

A Study on Core Stability Training for Postural Control Ability and Respiratory Function in Patients with Chronic Stroke

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Abstract

The purpose of this study was to examine the effects of the core-stability training on postural control ability and respiratory function in patients with chronic stroke. 30 subjects were randomly assigned to 2 groups. Experimental group (n=15) received core-stability training and control group (n=15) received general exercise. Each program was performed 30 min, 4 times a week for a period of 8 weeks. Core-stability training included a therapeutic program to train abdominal muscle strength. General exercise include weight bearing and weight shifts and joint movements to improve flexibility and the range of motion.

For all 30 subject, the items measured before the training were measured after the therapeutic intervention. To observe postural control changes, we measured maintenance & change of posture, balance and coordination ability with postural assessment scale for stroke (PASS) and trunk impairment scale (TIS). The respiratory functions were measured forced vital capacity (FVC), forced expiratory volume at one second (FEV₁) using spirometer.

After training, the PASS and TIS scores was significantly improved in experimental group ($p < .05$), and the experimental group showed significantly difference from control group ($p < .05$). In respiratory function test, experimental group more significantly increased than before ($p < .05$), and showed significantly difference from control group ($p < .05$).

The results of this study showed that the core-stability training may be appropriate for improving the trunk stability and respiratory function in chronic stroke patients.

Keywords: *Core-stability Training, Postural Control Ability, Respiratory Function, Stroke*

1. Introduction

Stroke is a common nervous system disorder that occurs due to abnormal blood circulation in the brain with a completely developed nervous system. This disease becomes the cause of considerable morbidity and mortality worldwide [1]. As the survival rate of patients with stroke increased owing to advances in medical technology, stroke became the most common internal cause of disablement [2].

In general, stroke patients experience weakness of muscles on the affected side [3]. The trunk muscle is the biggest part of our body and plays an important role in the

stabilization and movement of body segments. It also contributes to smooth central movement so that our body easily can be changed to new posture.

However, the weakness of trunk muscles moves the center of gravity backward, thereby causing thoracic bending. As this disturbs proper postural control by reducing the activation of abdominal muscles [4], it can become the primary cause of reduced balance and gait abilities [5]. Stroke patients employ abnormal postural control strategies while performing tasks due to the loss of postural control ability and physical imbalance [6], and they have their center of gravity moved toward the unaffected side. Therefore, they cannot perform symmetric weightbearing and have reduced limits of stability [7].

The weakness of trunk muscles in stroke patients also affects their primary and secondary respiratory muscles [8]. Therefore, it causes functional respiratory disorders which limit physical activities [9]. Damage to the motor cortex and the pyramidal tract due to a stroke leads to motor control disorders and co-contraction of trunk muscles due to abnormal levels of muscle tension and voluntary movement. As a result, the coordination and motor performance of respiratory muscles are impaired [10].

Thus, when planning the treatment for stroke patients, tests on their postural control ability and respiratory function should be considered as important factors to evaluate their functional abilities and determine their treatment and prognosis. Intervention programs to improve the postural control ability and respiratory function of stroke patients should focus on improving trunk stability. Trunk stability depends on coordinated activities of multiple trunk muscles, and therefore, these muscles should contract in a concerted manner to secure stability [11].

Core-stability is usually to strengthen the muscle around the abdominal, lumbar, and pelvic regions, because the muscles of these regions play an important role in stability as well as in controlling the lumbar posture by using tonic or postural muscles during whole-body exercise [12]. Core-stability is prerequisite for maintaining the proper posture of the lumbar and pelvic regions during activities.

Exercise for core-stability serve as treatment for simultaneously activating the abdominal and multifidus muscle in order to stabilize the body and head during the beginning of limb movement and during the course of these movements.[13] Stroke patients lack selective movement control and thus the order of muscle movement is changed. These patients thus move in an unusual pattern, which results in much waste of energy and malfunctioning movement pattern. Verheyden *et al.* [14] suggested that selective trunk stabilization exercises should be added to traditional exercise therapies to improve balance after a stroke.

This study was designed based on the results of previous studies demonstrated that the weakening of trunk muscle seen in chronic stroke patients causes disorders in postural control and respiratory function.

The purpose of this study was to evaluate the effects of trunk stabilization training, with a focus on strengthening trunk muscles, on the postural control and respiratory function of stroke patients. Then, based on the results, the study intends to support the effectiveness of trunk stabilization training for stroke patients.

2. Subjects and Methods

2.1. Subjects

The present study choose 30 subjects who consented study participation after hearing the objective of the study among those who chronic stroke patients treated the rehabilitation hospital located in Jinju city in Korea. All patients signed an informed consent form. The participants were divided into two groups: Experimental group (EG; n=15) received core- stability training for abdominal muscle strength. Control group (CG; n=15) received general exercise for increase balance ability.

The selection conditions for the subjects are as follows:

- 1) No impairment of corrected vision and hearing.
- 2) Duration of disorder > 6 months.
- 3) Do not have any problem in musculoskeletal model.
- 4) Absence of a cardiac disorder.
- 5) Having MMSE-K score >19.

