Influence of Cervical Posture on Breathing Pattern and Chest Expansion Among Neck Pain Population

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Abstract— Alteration in head posture and neck muscles activation has been observed among neck pain patients due to variation of motor dysfunction. Motor dysfunction can further lead to changes in thoracic and rib cage mechanics there by causing respiratory dysfunction. However, limited evidence exists regarding the alteration of cervical posture and respiratory involvement among neck pain patients. The main objective of this study was to compare the influence of cervical posture on the pattern of the breathing and chest wall expansion between healthy and neck pain population. 40 subjects (20 healthy and 20 neck pain subjects) were recruited based on the selected criteria as set by the study protocol. Electronic head posture instrument (EHPI) has been used to measure their cervical posture and the breathing pattern was assessed by palpation method. Finally, the chest expansion was measured using measuring tape. Data obtained were analyzed using SPSS version 21.0. The results of the study showed a significant difference (p<0.05) in cranio vertebral (CV) angle, breathing pattern, chest expansion between healthy and neck pain groups. Neck pain subjects showed reduced CV angle and chest expansion. In addition, there is also an alteration of the breathing pattern among neck pain patients. However, there is no significant difference in upper thoracic (UT) angle and 4th intercostal space chest expansion between the groups. The study proposed that neck pain patients may predispose to alteration in respiratory involvement. This study recommends that respiratory exercise could be included as part of rehabilitation measures among neck pain population.

Keywords— chest expansion, breathing pattern, cervical posture, neck pain

I. INTRODUCTION

Neck pain is one of the frequent musculoskeletal problem that leave an impact on individuals’ quality of life and their health [1]. An alteration in musculoskeletal structures with respect to motor control in cervical region has been commonly observed among neck pain population [2]. In addition, neck pain patients also being presented with decrease in neck cervical motion, neck muscle strength and endurance, reduced proprioception of neck region and impairment in the deep neck cervical muscles [1]. Previous studies [3][4] conducted among neck pain population in European and North American regions showed that approximately 33-54% of adults experience neck pain during their lifetime. Neck pain varies from 11.0% in the UK to 14.1% in Quebec, Canada among workers [5][6]. In this context, an earlier study carried out in Asian country [7] reported that Asian people have the highest incidence (36.1%) of neck pain.

Lau et al. (2010) reported that the causes of neck pain are proposed to be related to various anatomical structures such as facet joints and intervertebral discs. Out of many biomechanical alteration, motor dysfunctions are frequently reported among neck pain patients [2]. They are commonly presented with increased activation of superficial neck muscles [8]. In addition, neck pain patient also have shown an inhibition of deep cervical neck flexor muscle activation as well as increased in forward head posture [2][8]. Prolong forward flexion of cervical spine can result in increasing compressive loading of the cervical spine [9]. This can cause the cervical musculature such as sternocleidomastoid (SCM), anterior scalenes (AS) and upper trapezius (UT) to increase their activity and this was reported through electromyographic activity [1].

Muscular imbalance, segmental instability and alteration in force-length curves among neck pain was believed to cause dysfunction in local and global muscles which also alters mobility and head posture [10]. Thus, this problem can affect the role of thoracic cage and movement of rib cage [1]. Alteration in cervical and thoracic posture

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among neck pain population can affect the respiratory characteristics [10]. In this context, research evidences are lacking with relation to head posture and respiratory involvement. Therefore, the purpose of this study was to compare the influence of cervical posture on the breathing pattern of breathing and chest wall expansion between healthy and neck pain subjects.

