Effects of Dual Task Training with Visual Restriction and an Unstable Base on the Balance and Attention of Stroke Patients

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Abstract. [Purpose] The purpose of this study was to examine the effects of the visual restriction and unstable base dual-task training (VUDT), the visual restriction dual-task training (VDT), and the unstable base dual-task training (UDT) on the balance and attention of chronic stroke patients. [Subjects and Methods] The subjects were 38 chronic stroke patients, who were divided into two groups of 13 patients each and one group of 12 patients. They were given dual-task training for 30 minutes per session, three times a week, for eight weeks. Their balance was measured using the center of pressure (COP) migration distances, functional reach test (FRT), and Berg balance scale (BBS), and attention was measured with the Trail Making Tests and the Stroop test. [Results] In comparisons within each group, all the three groups showed significant differences before and after the training (p<0.05), and in the comparisons among the three groups, the VUDT group showed more significant differences compared with the other two groups in all tests (p<0.05). [Conclusion] Dual-task training applied with visual restriction and an unstable base in which the subjects attempted to maintain their balance was effective in improving the balance and attention of stroke patients, and the VUDT was more effective than VDT or UDT.
Key words: Balance, Dual task, Stroke

INTRODUCTION

Stoke is a central nervous system disease caused by partial loss of brain function[1]. It causes loss of positional control that leads to instability, which in turn brings about reduced balancing ability, concentration difficulty, and decreased independence in activities of daily living (ADLs)[2]. One of the goals for rehabilitation of stroke patient is to improve balance and functional movement[3]. Balance is a complicated process that includes recognition and structuralization of sensory information to achieve a good standing posture, which is necessary for performance of ADLs. Weight support ratio in the static stand-up position is highly correlated with center of pressure in the static standing position[4]. Moreover, balance consists of a mix of various factors, which is why it is hard to improve a stroke patient's balance ability[5].

Attention difficulty is one of the other most frequently reported disabilities caused by stroke in addition to balance problems[6]. A patient with decreased recognition ability af-

ter stroke is unable to participate actively in physical training in a rehabilitation setting. And the patient temporarily or permanently loses automatically processed normal posture control mechanism such as maintaining stand-up posture or dual-task performance[7].

Recently, research has been performed on dual-task training for rehabilitation of balance and concentration ability in stroke patients. Dual-task training is a training in which two or more tasks are performed at the same time continuously. These days, the roles of recognition and attention ability are emphasized in the dual-task method by including recognition tasks in posture and walking control[8]. According to task coordination and learning theory, single-task training has less processing requirements compared with dual-task training, and one cannot perform two tasks at the same time. However, dual-task training allows coordination of various tasks, as one can perform more than two tasks at the same time[8]. A group that performed recognition tasks and movement tasks at the same time showed improved ability in recognition tasks[9]. A recognition task influenced balance and walking ability[10], which tells us that concurrent performance of movement tasks and recognition tasks affects one or both performances[11].

A previous study was performed on stroke patients with dual-task training under various conditions. Among the different tasks, they found that speaking tasks had a great impact on walking[12]. Research related to unstable sup-

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porting plane. In it, the researchers conducted an 8-week experiment on chronic stroke patients with movement dual task, recognition dual task, movement and recognition dual task. The results indicated that the movement and recognition dual task group showed significant improvement in balance and walking ability compared with the other group[13]. Research related to restriction of vision has also been performed. In it, dual-task training was performed after blocking the eyesight of normal people and stroke patients, and their balance abilities were compared. The results indicated that the stroke patients showed a decrease in balance ability[14].

However, there are insufficient numbers of studies on balance and attention in stroke patients that have considered both vision control and supporting plane at the same time, which are related to factors affecting posture control when performing dual-task training. The aim of this study was to examine the effects of dual-task training on stroke patients under vision control and unstable supporting plane conditions to investigate changes in balance and attention.

SUBJECTS AND METHODS

Originally, this study recruited 45 patients from two rehabilitation hospitals in Korea (randomized with inclusion criteria). The subjects were diagnosed with stroke more than six months previously. The inclusion criteria were as follows: no musculoskeletal impairments that affect standing balance, no degenerative conditions, and no aphasia that deteriorates communication. Finally, the subjects were grouped as follows: 12 subjects were included in the vision control and unstable supporting plane dual-task group (VUDT), 13 subjects were included in the vision control dual-task group (VDT), and 13 subjects were included in the unstable supporting plane dual-task group (UDT). They were trained for 30 minutes three times a week for eight weeks.

