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Effects of Rib Cage Joint Mobilization Combined with Diaphragmatic Breathing Exercise on the Pulmonary Function and Chest Circumference in Patients with Stroke

Background: Patients with stroke have core muscle weakness and limited rib cage movement, resulting in restrictive lung disease.
Objectives: To examine the comparison of effects of rib cage joint mobilization combined with diaphragmatic breathing exercise and diaphragmatic breathing exercise on the pulmonary function and chest circumference in patients with stroke.
Design: A cluster randomized controlled trial.
Methods: Twenty-four patients were randomly assigned to an experimental group (rib cage joint mobilization combined with diaphragmatic breathing exercise group) and control group (diaphragmatic breathing exercise group). Patients in the experimental group underwent rib cage joint mobilization for 15 min and diaphragmatic breathing exercise for 15 min. The control group underwent diaphragmatic breathing exercise for 30 min. Both groups underwent exercise thrice a week for 4 weeks. The pulmonary function and chest circumference were measured using the MicroLab spirometer and a tape measure, respectively.
Results: After the intervention, the pulmonary function and chest circumference significantly improved in both groups. These improvements were significantly higher in the experimental group than those in the control group.
Conclusion: Rib cage joint mobilization combined with diaphragmatic breathing exercise improves pulmonary function and chest circumference in patients with stroke.

Keywords: *Diaphragmatic breathing exercise; Rib cage; Joint mobilization; Respiratory function; Stroke*

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INTRODUCTION

The causes of restrictive respiratory disease in patients with stroke are rib cage movement limitations and core muscle weakness.[1,2]

Breathing in patients with stroke decreases the maximum amount of spontaneous ventilation due to damage to the cortical-transverse membrane nerves and deterioration of the diaphragm.[3,4] The diaphragm is the main respiratory muscle responsible for 70% of one breath. In patients with stroke with weakened muscles, the respiratory function is reduced by approximately half.[5,6]

To increase the respiratory function of these patients, diaphragmatic breathing exercises have been implemented. The diaphragmatic breathing exercise is the easiest intervention in the early stages of respiratory rehabilitation. For the diaphragm to contract normally, not only the anterior protrusion of the abdomen but also the expansion of the lower rib cage is required. Maitland joint mobilization is a treatment technique that applies passive movement divided by the therapist's hand in five grades.[7] The more chronic the patient with stroke, the more soft tissue builds up, which leads to movement limitations.[8]

In particular, inhalation limitation occurs due to the rib cage construction,[1] and joint mobilization applied to the rib cage increases the respiratory function and muscle activity and tension in patients with stroke and improve functional activity.[9] As described earlier, joint mobilization applied to patients with stroke has been known as an intervention method for improving the respiratory function.[10] However, to date, most studies have compared diaphragmatic respiration and joint mobilization. In this study, we investigated the effects of diaphragmatic breathing exercise and diaphragmatic breathing exercise combined with rib cage joint mobilization on the pulmonary function and chest circumference.

SUBJECTS AND METHODS

Subjects

The study was an assessor-blinded and Cluster randomized trial. A total of 24 adult patients who were admitted to the B hospital participated in this study. These patients were hospitalized for stroke under the diagnosis of a rehabilitation medicine doctor at a nursing home hospital in Gyeonggi-do. The intervention period was conducted thrice a week for 30 min for four weeks. The inclusion criteria of the subjects were as follows: those who had been diagnosed with stroke for 6 months or more, had 10% less forced vital capacity (FVC) than the normal predicted value, and had a Korean-Mini Mental State Examination (K-MMSE) score of 24 or more. Those who had past or present lung-related damage and those with orthopedic disease in the rib cage, unstable angina, congestive heart failure, peripheral artery disease, and depression were excluded from this study. This study was approved by the Institutional Review Board of Yongin University (2-1040966-AB-N-01-20-1910-HSR-156-6). Before the initial evaluation, all subjects provided written informed consent.

Interventions

Three physical therapists, including researchers, with >3 years of experience in neurological physical therapy participated in the intervention. The diaphragmatic breathing exercise exerted force resistance upon inhalation in the supine position and induced contraction of the rectus abdominis during exhalation.[11] The diaphragmatic breathing exercise combined with rib cage joint mobilization was performed by turning the head from the prone position toward the comfortable side, followed by the center of the posterior-anterior mobilization and transverse mobilization. Each exercise was performed thrice a week for a total of 4 weeks (12 times).[12] In the case of diaphragmatic breathing exercise, the researcher applied resistance to the diaphragm during inhalation and stretched to the diaphragm muscle during exhalation. The subjects were instructed to relax, and both hands of the researchers were placed on the rectus muscle under the rib cartilage; then, the subjects were instructed to deeply and slowly inhale through the nose.[11,13] Rib cage joint mobilization in the center of the thoracic vertebrae felt the end feeling of each segment in the spine and recorded the joints with low mobility. The researcher put their thumb on one hand on a spinous process recorded as having low mobility and supported the hand with the other thumb. In transverse joint mobilization, both sides of the area where low mobility was recorded were compared and selected, and then, the thumb was placed in the transverse direction.[7] Joint mobilization was applied in grade 3 according to the Maitland classification, and the intervention time was 4 sets, 5 minutes per set, and the rest time was 1 minute, for a total of 23 minutes.

