



Original Article

The effects of inspiratory diaphragm breathing exercise and expiratory pursed-lip breathing exercise on chronic stroke patients' respiratory muscle activation

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Abstract. [Purpose] The purpose of this study is to examine the effects of inspiratory diaphragm breathing exercise and expiratory pursed-lip breathing exercise on chronic stroke patients' respiratory muscle activation. [Subjects and Methods] All experimental subjects performed exercises five times per week for four weeks. Thirty chronic stroke patients were randomly assign to an experimental group of 15 patients and a control group of 15 patients. The experimental group underwent exercises consisting of basic exercise treatment for 15 minutes and inspiratory diaphragm breathing exercise and expiratory pursed-lip breathing exercise for 15 minutes and the control group underwent exercises consisting of basic exercise treatment for 15 minutes and auto-med exercise for 15 minutes. The activation levels of respiratory muscles were measured before and after the experiment using MP 150WSW to obtain the results of the experiment. [Results] In the present study, when the pulmonary functions of the experimental group and the control group before and after the experiment were compared, whereas the experimental group showed significant differences in all sections. In the verification of intergroup differences between the experimental group and the control group before and after the experiment. [Conclusion] The respiratory rehabilitation exercise is considered to be capable of inducing positive effects on stroke patients' respiratory muscles through diaphragm breathing exercise and lip puckering breathing exercise.

Key words: Strokes, Diaphragm breathing exercise, Pursed-lip respiratory exercise

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INTRODUCTION

Stroke patients' respiratory functions are directly/indirectly affected by declines in the oxygen transport related cardiovascular system functions and heart beat functions and decreases in paretic side breast wall movements and electrical activities¹⁾ and the cardiovascular system functions decline remarkably due to reduction on the frequency of physical activities²⁾. Therefore, respiratory efficiency and changes in respiratory mechanism of patients reflect damage and asymmetry of thoracic wall movement and muscular paralysis. In order to resolve these problems, chest wall expansion and ventilation and pulmonary volume and capacity should be appropriately maintained³⁾ and evaluation of functional ability of the lungs through precise measurement of pulmonary functions, and diagnosis, prognosis, and degree of a disease may be made to obtain the ground for exercise prescription⁴⁾.

In the case of stroke patients, direct/indirect changes in muscle strength appear to obstruct daily living activities and asym-

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metric postures or movement forms appear to hamper the stability of the performance of motions making the performance of elaborate limb functions difficult. Such muscular weakening appears not only in limb muscles but also in muscles distributed in the trunk to affect respiratory muscles and accessory respiratory muscle among trunk muscles⁵). Since respiratory muscle weakening causes difficulties in breathing and declines in the ability to perform movements, therapeutic interventions that can improve respiratory muscle functions thereby relieving severely labored breathing and enhancing motion resistance such as ventilatory muscle training are required⁶).

When stroke patients performed muscle strength exercise along with aerobic exercise, significant increases in functional muscle strength were reported⁷). McCool and Tzelepis⁸) advised that when initial stroke patients performed exercise at sufficient intensity to increase muscle strength, respiratory muscle strength and endurance increased so that eventual improvement in respiratory functions could be expected. In addition, it was reported that when intervention methods for respiratory muscles were compared in inspiratory muscle weakening patients, inspiratory resistance exercise was shown to be more effective for muscle strengthening than 6 minutes walking or endurance exercise⁹). In addition, a study examined the effects of feedback respiratory equipment exercise on the endurance and quality of life of chronic obstructive lung disease patients¹⁰). Stroke patients increased muscle strength and improved postural stability through direct function strengthening training in a study¹¹), and Dietz¹²) reported that stroke patients improved muscle strength and coordination through large-scale resistance exercise using PNF.

Based on these various theoretical grounds, this study is intended to examine the effects of inspiratory diaphragm breathing exercise and expiratory pursed-lip breathing exercise of hemiplegia stroke patients manually implemented by therapists on the activation of stroke patients' paretic side respiratory muscles.

SUBJECTS AND METHODS

This study was conducted in K Hospital located in Daegu Metropolitan City from September 1 to September 30, 2016. The subjects of this study were 30 stroke patients who were diagnosed with a stroke 6 months or longer before through computed tomography or magnetic resonance, and they were randomly and equally assigned to an experimental group and a control group. All the subjects sufficiently listened to explanation on this study and consented to participate in the experiment. The criteria for inclusion were: those who did not have a history of pulmonary disease prior to the onset of a stroke, who did not have a damage accompanying orthopedic disease such as congenital thoracic deformation or rib fracture, who did not receive special treatment for pulmonary function improvement, who were able to walk independently, who did not receive drug therapy for the alleviation of stiffness, and whose mini mental state examination-Korean version score was 24 or higher so that they could understand and follow what the researcher instructed. This study was approved by the University institutional review board and was conducted in accordance with the ethical standards of the Declaration of Helsinki. The general characteristics of the both groups are schematized in Table 1.

