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Impact of Cervical Stabilization Exercises and Breathing Retraining Impact on the Respiratory Function of Elderly Stroke Patients with Hemiplegia: a Randomized Control Trial

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Abstract

This study investigated the effects of cervical stabilization and breathing retraining exercises to improve respiratory function in elderly stroke patients.Forty-five subjects were randomly allocated to three groups (each group, n=15). The exercise was performed five times a week for 6 weeks after general characteristics were confirmed. Experimental group1 performed cervical stabilization and respiratory breathing retraining exercises for 30minute in addition to conventional exercises. Experimental group2 performed respiratory breathing retraining exercises in addition to conventional exercises, and the control group performed self-respiration exercises for 30 min. An experienced physiotherapist provided a demonstration before the patients were assessed, and then the subjects were instructed to breathe only with their mouth in a sitting position with their pelvic joints and knee joints naturally flexed. Forced vital capacity (FVC) was measured to check for restrictive lung disease, and forced expiratory volume at one second (FEC1) was measured to check for obstructive lung disease. In a comparison of groups, there were significant differences in FVC not only between experimental group 1 and the control group but also between experimental group 2 and the control group. The cervical stabilization and respiratory breathing retraining exercises were more effective for FVC than the self-respiration exercises.This result may represent improvement in overall respiratory function and show that cervical stabilization and respiratory breathing retraining exercises are helpful for improving activities of daily living and motor function by increasing respiratory function in stroke patients.

Keywords: *Cervical stabilization exercise, breathing exercise, stroke hemiplegia patients*

1. Introduction

The increasing population of older individuals is emerging as a serious issue across the world, and the onset rate of chronic disease is also increasing. In many advanced countries, the aged population accounts for more than 10% of the total population. In South Korea, in 2000 the older population exceeded 7% of the total population. In 2006, the 65 years or older population accounted for 9.5% of the total population, and is expected to increase to more than 14% by 2019, making South Korea an aging society [1].Since the physical and mental problems of the older population are in the spotlight, providing rehabilitation treatment for older people who have mobility limitations is most important for improving functional disorders. When quality of life is evaluated, physical, functional, mental, and social wellness is considered. Symptoms related to health are

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mainly surveyed for the physical aspect, the performance of activities of daily living for the functional aspect, cognitive function, satisfactory emotional condition, general perception of happiness for mental health, and social contact and interaction for social health[2].

Regarding daily living and physical functions of the older population, they experience restriction in activities when they have a brain disease, and stroke is a representative brain disease. Stroke, a chronic disease, is a neurological deficit resulting from the loss of blood supply due to infarction or hemorrhage in brain that may lead to functional disability. Furthermore, stroke is the main cause of death in the adult population over 40 years old, and even survivors suffer from decreased quality of life caused by impediments of physical function and activities of daily living[3, 4].The importance of rehabilitation for elderly stroke patients has increased, and the difficulty and type of exercise for rehabilitation is influenced by age. The exercise program must be based on age and treatment period because the difficulty and type of exercise have a significant effect on physical function after rehabilitation[5].

Elderly stroke patients suffer from limited physical activities caused by the impairment of motor and sensory function especially in cognition, loss of sensory, and mobility and perception[6]. The main challenge for stroke patients is that social, psychological, and physical impediments last the rest of their lifetime, and 25–30% of patients suffer from severe motor deficits[7]. The impairment of the motor cortex and the pyramidal tract caused by a stroke leads to hemiplegic symptoms, and abnormal muscle tone and abnormal voluntary movements lead to movement disorders and co-contraction of the trunk muscles. This abnormality has a negative effect on the coordination of respiratory muscles and motor performance[8].In addition, motor function in the affected side decreases due to muscle weakness, loss of movement, and coordination, which results in limited activities of daily living[9]. Recovering physical function, the most difficult treatment, significantly influences an individual’s physical and psychological function and well-being[10]. The recovery of respiratory function is very important, and trunk movement and electrical activation around the affected side have direct and indirect effects on respiratory function[11].

Studies have reported that 40% of stroke patients who had respiratory disorder showed decreased electrical activation, and 50% had lower forced vital capacity (FVC), forced expiratory volume at one second (FEV1), and peak expiratory flow (PEF) levels than normal adults. Furthermore, oxygen saturation in arteries and the respiration pattern changed; thus, stroke patients show fatigue quickly in the inspiration muscles and have a higher rate of respiratory complications[12].The weakness of respiratory function in stroke patients is important, and accurate measurements of respiratory function make it possible to plan a treatment program by assessing a patient’s functional ability, diagnosing the disease, and investigating the prognosis and degree of disease[13].