II. MATERIALS AND METHODS

Forty subjects (20 healthy subjects and 20 neck pain subjects) were recruited for participation in this study (age 24.80 years ± 7.466 years, height 1.59m ± 0.08m, body mass index (BMI) 22.76kg/m² ± 5.037kg/m²). All the subjects who showed willingness were requested to sign an informed consent that was approved by the ethical board of Universiti Teknologi MARA Malaysia. Both healthy and neck pain subjects were free from traumatic cervical injury, spinal or chest surgeries and their age range were between 20 – 50 years old. The flow of the study were as follows:

A. Assessment of cervical posture

Initially the procedure was commenced with the cervical posture assessment in which cranio vertebral angle (CV angle) and upper thoracic angle (UT) of the subjects were measured using Electronic Head Posture Instrument (EHP) [11]. To measure CV angle, subjects were instructed to stand comfortably while their spinous process of C7 and T7 were palpated and marked. A camera with tripod stood with an attached plastic ruler was placed corresponding to the markers of C7 spinous process. Then the stationary arm was placed parallel to the floor and the moving arm was placed parallel to the tragus of the ear. The plastic ruler was adjusted according to the moving arm before digital inclinometer was placed on the ruler. Three readings were taken and the average reading was calculated. As for UT angle, the axis were placed in lateral aspect parallel to the C7 whereas the moving arm (plastic ruler) was placed on lateral aspect parallel to T7. The same method was used to obtain the reading of UV angle.

B. Breathing pattern assessment

Next, subjects were classified according to their breathing patterns which are costo diaphragmatic breathing type and upper costal breathing type. In order to assess the breathing pattern, they were instructed to remain standing, look straight ahead, with their feet 10 cm apart, and breathe normally for 2 minutes. Then the examiner placed their left hand on the upper chest and the right hand on upper back. Next, they placed their left hand on lower right costal and right hand on the upper abdomen. For each placement of clinical examination, 10 inspirations were checked. Then, subjects were classified into costo diaphragmatic or upper costal breathing type accordingly [12].

C. Chest expansion measurement

Following the procedures, both groups were asked to remain standing for the measurement of chest expansion. Tape measure was used to measure the chest expansion.

Anatomical land marks of axilla, forth intercostal space and xiphoid level were marked. To measure upper thoracic excursion, tape measure was placed in the axillary region, meanwhile for the midthoracic and lower thoracic excursion, the tape measure was placed at the intercostal and xiphoid process level respectively [13]. Subjects were instructed to inhale deeply, then exhale upon verbal instruction by the examiner. Three readings were taken at each level and average reading was calculated.

The independent t - test was used to analyze difference in the cervical posture, breathing pattern and chest expansion between healthy and neck pain subjects with confidence interval of 95%. Mann-Whitney U test was carried out to determine the significance of pattern of breathing between neck pain patients and healthy subjects. Meanwhile, a Spearman correlation test was carried out to determine the relationship between cervical posture with breathing pattern and chest expansion.

III. RESULTS

The characteristics of the study subjects were as follows:

Healthy subjects (age 24.80 years ± 7.466 years, height 1.59m ± 0.08m, body mass index (BMI) 22.76kg/m² ± 5.037kg/m²). Neck pain subjects (age 24.80 years ± 7.466 years, height 1.58m ± 0.066m, body mass index (BMI) 21.36kg/m² ± 3.586kg/m²) (Table I).

| TABLE I. PHYSICAL CHARACTERISTICS OF SUBJECTS |
| Demographic characteristics | Healthy (n=20) | Neck pain (n=20) |
| Age (years), Mean (± SD) | 24.80 ± 7.466 | 24.80 ± 7.466 |
| Height (m), Mean (± SD) | 1.59 ± 0.08 | 1.58 ± 0.066 |
| BMI (kg/m²), Mean (± SD) | 22.76 ± 5.037 | 21.36 ± 3.586 |

Independent t-test was carried out to determine the difference in cervical posture and chest expansion between neck pain and healthy groups. The test showed cranio vertebral angle, axilla level chest expansion and xiphoid level chest expansion have significant differences (p<0.05) between the two groups with p value 0.000, 0.036 and 0.000 respectively. However, there was no significant difference in UT Angle and chest expansion at T4 Intercostal level (p>0.05). Mann Whitney U test was performed to determine the significant difference of breathing pattern between the two groups. The p value is 0.000 showing significant difference in breathing type between the two groups (Table II).

