



Original Article

Effect of intensive aerobic exercise on respiratory capacity and walking ability with chronic stroke patients: a randomized controlled pilot trial

DAE-HYOUNG BANG, PT, PhD¹*, YOUNG-LAN SON, PT, MSC²

¹) Department of Physical Therapy, Oriental Hospital, Wonkwang University, Republic of Korea

²) Department of Physical Therapy, Graduate School of Seonam University: 439 Chunhyang-ro, Namwon-si, Jeollabuk-do, Republic of Korea

Abstract. [Purpose] To investigate the effects of intensive aerobic exercise on respiratory capacity and walking ability in chronic 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 intensive aerobic exercise for 30 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. The comparison of the two groups after the intervention revealed that the experimental group showed more significant improvements in the forced vital capacity, forced expiratory volume in one second, and six-minute walking test. There was no significant difference in saturation pulse oximetry oxygen and 10-meter walking test between the groups. [Conclusion] The results of this study suggest that intensive aerobic exercise has a positive effect on respiratory capacity and walking endurance in patients with chronic stroke.

Key words: Intensive aerobic exercise, Respiratory function, Walking

(This article was submitted Mar. 17, 2016, and was accepted May 14, 2016)

INTRODUCTION

Decreased respiratory is a well-established aftereffect of stroke and contributes to the limitation of independent life and activity in various countries¹). Many stroke patients do not spontaneously recover to their respiratory function²). This reduction in respiratory function might affect the recovery level of patients with stroke, who have a greater need for aerobic capacity for walking endurance and other highly-intensive activities of daily living³). Reduced aerobic capacity and muscle weakness impede participation in every day physical and social activities, and impaired social communication further reduces quality of life⁴). However, many rehabilitation approaches to chronic stroke patients rarely concern the assessment and improvement of respiratory capacity⁵).

Aerobic exercise has a positive effect on improving the cardiopulmonary endurance of patients with chronic stroke⁶). There has been a report indicating that the greatest benefits are achieved with high-intensity aerobic exercise, resulting in a more intense cardiorespiratory response⁷). In a systematic review, aerobic exercise was found to improve respiratory muscle strength and function in various diseases⁸). These results suggest that aerobic exercise can have a beneficial effect on respiratory muscle capacity in neurological conditions.

The same systematic review⁸) suggested that aerobic exercise could improve patient's respiratory capacity and walking ability. However, studies have rarely explored intensive aerobic exercise in chronic stroke patients in terms of aerobic capac-

*Corresponding author. Dae-Hyounk Bang (E-mail: bdhgenii@hanmail.net)

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ity and walking ability. Therefore, the aim of this study was to explore the effects of intensive aerobic exercise on respiratory capacity and walking ability of chronic 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, and (3) 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 intensive aerobic exercise with an ergonomic cycle for 30 minutes a day, five times a week, for four weeks. The intensity of the experimental group was 50–80% of the maximal heart rate (11–14 on the Borg Rating of Perceived Exertion scale)⁴. 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.

A four-week training study was designed to evaluate the effect of intensive aerobic exercise on the respiratory capacity and walking ability of chronic stroke patients. Follow-up was investigated four weeks after the experiment was completed.

The spirometer (Sensormedics Vmax, Sensormedics, USA) was used to assess the forced vital capacity (FVC) and the forced expiratory volume in one second (FEV₁). The subject was instructed to sit, wear nose clip, and blow into the spirometer for as long as possible, and at least for six 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 volume⁹. The FEV₁ was the volume exhaled during the first second of a forced expiratory maneuver started at the level of the total lung capacity⁹.

A hand-held pulse oximeter (MP110Plus, Metic Co., Korea) was used to assess the saturation pulse oximetry oxygen (SpO₂). SpO₂ stands for peripheral capillary oxygen saturation and estimation of the amount of oxygen in the blood. This value is represented by a percentage. Normal SpO₂ values vary between 95 and 100%¹⁰.

A walk test (10-meter walking test [10MWT]) was performed by having the patient walk 10 meter for the gait speed¹¹. The participants were asked to walk three times and the average time was recorded.

The six-minute walking test (6MWT) was used as an endurance test¹². Walking capacity was monitored using a standardized protocol. Distance walked (meter) was measured by the assessor.

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. The significance level was p<0.05.

