

Original Article

Effects of chest resistance exercise and chest expansion exercise on stroke patients' respiratory function and trunk control ability

GUI BIN SONG, MS, PT¹⁾, EUN CHO PARK, MS, PT²⁾*

¹⁾ Department of Physical Therapy, Yeungnam University College, Republic of Korea

²⁾ Department of Physical Therapy, College of Rehabilitation Science, Daegu University: 15 Jillyang, Gyeongsan-si, Kyeongbuk 712-714, Republic of Korea

Abstract. [Purpose] The purpose of this study was to examine the efficiency of chest resistance and chest expansion exercises for improving respiratory function and trunk control ability in patients with stroke. [Subjects] Forty patients with stroke were randomly allocated into a chest resistance exercise group (CREG, n = 20) and a chest expansion exercise group (CEEG, n = 20). [Methods] CREG patients underwent chest resistance exercises, and diaphragmatic resistance exercises by way of the proprioceptive neuromuscular facilitation. CEEG patients underwent respiratory exercises with chest expansion in various positions. Both groups received 30 minutes of training per day, five times per week, for eight weeks. [Results] Both the CREG and CEEG groups showed significant changes in FVC, FEV1, and TIS after the intervention. TIS was significantly increased in the CREG compared to the CEEG after the intervention. [Conclusion] Both chest resistance and chest expansion exercises were effective for improving respiratory function and trunk control ability in stroke patients; however, chest resistance exercise is more efficient for increasing trunk control ability.

Key words: Stroke, Respiratory function, Chest exercise

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INTRODUCTION

A stroke is often accompanied by secondary complications such as nutritional and metabolic disorders, endocrine dysfunction, mental problems, and cardiopulmonary disorders owing to neurological system and musculoskeletal system deficits associated with brain damage¹⁾. Among these complications, pulmonary disorders are more closely related to life and cause problems with the ability to adjust respiration, swallowing, as well as, language²⁾. Non-use of the paretic side muscles, and difficulty with movement, accompanied by direct restrictive pulmonary impairments, trigger a secondary reduction in cardiopulmonary function, and the asymmetric trunk induces inefficient energy use related to gait, resulting in a decrease in exercise endurance³⁾. Patients with hemiplegia caused by stroke undergo abnormal movement of the trunk and, in particular, abnormal movement in posture and motor control. In addition, damage to the abdominal area and chest wall, directly and indirectly decrease mobility of the respiratory muscles, and weakens their strength and endurance, affecting the respiratory

cycle^{4, 5)}. During aerobic exercise, which demands endurance, hemiplegic patients may become easily tired⁶⁾. When such patients return to their local community, they may have difficulty with activities of daily living, as well as, gait⁷⁾. General rehabilitation programs for stroke patients, that only aim towards functional recovery of the body, are not sufficient to enhance cardiopulmonary system function⁸⁾. As such, rehabilitation programs that integrate interventions related to respiration could be more effective in stroke patients for improving functional activities such as gait⁹⁾.

Chest resistance exercises promote the alignment of respiratory muscles with respiratory rhythms by providing resistance to the sternal and costal areas to resolve the respiratory problem itself¹⁰⁾. Conversely, a chest expansion exercise is a full-body exercise technique that combines deep breathing with active movements of the trunk and limbs. This exercise is an intervention method more specific to the musculoskeletal system as it moderates inspiration and expiration rates, improves mobility of the intercostal space, relaxes the stiff connective tissue, and relaxes soft tissues such as the pectoralis major, intercostal, and quadratus lumborum muscles¹¹⁾.