During respiration, air is exchanged between the inner and outer sides of the lung, according to the capacity change of the trunk. There are two types of respiratory muscle, inspiration and expiration. The agonistic inspiration muscles are the diaphragm and the lateral intercostalis, which are recruited for tidal breathing, and associated muscles are the sternocleidomastoid muscle, scalene, trapezius, and pectoralis muscles, serratus anterior, which act during deep, forced, and labored breathing. Muscles related to expiration are the rectus abdominis, transverse abdominis, lateral/medial oblique muscles, and medial intercostralis, which are activated during deep and forced breathing[14].

Researchers have reported that diverse exercises such as strengthening, thoracic expansion exercises, and aerobic exercise can improve respiratory function. In addition, recently, stroke patients with lung symptoms improved lung function by increasing respiration similar to other lung diseases; improved respiration function is necessary for stroke patients to perform independent activities of daily living[15, 16].Although many studies about aerobic and strengthening exercises related to respiration function have been conducted and respiratory function comprises an important part of independent activities of daily living of stroke patients, studies on breathing retraining and stabilization exercises for the cervical region are lacking. Thus, the purpose of this study was to investigate the effects of cervical stabilization and breathing retraining exercises to improve respiratory function in stroke patients.

2. Methods

2. 1. Participants

This study investigated patients with hemiplegia who were diagnosed with a stroke using computed tomography (CT) or magnetic resonance imaging (MRI) at a university hospital in D city. Before this study began, the institutional review board (IRB) of the hospital approved the study. The purpose of this study was demonstrated to the subjects, and informed consent was given. Subjects who had symptoms such as orthopedic disorders in the trunk, cervical and respiration disorders, and lung disease were excluded from this study. Forty-five subjects who had good coordination and scored higher than 24 points on the MMSE-K participated in this experiment.

2. 2.Experimental Design

In this study, all subjects were randomly allocated to three groups: experimental group 1 (15), experimental group 2 (15), and the control group (15). The participants performed the exercises five times a week for 6 weeks after general characteristics were confirmed. This study was performed randomly assign a number ticket to participants. Participants were divided into three groups according to the specified number. Participants are chosen according to the number 1 was assigned to the experimental groups 1. In the same way, 2 is a experimental groups 2 and 3 is a control group.All subjects performed conventional exercises consisting of range of motion (ROM), stretching, strengthening, and balance exercises and gait training for 30 min in each session.Experimental group 1 performed cervical stabilization and respiratory breathing retrainingexercises for 30 min in addition to the conventional exercises. Experimental group2 performed respiratory breathing retraining exercises in addition to the conventional exercises, and the control group performed self-respiration exercises for 30 min after the group received instructions from the physiotherapist. Assessments were conducted before and after the intervention for statistical analysis.

2. 3. Intervention

Cervical stabilization exercises strengthen the longus capitis and the longus coli, which are deep flexor muscles in the cervical region[17]. Head/cervical flexion is performed and maintained by the sternocleidomastoid and anterior scalene muscle, superficial flexor muscles that stretch. The cervical curvature was confirmed as flat using visual feedback from a pressure sensor that was filled with air and placed on the back of cervical region near the occipital groove. First, the pressure of air bag on back of the cervical region was set at 20 ㎜ Hg, and the bag was pressed slowly. At the same time, the therapist palpated the sternocleidomastoid and anterior scalene muscles to ascertain they were not contracted. Then, the pressure of the air bag smoothly increased by 2 ㎜ Hg until 30 ㎜ Hg. The contraction was maintained for 5sec and repeated five times. A 3- to 5-sec break was provided between contractions.

The breathing retraining exercises consisted of diaphragm resistance exercises during inspiration and pursed-lip breathing exercises during expiration[18]. The subjects were instructed to place one hand on the middle of the sternum and the other hand on the abdomen in the supine position with the shoulder and trunk muscles relaxed. The subjects were then instructed to forward the hand on abdomen during inspiration and to feel the abdomen fall during expiration. However, the other hand on the sternum was not allowed to feel movement. The ratio of inspiration to expiration was 1:2, and the subjects were instructed to breathe out as they inflated a balloon. The instructions were repeated two to three times, and if subjects felt vertigo or dizziness, a rest period was provided.

