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The Effects of Two Types of Trunk Stability Exercise on the Gait Factors of Stroke Patients

The purpose of this study is to identify the effects of two trunk stability exercise types on the gait factors of stroke patients. We randomly divided 24 old elderly patients with hemiplegia, who were hospitalized due to stroke, into a two groups, each with its own six-week exercise program: one that used of a dynamic trunk stability exercise using with physio-balls(n=12) and a group of one that used a static trunk stability exercise using on mats(n=12). After measuring the participants gait ability a sin a pre-test, we again measured their ability again as in a posttest after two-for both types of six-week exercise programs for each group. The analysis of the data analysis showed that both ball and mat exercise programs significantly improved the participants' gait velocity and stride length; cadence, however, was significantly changed only by the ball exercise program. In conclusion, both types of trunk stability exercise may be useful in improving the gait ability of stroke patients, and, in particular, the former can be used as an exercise method that effectively significantly affects more various other gait factors.

Key words: *Stroke; Hemiplegia; Trunk Stability Exercise; Gait*

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INTRODUCTION

One of the most common injuries after stroke is unilateral muscular weakness due to brain injury [1], which can reduce mobility. Reduction in mobility induces bodily imbalance, resulting in an asymmetric posture. Such postural asymmetry reduces patients ability to maintain their center of mass and also affects their righting and equilibrium reactions, causing significant problems in postural stability [2]. In turn, severe postural imbalance and lack of stability lead to abnormality in upper-limb functions and gait of hemiplegic patients [3]. After completing a rehabilitation program, approximately 60% to 80% of patients with motor impairment caused by stroke can walk independently [4, 5]. As the center of the body, the trunk controls posture through functional movements when the limbs move against gravity [6]. The muscular strength of the trunk shows a significant correlation with balancing ability [7, 8], and weak trunk muscles can adversely affect the balance, stability, and functional impairment of stroke patients [8]. Because weak trunk muscles are considered a major cause of decline in the balance and gait of stroke patients [9], trunk stability should be ensured in order to improve gait of stroke patients with hemiplegia.

For hemiplegic patients with trunk control disability, a trunk stability exercise consisting of rotation and lateral flexion of the asymmetric trunk can strengthen the trunk muscles to enhance movement and stability of the spine [10], to improve postural alignment and balancing [11, 12], and to promote gait [13, 14, 15].

Exercise balls are widely-used clinical tools in training for core muscle stability. Because balls supply an unstable surface, ball exercise provide marked loads trunk control and dynamic balancing [16, 17]. These exercise can enhance muscular strength, endurance, and coordination, as well as improving balancing ability by comprehensively developing the patient's perception and sense of balance [18, 19]. In addition, by adding a ball exercise to any trunk stability exercise, the proprioceptors can be stimulated more strongly, which improve balance and provides sustainability for enhancing physical functions [20, 21].

In this study, we identified function- centered changes in the gait factors of hemiplegic patients, who were hospitalized due to stroke, when they took part in two types of exercise program: on that used a dynamic trunk stability exercise with physio-balls or one that used a static trunk stability exercise on mats. We demonstrated the effects of such exercises on improving the gait of chronic hemiplegic patients, and we provided basic data for efficient interventions in both clinical situations and home-care physical therapy.

METHODS

Subjects

The subjects of this study were 24 hemiplegic patients with stroke who were admitted to a long-term care hospital located in Pohang City, Gyeongbuk. The patients were at least 65 years old, understood the purpose of the study, and consented to participate. The detailed inclusion criteria of the subjects are as follows:

(1) those who had a stroke one year or more before the study;
(2) those who scored 24points or higher for communication and understanding ability on the Mini-Mental State Examination-Korean(MMSE-K);
(3) those who could stand up without help and maintain a standing posture for one minute or more independently;
(4) those who could walk at least 10 meters independently; and
(5) those who had no pain that would restrict exercise performance.

Exercise Program

To select the 24 subjects in this study, we performed interviews, cognitive function tests, and gait tests for stroke patients. The selected participants were randomly divided into the ball exercise program group(BEPG; n=12) and the mat exercise program group(MEPG; n=12). After measuring their gait as a pre-test, each group began its respective type of exercise program. Each program consist of five 40-minute sessions per week for six weeks. Each session consisted of five minutes of stretching as a warm-up, 30minutes of the main exercise, and five minutes of stretching and deep breathing as a cool-down. Completing the below-mentioned course of tasks ten times was considered one set, and the subjects underwent two sets per session. Two minute rest were provided between the sets. Before performing each exercise program, all subjects underwent 40minutes of general physical therapy that consist of stretching, muscular strengthening, and joint range of motion. These sessions were led by physical therapists with at least three years of clinical experience. After the six-week programs, we again measured the participants gait as a post-test.

