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Original Article

The effect of feedback respiratory exercise on muscle activity, craniovertebral angle, and neck disability index of the neck flexors of patients with forward head posture

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Abstract. [Purpose] This study aimed to simultaneously investigate the activities of the sternocleidomastoid muscle and scalenus anterior muscle, which are agonists of neck and breathing accessory muscles, by implementing breathing exercises. [Subjects and Methods] Thirteen subjects were selected for the experimental group, which performed feedback respiratory exercises with McKenzie exercises, and 12 subjects were selected for the control group, which performed McKenzie exercises alone. The intervention program was performed for 30 minutes a session, once a day, four times a week, and for 2 weeks before conducting the experiment. Before intervention, muscle activity was measured using surface electromyogram, and the neck disability index was evaluated. [Results] There were meaningful differences in activities of the sternocleidomastoid muscle and the scalenus anterior muscle, craniovertebral angle, and neck disability index within both the experimental group and control group after intervention. There also were meaningful differences in sternocleidomastoid muscle and neck disability index changes between groups. [Conclusion] Neck flexors as accessory respiratory muscle can affect inefficient respiratory imbalance of forward head posture patients. Multimodal intervention method should be studied continually and not be exposed to upper chest breathing patterns by preventing such phenomenon.
Key words: Feedback respiratory exercise, Forward head posture, Neck disability index

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INTRODUCTION

The number of people who use imaging equipment in a fixed posture for long hours is increasing in modern society. The typical posture of such people is forward head posture (FHP)[1)]. FHP means that head is anterior to an imaginary vertical line on a horizontal plane penetrating the body's center of mass[2)]. Such posture is largely associated with muscle length and changes in muscle strength as well as weakness of deep cervical flexors, tightness of the suboccipital muscle, and abnormal sternocleidomastoid (SCM) and scalene muscle function[3)]. The cervical curve interacts with thoracic vertebrae and lumbar vertebrae. Increased kyphosis of lumbar vertebrae correlates with FHP, and when lumbar vertebrae flex, extension of cervical vertebrae increases[4)]. SCM and scalene neck flexors play a role in neck posture function and also act as accessory inspiratory muscles. During inspiratory respiration, they act on the chest wall to affect breathing movement, causing cranial displacement[5)]. Thus, SCM and scalene muscles are associated with functional neck movement and respiration. Because respiration correlates with neck pain, preventing compensation is necessary to not cause improper contraction and to exercise effectively[6)]. Neck pain occurs when FHP decreases neck muscle strength, and FHP also decreases respiratory muscle strength.

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Such correlation means motor control injury of cervical part. If McKenzie exercises are conducted to recover function that was weakened by neck postural changes, they will help relieve symptoms by correcting posture. Feedback respiratory exercises can help inhibit use of accessory muscles by adding visual factors that prevent compensation during breathing because FHP correlates with disability of respiratory function. Therefore, this study aims to implement respiratory exercise in patients suffering from FHP and to investigate the muscle activities of SCM and scalene muscles, which are agonists of neck and breathing accessory muscles. This study also aimed to suggest intervention methods to be used in the clinic by analyzing the neck disability index (NDI).

SUBJECTS AND METHODS

This study included 24 patients who visited a medical institution located in Jeollanamdo, South Korea from September 2015 to January 2016. Patients were between the ages of 25 and 40 years old, and they were diagnosed FHP anterior positioning over 5 cm from the vertical line passing through the acromion and the external auditory meatus[7]. This study excluded patients who had congenial deformities in the neck and thoracic cage, limited knee flexion, or pain during contraction of the abdominal muscles (Table 1).

This study was approved by the Bioethics Committee of Sehan University Center (IRB) (Approval number: 2015-13). Study subjects understood the purpose of this study very well and agreed to participate in this study voluntarily, and written informed consent was obtained from each subject.

Thirteen subjects were selected to undergo feedback respiratory exercise as the experimental group, and 12 subjects were selected to undergo McKenzie exercises as the control group. The intervention program was conducted for 30 minutes a session, once a day, four times a week, and for two weeks. The percent maximum voluntary isometric contraction (%MVIC) was measured by surface electromyogram (sEMG), and neck disability index (NDI) was measured using the NDI evaluation form prior to intervention. These measurements were obtained again and analyzed two weeks later.