2. 4. Measurement

Respiration function was assessed using a Cardio Touch 3000S(BIONET). An experienced physiotherapist demonstrated use of the device before the assessment was performed, and then the subjects were instructed to breathe only with their mouth in a sitting position with their pelvic joints and knee joints naturally flexed. FVC was measured to check for restrictive lung disease, and FEV1 was measured to check for obstructive lung disease. In addition, the ratio of expiratory volume to inspiratory volume was used to check for obstructive lung disease, and airway resistance was investigated using the maximal expiratory and inspiratory flow rates.

All measurements were repeated three times, and the largest value was selected for statistical analysis.Micro RPM was used to assess respiratory pressure. The measurement position was the same as the respiratory function assessment, and the breathing retraining method was repeated for subjects to become familiar. Maximal inspiratory pressure (MIP) was measured first, and then maximal expiratory pressure (MEP) was measured. Sufficient resting time was provided between the tests to avoid any possible fatigue.In the MIP measurement, the subjects were instructed to tightly inhale for 2sec as deeply and quickly as they could right after the maximal residual volume. In the MEP measurement, the subjects were instructed to exhale for 2sec as deeply and quickly as they could from the maximal total lung capacity.

2. 5. Statistical Analysis

In this study, SPSS Windows (version 20.0) was used to investigate the subjects' general characteristics. To analyze the difference before and after the intervention, the paired t-test was used after the mean value and the standard deviation were calculated for each group. In addition, one-way ANOVA was also used to investigate the differences among groups. Post-hoc analysis was conducted using least significant differences (LSD), and the significance level was 0.05.

3. Results

The subjects were analyzed using the independent t-test; the results are presented in Table 1.

Table 1. Patient Characteristics (Mean±SD)

	CS+BR(n=15)	BR(n=15)	Control(n=15)	p
	Experimental 1	Experimental 2		
Sex(male/female)	3/12	8/7	5/10	
Age(year)	61.06±9.54	64.26±8.22	65.20±8.59	.411
Height(cm)	161.60±8.84	163.13±7.89	161.93±7.93	.866

Weight(kg)	62.60±9.41	63.33±6.74	62.26±10.38	.946
Duration(month)	31.40±13.64	26.40±12.86	31.66±12.99	.474

*p<0.05, mean±SD : mean±standard deviation; CS : cervical stabilizing group; BR : breathing retraining group.

There were no significant differences among the groups (p>0.05).In each group, there were statistically significant changes in the FVC, FEV1, MIP, and MEP before and after the intervention. That is, each exercise may have had a positive effect on the FVC, FEV1, MIP, and MEP, and provide an effective approach for stroke patients with respiration disorders. However, there was no significant change in FEV1 to FVC ratio (Tables 2)(Tables3)(Tables 4).

Table 2. Comparison of Respiratory Function in the Experimental 1 Group (Mean±SD)

	Pre-test (n=15)	Post-test (n=15)	p
FVC	1.76±0.34	2.68±0.27	.000*
FEV1	1.39±0.27	2.23±0.32	.000*
FEV1/FVC	73.47±2.53	75.07±4.99	.095
MIP	34.53±6.31	50.13±7.24	.000*
MEP	33.27±5.82	47.87±6.73	.000*

*p<0.05, mean±SD : mean±standard deviation; FVC : forced vital capacity; FEV1 : forced expiratory volume at one second; MIP : maximal inspiratory pressure; MEP : maximal expiratory pressure.

Table 3. Comparison of Respiratory Function in the Experimental 2 Group (Mean±SD)

	Pre-test (n=15)	Post-test (n=15)	p
FVC	1.80±0.37	2.49±0.27	.000*
FEV1	1.36±0.25	1.89±0.21	.000*
FEV1/FVC	75.33±6.13	74.87±5.76	.610
MIP	28.13±10.64	44.40±7.59	.000*
MEP	30.40±9.32	42.47±8.39	.000*

*p<0.05, mean±SD : mean±standard deviation; FVC : forced vital capacity; FEV1 : forced expiratory volume at one second; MIP : maximal inspiratory pressure; MEP : maximal expiratory pressure.

Table 4. Comparison of Respiratory Function in the Control Group (Mean±SD)

	Pre-test (n=15)	Post-test (n=15)	p
FVC	1.62±0.31	1.87±0.49	.004*
FEV1	1.31±0.53	1.61±0.55	.000*
FEV1/FVC	75.60±5.62	76.60±9.02	.636
MIP	29.20±11.55	33.53±11.12	.012*
MEP	31.47±5.99	35.00±4.95	.014*

*p<0.05, mean±SD : mean±standard deviation; FVC : forced vital capacity; FEV1 : forced expiratory volume at one second; MIP : maximal inspiratory pressure; MEP : maximal expiratory pressure.

