scapulae							
Right	861.08 ± 216.92	1143 ± 176.05	-281.92	-373.48	-190.36	-6.14	0.001
Left	958.97 ± 320.48	1147.92 ± 336.99	-188.95	-342.35	-37.54	-2.48	0.01
Pectoralis major							

Right	1078.73 ± 155.25	1178.49 ± 189.98	-99.76	-180.16	-19.35	-2.47	0.01
Left	1038.22 ± 195.87	1185.29 ± 156.83	-147.07	-229.31	-64.85	-3.56	0.001

SD, standard deviation; MD, mean difference; CI, Confidence interval; p-value, probability value

DISCUSSION

The result of the study revealed that in subjects with UCS there was significantly decrease in CVA and significantly increase in kyphosis, FSA, flexion JRE and extension JRE compared with healthy subjects. There was a significantly decrease in duration of right and left Levator scapulae muscles and a significantly decrease in amplitude of right and left Levator scapulae muscles and right and left Pectoralis major muscles in subjects with UCS, while there was no significant difference in duration of Pectoralis major between groups.

This was supported by the findings of Khan et al., 2020, [2], who found that JRE was significantly impaired in individuals with FHP relative to those with normal head posture. Also, our result regarding JRE was augmented by a previous study by Haejung et al., 2005 [13] which involving assessment of HRA in individuals with various types of neck disorders.

Our finding regarding CVA means values came in agreement with the result of Lee et al., 2014 [14] who found significant correlation between head reposition accuracy (HRA) and CVA, which means that the more severe the FHP, the worse the HRE also becomes. This may be due to the fact that FHP changes the alignment of the cervical spine and the length of the cervical muscles. It also produces extra loads on the facet joints and the posterior capsule. Therefore, as a result of the changed mechanical loads on the articular and muscular structure, the afferent signals of mechanoreceptors and muscle spindles are affected negatively.

Our results of the EMG mean values also agreed with Rahnama et al., 2017 [15] That showed alteration in muscle activity that could be attributed to the kinematic changes in scapular motion that are seen in UCS and are linked to muscle force disturbance. During activity of the neck and shoulder joint, the upward rotation of the scapula is controlled by the coordinated efforts of the UT and levator scapulae muscles. Forward head posture increases tension in muscle which prohibits upward rotation of the scapula. Moreover, we speculate that faulty FHP for prolonged periods alters the length−tension relationship of the neck muscles, which increases the stabilization demands on the stabilizer muscles of the cervical spine; when they are not able to meet these demands, they are compensated by increased activity of the muscles around the neck.

Limitations of the current study include: CVA was measured by taking digital pictures rather than more robust cephalometric radiographic analysis. And second the study evaluated only two muscles that are affected in upper crossed syndrome and did not the rest of muscles

CONCLUSION

In the current study it was concluded that cervicocephalic kinesthesia and activation patterns of neck and shoulder muscles are significantly altered in subjects with UCS.

Conflict of interest

The authors state that there is no conflict of interest concerning the publication of this paper.

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