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Effects of Feedback Respiratory Exercise and Diaphragm Respiratory Exercise on the Pulmonary Functions of Chronic Stroke Patients

This study is to examine the effects of a feedback breathing device exercise and diaphragm breathing exercise on pulmonary functions of chronic strokes patients. The selection of 20 subjects was divided equally and placed into a experiment group and a control group and the intervention was applied four times per a week for five weeks. In each session, both groups received rehabilitative exercise treatment for 30 minutes, and a feedback breathing device exercise for 15 minutes. In addition, experimental group conducted a combination of diaphragm breathing exercise for 15 minutes. Prior to and after the experiment, patients' pulmonary functions were measured using a spirometer. The pulmonary function tests included FVC, FEV1, FEV1/FVC, PEF, VC, TV, IC, ERV, IRV. With respect to changes in the pulmonary functions of both groups, the experimental group significantly differed in FVC, FEV1, TV, ERV but did not in PEF, FEV1/FVC, VC, IRV. The control group did not significantly differ in any of the tests. There were significant differences in FEV1, FEV1/FVC, TV, ERV between the two groups, but no significant differences in FVC, PEF, FEV1/FVC, VC, IRV between them after the experiment. The experimental group, which conducted a combination of a feedback breathing device exercise and diaphragm breathing exercise, saw their respiratory ability increase more significantly than the control group. The breathing exercise was found to improve pulmonary function in chronic stroke patients.

Key words: *Strokes; Feedback Breathing Device Exercise; Diaphragm Breathing Exercise.*

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INTRODUCTION

Stroke patients show respiratory insufficiency due to limited physical activity(1). In particular, the patients' cardiopulmonary functions are directly and indirectly affected due to decreased movement of the chest wall and electrical activity of the paretic side(2). Furthermore, the respiratory muscles, including the diaphragm, are paralyzed so that the lung and the thorax cannot be sufficiently dilated. If this condition persists, the thoracic tissues may be shortened, and the thoracic muscles may undergo fibrosis to reduce the compliance of the thorax. This in turn causes various respiratory system complications, such as atelectasis, changes in muscle force, which may directly and/or indirectly obstruct the performance of daily living activities, and asymmetrical postures or movement forms, which may hamper the stability of motion thereby making the performance of fine extremity functions difficult(3).

This muscle force weakening appears not only in extremity muscles but also in the muscles distributed in the trunk, affecting both the major and accessory respiratory muscles(4). In particular, respiratory muscle weakening affects dyspnea and the ability to perform exercise so that therapeutic interventions, such as ventilatory muscle training, are required to reinforce respiratory muscle functions in order to relieve gasping respiration and improve exercise tolerance(5). Therefore, to solve the problems of declining efficiency in patients' breathing and changes in patients' respiratory mechanisms, chest wall dilation and ventilation and lung capacity and volume need to be appropriately maintained(6), after assessing patients' functional abilities. This is done by accurately measuring their pulmonary function, diagnosing their diseases, and assessing the prognosis and degrees of their diseases to obtain the basis of appropriate exercise prescriptions(7).

Many studies related to breathing exercises have been conducted with a view to reinforcing respiratory function. One of these studies reported that therapy that combines diaphragm breathing and pursed-lip breathing exercises, which are widely performed by chronic obstructive pulmonary disease(COPD) patients, showed larger improvements in patients' respiratory rates and oxygen consumption compared to other exercises(8). Another study reported that pursed-lip breathing exercises performed by COPD patients showed decreases in the last expiratory capacity and the last inspiratory capacity as well as increases in instantaneous ventilation(9). A further study reported that, after respiratory system kinesiotherapy in myotonic muscular dystrophy patients, breathing capacity per session at normal times, oxygen saturation, and instantaneous ventilation increased while respiratory rates and the last expiratory capacity decreased(10).

In a study of breathing exercises for cystic fibrosis patients using breathing apparatus along with expiratory positive pressure treatment, it was reported that increases in lung capacity made air turn the secretions clogging small airways around and help them move(11). A study conducted by McConnell and Romer established that, when normal persons were trained using feedback breathing device, their inspiration significantly increased(12), and Spengler et al reported that vital capacity increased in an experiment with feedback breathing device(13). Later studies aiming to improve stroke patients' respiratory functions have also been conducted. Lee JH. found that significant increases in forced vital capacity and pulmonary functions appeared after breathing training for stroke patients using breathing device(14).

However, in other studies, when stroke patients received direct function reinforcement training, which included muscle force and aerobic exercises, the patients' metabolism levels and functional muscle force significantly increased(15, 16), postural stability improved(17), and coordination was enhanced (18). Based on these theoretical bases, implementing direct respiratory muscle training on stroke patients is effective; however, the reality is that, due to limited treatment time, the treatment of stroke patients is limited to interventions for physical functional recovery or relies on mechanical breathing training, even when breathing training is implemented.