In a comparison of the groups, there were significant differences in the FVC not only between experimental group 1 and the control group but also between experimental group 2 and the control group. This means that the cervical stabilization and breathing retraining exercises were more effective for the FVC of the experimental groups.There were significant differences in FEV1 between experimental groups 1 and 2 as well as between experimental group 1 and the control group. However, there was no significant difference between experimental group 2 and the control group. This result suggests that cervical stabilization exercises accompanied by respiratory breathing retraining exercise are effective for improving the FEV. However, there was no significant difference in the FEV1 to FVC ratio among the groups. In the MEP measurement, there were significant differences between experimental group 1 and the control group as well as between experimental group2 and the control group, which shows cervical stabilization and respiratory breathing retraining exercises can improve MEP. There were statistically significant differences in the MIP between experimental group1 and the control group, between experimental group2 and the control group as well as experimental group1 and experimental group2. These results imply that each exercise may have a positive effect on increasing MIP (Table 5).

Table 5. Comparison of Between Groups (Mean±SD)

		CS+BR (n=15)	BR (n=15)	Control (n=15)	*p*
FVC	Pre	1.76±0.34	1.80±0.37	1.62±0.31	.348
	6weeks	2.68±0.27	2.49±0.27	1.87±0.49	.000*
FEV1	Pre	1.39±0.27	1.36±0.25	1.31±0.53	.847
	6weeks	2.23±0.32	1.89±0.21	1.61±0.55	.000*
FEV1 /FVC	Pre	73.46±2.53	75.33±6.13	75.60±5.62	.455
	6weeks	75.06±4.99	74.86±5.76	76.60±9.02	.750
MIP	Pre	34.53±6.31	28.13±10.64	29.20±11.55	.171
	6weeks	50.13±7.24	44.40±7.59	33.53±11.12	.000*
MEP	Pre	33.26±5.82	30.40±9.32	31.46±5.99	.552
	6weeks	47.86±6.73	42.46±8.39	35.00±4.95	.000*

*$p<0.05$, mean±SD : mean±standard deviation; CS : cervical stabilizing group; BR : breathing retraining group; FVC : forced
vital capacity; FEV1 : forced expiratory volume at one second; MIP : maximal inspiratory pressure; MEP : maximal expiratory pressure.

4. Discussion

The older population is rapidly increasing due to developments in medical science that have extended lifespans, but at the same time, diagnoses of dementia related to older age are increasing. The best quality of life occurs when an individual is satisfied physically, mentally, and socially, and his or her abilities are maximized. Everyone wants to enjoy a healthy old age with a high quality of life, a subject of increased interest at present since the older population is increasing.This study was conducted to find the beneficial effects of breathing exercises on breathing ability for hemiplegic patients with stroke, a medical condition that can lead to dementia, who were divided into a group who applied breathing retraining exercises combined with cervical stabilization exercises (experimental group1), a breathing retraining group (experimental group2), and a control group who performed self-breathing exercises after receiving instruction from the therapist.

Elderly stroke patients often have decreased respiratory function. However, it is easy to overlook because the physical motor deficit caused by hemiplegia is prominent and the change in respiratory function that occurs after stroke may not cause acute respiration disease. Furthermore, stroke causes physical disorders accompanied by decreased flexibility and muscle weakness, and asymmetric breathing is caused by an increase in sensitivity to carbon dioxide and a decrease in voluntary breathing, which can change respiration control[19-21].Since respiration is one of the most important functions for human life, patients' functional ability must be assessed, to diagnose disease and to investigate the prognosis with cardiopulmonary function measurements.Aging can change sensorimotor processing, and the older neuromuscular system is weakened by 40% compared to normal healthy adults[22].Generally, stroke, which occurs in the middle-aged and older population, is a neurological disorder and shows diverse symptoms such as decreased sensorimotor function, perception, cognition, verbal function, and psychological disorder. Moreover, many patients have permanent disability without the recovery of function[23].