<p>| TABLE II. CV ANGLE, UV ANGLE, BREATHING PATTERN AND CHEST EXPANSION LEVEL BETWEEN HEALTHY AND NECK PAIN SUBJECTS |</p>
<table>
<thead>
<tr>
<th>Variables</th>
<th>Groups</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healthy Mean (SD)</td>
<td>Neck pain Mean (SD)</td>
</tr>
<tr>
<td>CV angle (°)</td>
<td>56.69 (2.117)</td>
<td>47.90 (3.801)</td>
</tr>
<tr>
<td>UT angle (°)</td>
<td>99.49 (4.075)</td>
<td>101.03 (4.752)</td>
</tr>
<tr>
<td>Breathing pattern</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Research Management Centre (RMC) and the Ministry of Higher Education (MOHE)
Spearman correlation test was conducted to determine the relationship of cervical posture and breathing type among neck pain patients. Based on the test done, it is found that cervical posture was not significantly correlated with breathing types ($r < 0.3, p > 0.05$) (Table III).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Neck pain group (n=20)</th>
<th>Cranio vertebral angle ($r$)</th>
<th>Upper thoracic angle ($r$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breathing type</td>
<td></td>
<td>0.375 (0.076)</td>
<td>0.346 (-0.095)</td>
</tr>
</tbody>
</table>

Table IV showed the results of Spearman correlation test which was carried out to determine the relationship between cervical posture and chest expansion. Cranio vertebral angle has significant relationship with xiphoid level of chest expansion with $p$ value 0.028. All the other correlation were not significant ($r < 0.3, p > 0.05$) (Table IV).

<table>
<thead>
<tr>
<th>Chest expansion</th>
<th>Neck pain group (n=20)</th>
<th>Cranio vertebral angle ($r$)</th>
<th>Upper thoracic angle ($r$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axilla level</td>
<td></td>
<td>0.272 (0.144)</td>
<td>0.186 (-0.211)</td>
</tr>
<tr>
<td>T4 intercostal level</td>
<td></td>
<td>0.147 (-0.747)</td>
<td>0.307 (-0.170)</td>
</tr>
<tr>
<td>Xiphoid level</td>
<td></td>
<td>0.028 (-0.433)</td>
<td>0.264 (-0.150)</td>
</tr>
</tbody>
</table>

IV. DISCUSSION

This research has shown that patients with neck pain problem has reduced CV angle with increase in UT angle. The results of the angulation are in contrast with healthy subjects, in which the UT angle is lesser than the CV angle. Greater UT angle with smaller CV angle can reduce the neck flexion and rotation which further leads to neck pain [2]. The finding of the study is in agreement with previous studies which examined the changes of CV angle among the neck pain subjects [14][15][16] in which the patients reduced their CV angle. This lead forward head posture to increase [16].

Forward head posture results in increase of gravitational load to certain cervical motion segments which can cause myofascial pain [16]. Prolong sustained position will overwork the muscles, thus change the activation of the neck muscles which further lead to neck pain. In addition, poor cervical resting posture can increase the amount of effort needed to balance the head against the gravitational force thus stress the cervical structures [4].

Although there is no significance difference of UT angle among neck pain, however, when the results is compared to the healthy subjects it is showed that the UT angle of neck pain patients is greater compared to healthy population. Earlier studies stated that UT angle was a better predictor for neck pain compared to the CV angle [4]. This is because, all neck motions were contributed by thoracic spine, especially among asymptomatic subjects [2]. Furthermore, as the thoracic angle increased, the higher pain score is reported among neck pain subjects [4]. Besides that, CV angle had no significant correlation with neck pain severity [4]. However, CV angle is important because as the CV angle reduces, the tendency have forward head posture increases among these populations [4].

Based on the results, it can be observed that most of neck pain patients have altered their breathing pattern in which majority of them were using upper costal breathing pattern instead of a costodiaphragmatic breathing pattern. This indicates that their accessory muscles were more activated compared to the diaphragm. This type of breathing produces a lesser expansion of the rib cage, thus reduces the amount of lung capacity and gas exchange [11][12]. In order to compensate with this type of breathing, patient might use the accessory muscles to accomplish gaseous exchange [12].