The experiment was conducted five times per week for four weeks. Both groups received ordinary physical therapy for 15 minutes consisting of joint mobilization exercise, muscular strengthening exercise, and extension exercise. Thereafter, the experimental group underwent breathing exercise that combined inspiratory diaphragm breathing exercise and expiratory pursed-lip breathing exercise for 15 minutes. First, inspiratory diaphragm breathing exercise was implemented. To implement this exercise, the therapist placed his/her hands on the superior rectus abdominis immediately below the anterior costal cartilage and induced inspiratory diaphragm breathing by instructing the patient to slowly and deeply inhale the air through the nose. When the rectus abdominis of the subject was raised, the experimenter applied appropriate resistance to the superior rectus abdominis to induce deep inspiration¹³). Immediately after completion of the inspiratory diaphragm breathing, the patient was instructed to perform expiratory pursed-lip breathing exercise by continuously exhale the air for a certain time using adjusted deep expiration while puckering the lips^{14, 15}). When a patient complained about fatigue or dizziness during breathing exercise, the patient took a rest and conducted breathing exercise again. The control group after receiving ordinary physical therapy comprised of joint mobilization exercise, muscle strengthening exercise, and extension exercise for 15 minutes performed auto-med exercise (RECK-Technik GmbH & Co., Betzenweiler, Germany) that did not affect breathing exercise at an intensity of no more than 20% of heart rate reserve for 15 minutes¹⁶).

Table 1. General participant characteristics

	EG (n=15)	CG (n=15)
Gender (male/female)	7/8	8/7
Age (years)	63.6 ± 3.7	66.5 ± 8.1
Height (cm)	163.3 ± 6.2	166.1 ± 8.1
Weight (kg)	67.2 ± 5.7	62.6 ± 6.2
Paretic side (right/left)	7/8	9/6
Onset duration (months)	9.1 ± 6.8	10.3 ± 3.1

Values are means ± SD, EG: exercise group; CG: control group

As measurement equipment for the experiment, MP 150WSW (Biopac System Inc., CA, USA) was used. For electromyographic measurement, while a patient in a sitting position was breathing deeply, data filtering and other signal processing were made using ACqknowledge 3.8.1 software on a personal computer. Surface electrodes were attached to the lateral middle area of the acromion from the seventh cervical vertebra on the upper trapezius (UT), the inferior angle of the scapula from the tenth thoracic vertebra on the latissimus dorsi (LD), 1 cm area upward from the 2 cm side from the center of the navel on the rectus abdominis (RA), the lowest area of the thorax on the external abdominal oblique (EAO), and 1 cm medial area in the central part from the anterior superior iliac spine on the internal abdominal oblique (IAO). The reference electrode was attached to the spinous process of the seventh cervical vertebra¹⁷). An EMG surface electrode Ag/AgCl (Biopac, diameter 2 cm) was attached on the muscle belly where muscles developed most after measurement errors were eliminated and medical alcohol was used to clean the area⁷).

For electrode analysis of respiratory muscles, muscle contraction of specific motions was assumed as reference voluntary contraction (RVC) and based on this, standardization was made (%RVC method)¹⁸) and electrode values on the effect of respiratory training were observed using integrated EMG¹⁹). In order to minimize differences between individuals and areas within each individual and observe overall trends, normalization process is needed²⁰). Therefore, the subjects' muscle activity during deep respiration prior to and after the experiment was measured and the entire area of each muscle was calculated and the average value was set at 100% and then muscle activity in accordance with the experimental period was normalized. As for measurement time, motions for 5 seconds were conducted three times in order to obtain average values among 5-second measured time and in order to measure average activity, average values of the middle three seconds excluding the first second and the last second were obtained²¹). Sampling rates of electrode signals were set at 1,024 Hz. In order to remove noise from the measured EMG signals, raw data were band pass filtered at 10–20 Hz and smoothing filtered at RMS 20 ms through rectification. EMG signals were analyzed using MyoResearch program after measuring changes in muscle activity and collecting EMG signals²²).