The Surface EMG MP100 system (Biopac, USA) was used to collect sEMG data to investigate SCM and scalene activities. The sampling rate for sEMG signal collection was set to 1,000 Hz, and the frequency band pass filter was set to 20–450 Hz. Electrodes were attached to each muscle, and before attaching electrodes, the skin of each subject was swabbed with alcohol-soaked cotton to minimize resistance. Electrodes were attached at regular 2-cm intervals. Electrodes were also attached to the midpoint between the mastoid process and clavicle along the SCM muscle. The anterior scalene electrode was attached parallel to the direction of the muscle fiber of the anterior upper trapezius away from the SCM muscle[5]. To normalize the signal for muscle contraction, the root mean square (RMS) was collected while subjects lifted their heads maximally and maintained the position for 5 seconds. While resistance was applied to the head in a sitting position for 5 seconds, the RMS of maximum voluntary isometric contraction was collected. The %MVIC was assessed using these results. The RMS for seconds 2–4 was used for all RMS signals. All measurements were repeated three times, and the average values were calculated. Subjects rested after every measurement.

The craniovertebral angle (CVA) is the angle formed by the line connecting the seventh cervical vertebra and tragus and a horizontal line. Subjects with FHP have a smaller CVA and show increased flexion of lower cervical vertebrae[8].

The neck disability index (NDI) was assessed via a questionnaire. Subjects answered one of six questions related to 10 items, including pain intensity, daily life, lifting, reading, headache, concentration level, work, driving, sleep, and leisure life, that were scored 0–5 points. Higher scores indicate larger functional disability related to neck abnormality[9].

Feedback respiratory exercises were performed using SPIROTIGER® (Idiag AG, Switzerland). Subjects sat down with stretched bodies and held a mouthpiece in their mouth. When the therapist pressed the start button of the coupling device, subjects inhaled when the orange gradation faced the "in" side, and they exhaled when it faced the "out" side. Feedback respiratory exercises were performed for 30 minutes and were composed of warming up and main exercises. Warming up was

Table 1. General subject characteristics

Variables	Experimental group (n=13) M ± SD	Control group (n=11) M ± SD
Age (years)	34.3 ± 4.8	32.2 ± 3.9
Height (cm)	169.4 ± 6.4	168.1 ± 5.8
Weight (kg)	65.8 ± 5.8	67.1 ± 6.9
SCM (%)	40.3 ± 4.8	38.8 ± 5.1
Scalenus-A (%)	47.2 ± 5.2	44.9 ± 6.3
CVA (°)	47.3 ± 3.1	46.8 ± 2.8
NDI (points)	17.6 ± 1.8	17.1 ± 1.5

Shapiro-Wilk.
SCM: sternocleidomastoid muscle; scalenus-A: Scalenus anterior; CVA: craniovertebral angle; NDI: neck disability index

performed for 2 minutes by breathing 26–27 times a minute and then resting for 2 minutes. The main exercise consisted of 7 total sets of 29–30 breaths per minute for two minutes. After performing 1 set, subjects rested for 2 minutes[10].

McKenzie exercises consist of seven exercise motions performed for 10 seconds at static maximum muscle strength and repeated 15–20 times. Enough explanation and demonstration were given for subjects to perform the exact exercises, and they were supervised by a researcher[11].

This study used SPSS 18.0 to analyze data, and the Shapiro-Wilk test was used to test the normality of general subject characteristics. Paired t-tests were used to analyze changes within groups, and the covariance was set using examination before performing the experiment to control for examination values when comparing changes between groups. An ANCOVA was performed using examination values between groups after performing the experiment. The significance level was set as p=0.05.

RESULTS

There were significant differences in SCM muscle and scalenus muscle activities, CVA, and NDI within both the experimental group and control group after intervention (p<0.05, p<0.01, and p<0.001, respectively). There were also significant differences in changes in SCM and NDI between groups after intervention (p<0.05 and p<0.01, respectively; Table 2).