A previous study in stroke patients¹²⁾ noted that chest resistance exercises and diaphragmatic resistance exercises, by way of the proprioceptive neuromuscular facilitation (PNF) method, improved the subjects' pulmonary function, leading to expansion of the pulmonary tissue, improvements in thorax movement, strengthening of the respiratory muscles, and an enhancement in endurance. Britto et al.⁴⁾

*Corresponding author. Eun cho Park (E-mail: euncho76@naver.com)

applied inspiratory muscle training to chronic stroke patients and reported strengthening of the inspiratory muscles, as well as, an improvement in endurance within a short time period. In another study by Leelarungrayub et al.¹³⁾, in which chronic obstructive pulmonary disease patients conducted chest expansion exercises, there was significant improvement in pulmonary function, dyspnea, and the degree of chest expansion. Moreover, when stroke patients performed chest resistance exercises based on the PNF method, there was significant improvement in their gait ability, degree of chest expansion, and forced expiratory volume in 1 second (FEV1)¹⁴⁾.

Indeed, various previous studies in healthy individuals, as well as patients with obstructive pulmonary disease, spinal cord injuries, cerebral palsy, and neuromuscular disease have been performed; however, studies evaluating respiratory function in stroke patients following chest resistance and chest expansion exercises, and examining the relation of trunk control ability with respiratory function, are lacking. Accordingly, this study aims to examine the efficiency of chest resistance and chest expansion exercises for improving respiratory function and trunk control ability in patients with hemiplegia caused by a stroke, and to compare the effects of these interventions.

SUBJECTS AND METHODS

Study subjects were stroke patients who had suffered a stroke and were hospitalized and treated at the N hospital located in Daegu City, Korea. All subjects were randomly allocated to a chest resistance exercise group (CREG, $n = 20$) or chest expansion exercise group (CEEG, $n = 20$). The criteria for study subject selection included those who were chronic stroke patients whereby the onset of stroke occurred at least six months prior; those whose Korea mini mental state examination score was 24 points or higher; those who had no special pulmonary disease before the onset of stroke; those who had no innate deformation of the thorax or rib fracture; and those who were able to sit independently. This study was approved by the Daegu University institutional review board and all study-related procedures were conducted in accordance with the ethical standards of the Declaration of Helsinki. All subjects understood the purpose of the study and written informed consent was received from all subjects prior to their participation.

There are two intervention groups: chest resistance exercise group and chest expansion exercise group.

The patients assumed a supine and side-lying position while undergoing chest resistance exercise patterns and the diaphragmatic palpation technique of the PNF on the costal area. Briefly, the therapist places both hands on the costa of the patient, with the fingers placed diagonally along the costal line. Pressure is then applied from the costal area, in a caudal and medial direction, in line with the patient's respiratory rhythm so that the patient can sufficiently breathe out during expiration, while in supine position. And the therapist places the hands on the chest area to reinforce. The therapist diagonally applies pressure in a caudal and medial direction along the costal line, drawing an arc in line with the patient's respiratory rhythm on side-lying position.

The diaphragm is then palpated by pushing it superiorly

and laterally with the thumb or other finger from below the thorax. The therapist gives resistance to the inferior movement of the contracting diaphragm. In order to provide indirect palpation, the therapist places both hands on the abdominal area and has the patient inhale while pushing diaphragm superiorly with smooth pressure on supine position.

Chest expiration exercise group

In this interventional method, the therapist pushes the patient's shoulder area in an anterior-inferior direction and pulls the pelvic area in a posterior-superior direction, in line with the patient's respiratory cycle. During inspiration, the therapist pulls the shoulder area in a posterior-superior direction and pushes the pelvic area in an anterior-inferior direction so that the thorax can be sufficiently expanded during inspiration while in the side-lying position. The patient's also underwent trunk rotation exercises. During expiration, the patient's trunk is rotated and flexed in the direction of the non-paretic side and the paretic side elbow is pushed in an anterior-inferior direction toward the non-paretic side knee. During inspiration, the trunk is maximally rotated in the paretic side direction such that the elbow is in a posterior-superior direction to sufficiently expand the paretic side thorax while the patient is in a seated position. The chest stretching exercise was also conducted with the patient in a seated position. During expiration, the therapist pushes together the bilateral elbows anteriorly and flexes the upper part of the patient's trunk. During inspiration, the patient spreads the bilateral elbows externally and extends the trunk to expand the thorax. All subjects who participated in the study conducted an ex-ante evaluation before initiating the exercise program, and were re-evaluated eight weeks later. The subjects' respiratory function was assessed based on forced volume vital capacity (FVC), and FEV1, and their trunk control ability was measured using the trunk impairment scale (TIS).

