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Original Article

Effect of inspiratory muscle training on respiratory capacity and walking ability with subacute stroke patients: a randomized controlled pilot trial

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Abstract. [Purpose] To investigate the effects of inspiratory muscle training on respiratory capacity and walking ability in subacute stroke patients. [Subjects and Methods] The subjects were randomly assigned to an experimental group (n=6) or a control group (n=6). Patients in the experimental group received inspiratory muscle training for 30 minutes (six sets of five-minutes) and traditional physical therapy once a day, five days a week, for four weeks. The control group received aerobic exercise for 30 minutes and traditional physical therapy for 30 minutes a day, five days a week, for four weeks. [Results] After the intervention, both groups showed significant improvements in the forced vital capacity, forced expiratory volume in one second, 10-meter walking test, and six-minute walking test over the baseline results. There were significant between-group differences for the forced vital capacity, forced expiratory volume in one second, and six-minute walking test. No statistically significant differences were observed for measures of saturation pulse oximetry oxygen and 10-meter walking test between the groups. [Conclusion] These findings gave some indications that inspiratory muscle training may benefit in patients with subacute stroke, and it is feasible to be included in rehabilitation program with this population.

Key words: Inspiratory muscle training, Respiratory function, Walking

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INTRODUCTION

Stroke can lead to recurrent lower respiratory functions and worsening pulmonary fucntion, with increased morbidity and mortality[1)]. Reduced respiratory function impede participation in every day activities and social participation[2)]. Impaired respiratory fucntion may be a consequence of weakness of the respiratory muscles and postural trunk dysfunction. Several studies consistently reported highter positioning of the paretic hemidiaphragm associated with decreases in diaphragmatic excursion during spontaneous breathing and hyperventilation[3)]. Previous studies[1–3)] suggested that inspiratory muscle are critical factor to solve this problems.

Inspiratory muscle training (IMT) have been found to improve respiratory muscle strength and function in mutilple sclerosis and Parkinson's disease[1)]. IMT may be perfomed with gradual functional overloads, and most indicated devices ar the linear ones, such as the Threshold. Studies[1, 4, 5)] that evaluated effects of IMT reported decreases in dyspnea and better tolerance to exercise associated with better capacity to perform activities of daily livings (ADLs). These results suggest IMT can have a positive effect on respirtory muscle function and ADLs in people with central nervous system disorders.

The systemtic review[1)] suggested that IMT could improve patitnet's respiratory capacity and walking ability. However,

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Table 1. General characteristics of the subjects

	Experimental group (n=6)	Control group (n=6)
Gender		
Male/Female	2/4	3/3
Paretic side		
Right/Left	4/2	3/3
Age (years)	61.2 ± 4.2[a]	62.2 ± 5.3
Weight (kg)	67.8 ± 7.2	64.9 ± 6.8
Height (cm)	168.3 ± 5.4	164.81 ± 9.2
Duration (months)	3.2 ± 0.8	3.1 ± 0.7

[a]Mean ± SD

relatively little is known about the effects of subacute stroke on respiratory muscle function or effective rehabilitation strategy to improve muscle function and walking ability. Therefore, the aim of this study was to investigate the effects of IMT on respiratory capacity and walking ability of subacute stroke patients.

SUBJECTS AND METHODS

The subjects were 12 post-stroke individuals admitted to a rehabilitation center in the Republic of Korea. The inclusion criteria were (1) history and clinical presentation (hemiparesis) of stroke (first hemorrhage or infarction), (2) event occurring<six months previously, (3) ability to use a cycle ergometer, (4) no restriction in lung function and no neurologic, orthopedic, or unstable cardiac condition, and (5) ability to walk a distance of 100 meters with or without assistance. The exclusion criteria were: (1) the presence of any comorbidity or disability other than stroke that would preclude study, and (2) any uncontrolled health condition for which exercise is contraindicated. Participation in the study was voluntary, and the subjects fully understood the contents of this study. An explanation of the study purpose and the experimental method and processes was provided to patients, and written consent from all of the subjects was obtained. The study was approved by the institutional review board and followed the principles outlined in the Declaration of Helsinki. The participants were randomly assigned into an experimental group (n=6) or control group (n=6). The intervention was comprised of four weeks of inpatient treatment. The randomization was performed by selection from opaque, closed envelopes containing the group assignment. The participants of the experimental group received IMT 6 series of 5 minutes each for 30 minutes a day, five times a week, for four weeks. We used the training program method of Larson et al.[6]. The IMT with the Threshold regulated at 30% of participant's maximal inspiratory pressure values. The participants of the control group received a self-selective intensity exercise with an ergonomic cycle for 30 minutes a day, five times a week, for four weeks. In addition, all of the participants of this study received traditional physical therapy and occupational therapy.

The spirometer (Sensormedics Vmax, Sensormedics, USA) was used to assess the forced vital capacity (FVC) and the forced expiratory volume in one second (FEV_1)[7]. Participants were instructed to inhale to total lung capacity and then breathe out as hard and fast as possible for 6 to 7 seconds. At least three blows were required. The FVC was the volume change of the lung between a full inspiration to total lung capacity and a maximal expiration to residual volume. The FEV_1 was the volume exhaled during the first second of a forced expiratory maneuver started at the level of the total lung capacity.