Table 1. General Characteristics of Each Group

Group	Gender(M/F)	Age(year)	Weight(kg)	Height(cm)	MMSE-K(score)
EG (n=15)	10/5	61.45±4.56	64.83±11.46	165.73±9.64	27.07±3.85
CG (n=15)	9/6	62.85±3.21	61.03±9.86	162.23±7.96	28.86±4.76

2.2. Training Program

The present used training program that it is based on trunk stability training program developed by Kim [15]. Each program was performed 30 min, 4 times a week for a period of 8 weeks.

Core-stability training is a therapeutic program to train abdominal muscle strength. General exercise is a therapeutic program to increase balance ability and symmetry.

Table 2. Core-stability Training Program for Experimental Group

Performance	
1	Abdomen retract to back (Supine, knee joint 70~90 flex) Hold 5, 10, 15, 20 sec
2	Upper part of the back lifting (Supine, knee joint 70~90 flex) Hold 5, 10, 15, 20 sec
3	Low limb elevation and rotation (Supine knee joint 70~90 flex) Hold 5, 10, 15, 20 sec

Table 3. General Training Program for Control Group

Performance	
1	Lateral weight shifting to affected side(Standing, Hip & knee joint extend)
2	Lifting unaffected side leg on board (Standing, Hip & knee joint extend)
3	Anterior and Posterior weight shifting (Standing, Hip & knee joint extended)

2.3. Outcome Assessment

To observe postural control changes, we measured maintenance and change of posture, balance and coordination ability with postural assessment scale for stroke (PASS) and trunk impairment scale (TIS). The respiratory functions were measured forced vital capacity (FVC), forced expiratory volume at one second (FEV1) with spirometer (micro Lab MK8 Spirometer, CareFusion 232 Ltd, UK).

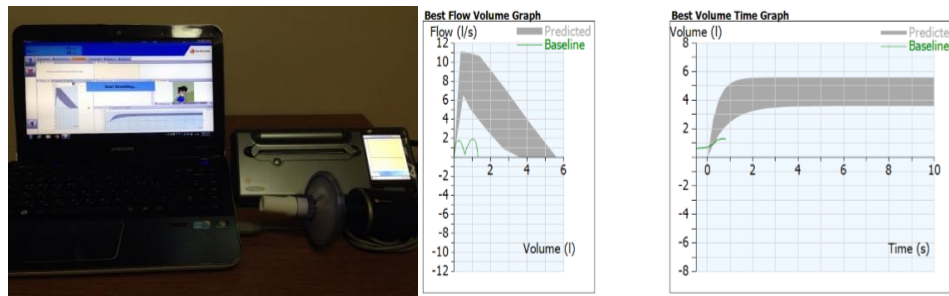


Figure1.Spirometer Device (micro Lab MK8 Spirometer, CareFusion 232 Ltd, UK)

2.4. Statistical Method

For the statistical analysis of this study, SPSS 12.0 ver. for window[®] was used. The results of all experiments were expressed as a mean and standard deviation. Independent t-test was used for the comparison between experimental group and a control group.

The comparison on postural control ability and respiratory function change of value paired t-test was used for the comparative verification on pre and post of training programs in each group. If 'p' value is less than 0.05, statistical significance level was used.

3. Result

3.1. Changes of Postural Control Ability

The PASS and TIS test revealed that both group showed increased. The experimental group showed significantly different between pre and post in PASS and TIS ($p < .05$), and control group showed significantly different between pre and post in TIS ($p < .05$). The experimental group showed significantly different from control group at post in TIS ($p < .01$).

Table 4.Changes of Postural Assessment Scale for Stroke (PASS) in Each Group

	Experimental group		Control group	
	Pre	Post	Pre	Post
PASS	28.93±2.02	32.01±1.81**	29.13±1.89	30.93±1.84

All values showed mean ± SD

Test by paired t-test (*; $p < .05$, **; $p < .01$)

Test by independent t-test (#; $p < .05$, ##; $p < .01$)

Table 5.Changes of Trunk Impairment Scale (TIS) in Each Group

	Experimental group		Control group	
	Pre	Post	Pre	Post
TIS	13.47±2.55	18.13±2.06 [#]	15.07±2.57	16.13±2.39 ^{*##}

All values showed mean ± SD

Test by paired t-test (*; $p < .05$, **; $p < .01$)

Test by independent t-test (#; $p < .05$, ##; $p < .01$)

3.2. Changes of Respiratory Function

The FVC and FEV₁ test revealed that both group showed increased. The experimental group showed significantly different between pre and post in FVC and FEV₁ (p<.05). The experimental group showed significantly different from control group at post in FVC and FEV₁ (p<.05).

