



Original Article

Effect of respiratory exercise on pulmonary function, balance, and gait in patients with chronic stroke

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Abstract. [Purpose] This study investigated the effect of respiratory exercise on pulmonary function, balance, and gait in chronic stroke patients. [Participants and Methods] Twenty patients with chronic stroke were randomly assigned to experimental and control groups (n=10 each). The patients in both groups underwent neurodevelopmental treatment. Moreover, the experimental group performed respiratory exercise. Pulmonary function was measured using a pneumatometer. Balance was measured using a Berg Balance Scale and Functional Reach Test. Gait was measured with a 10-m walk test and Timed Up-and-Go Test. [Results] Intragroup comparison showed significant differences in forced vital capacity, forced expiratory volume in one second, Berg Balance Scale, Functional Reach Test, 10-meter walk test, and Timed Up-and-Go Test. Intergroup comparison showed that the differences in forced vital capacity, forced expiratory volume in one second, Berg Balance Scale, Functional Reach Test, 10-meter walk test, and Timed Up-and-Go Test for the experimental group were significantly related to those for the control group. [Conclusion] Based on these results it was concluded that respiratory exercise effectively improves the pulmonary function, balance, and gait in patients with chronic stroke.

Key words: Respiratory, Balance, Gait

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INTRODUCTION

Stroke, a cerebrovascular disease, is caused by insufficient supply of blood to the brain because of ischemia or hemorrhage, and accompanies disorders related to consciousness, perception as well as verbal, sensory, and exercise functions¹⁾. Hemiplegia, which is caused by stroke, causes asymmetrical posture, balance, and the lack of weight-bearing and walking abilities^{1, 2)}. Decline in balance and walking ability hampers recovery with exercise, makes return to daily life difficult, and increases the risk of fall, causing secondary complications such as fracture and soft tissue damage^{3, 4)}. Stroke patients experience limited respiratory function because their diaphragm, intercostal muscles, and abdominal muscle are weakened⁵⁾. Weakened respiratory functions consequently decrease the ability to perform physical functions and to walk independently⁶⁾. Recently, many studies have reported on improving physical function in stroke patients through respiratory exercise. The results of introducing respiratory exercise in patients with chronic obstructive pulmonary disease showed improvement in their endurance and quality of life⁷⁾. An exercise therapy using a pneumatometer was effective in improving the pulmonary function in patients with amyotrophic lateral sclerosis⁸⁾. Several studies have been conducted to date to show the effects of respiratory exercise on patients with respiratory diseases; however, only few studies have reported the effects of respiratory exercise, by using a respiratory exercise equipment, on pulmonary function, balance, and gait in patients with chronic stroke.

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This study investigate the effects of respiratory exercise on pulmonary function, balance, and gait in the aforementioned patient population.

PARTICIPANTS AND METHODS

In this study, 20 patients diagnosed with stroke >6 months ago, as confirmed by computed tomography and magnetic resonance imaging, were randomly assigned to two groups: 10 patients (five men, five women) in the experimental group and 10 patients (five men, five women) in the control group. All patients scored at least 24 points in the Mini-Mental Status Examination, were able to perform tasks, walked independently for >10 m, had no visual impairment, and had no orthopedic problems in either lower extremity. The patients were fully informed about the study purpose and methods. This study complied with the ethical standards of the Declaration of Helsinki. The Nambu University Research Ethics Board approved the study protocol, and all patients provided informed consent. For the experimental group, average age of 62.2 ± 2.3 years; average height, 159.8 ± 3.7 cm; and average weight, 63.6 ± 10.3 kg were considered. For the control group, average age of 64.2 ± 5.4 years; average height, 161.6 ± 6.9 cm; and average weight, 64.4 ± 7.1 kg were considered.

The experimental and control groups underwent neurodevelopmental treatment: 30 min/day, 5 times a week for 4 weeks. In addition, the experimental group underwent respiratory exercise using respiratory exercise equipment (Lung Boost Respiratory Trainer MD8000) for 20 min a day, 5 times a week, for 4 weeks. Before the exercise, the patients were educated about the respiratory exercise method. They were instructed not to breathe through their nose during the respiratory exercise, and to rest until they calmed down if they felt fatigued or dizzy, and then resume the exercise. The patients stood with both feet apart at shoulder width; sat down with the feet resting flat on the floor in a proper posture; placed the respiratory exercise equipment at the head height; held the equipment on one hand; pulled the chin; and maintained a neutral posture. The patient wore the mouthpiece, stared at the respiratory-exercise-equipment, and performed inhalation and exhalation. Difficulty level 1 without resistance was applied in the first week followed by level 2 with 50% resistance in the second week, level 3 with 60% resistance in the third week, and level 4 with 70% resistance in the fourth week.

Pulmonary function was measured using a pneumatometer. The patients were comfortably seated, and their forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) were measured and compared. Balance was measured using the Berg Balance Scale (BBS) and Functional Reach Test (FRT). The BBS included 14 items divided into three areas: sitting, standing, and posture change. The total possible score is 56; the higher the score, the better the balance. FRT was used to measure the distance between the start and end points, by raising the arm at 90 degrees in a relaxed standing position and extending as far as possible without losing balance. Gait was measured with the 10-meter walk test (10MWT) and Timed Up-and-Go Test (TUGT). The 10MWT was used to assess gait speed. It involved walking upto 14 m and measuring the time taken for 10-m walk, excluding the beginning and end of the walk (2-m each). TUGT was used to assess functional mobility, measuring the time taken for sitting on a chair with armrests, walking 3 m away from the chair, and returning to the chair.