Ball exercise program

We selected five tasks that could be easily performed by hemiplegic patients from the exercise programs provided by Norris [21] and Ko et al. [11] for

Table 1. General characteristics of the subjects

	Ball exercise program group	Mat exercise program group
Gender(male/female)	3/9	2/10
Affected side(Rt/Lt)	8/4	9/3
Duration of onset(months)	16.00±1.55	17.10±2.35
Age(years)	69.75±2.05	70.83±2.31
Weight(kg)	57.87±4.99	58.83±3.76
Height(m)	1.60±.04	1.58±.06
MMSE-K(score)	23.25±.88	24.00±1.54

the dynamic trunk stability exercise using balls in this study. The five tasks are as follows:

(1) Bridge exercise I : supporting oneself on the ground with both arms in a supine position, raising both legs onto the ball, and holding a bridge position for five seconds;
(2) Bridge exercise II : supporting oneself on the ground with both arms in a supine position, raising both legs onto the ball to assume a bridge position, and pulling the ball forward and pushing it backward with both feet(by repeating knee flexion and extension);
(3) Single leg heel bridge exercise : supporting oneself on the ground with both arms in a supine position, raising both legs onto the ball to adopt a bridge position, and alternately lifting and holding leg up for five seconds;
(4) Prone arm and leg lift exercise : prone position on the ball and raising one leg while lifting the opposite arm, alternating limbs, and holding each position for five seconds; and
(5) Standing sitdown exercise : standing up while putting one foot forward and the other backward, leaning against wall while putting the ball between one's back and the wall and undergoing lunge exercise.

Mat exercise program

We referred to the exercise programs provided by Choi et al. [20] and Bjerkefors et al. [23] to design the static trunk stability exercise using mats in this study as follows:

(1) Bridge exercise I : supporting oneself on the ground with both arms in a supine position, lifting the buttock while bending both knees at around 60° to adopt a bridge position and holding the position for five seconds;
(2) Single leg heel bridge exercise : supporting oneself on the ground with both arms in a supine position to adopt a bridge position and alternately stretching out each leg, holding it for five seconds;
(3) Four-point kneeling position to arm and leg lift exercise : four-point kneeling position to perform an arm and leg lift exercise and taking the same position to raise one leg while lifting the opposite arm for five seconds, alternately;
(4) Bilateral leg cycling : assuming a supine position, lifting both legs, and performing a cycling exercise for five seconds; and
(5) Prone arms and legs extended exercise (Superman Pose) : prone position on the mat and extending the body, while lifting both arms and legs and holding for five seconds.

Measurement

We used a GAITRite (CIR systems Inc., Sparta, NJ, USA) to analyze gait of the subjects. The gait analysis was performed before and after the six-week programs. Gait was measured three times and the average value was used. Subject was asked to walk on the five-meter-long GAITRite at the most comfortable pace after receiving an oral signal the investigator, who measured the subject's gait velocity, cadence, stance time, and stride length. The rater reliability of the test was set at r=.90. At a comfortable walking pace, the correlation coefficient among all gait measurements was .96 or more [24].

Data Analysis

SPSS(ver. 18) software was used for data processing. An independent t-test was conducted to identify differences in gait changes between the groups. A paired t-test was conducted to test differences within each group before and after the program. The statistical significance level was set at $p<.05$.

RESULTS

Changes in gait velocity of the BEPG and MEPG before and after the programs

Both groups showed a significant increase in gait velocity after the six-week programs. When the pre- and post- program changes in gait velocity were compared between the two groups, the BEPG showed a more significant increase than the MEPG ($p<.05$; Table 2).

Changes in cadence of the BEPG and MEPG before and after the programs

When the changes in cadence before and after the six-week programs were compared, those of the BEPG were significantly increased, while those of the MEPG showed no significant change. When

Table 2. Changes of gait velocity (unit : cm/sec)

BEPG(Mean±SD)			MEPG(Mean±SD)			p
Before	After	p	Before	After	p	.004‡
48.86±1.68	56.48±4.05	.000†	50.81±1.06	52.83±1.71	.014†	

BEPG : Ball exercise program group , MEPG : Mat exercise program group
†significant difference between pre–post within group, †p〈.05.
‡significant difference between two group, ‡p〈.05

Table 3. Changes of cadence (unit : step/min)

BEPG(Mean±SD)		p	MEPG(Mean±SD)		p	p
Before	After	p	Before	After	p	.007‡
71.05±2.71	76.98±3.64	.003†	71.15±2.73	71.41±4.43	.840	

BEPG : Ball exercise program group , MEPG : Mat exercise program group
†significant difference between pre–post within group, †p〈.05.
‡significant difference between two group, ‡p〈.05

the changes in cadence were compared between the two groups, the BEPG showed a more significant increase than the MEPG (p〈.05; Table 3).