Outcome Measures

Pulmonary function

All assessments were performed by an physical therapist unrelated to this study. The evaluator was thoroughly familiar with the evaluation method and blinded to the study group prior to the evaluation. A lung spirometer was used to evaluate the respiratory function in this study.[14] Pulmonary function measurements were conducted in accordance with the pulmonary function test guidelines. The subjects sat on a chair with a backrest, looked at the front, and exhaled air into the spirometer after the maximum possible exhalation (to maintain exhalation for 6 s). The measurement variables were the peak expiratory flow (PEF), amount of effort exhalation, and forced expiratory volume in 1 s (FEV1). All items were measured three times, and the average value was recorded.[15]

Chest circumference

To measure the ability to expand around the chest, a spring tape measure was used to measure the upper and lower chest circumferences. To measure the upper chest circumference, markers were used to mark the space between the third rib along the center

line of the clavicle and the fifth spine. The lower chest circumference was marked on the tip of the spinous process and the spinous spine of the tenth spine.[15]

Data and Statistical Analysis

All statistical data were analyzed using SPSS 21.0 software (IBM Corp., Armonk, NY, USA). Both the experimental and control groups satisfied the normal distribution. Thus, parametric tests were used. The homogeneity test between the two groups was performed using an independent t-test. The independent sample t-test and chi-square test were used for the general characteristics of the subjects. A paired t-test was performed for the effects of exercise. The within-subject factor was time (before and after the test), whereas the between-subject factor was group-by-time (experimental and control groups). When significant differences were the interactions or main effects (group-by-time), t-test was used. The statistical significance level was set at α=.05.

RESULTS

General characteristics of the subjects

The general characteristics of the subjects are shown in Table 1. The gender of the experimental group was 8 men and 4 women, the average age was 64.83±13.10 years, the average height was 165.34±8.34 cm, and the average weight Was 64.00±8.34 kg, the site of the paralysis was 7 right hemiplegic, 5 left hemiplegic, the average onset period was 9.33±1.50 months, and the average K-MMSE score was 25.42±2.07 points. The gender of the control group was 8 men and 4 women, the average age was 65.42±9.71 years, the average height was 165.33±9.22 cm, and the average weight was 63.56±10.56 kg, the site of the paralysis was 11 right hemiplegic, 1 left hemiplegic, the average onset period was 9.42±2.07 months, and the average K-MMSE score was 25.50±1.62 points.

Table 1. General characteristics

(Mean±SD)

	Experimental group (n=12)	Control group (n=12)	*P*
Gender (male/female)	8 / 4	8 / 4	1.000
Age (years)	64.83 ± 13.10	65.42 ± 9.71	.517
Height (cm)	165.34 ± 8.56	165.33 ± 9.22	.347
Weight (kg)	64.00 ± 8.34	63.56 ± 10.56	.460
Affected side (left/right)	7 / 5	11 / 1	.059
Onset (month)	9.33 ± 1.50	9.42 ± 2.07	.925
K-MMSE (point)	25.42 ± 2.07	25.50 ± 1.62	.613

*P<.05
K-MMSE: Korean version of Mini-Mental State Examination

Table 2. Comparison of the pulmonary function before and after

(Mean±SD)

	Experimental group (n=12)		Control group (n=12)		*t*	*P*
	Before	After	Before	After		
FEV1 (ℓ)	2.34 ± .62	2.70 ± .55†	2.18 ± .68	2.29 ± .70†	-2.698	.013*
FVC (ℓ)	2.74 ± .57	3.11 ± .56†	2.63 ± .55	2.89 ± .71†	-1.232	.231
PEF (ℓ/min)	245.58 ± 80.89	328.91 ± 76.08	224.75 ± 90.81	249.50 ± 96.06†	-2.870	.009*

*P<.05
†There was a significant difference between before and after the test (P<.05)
*The experimental group improved more than the control group
FEV1: Forced expiratory volume in 1 s
FVC: Forced vital capacity
PEF: Peak expiratory flow
Experimental group: Rib cage joint mobilization combined with diaphragmatic breathing exercise group
Control group: Diaphragmatic breathing exercise group