It is often observed that neck pain patients usually present with faulty breathing pattern [17]. The authors suggest that they were having tendency of lifting up the sternum vertically during inspiration, rather than widening in the horizontal plane. The reason for this compensation might be due to increase in bilateral muscle activation in the scalene, trapezius and levator scapulae musculature [17]. This faulty pattern was named “chest breathing” which is the most common fault in breathing pattern disorders. In order for neck pain patients to breathe properly, they might need to use the accessory muscle [12]. This is because the upper costal breathing is characterized by an outward, upward movement of the chest wall that requires more work to be done in lifting the rib cage [11][12].

Furthermore, neck pain patients showed greater chest expansion at axillary level but lower chest expansion at xiphoid level when compared to the healthy subjects. This indicates that neck pain patients predisposes to apical breathing because they use more accessory muscle to breathe in. This results were in agreement with earlier study who found neck pain patients reduce the chest expansion at T4 level with the widespread musculoskeletal conditions in the neck, mid and lower back regions [2]. Hence, it can be conclude that the neck pain population exhibits lower chest expansion. The probable reason for reduced chest expansion could be attributed to the weakness of respiratory muscle strength [10]. As the muscles unable to work properly, the global and local muscle activation also being altered. This is because the main function of the local muscles is to stabilize and controlling the movement meanwhile, global muscles
help the local muscles to provide the steady movement of neck [1]. Changes of the neck activation also reduced the endurance training of the neck muscles [10]. In contrast, earlier study stated that there was no difference of the xiphoid level of chest expansion among neck pain patients [2], which is not in conjunction with our present study.

Although there are differences in cervical posture and breathing pattern among neck pain patients, however this study showed no relationship between cervical posture and breathing pattern. The increase in forward head posture does not have effects on the breathing pattern. There is a lack of literatures regarding forward head posture and breathing type. Earlier study showed that there is no significant relationship between cervical posture and muscle activation of SCM [11]. The study highlighted that excessive activation of SCM was only observed in the upper costal types when they breathe rapidly, roughly which will not be observed during normal relaxed breathing. As the SCM muscle functions to pull the head forward and down, we can assume that a greater activity of these muscles will be presented on the subjects with forward head posture. However, the earlier study does not confirm this as there was no correlation found between the cranio-vertebral angle and the EMG activity of the SCM [11]. Study by Celhay et al. (2014) further supported the earlier study by stating that SCM and latissimus dorsi EMG activity was not significantly different between upper costal breathing and costodiaphragmatic breathing [11][18].

The present study showed that the alteration in CV angle results in reduced chest expansion at the xiphoid level. However, the reduction was only found in mean value among neck pain patients as compared to healthy subjects. Changes in cervical mobility, head posture and dysfunction of local and global muscle system are believed to predispose to muscular imbalances and segmental instability potentially affecting the function of the thoracic cage and rib cage mechanics [10]. These changes in rib cage biomechanics could lead to associated changes of respiratory muscles altering their force-length curves [10].

Earlier studies reported significant fair correlations between chest expansion and forward head posture [10]. However, the study did not specify which level of chest expansion was most affected as because of alteration in cervical posture. The correlations of chest expansion and cervical posture, which was substantially reduced in the neck pain patients, underline the importance of head posture and chest mobility for neck function. Therefore, a combination of postural correction, respiratory exercises and chest mobility exercise combined are to be considered during neck pain rehabilitation for neck pain patients [19].

The main limitation of the present study was the small sample size with a limited age range, which makes generalization of the results difficult. Furthermore, the amount of disability for the neck pain patients is not measured. The measurement of severity of disability may further enhance the significance of the study. Hence, future study need to be necessitated in order to categorize the severity of the individuals to correlate with cervical posture and chest expansion.

V. CONCLUSION

Neck pain patients exhibited forward head posture, change in the pattern of breathing and reduction in chest wall mobility. The study also found out that altered head posture also may contribute to reduction in chest wall mobility. Therefore, it is recommended along with routine rehabilitation the respiratory exercises are to be necessitated among this special population in order promote chest expansion along with postural correction.

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