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Original Article

Correlation between pulmonary functions and respiratory muscle activity in patients with forward head posture

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Abstract. [Purpose] The purpose of this study is to determine the effect that secondary postural deformities and chronic postural abnormalities have on lung capacity, as well as correlate the activity of the respiratory muscles. The results provide basic objective data about the forward head posture and respiratory muscle activity that can be used in clinical situations. [Subjects and Methods] The subjects used in this study were 24 patients aged 25 to 35 years old who visited a hospital in Jeollanam-do Province, Korea, between September 2015 and January 2016. The patients were diagnosed with forward head posture because the vertical line between the acromion process and the external acoustic meatus was at least 5 cm. We measured the craniovertebral angle, pulmonary functions, and respiratory muscle activity of the subjects for correlation analysis. [Results] A positive correlation was found between the craniovertebral angle and the forced vital capacity (r=0.63), while a negative correlation was found between the craniovertebral angle and the sternocleidomastoid muscle (r=–0.77). The craniovertebral angle and the anterior scalene muscle showed a negative correlation (r=–0.65). There were positive correlations between the forced vital capacity and the sternocleidomastoid muscle (r=0.71), and between the forced vital capacity and the anterior scalene muscle (r=0.59). [Conclusion] Severe forward head posture increased the activities of the sternocleidomastoid muscles and the anterior scalene muscles, and decreased the forced vital capacity. Thus, it is necessary to develop more efficient interventions for managing forward head posture based on pulmonary function and the activity of the respiratory synergist muscles.

Key words: Forward head posture, Pulmonary functions, Respiratory muscle activity

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INTRODUCTION

Forward head posture is one of the most common musculoskeletal disorders that is associated with the use of imaging devices. One of the symptoms of the forward head posture is musculoskeletal dysfunction, which is caused by motor control changes in the bones in the neck[1)].

Forward head posture occasionally causes dysfunction, such as round shoulders, that induce pain and disability in the body or in the limbs. Other typical dysfunctions include weakened and shortened muscles and muscular imbalance caused by abnormal connections of stability and movements of each muscle[2)]. When the head comes forward, the muscles in the front of the neck and immediately below the head at the back of the neck, in particular, contract. These muscles include the complex structure of the scalene muscle, the sternocleidomastoid muscle, and the auricularis posterior muscle[3)].

The scalene muscle and the sternocleidomastoid muscle are flexors of the neck bones and play a role in the posture control

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of the neck. They also operate as the accessory inspiratory muscles that lift the chest wall to help with breathing[4)]. Specifically, the muscles act on the chest wall during inhalation to induce the cranial displacement of the bones in the chest, including the ribs, upward. Thus, the muscles are not only related to the functional movements of the neck, but also to the act of breathing[5)].

Since the muscles around the neck and the shoulders directly participate in breathing, their alignment enables optimum respiratory function. An imbalance of these muscles caused by tension, weakness, or paralysis obstructs normal breathing[6)]. Consistent forward head posture shortens and weakens these muscles, resulting in weakened breathing.

In this context, we investigated the effects of secondary postural deformities and chronic postural abnormalities on lung capacity. We also correlated the activity of the respiratory muscles. The results provide basic objective data about the forward head posture and respiratory muscle activity that can be used in clinical situations.

Table 1. General characteristics of subjects

Item	Experimental group
Age (years)	29.5 ± 3.9
Height (cm)	169.5 ± 5.1
Weight (kg)	64.7 ± 4.8
CVA (Angle)	45.7 ± 3.4
FEV_1(%)	94.5 ± 7.8
FVC(%)	92.7 ± 8.1
FEV1/FVC(%)	96.1 ± 8.6
% SCM(%)	36.2 ± 4.9
% Scalenius-A(%)	45.8 ± 5.3

Data are presented as mean ± SD.
CVA: Cranio Vertebral Angle; FEV_1: forced expired volume in one second; FVC: Forced Vital Capacity; % SCM: sternocleidomastoid muscle activity; % Scalenius-A: Anterior Scalene muscle activity.