Table 3. Comparison of the chest circumference before and after (Mean±SD)

	Experimental group (n=12)		Control group (n=12)		*t*	*P*
	Before	After	Before	After		
Upper Ch (cm)	1.56 ± .37	2.49 ± .28†	1.40 ± .21	2.18 ± .23†	2.15	.043*
Lower Ch (cm)	2.20 ± .19	3.03 ± 0.18†	2.03 ± .23	2.72 ± .17†	1.87	.075

*P<.05
†There was a significant difference between before and after the test (P<.05)
*The experimental group improved more than the control group
Upper Ch: Upper chest circumference
Lower Ch: Lower chest circumference
Experimental group: Rib cage joint mobilization combined with diaphragmatic breathing exercise group
Control group: Diaphragmatic breathing exercise group

Changes in the pulmonary function and chest circumference between the two groups

After four weeks of intervention, all groups experienced significant increases in the pulmonary function and chest circumference. The pulmonary function and chest circumference were significantly different between the two groups (Tables 2 and 3).

DISCUSSION

This study confirmed the changes in Maitland joint mobilization and diaphragmatic breathing exercises applied to the pulmonary function and chest circumference in patients with stroke with reduced respiratory function. As a result of the study, both experimental and control groups showed significant differences between the pulmonary function and chest circumference before and after intervention.

Stroke is a disease that causes irreversible damage to the central nervous system due to bleeding and infarction in the cerebral blood vessels.[16] Patients with stroke develop respiratory failure due to damage to the nervous system.[17] Breathing in these patients generally results in weakened respiratory muscles and reduced pulmonary volume, and reduced diaphragmatic motion reduces the effectiveness of coughing. In addition, in patients with stroke, asymmetric chest pump movements, deterioration of the upper chest volume, and compensatory movements to expand the rib cages in the lower abdomen upon inspiration were associated with rib cage movements.[18] Recently, the respiratory muscle training increased chest circumference, reduced asymmetric chest circumference, and increased swelling through the inhalation trainer improved the quality of life of patients with stroke. The diaphragmatic breathing exercise is a method of contracting the diaphragm muscle in the state where the upper rib cage is relaxed as much as possible to effectively contract the diaphragm.[11] In a recent study, diaphragmatic breathing exercise was applied to patients with stroke in combination with various methods. Increasing diaphragm movement has been introduced as an effective method for improving the respiratory function in these patients. Because the diaphragm muscle is attached to the chest wall, the limit on diaphragm contraction decreases as the mobility of the rib cage increases.[19] Joint mobilization was used to reorder the joints of patients with stroke.[7] It is a manual treatment method to control pain and increase the range of joint movement and is graded in a total of 5 steps to induce recovery between the soft tissues or joints that are constructed by stretching and sliding them. Sutbeyaz et al.[10] showed that diaphragmatic breathing exercise showed a significant difference in the respiratory function tests in patients with stroke. Lee[20] found that the diaphragmatic breathing exercise was also significant for the pulmonary function tests and chest circumference. Repeated diaphragmatic breathing exercises helped to improve posture by relaxing the rigid rib cage and reducing the kyphosis of the spine.[21] This is considered to be the result of the positive effects on the activity of the respiratory muscles necessary for the respiratory function, ability to expand the rib cage, and improvement of the respiratory function, consistent with the results of this study. Park and Park[22] showed that Maitland joint mobilization applied to patients with chronic stroke was effective in the pulmonary function and chest circumference. Fugl-Meyer et al.[1] reported that the limit of inspiration is due to the formation of the breast cage. Kriel[23] suggested that rib cage joint mobilization increases the volume of the rib cage and increases inspiration. Rib cage flexibility and muscle

relaxation increased the muscle function and decreased the breathing effort. The activation of the parasympathetic nerves and suppression of the sympathetic nerves have created an environment of increased rib cage mobility and diaphragm contraction. Therefore, it was confirmed through this study that the diaphragmatic breathing exercise combined with rib joint mobilization was more significant for the pulmonary function and chest circumference. Since this study included patients with stroke for more than 6 months after the onset and we studied some stroke patients, future studies require various additional evaluation methods. It would be necessary to compare the differences between the methods.

CONCLUSION

In conclusion, rib cage joint mobilization with diaphragmatic breathing exercise improved FEV1, FVC, PEF, and chest circumference in patients with stroke. In addition, rib cage joint mobilization combined with diaphragmatic breathing exercise was more effective for FEV1, PEF, and upper chest circumference than only diaphragmatic breathing exercise.

CONFLICT OF INTERESTS

The author declares that there are no conflicts of interest.

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