RESULTS

All the participants completed the study. There were no significant group differences in gender, paretic side, age, weight, height, time after stroke, age, FVC, FEV₁, SpO₂, 10MWT, and 6MWT before the intervention (Table 1). After the intervention, both groups showed significant differences compared with before the intervention in FVC, FEV₁, 10MWT, and 6MWT (p<0.05) (Table 2). There were significant differences after intervention in FVC (z=-2.062, p=0.046), FEV₁ (z=-2.082, p=0.037), and 6MWT (z=-2.246, p=0.025) between the two groups. There was no significant difference after intervention in the SpO₂ (z=-0.082, p=0.935) and 10MWT (z=-0.514, p=0.078).

DISCUSSION

This study investigated the effect of intensive aerobic exercise on respiratory capacity and walking ability in patients with chronic stroke. Both groups showed significant changes after the intervention, and the experimental group showed more significant changes than the control group in FVC, FEV₁, and 6MWT. However, there was no significant change in SpO₂ and 10MWT. The findings of this study show that intensive aerobic exercise improved the respiratory capacity and walking endurance of chronic stroke patients.

Respiratory muscle strength and/or aerobic exercise in previous studies of stroke patients showed similar improvement in aerobic capacity^{5, 8}. Respiratory capacity depends on persistent cardiopulmonary organ and neuromuscular system interaction, and is crucial for stroke patients because of decreased physical condition. In this study, the use of cycle ergometry for

Table 1. General characteristics of the subjects

	Experimental group (n=6)	Control group (n=6)
Gender		
Male/Female	3/3	4/2
Paretic side		
Right/Left	3/3	4/2
Age (years)	56.8 ± 6.5 ^a	63.7 ± 5.8
Weight (kg)	66.3 ± 5.1	62.0 ± 6.2
Height (cm)	164.2 ± 8.4	163.4 ± 11.7
Duration (months)	13.7 ± 1.5	14.3 ± 1.5

^aMean ± SD**Table 2.** Outcome measures

	Experimental group (n=6)			Control group (n=6)		
	Pretest	Posttest	Follow-up	Pretest	Posttest	Follow-up
FVC (l)	2.7 ± 0.3 ^a	3.2 ± 0.3 ^{*+}	3.2 ± 0.2 ⁺	2.3 ± 0.2	2.8 ± 0.2 [*]	2.9 ± 0.2
FEV ₁ (l)	1.9 ± 0.2	2.4 ± 0.2 ^{*+}	2.4 ± 0.2 ⁺	1.9 ± 0.2	2.0 ± 0.2	2.1 ± 0.2
SpO ₂ (%)	95.8 ± 0.9	96.4 ± 0.8	96.9 ± 0.7	95.8 ± 0.6	96.4 ± 0.7	96.9 ± 0.7
10MWT (sec)	14.5 ± 1.3	10.2 ± 0.7 [*]	10.4 ± 0.9	14.9 ± 2.2	11.4 ± 0.9 [*]	11.5 ± 1.1
6MWT (m)	251.3 ± 52.6	318.0 ± 41.2 ^{*+}	318.0 ± 33.1 ⁺	229.5 ± 46.9	259.0 ± 47.4 [*]	265.2 ± 46.1

^aMeans ± SD^{*}Significant difference within group. ⁺Significant difference between groups.FVC: forced vital capacity; FEV₁: forced expiratory volume in one second; SpO₂: 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.

exercise may improve respiratory capacity and walking endurance in both groups. However, the intensive aerobic exercise group showed more significant differences in respiratory capacity (FVC and FEV₁) and walking endurance (6MWT) than the control group (p<0.05).

Decreased respiratory capacity may be induced through activity limitation and restriction of the social participation of stroke patients¹³⁾. In a study by Sandberg et al.⁴⁾, the participants of the experimental group had improved their respiratory capacity, walking endurance, and balance ability. The results of this study are similar to the above results. In this study, the experimental group showed better improvement in the FVC, FEV₁, and 6MWT than the control group (p<0.05). For independent life and social participation, respiration capacity and walking endurance are needed for patients with central nervous system damage.

In conclusion, this study explored the effect of intensive aerobic exercise on respiratory capacity and walking ability in chronic stroke patients using FVC, FEV₁, SpO₂, 10MWT, and 6MWT. It revealed that intensive aerobic exercise positively affected the FVC, FEV₁, and 6MWT that are respiratory capacity and walking endurance measurement. Thus, intensive aerobic exercise is effective for the improvement of respiratory capacity and walking endurance in chronic stroke patients.

ACKNOWLEDGEMENT

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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