Changes in stance time of the BEPG and MEPG before and after the programs

When the changes in stance time before and after the six-week programs were compared, those of the BEPG showed no significant change, while those of the MEPG were significantly increased. Meanwhile, no significant differences were observed when the changes in stance time were compared between the two groups(p〈.05; Table 4).

Table 4. Changes of stance time (unit : sec)

BEPG(Mean±SD)			MEPG(Mean±SD)			p
Before	After	p	Before	After	p	.550
1.14±.09	1.18±.09	.352	1.20±.05	1.25±.06	.027†	

BEPG : Ball exercise program group , MEPG : Mat exercise program group
†significant difference between pre–post within group, †p〈.05.

Changes in stride length of the BEPG and MEPG before and after the programs

Both groups showed significant increase in stride length after the six-week programs as compared to the stride length measured before the programs. When the changes in stride length were cpmpared between the two groups, the BEPG showed a more significant increase than the MEPG(p〈.05; Table 5).

Table 5. Changes of stride length (unit : cm)

BEPG(Mean±SD)			MEPG(Mean±SD)			p
Before	After	p	Before	After	p	.015‡
61.89±1.14	67.57±3.23	.000†	63.67±1.36	66.11±1.73	.001†	

BEPG : Ball exercise program group , MEPG : Mat exercise program group
†significant difference between pre–post within group, †p〈.05
‡significant difference between two group, ‡p〈.05

DISCUSSION

As hemiplegic patients show abnormal gait patterns, it is important to enhance their gait ability in order to improve their functional independence in daily life [25]. Muscles contributing to trunk stability—that is, the internal abdominal oblique and the erector spinae muscles—play an important role in heel strikes while walking [26], thus, muscular activation through exercise is required to improve gait.

In this study, we identified function- centered changes in gait factors of 24 patients, who were 65 years older and had hemiplegia due to stroke, after they underwent six-week programs for the dynamic trunk stability exercise using physio-balls(for the BEPG) or the static trunk stability exercise using mats(for the MEPG). As a result, the gait velocity and stride length of participants showed significant changes both in the BEPG and the MEPG, while cadence was significant changed only in the BEPG, and stance time was significantly changed only in the MEPG. Significant differences were observed between the two groups in gait velocity, cadence, and stride length.

The results of this study are consistent with those of other studies, including Song and Kim [27], who reported that the gait velocity of stroke patients was improved after trunk stability exercise on various surfaces that provide instability. Ko et al. [11] also reported that the gait velocity of stroke patients improved after a trunk stability exercise using balls, and in Chung et al. [28], the gait velocity of stroke patients was improved after a core stability exercise. Similarly, the gait velocity of elderly patients was improved after a dynamic trunk exercise in Kim et al. [29], and Choi et al. [20] found that the gait velocity of elderly women was improved after a ball exercise was implemented. However, the results of the present study differed slightly from those of Kim et al. [29], in which gait velocity was more significantly increased in isometric trunk exercise than in dynamic trunk exercise(though there were some differences in the organization of the exercise programs in both studies).

Trunk stability exercise using balls can provide instability for the body, thus improving muscular strength and flexibility and appropriately activating the proprioceptors for dynamic balancing. This activation may increase trunk stability in gait to improve gait velocity and stride length(17, 30, 31). It could be argued that the gait velocity and stride length of the MEPG were improved, to some degree, because improvement in trunk stability enhanced strength of trunk muscles in gait and because ground reaction force could be appropriately used by the improved strength of leg muscles. Despite the lack of significant differences between the two groups, the increase stance time of the MEPG in the static trunk stability exercise might have been caused by increase in balancing ability during gait and improvement in muscular strength by enhanced efficiency in energy consumption.

The results of this study show that both types of trunk stability exercise—that is, the dynamic trunk stability exercise using balls and the static exercise using mats—may be useful in improving the gait of stroke patients; the results also show that the former exercise has a significant effect on other gait factors of various types. Further studies may be needed to investigate changes in the activity of main muscles and balancing while walking and to determine the correlation between gait factors after the application of similar exercise programs.

CONCLUSIONS

In order to investigate the effects of different trunk stability exercise types on the gait factors of stroke patients, we randomly divided 24 elderly patients with hemiplegia, who were hospitalized due to stroke, into two groups: one that used the dynamic trunk stability exercise and one that used static trunk stability exercise. After measuring the participants' gait ability as a pre-test, we measured their ability again as a post-test after the six-week exercise program for each group. The analysis of the data showed that both ball and mat exercise programs significantly improved gait velocity and stride length; cadence, however, was significantly changed only by the ball exercise program. The results of this study not only show that both types of trunk stability exercise may be useful in improving gait for stroke patients, but also show that the former can serve as an exercise that significantly affects various gait factors.

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