Therefore, the purpose of the present study is to examine the effects of a combination of direct resistant Diaphragm breathing exercise and feedback breathing device exercises for stroke patients' respiratory functions

METHODS

Subjects and Period

This study was conducted in a hospital located in Daegu Metropolitan City, from March 1 to May 31, 2012. The subjects understood the purpose of this study and agreed to participation in it. The subjects of this study were 20 chronic stroke patients who had been diagnosed with stroke by computed tomography or magnetic resonance imaging(MRI), with a duration of at least six months after the onset of their stroke.

The subjects of the study were selected from among patients without any particular history of respiratory disease before the onset of stroke, and without combined injury such as congenital chest deformity, rib fracture, or history of treatment to increase pulmonary function. A further criterion for inclusion was that all subjects had to score 22 points or higher on the MMSE-K to ensure that they were able to understand and follow the researcher's orders. The selection of 20 subjects was divided equally and placed into a experimental group and a control group.

Procedures

Before training, all the patients were identically encouraged to receive conservation physical therapy for 30 minutes by a physical therapist having at least 5 years experience and the experimental group were there after made to train for four times a week for 30 minutes over a period of five weeks with additional tasks.

First, for the feedback breathing device exercise for 15 minutes, a therapist manipulated the device and the start button was pressed. When the scarlet notch was set to "in," the patient breathed in, and when the notch was set to "out," the patient breathed out. What was important here was that when the scarlet pilot lamp indicated "in" or "out," a green light was displayed, and a "bee" sound was heard. Thereafter, the normal feedback breathing exercise was initiated(14). If a patient complained of fatigue or dizziness during the breathing exercise, he or she took a rest before restarting the exercise.

The experimental group conducted a combination of the diaphragm breathing exercise for 15 minutes. For the inspiratory diaphragm breathing exercise, the therapist placed his or her hands on the rectus abdominis muscle, just below the anterior costal cartilage, and induced inspiratory diaphragm breathing so that the patient breathed in slowly and deeply through his or her nose. The therapist then provided the appropriate resistance when the rectus abdominis muscle went up so that the patient could breathed in deeply. When the patient breathed in deeply, he or she maintained his or her shoulders in a relaxed state and did not move the upper chest, thus allowing only an abdominal rise. The patient breathed only his or her nose in air and then pursed lip with adjusted deep breathed out as much air as possible to slowly(8).

Measurement

A CardioTouch 3000S(Bionet, USA) was used as the measuring equipment for the pulmonary function test. Before measuring pulmonary function, the patient was asked to wear a nose clip to prevent nose breathing. The patient then was instructed to put on a mouthpiece and breathed three to five times in the usual manner. While doing so, and upon hearing the starting signal from the respiratory device, the patient was directed to speedy exhale and inhale as much air as possible. The measurement was completed after another two or three regular and complete breaths. For accuracy, the measurements at two group were taken after the researcher had given the patient a thorough explanation and demonstrated the methods of measuring pulmonary function. In each group, voluntary capacity(forced vital capacity(FVC), forced expiratory volume at one second(FEV1), forced expiratory volume at one second/forced vital capacity(FEV1/FVC), peak expiratory flow(PEF), tidal volume(TV), vital capacity(VC), inspiratory reserve volume(IRV), expiratory reserve volume(ERV), and inspiratory capacity(IC))were measured.

Data Analysis

The data obtained from the A CardioTouch 3000S was statistically analyzed using SPSS 12.0 for Microsoft Windows. The change in each group's pulmonary function between before and after the experiment, and the difference between the groups before and after the experiment, were analyzed using the paired comparison t-test and the independent sample t-test, respectively. Significance level was set to .05.

RESULTS

General Characteristics of the Subjects

The general characteristics of the both groups are schematized in Table 1.

Table 1. General characteristics of the subjects

	EG(n=10)	CG(n=10)	p
Sex(male/female)	3/7	6/4	
Age(years)	63.16±2.87	61.53±3.24	.52
Height(㎝)	161.35±2.11	164.57±4.32	.21
Weight(㎏)	60.41±3.22	62.87±6.24	.24
Paretic side (right/left)	4/6	7/3	
Onset duration (months)	4.32±2.43	5.23±1.43	

Mean±SD, $p<.05$
EG: Experimental Group; CG: Control Group

Changes of Pulmonary Functions

In pulmonary functions prior to and after the experiment, the experimental group differed significantly in FVC, FEV1, TV, ERV($p<.05$), but did not in PEF, FEV1/FVC, VC, IRV after the intervention ($p>.05$). The control group did not differ in any of the items($p>.05$).

There were significant differences in FEV1, FEV1/FVC, TV, ERV between the two groups after the experiment($p<.05$), but no differences in FVC, PEF, FEV1/FVC, VC, IRV($p>.05$)(Table 2).