DISCUSSION

Weakness of neck flexors appeared clearly for subjects with FHP. This cannot be ignored because excessive SCM activation compensates for this weakness[12]. Terret et al.[13] reported excessive SCM activation in their study, and Koh and Jung[14] investigated %MVIC of SCM and scalene muscles in FHP and neutral position in their study. Both muscles showed higher muscle activities when subjects were in FHP than when they were in the neutral position. Such long-term activation can elicit poor respiratory habits by facilitating the action of accessory respiratory muscles. Borisut et al.[15] reported that SCM, anterior scalene, and erector spine muscle activities increased in all groups except for the control group as a consequence of mediating extensional movement and endurance exercise for 12 weeks for 25 patients with chronic neck pain. They showed that conducting neck exercises is useful to improve the activities of muscles around the neck. Jang[16] suggested that running while performing breathing exercises is effective in improving function for patients with FHP. This study suggested that SCM and anterior scalene activities increased in both groups when comparing the changes within groups. However, feedback respiratory exercises more effectively induced activity changes in the SCM when comparing changes between 1groups. Excessive tension and contraction of neck muscles happens by compensation for patients with FHP. This leads to decreased frequency of contraction and relaxation of muscles as muscle activities due to stiffness of neck flexors increase. However, inhibition of compensation is effective if a proper load is applied during inhalation and exhalation using feedback respiratory exercises. It is more effective to prevent stiffness by activating SCM contraction and relaxation. FHP causes twisting of the alignment from the head to the trunk by increasing kyphosis of the thoracic vertebrae as well as the neck bone. Neck posture alignment to maintain balance of the neck muscles is important to prevent musculoskeletal disorders[1]. Jung[11] analyzed CVA by mediating McKenzie exercises 4 days a week for 4 weeks in patients with chronic neck pain, and CVA increased in those patients. Kim et al.[17] mediated sling exercises for 4 weeks for patients with FHP to reveal a meaningful difference in CVA, and there was a correlation with neck muscle activity. This study supported the results of the previous research within groups, but there was no significant result between groups. Cho[18] reported that CVA increased meaningfully when applying orthotherapy along with accessory muscle breathing exercises in 18 patients with FHP. Kang[19] mediated flexion

Table 2. Comparison of muscle activity changes, CVA, and NDI within group and between groups

Variables	Group	Pre-test M ± SD	Post-test M ± SD	
SCM (%)	Experimental group	40.3 ± 4.8	59.8 ± 4.1***	**
	Control group	38.8 ± 5.1	49.2 ± 4.4*	
Scalenus-A (%)	Experimental group	47.2 ± 5.2	56.2 ± 5.3*	
	Control group	44.9 ± 6.3	51.3 ± 4.8*	
CVA (°)	Experimental group	47.3 ± 3.1	55.1 ± 2.5*	
	Control group	46.8 ± 2.8	52.5 ± 3.4*	
NDI (points)	Experimental group	17.6 ± 1.8	12.3 ± 1.1**	*
	Control group	17.1 ± 1.5	14.9 ± 1.1*	

Paired t-test, ANCOVA.
SCM: Sternocleidomastoid muscle; Scalenus-A: Scalenus anterior muscle; CVA: Craniovertebral angle; NDI: Neck disability index.
*p<0.05, **p<0.01, ***p<0.001

exercises for deep neck flexor muscles using feedback equipment for 10 minutes a day, three times a week, for 6 weeks. As a result, the range of motion and CVA increased. This was inconsistent with the results of this research. This could be because advanced research targeted selective respiratory accessory muscles, and the period of mediation was longer than that of this study by over 6 weeks. Gong[20] reported that CVA positively correlates with NDI as a consequence of performing correlation analysis between CVA, the range of motion of deep neck flexors, and NDI using data from 24 normal people. Iqbal[9] showed improvement of NDI after mediating neck flexion exercises using biofeedback equipment for 4 weeks for 30 teachers complaining of neck pain. This study showed that NDI was more effective in the experimental group. Katayama et al.[21] reported that proper breathing can release the body by stimulating activity of the sympathetic nervous system, and Kim et al.[22] reported that neck pain and NDI improved after mediating active release techniques for 3 weeks for 24 patients with chronic neck pain. based on these studies, when breathing exercises are mediated, they are effective in releasing the body. Exercises are thought to effectively improve the NDI, which is a subjective functional scale. This study suggests that is more efficient in SCM activity, neck flexor, and NDI by mediating feedback respiratory exercise than those in control group. Such results can affect inefficient breathing imbalances of patients with FHP, as neck flexors are accessory respiratory muscles. Active intervention methods should be studied continually in order to not affect upper chest breathing patterns by preventing such phenomenon in future.

This study limited subjects to patients with FHP within one medical institution. Therefore, the ability to generalize about all patients with FHP is limited, and other variables may exist due to the difficulty of controlling drugs and daily life habits.

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