Table 6.Changes of Forced Vital Capacity (FVC) in Each Group

	Experimental group		Control group	
	Pre	Post	Pre	Post
FVC	2.01±0.29	2.56±0.33 [*]	2.22±0.36	2.29±0.34 [#]

All values showed mean ± SD

Test by paired t-test (^{*}; p<.05, ^{**}; p<.01)

Test by independent t-test ([#]; p<.05, ^{##}; p<.01)

Table 7.Changes of Forced Expiratory Volume at One Second (FEV₁) in Each Group

	Experimental group		Control group	
	Pre	Post	Pre	Post
FEV ₁	1.64±0.19	1.90±0.40 ^{***}	1.57±0.31	1.63±0.30 ^{##}

All values showed mean ± SD

Test by paired t-test (^{*}; p<.05, ^{**}; p<.01)

Test by independent t-test ([#]; p<.05, ^{##}; p<.01)

4. Discussion

Recent studies have focused on the postural control ability and respiratory function of chronic stroke patients because reduction in the motor control ability of muscles involved in breathing, due to the weakening of trunk muscles on the affected side, has been known to be associated with declines in thoracic movement and strength of respiratory muscles [16].

Chen *et al.* [17] reported that the lost strength of abdominal and thoracic expiratory muscles reduces the ability to effectively cough and remove sputum, which results in various respiratory complications due to the accumulation of secretions within the respiratory tract.

In other words, the weakness of trunk muscles in stroke patients affects their primary and secondary respiratory muscles and postural control ability. Therefore, it causes functional respiratory disorders which limit physical activities.

Since the 1990s, core-stability training has been implemented as a therapeutic intervention to reduce pain and increase abdominal and lumbar stability, particularly for patients with chronic lumbar pain. In recent years, it has been suggested as an intervention to strengthen the trunk muscles of stroke patients.

Marshall and Murphy [12] reported that trunk stabilization training alleviates the imbalance of muscles necessary for postural maintenance by activating abdominal muscles and small vertebral muscles in a coordinated and simultaneous manner.

Considering these findings, this study evaluated an eight-week trunk stabilization training program as a method for strengthening the trunk muscles of chronic stroke

patients intensively, and then analyzed its outcome by comparing the results with those of a general exercise therapy program aimed at improving balance and symmetry.

Postural control ability refers to the trunk's anticipatory postural adjustment exhibited before the movement of the extremities [18]. Most patients with hemiplegia experience difficulties in this postural control ability.

In this study, the result of postural control ability test, postural assessment scale for stroke (PASS) and trunk impairment scale (TIS) test revealed that both groups showed increased. The experimental group showed significantly different from control group at post in TIS ($p < .01$).

This suggests that both core-stability training and general exercise therapy may have positive effects on improving the postural control ability of chronic stroke patients. The control group underwent a general exercise therapy program consisting of lateral weight shift, lifting the foot on a footboard, and proprioceptive exercises.

Control group may have improved postural control ability by inducing balance increases through stretching the whole body and increasing symmetry. The experimental group performed core-stability training that consisted of holding the stomach inward, lifting the trunk, and rotating the lower extremities.

As the patients in experimental group strengthened their abdominal and lumbar muscles intensively, they were able to strengthen the trunk muscles and improve the control of selective muscle movements. As a result, experimental group may have shown an overall higher level of postural control ability compared to the control group.

In a previous study, Verheyden [14] implemented a five-week trunk exercise program in 33 stroke patients, and reported that the test group showed a statistically significant level of improvement in postural control ability compared to the control group that received general exercise therapy.

Saeyns et al. [19] also reported in their study that trunk exercises were more effective than general exercise therapy for stroke patients in terms of postural control ability, balance, and motor skills. Their findings support the results of this study.

The weakening of respiratory function is the most important issue in supporting the life of stroke patients. In addition, the accurate measurement of respiratory function is essential for evaluating the functional abilities of patients, diagnosing their diseases, and assessing their prognosis and degree of impairment, thereby allowing proper exercise prescriptions to be made.

In this study, the result of respiratory function test, forced vital capacity (FVC) and forced expiratory volume at one second (FEV_1) test revealed that both groups showed increased. The experimental group showed significantly different from control group at post in FVC and FEV_1 ($p < .05$).

The above results may illustrate that core stability training also has positive effects on the respiratory function of chronic stroke patients by improving their postural control.

Bach et al. [20] supported the interpretation of the results of this study by arguing that abdominal and lumbar strengthening exercises improve expiratory function and thoracic expansion, thereby increasing forced expiratory volume. Lung capacity and forced expiratory volume are closely associated with the strength of respiratory muscles [21].

This study showed that an eight-week core-stability training program applied in chronic stroke patients had positive effects on their postural control ability and respiratory function. In particular, core-stability training was demonstrated to contribute further to improving balance, postural stability, and lung capacity, compared to general exercise therapy.

A comprehensive review of the above results suggests that when physical therapists aim to improve the postural control and respiratory function of chronic stroke patients, core-stability training performed to strengthen trunk muscles through direct interaction with patient increases therapeutic efficiency and effects.

5. Conclusion

This study confirmed that an eight-week core-stability training program was more effective than a general exercise therapy program in improving the postural control ability and respiratory function of chronic stroke patients.

Therefore, the results of this study are likely to become essential information showing the effectiveness of core stability training for the rehabilitation of chronic stroke patients in clinical practice.

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