SUBJECTS AND METHODS

The subjects of this study were 24 patients (25 to 35 year old) who visited a hospital in Jeollanam-do Province, South Korea, between September 2015 and January 2016. They were diagnosed with forward head posture because the vertical line between the acromion process and the external acoustic meatus was at least 5 cm. Patients who had congenital anomalies in the neck and the thoracic cage, severe surgical or neurological disorders, limitations in the hip or knee joint flexion, and pain during abdominal contractions were excluded from this study. All subjects fully understood the purpose and methods of this study and voluntarily agreed to participate in the experiment (Table 1).

The activities of the respiratory muscles were measured with a surface EMG MP100 system with two channels (Biopac Systems, Inc., USA). The sampling rate for the EMG signal collection was set at 1,000, and the frequency band filter was set at 20–450 Hz. To minimize the skin resistance to the EMG signals, we removed the hair and dead cells from the subjects' skin using fine sandpaper and cleaned the skin using alcohol cotton. Two Ag/AgCl surface electrodes were attached to the belly of each muscle at 2-cm intervals parallel to the muscle fibers. The reference electrodes were attached to the spine of the scapular, and the spinous process of the thoracic spine. The EMG signals were collected from the right sternocleidomastoid muscle and the anterior scalene muscle. The EMG signals from the muscles were converted into the root mean square (RMS). The EMG signals were analyzed with the Acqknowledge 3.9.1 software program (Biopac Systems, Inc., USA). In order to normalize the EMG signals of the subjects, the subjects were asked to sit comfortably and to breathe naturally for 10 s. The average RMS value was determined for 6 s; the breaths from the initial 2 s and the final 2 s were excluded during the reference action. Using a Threshold Inspiratory Muscle Trainer (NJ, USA), a device that is used for inhalation exercises, we quantified the RMS values when the subjects breathed at a level of 30% of the maximum inspiratory pressure[7)].

Pulmonary functions were measured with a Chestgraph HI-701 (Chest M.I., Inc., Japan). While sitting, the subjects placed the respiratory apparatus in their mouths and inhaled and exhaled as much as possible. The pulmometry was performed at least three times; the measurement was recorded when the difference between the two largest values was within 5% or 200 ml[8)].

For data analysis, we used SPSS 18.0 for Windows (IBM Corporation, USA) to provide the descriptive statistics about the general characteristics of the subjects, the pulmonary functions, the craniovertebral angle (CVA), and the average values of the respiratory muscle activity. We used the Pearson's correlation analysis to identify the correlations among the pulmonary functions, the CVA, and the respiratory muscle activity. The significance level was set at $\alpha=0.05$.

RESULTS

A positive correlation was observed between the CVA and the forced vital capacity (FVC) ($r=0.63$, $p<0.05$), while a negative correlation was observed between the CVA and the sternocleidomastoid muscle ($r=-0.77$, $p<0.01$). The CVA and the anterior scalene muscle showed a negative correlation ($r=-0.66$, $p<0.01$). However, there were positive correlations between the FVC and the sternocleidomastoid muscle ($r=0.71$, $p<0.01$), and the anterior scalene anterior muscle ($r=0.59$, $p<0.05$) (Table 2).

DISCUSSION

This study aimed to determine the effects of the forward head posture with inadequate postural alignment on pulmonary function and respiratory muscle activity. Forward head posture produces intense stiffness in the neck flexors through repeated

Table 2. Correlation of CVA, pulmonary function and respiratory muscle activity

	CVA	FEV_1	FVC	FEV1/FVC	SCM	Scalenius-A
CVA	1					
FEV_1	0.31	1				
FVC	0.63^{*}	0.12	1			
FEV1/FVC	0.21	0.16	−0.09	1		
SCM	-0.77^{**}	0.08	-0.71^{**}	−0.12	1	
Scalenius-A	-0.66^{**}	0.04	-0.59^{*}	−0.09	0.32	1