Collected data were analyzed using SPSS 12.0. Descriptive statistics were used to compare the general characteristics of the participants. The paired t-test was used to compare the values before and after the experiment. An independent t-test was conducted to compare the intergroup differences among the changes before and after the experiment. The statistical significance level was set at $\alpha=0.05$.

RESULTS

Intragroup comparison showed significant differences in FVC, FEV1, BBS, FRT 10MWT, and TUGT in the experimental group ($p<0.05$) (Table 1). Intergroup comparison showed that differences in FVC, FEV1, BBS, FRT, 10MWT, and TUGT for the experimental group were significantly related to those for the control group ($p<0.05$) (Table 1).

DISCUSSION

This study investigated the effects of respiratory exercise on pulmonary function, balance, and gait in chronic stroke patients. Intragroup comparisons revealed significant differences in the pulmonary functions of patients in the experimental group. Intergroup comparisons showed that the pulmonary function improved more significantly in the experimental group than in the control group. Respiratory strengthening training in stroke patients improved the pulmonary function⁹. Kim and Shin¹⁰ reported that respiratory exercise is effective for improving pulmonary functions in stroke patients. The results of employing respiratory exercise in stroke patients with restrictive ventilator disturbance showed that the endurance of their trunk muscles improved, and the FVC increased because of the increased deep breathing capacity, and this consequently increased the exhalation volume. Moreover, FEV1 also improved, as the respiratory exercise increased the strength and coordination of trunk muscles and improved respiratory function.

In this study, the balance ability was improved in the experimental group after performing respiratory exercise. When breathing exercises were performed by patients with chronic obstructive pulmonary disease, the muscular strength of the diaphragm and its activity during respiratory exercises improved⁷. When respiratory exercises were performed by stroke

Table 1. Comparison of the results of the FVC, FEV₁, BBS, FRT, 10MWT and TUGT between the experimental and control groups

	Experimental group (n=10)			Control group (n=10)		
	Pre	Post	Post-Pre	Pre	Post	Post-Pre
FVC (l)	1.9 (0.1)	2.4 (0.1) *	0.4 (0.2) †	2.1 (0.1)	2.2 (0.1)	0.0 (0.1)
FEV1 (l)	2.1 (0.0)	2.7 (0.3) *	0.5 (0.3) †	2.1 (0.0)	2.2 (0.1)	0.1 (1.1)
BBS (scores)	40.6 (1.6)	44.2 (1.3) *	3.6 (1.5) †	39.4 (2.5)	40.2 (2.2)	0.8 (0.8)
FRT (cm)	17.2 (2.8)	21.2 (2.3) *	4.0 (1.8) †	18.8 (1.4)	19.6 (0.8)	0.8 (1.6)
10MWT (sec)	17.2 (1.0)	12.4 (1.8) *	-4.8 (2.4) †	16.8 (2.2)	15.8 (0.8)	-1.0 (1.8)
TUGT (sec)	22.8 (1.4)	18.2 (2.9) *	-4.6 (2.5) †	21.2 (1.6)	20.4 (1.1)	-0.8 (2.3)

Values are mean (standard deviation).

BBS: Berg Balance Scale; FRT: Functional Reach Test; 10MWT: 10 Meter Walk Test; TUGT: Timed Up and Go Test; FVC: Forced vital capacity; FEV1: Forced expiratory volume at one second.

*p<0.05: Significant differences between pre- and post-test.

†p<0.05: Significant differences between the experimental and control groups.

patients, the muscular activity of the diaphragm and external intercostal muscles improved¹¹⁾. These study results are consistent with those of previous studies, which showed that the muscle activity of respiratory root increases through respiratory exercise and respiratory roots are closely related with the posture adjustment ability of trunk. The trunk control ability plays an important role in maintaining balance and performing functions by adjusting weight distribution and maintaining a standing position¹²⁾. These results showed that the stability and balance control by the trunk improved because of the improvement in the muscle activity of trunk by respiratory exercises.

In this study, the gait ability improved in the experimental group after respiratory exercises. The gait ability of chronic stroke patients improved after applying respiratory exercises¹⁰⁾. This study result could be supported because Jung and Bang¹³⁾ reported in their study that respiratory strengthening training improve the gait ability of stroke patients. This is because respiratory exercises enhanced the motility, muscular strength, and endurance of respiratory muscles, which were weakened due to hemiplegia. The trunk stability while gait also improved, consequently improving weight distribution and balance ability, thus improving the gait ability. These study results confirmed that respiratory exercise was effective for improving the pulmonary functions, balance, and gait in chronic stroke patients.

The study limitation is the short duration and a lack of follow-up; hence, the long-term effects of the study could not be determined. Moreover, the small sample size is insufficient to generalize the results to all patients with chronic stroke. An additional study may be necessary for improving these problems.

Conflict of interest

None.

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