



Original Article

The effect of respiratory exercise on trunk control, pulmonary function, and trunk muscle activity in chronic stroke patients

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Abstract. [Purpose] This study aims to identify the effect of respiratory exercise on trunk control, pulmonary function, and trunk muscle activity in chronic stroke patients. [Subjects and Methods] The study included 24 chronic stroke patients who were randomly assigned, 12 each, to the experimental and control groups, and received neurodevelopmental treatment. Moreover, the experimental group underwent respiratory exercise. In each patient, the trunk control was measured using the Trunk Impairment Scale (TIS); muscle activity of the trunk, through the surface electromyogram; and pulmonary function, using the pneumatometer. [Results] The intragroup comparison showed significant differences in TIS, Forced vital capacity (FVC), Forced expiratory volume at one second (FEV1), Rectus Abdominis (RA), Internal Oblique (IO) and External Oblique (EO) in the experimental group. The intergroup comparison showed that the differences in TIS, FVC, FEV1, RA, IO and EO within the experimental group appeared significant relative to the control group. [Conclusion] Based on these results, this study proved that respiratory exercise was effective in improving trunk control, pulmonary function, and trunk muscle activity in patients with chronic stroke.

Key words: Trunk, Respiratory, Stroke

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INTRODUCTION

Stroke is a brain functional disorder caused by rupture or clogging of the cerebrovascular system, leading to hemiplegia wherein one side of the body is paralyzed and trunk stability is abnormal¹⁾. Stroke patients lose control of the trunk function due to reduced exercise of the upper and lower limbs and mal-arrangement of the body that weaken the trunk muscle and cause asymmetrical muscular activity²⁾. There is thus difficulty in maintaining balance because such abnormal trunk ability also affects the proprioceptive sense³⁾. Moreover, due to the loss of trunk ability, the lung and chest cannot expand enough, and the paralysis of respiratory muscles can cause complications such as pneumonia⁴⁾. Therefore, improving the trunk ability is emphasized in rehabilitation of stroke patients³⁾.

Recently, there have been many studies on improving physical function through respiratory exercise. The results of introducing a respiratory exercise in patients with chronic obstructive pulmonary disease showed improvement in their endurance and quality of life⁵⁾. An exercise therapy using a pneumatometer was effective in improving the pulmonary function in patients with amyotrophic lateral sclerosis⁶⁾. So far, respiratory exercise in research has been mostly conducted in patients with respiratory disease, but few studies have reported the effects of respiratory exercise, using respiratory exercise equipment, on the trunk control, trunk muscle activity, and pulmonary function of patients with chronic stroke. This study aims to identify the effects of respiratory exercise on trunk control, pulmonary function, and trunk muscle activity in patients with chronic stroke.

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SUBJECTS AND METHODS

This study was performed on 24 patients diagnosed with stroke through CT and MRI more than 6 months ago, and randomly assigned, 12 subjects each, to the experimental (6 males, 6 females) and control (6 males, 6 females) groups. All subjects selected could perform assignments as they received a score of 24 or more on the Mini-Mental State Examination (MMSE), could walk 10 m or more independently, and had no visual disorder, visual field defect, and lower limb orthopedic disorder. The hypothesis of this study is that there will be a significant difference between respiratory exercise on trunk control, pulmonary function and trunk muscle activity in chronic stroke patients. Before the experiment, the subjects received sufficient explanation on the purpose and method of this research, and their consent was obtained. The Dongshin University Research Ethics Board approved the study protocol, and all the subjects gave their informed consent. For the experimental group the average age was 61.7 ± 6.2 years, the average height was 162.5 ± 3.4 cm, and the average weight was 64.2 ± 5.2 kg. For the control group the average age was 59.2 ± 4.6 years, the average height was 164.3 ± 5.6 cm, and the average weight was 62.7 ± 8.6 kg.

The experimental and control groups received a neurodevelopmental treatment for 30 min a 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 on the respiratory exercise method. They were instructed not to breathe through their nose during the respiratory exercise, and to take rest until they calmed down if they felt fatigued or dizzy, and then resume the exercise. The patient stood with both feet apart at shoulder width, sat down with the feet resting flat on the floor in a proper posture, put the respiratory exercise equipment on a head height, held the equipment on one hand, pulled the chin, and made a neutral posture. The patient held a mouthpiece over the mouth, stared at the respiratory exercise equipment, and carried out inhalation and exhalation. Difficulty level 1 without resistance was applied in the first week followed by difficulty level 2 with 50% resistance in the second week, difficulty level 3 with 60% resistance in the third week, and difficulty level 4 with 70% resistance in the fourth week.

Trunk control was measured using the Trunk Impairment Scale (TIS). TIS had 17 items, consisting of 7 points for static balance in the sitting position, 10 points for dynamic balance, and 6 points for coordination ability. The score ranged from 0 to 23, and the higher the score, the better the trunk control ability.

Trunk muscle activity was measured using the surface electromyogram (LXM 5308, Laxtha Inc., Daejeon, Korea). The configuration was set at a sampling rate of 1,024 Hz, band pass filter of 20–450 Hz, and notch filter of 60 Hz. The obtained muscle activity signals were analyzed using the electromyogram software (Telescan 3.11, Laxtha Inc., Daejeon, Korea), by processing with root mean square (RMS). The body parts with the attached surface electrodes were rubbed with sandpaper, and the horny layer of the skin was removed with cotton swabs containing alcohol, in order to reduce the skin resistance. The surface electrodes were attached to the rectus abdominis, external abdominal oblique, and internal abdominal oblique muscles. For the normalization of surface electromyogram signal, reference voluntary contraction was used. The reference contraction value was measured when the patient was comfortably sitting on a chair, and the reference voluntary contraction value was measured when the patient stood up naturally from the seated position. The movements were measured thrice and the average value obtained to minimize measurement errors; the measurement time was analyzed by collecting 3-s signals that eliminated the first and last 1 s and applying %RVC value from the electromyogram signal recorded by measuring for 5 s.