Data of this study were analyzed using SPSS win 16.0 program. Paired sample t-tests were conducted to compare the respiratory muscle activity levels of the experimental group and the control group before and after the experiment conducted through diaphragm breathing exercise and pursed-lip breathing exercise and independent t-tests were used to compare differences between before and after the experiment in the experimental group and the control group. A statistical significance level was set at $\alpha=0.05$.

RESULTS

When the paretic side respiratory muscle activity levels of the experimental group and the control group before and after the experiment were compared, whereas the experimental group showed significant differences in all sections ($p<0.05$), the control group showed no significant difference in any section ($p>0.05$). In the verification of intergroup differences between the experimental group and the control group before and after the experiment, whereas the paretic side UT, LD, RA, and IAO showed significant differences ($p<0.05$), the paretic side EAO showed no significant difference ($p>0.05$) (Table 2).

DISCUSSION

In this study, changes in the activity levels of paretic side respiratory muscles between before and after exercise were examined through training for four weeks of an experimental group that underwent inspiratory diaphragm breathing exercise and expiratory pursed-lip breathing exercise and a control group. In this study, when the activity levels of paretic side respiratory muscles before and experiment were compared, the experimental group showed relatively more significant increases in efficiency in all muscles than the control group. These results are considered attributable to the therapist's manual resistance directly applied during the subject's inspiration that increased the activity of diaphragm muscles while increasing the activity of abdominal respiratory muscles and the patient's expiratory pursed-lip resistance exercise that increased pressure in the

Table 2. Comparison of RVC of experimental group and control group

	EG (n=15)		CG (n=15)	
	Pre-test	Post-test	Pre-test	Post-test
UT (%)	100.0 ± 0.0	143.1 ± 3.6 ^{*a}	100.0 ± 0.0	104.2 ± 13.1
LD (%)	100.0 ± 0.0	135.1 ± 4.4 ^{*a}	100.0 ± 0.0	101.3 ± 3.8
RA (%)	100.0 ± 0.0	139.8 ± 9.5 ^{*a}	100.0 ± 0.0	107.5 ± 9.1
EAO (%)	100.0 ± 0.0	122.4 ± 5.1 [*]	100.0 ± 0.0	100.9 ± 7.5
IAO (%)	100.0 ± 0.0	128.1 ± 7.4 ^{*a}	100.0 ± 0.0	102.4 ± 9.2

Mean ± SD, ^{*}significant difference from pre-test at <0.05 . ^asignificant difference in gains between two groups at $p<0.05$, UT: upper trapezius, LD: latissimus dorsi, RA: rectus abdominis, EAO: external abdominal oblique, IAO: internal abdominal oblique

abdomen leading to drastic increases in lung ventilation that had been reduced and improved the expansive motility of the breast wall leading to increases in the activity of respiratory muscles.

Park et al.²³⁾ implemented respiratory muscle strengthening programs with cerebral palsy children to find significant increases in the activity of the rectus abdominis and Kim²⁴⁾ found improvement instability and abdominal muscle development after cerebral palsy children's respiratory muscle control training which increased the activity of the abdominal muscles in the trunk. In addition, Jo²⁵⁾ implemented cerebral palsy children's postural control exercise programs to find significant differences in the activity of the left and right trapezius muscle, the left and right latissimus dorsi muscles, and the left and right rectus abdominis muscles. De Andra et al.²⁶⁾ reported that when they measured the muscle activity of COPD patients through breathing exercise, the activity of the trapezius muscle showed significant increases. Zupan et al.²⁷⁾ reported that the activity of the abdominal muscles of quadriplegia patients was improved through respiratory muscle training. Jang²⁸⁾ reported that normal persons' breathing ability strengthening exercise showed effects on the activation of the left and right trapezius muscle and the sternocleidomastoid muscle although the effects were not significant. Saleem et al.²⁹⁾ suggested an effect on aerobic muscular strength by improving aerobic capacity in aerobic muscle strengthening training for patients with idiopathic Parkinson's disease for 4 weeks. Kim et al.³⁰⁾ implemented abdominal breathing exercise with low back pain patients and found significant increases in the activity of the oblique muscle of abdomen. Although previous studies did not implement inspiratory diaphragm breathing exercise and expiratory pursed-lip breathing exercise simultaneously with stroke patients as with this study, the results of those studies that implemented diverse breathing exercises are consistent with the results of this study.

The results of this study are thought to be good enough to be suggested as new breathing physical therapy intervention methods and the development of new breathing exercise that can be popularized as breathing exercise programs is considered necessary.

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