The problems of chronic stroke patients include weakness of the cardiovascular system and decreased physical function and respiratory function that decreases gait and activities of daily living[24]. The physical activities and emotional disorder of older hemiplegic patients could not be prevented, but adequate physical activities and exercise combined with regular breathing have been reported to have positive effects on physical as well as emotional functions[25].Thus, in this study, FVC, FEV1, the FEV1 to FVC ratio, MIP, and MEP were used to compare and measure the respiratory function of stroke patients. These measurements are widely used in the clinical setting and have lower variability than other respiratory indices[26]. In this study, there were significant changes in FVC in all groups, and there were also significant differences between experimental group1 and the control group as well as between experimental group2 and the control group after 6 weeks. Although the difference between experimental groups1 and 2 was not significant, experimental group1 increased more than experimental group2.

Patients who have chronic cervical pain have been reported to complain about decreased respiratory function related to postural change such as the forward head posture[27], and another study showed that the FVC was significantly decreased[28]. Based on these studies, the combination of cervical stabilization and respiratory breathing retraining exercises resulted in the improved FVC for experimental group1.In this study, there were significant changes in FEV1 before and after the intervention in all groups. In the comparison between groups, there were significant differences between experimental groups1 and 2 as well as experimental group1 and the control group. However, there was no significant difference between experimental group2 and the control group. This result is in line with the results of a previous study about cardiopulmonary and metabolism that reported maximal and aerobic exercise can improve FEV1 and overall respiratory function[29, 30].

In this study, there was no significant difference in the FEV1 to FVC ratio before and after the intervention in all groups as well as between groups. It is believed that FVC and FEV1 increased along with each other.There was a significant change in MIP after the intervention, and there were also significant differences not only between experimental group1 and the control group but also between experimental group2 and the control group after 6 weeks. Even though there was no significant difference between experimental groups1 and 2, the MIP of experimental group1 increased increase more than that of experimental group2. Since patients with neuromuscular disorder have a relatively normal MIP, MEP is a more sensitive index for respiratory disorder and cough[31]. In this study, there were significant changes in MEP in all groups after the intervention and statistically significant differences in all comparisons between the groups. The increased muscle strength around the cervical region and the trunk resulted from the cervical stabilization exercises, which improved the pressure during inspiration and expiration.In a previous study in which patients with chronic obstructive pulmonary disease (COPD) performed pursed-lip breathing exercises, MIP and MEP were increased significantly, which is in line with the results of this study[32]. In addition, it has also been reported that the MIP and MEP of patients with COPD increased significantly after a respiratory muscle exercise program was applied[33]. Breathing retraining exercises have usually been applied to patients with COPD. However, these exercises were performed by hemiplegic stroke patients in this study[34].

These studies confirmed that as a secondary impairment of stroke, exercise performance ability and activity decreased. Furthermore, respiratory function was also decreased by the decrease in the coordination and strength of respiratory muscles and respiratory function was improved through diverse interventions. In the results of this study, although two groups such as experimental groups1 and2 showed significantly increased respiratory function, experimental group1, who performed cervical stabilization as well as respiratory breathing retraining exercises had more effective results in general than experimental group2.The abnormal arrangement of the cervical region and unstable posture in stroke patients shortens the sternocleidomastoid and anterior scalene muscles, which can result in decreased respiratory function.To resolve these problems, cardiopulmonary physical therapy is necessary. The study results suggest that not only cervical stabilization exercises accompanied by respiratory breathing retraining but also respiratory breathing retraining exercises have a positive effect on improving respiratory function in stroke patients.

The clinical finding of this study must be assessed in further studies. In addition, this study had several limitations. First, the number of subjects was too small to generalize the intervention. Second, it is difficult to investigate the long-term therapeutic effect because the intervention lasted only 6 weeks.To address this problem, intervention of breathing physical therapy is required for older patients with stroke. Breathing retraining exercises combined with the cervical stabilization and breathing retraining exercises were helpful intervention methods for improving the breathing ability of stroke patients.

5. Conclusions

In this study, to investigate the effect of cervical stabilization exercises accompanied by respiratory breathing retraining on respiratory function in stroke patients, 45 subjects were randomly allocated to experimental group1, experimental group2, and the control group.All subjects performed 30-min conventional therapy. Experimental group1 performed additional cervical stabilization exercises accompanied by respiratory breathing retraining, and experimental group2 performed additional respiratory breathing retraining for 30 min.In the results of this study, there were statistically significant differences in all variable items. This result may represent an improvement in overall respiratory function, and cervical stabilization exercises accompanied by respiratory breathing retraining is helpful to improve activities of daily living and motor function by increasing respiratory function in stroke patients. In addition, this intervention is an effective respiratory physical therapy, and further study is needed to increase the clinical application.

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