Pulmonary function was measured using the pneumatometer. While the patients were comfortably seated, their forced vital volume (FVC) and forced exhalation volume at 1 s (FEV1) were measured and compared.

SPSS software version 19.0 was used to statistically process and analyze the collected data. A paired t-test was performed to compare the extent of trunk control, pulmonary function, and trunk muscle activity in both groups before and after the study. An independent t-test was used to compare differences between the groups, and statistical significance level was set at $p=0.05$.

RESULTS

The intragroup comparison showed significant differences in TIS, FVC, FEV1, RA, IO and EO in the experimental group ($p<0.05$), as shown in Table 1. The intergroup comparison showed that the differences in TIS, FVC, FEV1, RA, IO and EO within the experimental group appeared significant relative to the control group ($p<0.05$), as shown in Table 1.

DISCUSSION

This study aims to identify the effect of respiratory exercise on trunk control, pulmonary function, and trunk muscle activity in chronic stroke patients. There was a significant difference in the trunk control of the experimental group, based on the intragroup comparisons. The trunk control improved more significantly in the experimental group than the control group, according to the intergroup comparisons. Kim et al.⁷⁾ reported that respiration strengthening training was effective in stabilizing trunk control in stroke patients; Kim⁸⁾ also reported that complex breath exercise was effective in stabilizing trunk control in stroke patients; these results support those of this study. The loss of trunk muscle control in stroke patients

Table 1. Comparison of the results of the TIS, RA, IO, EO, FVC, and FEV₁ between the experimental and control groups

| | Experimental group (N=12) | | | Control group (N=12) | | |
|------|---------------------------|-------------|-------------|----------------------|------------|-----------|
| | Pre | Post | Post-Pre | Pre | Post | Post-Pre |
| TIS | 12.2 (1.9) | 16.6 (1.1)* | 4.4 (1.6)# | 11.6 (0.8) | 12.8 (0.8) | 1.2 (1.4) |
| RA | 33.9 (1.6) | 47.8 (4.6)* | 13.9 (4.4)# | 38.6 (3.8) | 43.8 (4.8) | 5.2 (4.7) |
| IO | 23.2 (2.2) | 34.4 (4.1)* | 11.1 (6.2)# | 31.6 (5.1) | 34.5 (2.6) | 2.9 (4.5) |
| EO | 33.7 (4.4) | 44.4 (3.5)* | 10.6 (5.0)# | 36.8 (1.6) | 40.0 (3.7) | 3.2 (4.0) |
| FVC | 2.0 (0.1) | 2.6 (0.1)* | 0.6 (0.2)# | 2.2 (0.1) | 2.3 (0.1) | 0.1 (0.1) |
| FEV1 | 2.0 (0.2) | 2.5 (0.4)* | 0.5 (0.3)# | 1.9 (0.1) | 2.0 (0.1) | 0.1 (0.2) |

Values are mean (standard deviation).

TIS: Trunk Impairment Scale; RA: Rectus Abdominis; IO: Internal Oblique; EO: External Oblique; 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.

meant reduced posture stability, and the muscles connected with respiration were closely related to maintaining posture⁹). On a study of correlation among trunk muscles, trunk control, and pulmonary function in stroke patients, a significant difference was shown from the trunk control and pulmonary function¹⁰). Since the pulmonary function improved after the respiratory exercise in this study, the trunk control ability is considered to have improved as well.

The trunk muscle activity of the rectus abdominis, external abdominal oblique, and internal abdominal oblique muscles of the experimental group showed significant improvement after performing the respiratory exercise. There was a significant difference in the trunk muscle activity of the rectus abdominis, external abdominal oblique, and internal abdominal oblique muscles on introducing complex respiratory exercise in patients with chronic stroke⁸). Jo¹¹) reported that respiratory exercise was effective in stabilizing the trunk muscle activity of the rectus abdominis, external abdominal oblique, and internal abdominal oblique muscles in patients with chronic stroke, which was consistent with the results of this study. When trunk stabilization was needed, the functional changes in the trunk muscle required the coordination of the tonicity and phasic pain of the diaphragm and transversus abdominis muscle, facilitating the coordination reaction of the central nervous system between respiration and trunk movement^{12, 13}). Such results imply that the improvement of trunk muscle activity due to respiratory exercise has improved trunk stability as well.

Kim¹³) showed that FVC and FEV1 improved significantly after performing a respiratory exercise, and Kim et al.⁷) reported that respiration strengthening training positively affected the pulmonary function of stroke patients, supporting the results of this study. The results of introducing respiratory exercise in stroke patients with restrictive ventilator disturbance showed that the endurance of their trunk muscles improved and the FVC increased resulting in an increase in deep breathing ability and exhalation volume. Moreover, as the respiratory exercise increased the strength and coordination of trunk muscles and improved respiratory function, FEV1 is also considered to have improved. This study confirmed that the respiratory exercise was an intervention that positively helped improve trunk control, trunk muscle activity, and pulmonary function in patients with chronic stroke.

The limitation of this study 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 chronic stroke patients in choosing the subjects. An additional study improving these problems is considered necessary.

Conflict of interest

None.

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