Statistical analysis

Statistical processing of the data was conducted using SPSS ver. 12.0, and descriptive statistics was used to analyze the subjects' general characteristics. A paired t-test was carried out to examine group differences, before and after the experiment, and an independent t-test was conducted to evaluate differences between the two groups. Statistical significance was set at $p < 0.05$.

RESULTS

Table 1 shows the general characteristics of the study subjects. There were no significant differences in any of the characteristics between the CREG and CEEG groups ($p > 0.05$).

Table 2 shows group comparisons of respiratory function and trunk control ability. Both the CREG and CEEG groups showed significant changes in FVC, FEV1, and TIS after the intervention ($p < 0.05$), but there was no significant difference in either group in FEV1/FVC before and after the intervention ($p > 0.05$, Table 2).

Between-group comparisons, before and after the intervention, showed no significant differences between the two

Table 1. General characteristics (mean \pm SD)

	CREG	CEEG
Gender (Male/Female)	12 / 8	11 / 9
Paretic side (Right/Left)	9 / 11	9 / 11
Diagnosis (infarction/hemorrhage)	11 / 9	9 / 11
Age	55.50 \pm 11.43	58.30 \pm 11.10
Time since stroke	4.70 \pm 1.69	3.95 \pm 1.63
MMSE-K	28.25 \pm 1.83	27.35 \pm 1.81

*CREG: Chest Resistance Exercise Group, CEEG: Chest Expansion Exercise Group, MMSE-K: Mini Mental status examination-Korea version, $p > 0.05$.

Table 2. Comparison of CREG and CEEG respiratory function and trunk control ability (mean \pm SD)

	CREG		CEEG	
	Pretest	Posttest	Pretest	Posttest
FVC (l)	2.13 \pm 0.90	2.68 \pm 1.21*	1.89 \pm 1.00	2.62 \pm 10.93*
FEV1 (l)	1.65 \pm 0.70	2.03 \pm 0.83*	1.52 \pm 0.73	2.18 \pm 0.69*
FEV1/FVC (%)	82.52 \pm 22.13	81.42 \pm 18.72	82.19 \pm 16.43	86.88 \pm 10.68
TIS	11.56 \pm 0.88	14.13 \pm 0.92* ^a	11.49 \pm 1.14	12.17 \pm 1.17*

*significant difference from the pretest at < 0.05 . ^a significant difference in gains between the two groups at < 0.05 . CREG: Chest Resistance Exercise Group, CEEG: Chest Expansion Exercise Group. FVC: Forced Volume vital Capacity, FEV1: Forced Expiratory Volume at one second, TIS: Trunk Impairment Scale

groups in FVC, FEV1, and FEV1/FVC ($p > 0.05$). However, TIS was more significantly improved in the CREG compared to the CEEG after the intervention ($p < 0.05$, Table 2).

DISCUSSION

This study compared chest resistance exercises and chest expansion exercises applied to patients with stroke-related hemiplegia by closely examining the efficiency of the interventions in improving respiratory function and trunk control ability. To examine respiratory function of the subjects, this study measured FVC, FEV1, and FEV1/FVC. According to the results of this study, both the CREG and the CEEG groups showed significant improvements in respiratory function and trunk control ability.