The VUDT group performed two sets of the following 15-minute training session; firstly, the subjects stood on a stable surface with their eyes covered with an eye patch to prevent receipt of visual information (visual restriction) and were then told to maintain that posture and perform a recognition task (speaking a random number, spelling numbers or characters backward, remembering the names of objects, sentence completion, talking, and mimicking sentences); secondly, they were told to maintain a posture on an unstable supporting plane (somatosensory control) while performing the recognition task. The VDT group performed two sets of the following 15-minute training session; they were told to maintain a posture on a stable supporting plane with their eyes covered with an eye patch to prevent receipt of visual information (visual restriction) and perform the previously mentioned recognition task at the same time. The UDT group performed two sets of the following 15-minute training session; they were told to maintain their balance on an unstable supporting plane (somatosensory control) and perform the previously mentioned recognition task at the same time[8]. All subjects received the same treatment, except for the intervention.

To observe the changes in balance ability in the subjects, this study used the center of pressure (COP) moving distance, functional reach test (FRT), and Berg balance scale (BBS). For attention, the present study used the Trail Making Test and Stroop test. For measuring COP, we used a BioRecue system (an analysis system with biofeedback, AP1153 BioRescue, France). COP moving distance was measured as the subjects were maintaining an upright position while spreading their legs at 30 degrees and keeping their eyes forward. FRT was used to measure the maximum reachable distance when the subjects stretched their arms horizontally while maintaining their base of support in a comfortable upright position. It is a simple and reliable testing tool that measures limits of stability relatively well[15]. The BBS consists of 14 items that can be categorized into three categories such as sitting down, standing up, and postural change. Each item is scored on a scale ranging from 0 (min) to 4 (max). The total score for the 14 items is 56. All balance tests were performed three times, and the mean score was recorded.

This study used the Trail Making Test (TMT) to test the dichotomy of attention, recognition stage, and trails of complex concepts that affect the ability to cope with various stimulations. We used the Stroop test to test selective attention. The evaluation items were total time taken and number of wrong answers. All attention tests were conducted three times, and the mean values were recorded.

This study complied with the Declaration of Helsinki, and all the subjects received explanations about the purposes and procedures of the study and voluntarily agreed to participate in it[16]. All subjects signed an informed consent from before taking part in the study.

This study used PASW Statistics 18.0 for all statistical analyses. General characteristics such as sex, paralyzed side, and types of stroke were verified using the Chi-square test. Age and homogeneity of dependent variables before the training were verified using one-way ANOVA. Differences between before and after the training within each group were tested by Paired t-test, and ANCOVA was used to compare the differences between the groups. The significance level for all statistical data was $\alpha = 0.05$.

RESULTS

General characteristics of the subjects are displayed in Table 1.

For balance, significant differences ($p<0.05$) were shown in all three groups before and after the training. In a comparison of the three groups, the VUDT group showed significant improvement in the COP, the FRT, and the BBS scores compared with the VDT and UDT groups ($p<0.05$). For attention, significant differences ($p<0.05$) were also shown in all three groups before and after the training. In a comparison of the three groups, the VUDT group showed significant improvement in the TMT-A, TMT-B, STT, and STE compared with the other two groups ($p<0.05$) (Table 2).

Table 1. General characteristics of the subjects (N=38)

	VUDT (n=12)	VDT (n=13)	UDT (n=13)
Age (years)	52.4 ± 2.6	58.9 ± 3.1	57.4 ± 3.5
Gender			
Male	7 (58.3)	5 (38.5)	4 (30.8%)
Female	5 (41.7)	8 (61.6)	9 (69.2%)
Diagnosis			
Infarction	6 (50)	9 (62.9)	7 (53.8)
Hemorrhage	6 (50)	4 (30.8)	6 (46.2)
Affected side			
Left	6 (50)	6 (46.2)	5 (38.5)
Right	6 (50)	7 (53.8)	8 (61.5)

Values are numbers (%) or mean ± SD; VUDT, vision restriction and unstable base dual-task training; VDT, Visual restriction dual-task training; UDT, unstable base dual-task training

Table 2. Comparison of balance and attention ability among the three groups (N=38)