DISCUSSION

Stroke patients show changes in respiratory regulation because increased carbon dioxide sensitivity and decreased voluntary breathing on the paretic side induce asymmetrical breathing(19). These changes in the efficiency of breathing and the respiratory mechanism reflect damage to the movement of the chest wall, asymmetry, and the degree of muscular paralysis. To solve these problems, the chest wall dilation and ventilation and the lung

Table 2. Comparison of pulmonary function measurement of experiment and control groups (unit : ℓ)

	EG		p	CG		p
	Pre-test	Post-test		Pre-test	Post-test	
FVC	1.79±0.19	2.00±0.22	.03*	1.75±0.73	1.81±0.57	.08
FEV_1	1.61±1.03	1.87±0.14[a]	.04*	1.76±1.04	1.80±0.12[a]	.31
PEF	3.48±0.48	3.84±0.33	.35	3.33±0.71	3.45±1.03	.27
FEV_1/FVC	88.66±6.81	91.24±2.64[a]	.33	86.42±5.17	89.10±8.12[a]	.42
TV	0.64±0.15	0.71±0.3[a]	.01*	0.46±0.13	0.52±0.23[a]	.14
VC	3.58±1.18	4.97±1.85	.32	3.25±0.92	3.97±0.16	.09
ERV	1.29±0.24	1.69±0.42[a]	.02*	1.03±0.37	1.51±0.23[a]	.23
IRV	1.90±0.15	2.30±0.24	.11	1.93±0.27	2.01±0.53	.22

Mean±SE,
*significant difference from pre-test at p<.05.
[a]significant difference in gains between two group at p<.05.
EG: Experimental Group; CG: Control Group

capacity and volume need to be appropriately maintained(6).

Many studies have been conducted on breathing exercises with a view to improving the condition of respiratory function weakening caused by diverse diseases. In a study by Scherer et al., after continuous breathing training of COPD patients, significant increases in ventilation, inspiration threshold loads, and expiratory pressure were observed(20), and Sartori et al. reported that forced expiratory volumes for one second in patients with fibrous cysts significantly increased as a result of feedback breathing exercises(21). Liaw et al. demonstrated that, after spinal cord injury patients performed resistant inspiratory muscle strengthening exercises, the experimental group showed a 67% increase in vital capacity(22). In their research, Van Houtte et al. found that, after performing exercises with gradually increasing expiratory loads, spinal cord injury patients showed a 34% increase in their vital capacity(23), while Estenne et al. described how, after performing pectoralis major muscle strengthening exercises, quadriplegia patients showed increases in expiratory reserve volumes of 47%(24). Jones et al. established that the TV of COPD patients increased through diaphragm breathing exercises(8), and another study determined that the last expiratory volumes and instantaneous ventilation of COPD patients increased through pursed-lip breathing exercises(24).

Although there has not been as much research regarding training methods for stroke patients, a study by Lee JH. reported that, for pulmonary rehabilitation to be effective(14), it should be performed for 20-30 minutes per session, 2-5 times per week for 4-12 weeks(24).

Therefore, in this study, stroke patients were divided into an experimental group that used feedback breathing device exercise together with diaphragm breathing exercises, and a control group that received only general physical therapy. The patients performed the training and exercises four times a week for five weeks, and changes in the patients' pulmonary functions between, before, and after the training and exercises were measured.

When pulmonary functions before and after the experiment were compared, the experimental group showed relatively improvements compared to the control group in all sections, and in particular, showed significantly greater increases in FVC, FEV1, TV, and ERV. Given these results, it is considered that the feedback breathing equipment training induced forced breathing by using certain mechanical signals to reinforce the respiratory muscle at constant intervals and intensity. Furthermore, the direct resistant inspiratory training, with assistance from the therapist, raised the patients' intra-abdominal pressure to promote the activity of the diaphragm muscles thereby increasing the efficiency improve of respiratory major muscle and increased of elasticity of the chest wall. This led to increased vital capacity, in a similar way to the results of other previous studies.

CONCLUSION

This study is to examine the effects of a feedback respiratory exercise and diaphragm respiratory exercise on pulmonary functions of chronic strokes patients. The experimental group, which conducted a combination of the feedback breathing device exercise and the diaphragm breathing exercise saw their respiratory ability increase more significantly. Therefore, it is the author's hope that, based on the results of the present study, the training, which combines feedback breathing device exercises and the diaphragm breathing exercise will be actively used in addition to general physical therapy in the rehabilitation of stroke patients. The results of the present study can be effectively utilized as objective data on neuromuscular disease patients to improve weakened respiratory functions.