A hand-held pulse oximeter (MP110Plus, Mekic Co., Korea) was used to assess the saturation pulse oximetry oxygen (SpO_2)[8]. SpO_2 stands for peripheral capillary oxygen saturation and estimation of the amount of oxygen in the blood. This value is represented by a percentage. Normal SpO_2 values vary between 95 and 100%.

A walk test (10-meter walking test [10MWT]) was performed by having the patient walk 10 meter for the gait speed[9].

The six-minute walking test (6MWT) was used as an endurance test[10].

All analysis were carried out using SPSS 16.0 version for Windows software by an independent physical therapist who also was unware of assignment. Descriptive statistics were used to summarize baseline data. Category variables were compared between the groups using the Fisher's exact test. Between-group comparisons of baseline characteristics were performed using the Mann-Whitney U-test. Within-group comparisons of pre- and posttest values in each group were made using Wilcoxon signed rank test and between-group comparison for posttest values was performed using the Mann-Whitney U-test. Significance level was set at $p<0.05$.

RESULTS

There were 12 patitents admitted during the study period. All the participants completed the study. There were no significant group differences in gender, paretic side, age, weight, height, time after stroke, age, FVC, FEV_1, SpO_2, 10MWT, and 6MWT before the intervention (Table 1). After the intervention, both groups showed significant differences compared with

Table 2. Outcome measures

	Experimental group (n=6)		Control group (n=6)	
	Pretest	Posttest	Pretest	Posttest
FVC (l)	2.6 ± 0.2	3.1 ± 0.1*+	2.7 ± 0.3	2.8 ± 0.2*
FEV_1 (l)	1.8 ± 0.2	2.4 ± 0.3*+	1.9 ± 0.1	2.0 ± 0.1*
SpO_2 (%)	95.9 ± 0.8	96.8 ± 0.5	95.6 ± 0.5	96.3 ± 0.6
10MWT (sec)	13.9 ± 1.8	10.1 ± 1.2*	14.0 ± 2.5	11.4 ± 1.2*
6MWT (m)	262.0 ± 62.8	330.1 ± 52.9*+	249.8 ± 58.2	280.3 ± 58.0*

*Significant difference within group. +Significant difference between groups.
FVC: forced vital capacity; FEV_1: forced expiratory volume in one second; SpO_2: saturation pulse oximetry oxygen; 10MWT: 10-meter walking test; 6MWT: six-minute walking test.
The pretest was performed before the intervention, and the posttest was performed after four weeks.
The significance of differences was accepted for values of p<0.05

before the intervention in FVC, FEV_1, 10MWT, and 6MWT ($p<0.05$) (Table 2). There were significant differences after intervention in FVC (z=−1.601, p=0.049), FEV_1 (z=−2.562, p=0.009), and 6MWT (z=−1283, p=0.048) between the two groups. There was no significant difference after intervention in the SpO_2 (z=−1.457, p=0.180) and 10MWT (z= −1.761, p=0.093).

DISCUSSION

This study investigated the effect of IMT on respiratory capacity and walking ability in patients with subacute stroke. Both groups showed significant changes after the intervention, and the experimental group showed more significant changes than the control group in FVC, FEV_1, and 6MWT. However, there was no significant change in SpO_2 and 10MWT. These results partically supported the hypothesis that IMT would be beneficial for stroke survivors. The findings of this study show that IMT improved the respiratory capacity and waking endurance of subacute stroke patients.

In general, our findings are consistent with the previous studies[1, 5, 6]. However, it is difficult to compare the results from present study with other research findings because our study was conducted within 6 months of the stroke. Although muscle weakness is often present in the acute stages of stroke[11], a means of improving respiratory muscle strength may be beneficial for stroke patients.

Respiratory capacity depends on persistent cardiopulmonary organ and neuromuscular system interaction, and is crucial for stroke patients because of decreased physical condition[2]. In this study, the IMT with the Threshold and the use of cycle ergometry for exercise may improve respiratory capacity and walking endurance in both groups. However, the IMT with Threshold group showed more significant differences in respiratory capacity (FVC and FEV_1) and walking endurance (6MWT) than the control group ($p<0.05$).

In a study by Sutbeyaz et al.[12], found significant effects of IMT on several outcomes in subjects with subacute stroke. They reported improvements in inspiratory muscular function that were associated with increases in lung volume and exercise capacity, sensation of dyspnea, and quality of life compared with the group that received breathing retraining, diaphragmatic breathing, and pursed-lip breathing, as well as the control group. The results of this study are similar to the above results. In this study, the experimental group showed better improvement in the FVC, FEV_1, and 6MWT than the control group ($p<0.05$).

In conclusion, this study explored the effect of IMT on respiratory capacity and walking ability in subacute stroke patients using FVC, FEV_1, SpO_2, 10MWT, and 6MWT. It revealed that IMT positively affected the FVC, FEV_1, and 6MWT that are respiratory capacity and walking endurance measurement. Thus, IMT is effective for the improvement of respiratory capacity and walking endurance in subacute stroke patients.

This study has several limitations that can be improved by future studies. The small sample size may limit the generalization of the finding of this study, and the absence of a follow-up period hinders the effects of this study.

Conflict of interest

None.

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