

# Effects of Dual-task Balance Exercise on Stroke Patients' Balance Performance

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**Abstract.** [Purpose] The purpose of this study was to evaluate the effects of dual-task balance training on stroke patients' balance performance. [Subjects and Method] Forty stroke patients were allocated equally and randomly to an experimental group and a control group. The experimental group performed the dual-task balance training of standing on a balance pad and moving a cup containing water. The control group performed the single-task balance training of maintaining balance on a balance pad. All the subjects exercised five times per week for 4 weeks. Each group's balance performance (sway area, sway path, and maximum velocity) was measured using a balance performance monitor, both prior to and after the exercise program. [Results] Comparing measurements from before and after the exercise program, both the experimental group and the control group showed statistically significant changes in sway area and maximum velocity, but not for sway path. Comparing the two groups, the experimental group showed more significant changes than the control group in sway area and maximum velocity, but there were no significant differences in sway distance between the two groups. [Conclusion] For the stroke patients, Dual-task balance training was more effective than single-task balance training. The results should help to promote the wider clinical application of dual-task balance training programs for stroke patients.

**Key words:** Strokes, Dual-task, Balance training

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## INTRODUCTION

Balance is a process in which the human body's senses perceive motions, its central nervous system integrates them, and its musculoskeletal system responds to them appropriately<sup>1)</sup>. For the body to maintain balance, the center of gravity within the base of support must be continuously regulated, and normal input and appropriate integration and regulation of the higher centers are required<sup>2)</sup>. Balance must also be maintained while a single task is performed or while multiple tasks are simultaneously performed<sup>3)</sup>.

People's ability to balance varies, subject to such diverse factors as age, gender, cognitive ability, and musculoskeletal disorders. In particular, in stroke patients, right-left imbalance causes asymmetric posture and reduces individual's ability to control center of gravity. This triggers serious problems in the body's ability to balance and to regulate posture resulting in gait disturbances<sup>4)</sup>. This inability to properly balance primarily restricts stroke victims' daily activities and increases their risk of falling, thereby posing a serious threat to their health<sup>5)</sup>. Clearly, stroke patients' recovery of their ability to balance themselves is crucial for preventing falls and regaining an independent life style<sup>6)</sup>.

Diverse exercise programs for improving stroke patients' balance performance have been tried: lateral weight

movement exercises<sup>7)</sup>, exercises using a ball<sup>8)</sup>, exercises involving raising the nonparetic foot on a foot plate of a certain height<sup>9)</sup>, visual feedback training<sup>1)</sup>, auditory feedback training<sup>10)</sup>, exercising using a balance pad<sup>6)</sup>, and a task-oriented functional training program<sup>5)</sup>.

Thus far, balance training for stroke patients has been conducted largely under single-task conditions<sup>11)</sup>. Simultaneous task-performance exercise, as recently practiced<sup>3)</sup>, is a training program that complements stroke patients' reduced balance, and the results from this training suggests that accurate evaluation and treatment of patients under dual-task conditions is necessary.

Accordingly, this study examined stroke patients' changes in balance by subjecting them to a dual-task balancing exercise that simulated a practical, ordinary activity of independent living, in order to provide basic data on their balance for their treatment.

## SUBJECTS AND METHODS

### Subjects

This study was conducted in a hospital located in Daegu Metropolitan City, from October 1 to October 30, 2011. Forty stroke patients who had been diagnosed by computed

**Table 1.** General characteristics of subjects

	Experimentals (n=20)	Controls (n=20)
Sex (male/female)	10/10	10/10
Age (years)	55.8 ± 3.6	56.7 ± 2.4
Height (cm)	161.2 ± 1.9	163.3 ± 2.3
Weight (kg)	62.0 ± 2.6	63.2 ± 3.2
Paretic side (right/left)	12/8	10/10
Onset duration (months)	7.2 ± 2.4	6.7 ± 2.4

Values are Mean ± SD

tomography (CT) or magnetic resonance imaging (MRI) at least six months before were allocated randomly and equally to an experimental group and a control group. A sufficient explanation of this study was given to them, and they consented to participation in this study. Only those whose mini-mental state examination Korean version, (MMSE-K) scores were 24 or higher were selected, in order to and those patients who were able to walk independently, who did not need drug treatment to mitigate spasticity, and who could understand and follow the researchers' instructions were recruited. The general characteristics of both groups are schematized in Table 1.

### Methods

The experiment was conducted five times per week for 4 weeks. Prior to the experiment, all the subjects received ordinary physical therapy composed of joint mobilization, muscle strengthening, and stretching exercises that were conducted by physical therapists with five or more years of clinical experience.

The experimental group then undertook a balance exercise with a dual-task condition, maintaining their balance for 30 minutes while standing on a balance pad and moving a cup containing water. The patients repeated the following motion: they held the cup in front of them and moved it so it crossed the centerline of their body until it reached a point in front of them and on the opposite side.

They repeated this movement, alternating between using their non-paretic and paretic hands. When subjects could

not actively hold the cup with the paretic hand, the therapist aided them. The control group undertook a balance exercise with a single-task condition, maintaining their balance for 30 minutes while standing on a balance pad<sup>6)</sup>.

The equipment used to measure the subjects' balance performance was a balance performance monitor (BPM). This is a system devised for balance exercise and provided various visual and auditory feedback data as well as measuring balance. Economy and mobility are two of this system's merits. It consists of a computerized foot plate for the subject to stand on with both feet, and a display console to provide visual and auditory feedback. The computer, display console, and printer are connected. The foot-plate sensor detects the standing person's motions and the computer screen quantifies and graphically shows sway area, sway path, and sway velocity<sup>12)</sup>.