REFERENCES

1. Macko RF, Ivey FM, Forrester LW, Daniel H, John DS, Leslie IK, Kenneth HS, Andrew PG. Treadmill exercise rehabilitation improves ambulatory function and cardiovascular fitness in patients with chronic stroke. Stroke 2005; 36: 2206-11.
2. Ferretti G, Girardis M, Moia C, Antonutto G. Effects of prolonged bed rest on cardiovascular oxygen transport during submaximal exercise in humans. Eur J Appl Physiol Occup Physiol 1998; 78(5): 398-402.
3. Fugl-Meyer AR, Linderholm H, Wilson AF. Restrictive ventilator dysfunction in stroke: its relation to locomotor function. Scand J Rehabil Med Suppl 1983; 9(2): 118-124.
4. Bohannon RW. Recovery and correlates of trunk muscle strength after stroke. Int J Rehabil Res 1995; 18(2): 162-167.
5. Weiner P, magadle R, Beckerman M. Comparison of specific expiratory, inspiratory, and combined muscle training programs in COPD. Chest 2003; 124(4): 1357-1364.
6. Frownfelter D, Dean E. Cardiovascular and pulmonary physical therapy: evidence and practice. 4th ed. Philadelphia, Mosby 2006; 569-593.
7. Skinner JS. Exercise Testing and Exercise Prescription For Special Cases: Theoretical Basis and Clinical Application(3rd Ed.). Philadelphia: Lippincott Williams & Wilkins 2005; 38-53.
8. Jones AY, Dean E, Chow CC. Comparison of the oxygen cost of breathing exercise and apontaneous breathing in patients with stable COPD. Phys ther 2003; 83(5): 424-431.
9. Bianchi R, Gigliotti F, Romagnoli I, Lanini B, Castellani C, Grazzini M, Scano G. Chest wall kinematics and breathlessness during pursed-lip breathing in patients with COPD. Chest 2004; 125(2): 459-465.
10. Ugalde V, Breslin EH, Walsh SA, Bonekat HW, Abresch RT, Carter GT. Pursed lips breathing improves ventilation in myotonic muscular dystrophy. Arch Phys Med Rehabil 2000; 81(4): 472-478.
11. Pryor JA, Prasad SA. Physiotherapy for Respiratory and Cardiac Problems(3rd ed.). Singapore: Churchill Livingstone 2002; 658.
12. McConnell AK, Romer LM: Respiratory muscle training in healthy humans: resolving the controversy. Int J Sports Med 2004; 25(4): 284-293.
13. Spengler CM, Roos M, Laube SM, Boutellier U. Decreased exercise blood lactate concentrations after respiratory endurance training in humans. Eur J Appl Physiol Occup Physiol 1999; 79(4): 299-305.
14. Lee JH. The Effect of Pulmonary Function in the Stroke Patients after Feedback Breathing Exercise. Graguate school Daegu University 2008.
15. Riolo L, Fisher K. Is there evidence that strength training could help improve muscle function and other outcomes without reinforcing abnormal movement patterns or increasing reflex activity in a man who has had a stroke?. Phys Ther 2003; 83(9): 844-851.
16. Krebs DE, Scarborough DM, McGibbon CA. Functional vs. strength training in disabled elderly outpatients. Am J Phys Med Rehabil 2007; 86(2): 93-103.
17. Trueblood PR. Partial body weight treadmill training in persons with chronic stroke. NeuroRehabilitation 2001; 16(3): 143-153.
18. Dietz B. International PNF Basic Course Book. Gwangjoo. Korea 2006.
19. Lanini B, Bianchi R, Romagnoli I, C Claudia, Binazzi B, Gigliotti F, Pizzi A, Grippo A, Scano G. Chest wall kinematics in patients with hemiplegia. Am J Respir Crit Care Med 2003; 168(1): 109-113.
20. Scherer TA, Spengler CM, Owassapian D, Imhof E, Bouterrier U. Respiratory muscle endurance training in chronic obstructive pulmonary disease: impact on exercise capacity, dyspnea, and quality of life. Am J Respir Crit Care Med 2000; 162(5): 1709-1714.
21. Sartori R, Barbi E, Poli F, Ronfani L, Marchetti F, Amaddeo A,Ventura A. Respiratory training with a specific device in cystic fibrosis: A prospective study. J Cyst Fibros 2008; 7(4): 313-319.
22. Liaw MY, Lin MC, Cheng PT, May-Kuen AW, Fuk-Tan T. Resistive inspiratory muscle training: its effectiveness in patients with acute complete cervical cord injury. Arch Phys Med Rehabil 2000; 81(6): 752-756.
23. Van Houtte S, Vanlandewijck Y, Gosselink R. Respiratory muscle training in persons with spinal

24. British Thoracic Society Standards of Care Subcommittee on Pulmonary Rehabilitation. Pulmonary rehabilitation. Thorax 2001; 56(11), 827-834.