*$p<0.05$, **$p<0.01$.
Pearson correlation.
CVA: Cranio Vertebral Angle; FEV_1: forced expired volume in one second; FVC: Forced Vital Capacity; SCM: sternocleidomastoid muscle; Scalenius-A: Anterior Scalene muscle.

periods of excessive tension and the contraction of the neck muscles to resolve an unstable head posture[9]. The forward head posture also alters the length–tension relationship of the force in the respiratory muscles associated with the neck flexors[10]. This change requires the mechanical transformation of the muscles to correspond to the ability of the respiratory muscles to produce an appropriate level of force. However, when the anatomical structure of the bones of the neck and spine are abnormally changed, it produces neck pain, which can be exacerbated to be irreversibly plastic deformity and can lead to respiratory dysfunction[11].

Han et al.[12] studied a normal posture group and a forward head posture group and found that FVC, FEV1, and maximum voluntary ventilation (MVV) were all decreased in the forward head posture group. According to Lee and Chu[13], there were positive correlations between the CVA and oxygen uptake and CO_2 emission, which indicates that respiratory activity decreases as the angle of the forward head posture is reduced. The results of our study were consistent with the results of the previous study. These results suggested that the length imbalance caused by the contraction and extension of the respiratory synergist muscles affected the length–tension relationship of the muscles, and that the FVC decreased in the forward head posture due to the tension and weakness of the muscles.

Koh et al.[14] investigated the activities of the sternocleidomastoid muscle and the scalene muscle by measuring the maximum voluntary muscular contraction of the two muscles based on the head posture and breathing patterns in 17 subjects. They found that the activities of the sternocleidomastoid muscle was 47.12% in the forward head posture and 36.24% in a neutral posture. The activities of the scalene muscle in the forward head posture and the neutral posture were 54.17% and 53.24%, respectively. These results, which showed that the respiratory muscle activities decreased in the forward head posture, contradicted the results of our study in which the activities of the sternocleidomastoid muscle and the scalene muscle increased during breathing (a negative correlation) and increased as the forward head posture became more severe. This inconsistency may be caused by differences in measurements. The previous study measured the maximum voluntary muscular contraction, while we measured the muscle activities during breathing. Overall, the results may indicate that the forward head posture reduces lung capacity, which can lead to decreased movability and function of the diaphragm and inefficient breathing patterns.

Kapreli et al.[11] compared the pulmonary functions of 20 patients with neck pain and 12 healthy people, and found no significant differences in the ratio of FEV in 1 s to FVC, although the FVC was reduced in patients with chronic neck pain. Their results suggested that decreased pulmonary functions were associated with restrictive respiratory disease. Dimitriadis et al.[15] investigated 45 patients with chronic neck pain and healthy people, and found that the respiratory muscles of the patients with chronic neck pain were weaker than the muscles in healthy people. In our study, when the relationship between the CVA and the pulmonary functions was examined, only the CVA showed a positive correlation. As the FVC decreased, the activities of the sternocleidomastoid muscle and the anterior scalene muscle increased (a negative correlation). When Kim et al.[16] compared the pulmonary functions of a forward head posture group and a control (healthy) group, the FVC was 81.95% in the forward head posture group and 93.54% in the control group; this shows that the FVC in the forward head posture group was significantly smaller than in the control group. Janda et al.[17] determined that the forward head posture that is included as part of the upper crossed syndrome was associated with kyphosis and round shoulders. The results of this study showed that the FVC was reduced because of the changes in lung capacity caused by abnormal spinal posture accompanied with the forward head posture.

The results of this study showed that severe forward head posture increased the activities of the sternocleidomastoid muscles and the anterior scalene muscles in breathing and decreased the FVC. According to these results, further development of efficient interventions for managing forward head posture should be based on pulmonary function and the accessory respiratory synergist muscles.

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