In a previous study, Sutbeyaz et al.¹⁵⁾ classified stroke patients in a sub-acute state into an inspiratory muscle training group, a respiratory retraining group, and a control group, and applied interventions six times per week for six weeks to compare pulmonary function between groups. The results showed that FVC and FEV1 of the inspiratory muscle training group significantly increased. Similarly, Kim Jae-hyeon¹²⁾ applied chest mobility exercises, chest resistance exercises using the PNF method, and respiration exercises using diaphragmatic respiration exercise in stroke patients for four weeks, and their vital capacity, FVC, FEV1, and maximal voluntary ventilation significantly changed. In another study by Mueller et al.¹⁶⁾, respiration exercises in spinal cord injury patients resulted in a significant increase in FEV1/FVC and FEV1. Jeong Ju-hyeon and Kim Nan-su¹⁷⁾ reported that following breathing exercises for six weeks using resistive inspiratory muscle training, the subjects' FEV1 and maximal expiratory pressure significantly improved but

FVC and FEV1/FVC did not significantly increase. Britto et al.⁴⁾ applied respiration exercises, using a respiratory resistance instrument in stroke patients, and reported that there were significant changes in the maximal inspiratory pressure and inspiratory muscle endurance.

In line with the results of the previous studies mentioned above, the subjects' FVC and FEV1, in the present study, significantly improved after undergoing chest resistance exercises for eight weeks. This finding is not surprising given that the provision of resistance would be expected to ameliorate the strength and endurance of the respiratory muscles, with effective improvements in the subjects' respiratory functions. Kim Sang-hoe¹⁸⁾ reported that a combination of lumbar stabilization exercises and trunk stretching significantly improved FVC. Lima et al.¹⁹⁾ applied a neck and trunk muscle mobilization technique in healthy subjects and found that the FEV1 and peak expiratory flow rate were significantly improved. Seo Gyo-cheol et al.¹⁴⁾ applied chest expansion exercises and resistance exercises to subjects for four weeks and reported that there were significant changes in FVC, FEV1, and maximal expiratory flow, but not in FEV1/FVC. Similarly, in the present study, the subjects' FVC and FEV1 significantly improved after the chest expansion exercises. This result supports Burianova's opinion²⁰⁾ that chest expansion exercises achieve appropriate contraction of the respiratory muscles and enhance ventilation by promoting muscle activity.

The present study also applied the TIS to examine changes in trunk control ability. Jandt et al.²¹⁾ compared the association between trunk control, respiratory muscle strength, and pulmonary function in stroke patients and noted that a consistent and statistically significant correlation was found between TIS and Peak expiratory flow and between TIS and

Maximum expiratory pressure.

In a study by Kim Min-hwan²²⁾ where stroke patients received expiratory muscle training five times per week for six weeks, the experimental group showed significant improvements in trunk control ability compared to the control group. Gu Tae-wu²³⁾ observed that a combination of thoracic mobilization and respiration exercises resulted in significant enhancements in the subjects' trunk control ability.

In the present study, which examined the subjects' trunk control ability after the application of chest resistance and chest expansion exercises, the TIS significantly improved in both groups with more significant improvements in the CREG than in the CEEG. This is likely due to improvements in respiratory muscle function following the application of each exercise program which could affect trunk control ability. More significant improvements observed in the CREG group could be attributed to enhancements in respiratory muscle strength and endurance with chest resistance exercises, which more greatly affect trunk stability in comparison to chest expansion exercises.

A limitation of the present study is that it is difficult to generalize the current observations, as the number of subjects is small. As such, further long-term studies on a larger subset of stroke patients, and with regular follow-up intervals to ascertain how long the effect of training endures, are still needed. Nevertheless, the results of the present study show that both chest resistance exercises and chest expansion exercises were effective in improving respiratory function and trunk control ability in hemiplegic stroke patients, however chest resistance exercises were more effective than chest expansion exercises. Thus, chest resistance exercises and chest expansion exercises may be suitable and effective therapeutic intervention methods to improve respiratory function and trunk control ability in stroke patients.

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