The data obtained from the BPM was statistically analyzed using SPSS 12.0 for Microsoft Windows. The change in each group's balance ability between before and after the experiment, and the difference between the groups before and after the experiment, were analyzed using the paired comparison t-test and the independent sample t-test, respectively. A p-value less than 0.05 was considered statistically significant.

### RESULTS

With regard to changes in sway area scores, the experimental group showed significant decreases on both the paretic and the non-paretic sides ( $p < 0.05$ ), but the control group did not ( $p > 0.05$ ). There was a significant difference between the two groups after the experiment in sway area scores ( $p < 0.05$ )(Table 2).

Regarding changes in sway path scores, the experimental group showed significant decreases on both the paretic and the non-paretic sides ( $p < 0.05$ ), but for the control group, only on the paretic side. However, after the intervention, no significant differences were found between the two groups ( $p > 0.05$ )(Table 2).

Regarding the maximum velocity scores, the experimental group showed significant decreases on both the paretic and the non-paretic sides ( $p < 0.05$ ), but the control group showed a significant decrease only on the paretic side ( $p < 0.05$ ). There were significant differences between the two groups after the intervention ( $p < 0.05$ ) (Table 2).

**Table 2.** Comparison of balance performance scores of experimental and controls

		Experimentals		Controls	
		Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Sway area (point)	A	310.5 ± 15.5	241.1 ± 10.2*a	328.1 ± 14.1	278.6 ± 11.9a
	N	356.5 ± 21.0	232.2 ± 19.1*a	329.7 ± 14.3	258.5 ± 29.7a
Sway path (point)	A	274.3 ± 11.8	219.0 ± 10.6*	309.1 ± 17.3	263.8 ± 15.6*
	N	271.6 ± 13.4	213.7 ± 19.6*	264.7 ± 30.3	233.3 ± 18.2
Max velocity (point)	A	50.6 ± 3.7	34.0 ± 0.8*a	53.1 ± 2.7	40.1 ± 2.0*a
	N	43.0 ± 4.2	33.5 ± 0.9*a	38.7 ± 2.2	35.2 ± 1.6a

Values are Mean ± SE; \* $p < 0.05$ ; A: affected side, N: normal side; \*: significant difference from pre-intervention at  $< 0.05$ ; a: significant difference in gains between two group,  $p < 0.05$ ;

## DISCUSSION

For stroke patients' functional recovery and successful return to ordinary life, it is important to evaluate and appropriately deal with their balance disorder early on, and to provide treatment to improve their balancing ability<sup>13)</sup>.

Recently, many studies of stroke patients' changes in balance ability have been conducted. Ahn et al.<sup>6)</sup> reported that exercise using a balance pad effectively improved 15 stroke patients' ability to balance, and Kim et al.<sup>14)</sup> noted that task-oriented functional exercise influenced stroke patients' dynamic balance. Alain et al.<sup>15)</sup> reported that a task-oriented exercise program significantly increased stroke patients' balance, mobility, and postural stability. Recently, exercises for stroke patients have shifted from the previously used single-task methods to dual-task methods. Haggard et al.<sup>16)</sup> verified that stroke patients' gait time rose by an average of 7% when they walked under dual-task conditions similar to those they frequently faced in their ordinary life. Bowen et al.<sup>17)</sup> noted that stroke patients' gait velocity increased but their ability to balance decreased while walking under dual-task conditions. Bensoussan et al.<sup>4)</sup> reported that stroke patients' postural adjustment capability declined when they performed dual tasks, and Cockburn et al.<sup>18)</sup> noted that stroke patients' gait velocity and performance of dual tasks decreased while walking under dual-task conditions.

This study selected single- and dual-task balance exercises as methods to evaluate the training of stroke patients' ability to balance. The balance exercise under the single-task condition required subjects to carry out postural adjustments while standing on a balance pad. The balance exercise under the dual-task condition involved simultaneously carrying out postural adjustment while standing on a balance pad and performing the task-oriented motion of stretching out one arm and moving a cup held in the hand. The resulting sway area, sway path, and maximum velocity scores significantly decreased. Except for sway path, the balance exercise done under the dual-task conditions improved the patients' balance more than the exercise under the single-task condition in all cases, particularly among stroke patients who were paretic on their right side.

These results are consistent with Riley et al.<sup>19)</sup>, who studied the performance of a high-level dual task, in which subjects' concentrated on maintaining hand contact with a curtain while regulating their lower extremity posture at the same time. They found this reduced postural sway more than a single task of only regulating lower extremity posture. Stoffregen et al.<sup>20)</sup> found decreased postural sway following practice of a dual task of regulating postural adjustment (a high-level task) of the upper extremities while conducting postural adjustment of the lower extremities. McNeven et al.<sup>21)</sup> verified that patients improved their ability to hold a long stick horizontal (a high-level postural regulation task) while performing a postural adjustment task. Wulf and Prinz<sup>22)</sup> consistently found that it was more effective for subjects to concentrate on the results of their motions than on the motions themselves.

Based on the above results, if clinically performed

balance exercise programs for stroke patients include balance exercise with a dual-task condition, they will qualitatively improve stroke patients' lives through the enhancement of their balance ability. Additional research on the effects of dual-task balance exercise for stroke patients, in accordance with the type and location of the lesion and the presence or absence of unilateral spatial neglect or pusher syndrome, is also needed.

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