Group		VUDT (n=12) Mean ± SD	VDT (n=13) Mean ± SD	UDT (n=13) Mean ± SD
COP (cm)	Pre-	25.3 ± 11.5	32.9 ± 10.4	38.0 ± 12.0
	Post-	20.0 ± 8.5	30.9 ± 10.4	36.1 ± 11.7
	Change	−5.3 ± 1.7[*2,3]	−2.0 ± 0.9[*1]	−1.9 ± 0.4[*1]
FRT (cm)	Pre-	15.6 ± 7.8	18.8 ± 4.9	18.6 ± 5.4
	Post-	21.1 ± 7.4	22.5 ± 4.4	21.8 ± 5.3
	Change	5.5 ± 0.5[*2,3]	3.7 ± 0.5[*1]	3.2 ± 0.3[*1]
BBS	Pre-	40.3 ± 7.5	41.2 ± 5.7	42.0 ± 4.4
	Post-	46.3 ± 7.4	45.1 ± 5.4	45.7 ± 4.8
	Change	5.9 ± 0.5[*2,3]	3.9 ± 0.5[*1]	3.7 ± 0.6[*1]
TMT-A (sec)	Pre-	31.3 ± 3.1	32.9 ± 3.0	32.0 ± 2.7
	Post-	27.4 ± 2.8	30.9 ± 2.9	29.8 ± 3.1
	Change	−3.9 ± 0.4[*2,3]	−2.0 ± 0.4[*1]	−2.2 ± 0.4[*1]
TMT-B (sec)	Pre-	44.2 ± 6.6	45.8 ± 3.0	45.9 ± 6.1
	Post-	36.8 ± 6.1	42.2 ± 3.2	41.7 ± 6.4
	Change	−7.4 ± 1.0[*2,3]	−3.5 ± 0.4[*1]	−4.2 ± 0.5[*1]
STT (sec)	Pre-	43.0 ± 6.3	44.7 ± 7.9	45.9 ± 6.7
	Post-	35.9 ± 6.0	40.6 ± 8.2	42.1 ± 5.5
	Change	−7.1 ± 0.6[*2,3]	−4.1 ± 0.6[*1]	−3.9 ± 0.5[*1]
STE	Pre-	4.1 ± 1.6	3.9 ± 1.3	4.3 ± 1.2
	Post-	2.0 ± 1.0	2.9 ± 1.1	3.3 ± 1.1
	Change	−2.1 ± 0.3[*2,3]	−1.0 ± 0.2[*1]	−1.0 ± 0.2[*1]

$*p<0.05$. VUDT, visual restriction and unstable base dual-task training; VDT, visual restriction dual-task training, UDT, unstable base dual-task training; COP, center of pressure; FRT, functional reach test; BBS, Berg balance scale; TMT-A, Trail Making Test A; TMT-B, Trail Making Test B; STT, Stroop test time; STE, Stroop test error
[1] significantly different compared with VUDT
[2] significantly different compared with VDT
[3] significantly different compared with UDT

DISCUSSION

This study looked into the effect of dual-task training on balance and attention under vision restriction and unstable supporting surface conditions. Improvement in balance and attention was seen in each group, while the VUDT group showed greater improvement than the VDT and UDT groups.

In terms of COP change, the VUDT group showed the most reduced COP movement length. This corresponds with previous research results showing that dual-task training reduced postural sway in stroke patients[17, 18]. Balance

exercise on an unstable supporting surface increases the sensitivity of the muscle spindle via the gamma motor neuron, which in turn improves motor output and affects joint stability[19]. Various organs increase signals related to postural balance as the difficulty levels of a postural task increase. When too much attention is needed to deal with these signals, it creates an exaggerated postural reaction[20]. However, it seems that dual-task training decrease postural sway by preventing the tipping effect. Decreased COP distance in a static standing position indicates decreased body sway and can be seen as stability improvement in a static standing position.

Regarding the FRT, the VUDT group showed the biggest improvement among the three groups. This was similar to the results of the study conducted by Smania, Picelli, Gandolfi, Fiaschi and Tinazzi[21], which showed that chronic stroke patients exhibited significant differences in balance and walking speed before and after balance training on an unstable supporting surface. The result was also similar to that of a study conducted by Bonan[5], which showed that chronic stroke patients exhibited significantly improved balance ability after going through vision restricted training. Since FRT is not only related to lower body stability strategy but is also related to upper body flexibility, an improved FRT score can mean improvement of a patient's functional activities of daily living.

In the case of the BBS, the VUDT group showed the biggest improvement among the three groups. This result is similar to that in the study of Her et al.[13] which showed significant improvement in the BBS score after training in VDT, UDT, and VUDT groups. Improved BBS score indicates improvement of a stroke patient's balance ability, as it tests balance ability within many different tasks.

The Trail Making Test and Stroop test are used to evaluate attention, and the VUDT group showed the biggest improvement among the three groups. This result corresponds with the findings of Hiyamizu et al[9]. The VUDT group used various balancing conditions in turn considering factors such as strong attention, rotational attention, and separated attention as a direct treatment for attention among various approaches of treating a patient's attention loss. It is considered that intensive task training improved attention[22]. Improvement in the result of Trail Making Test, which tests the dichotomy of attention, recognition stages, and trails of complex concepts and Stroop test, which tests selective attention, reflect improvement of attention in stroke patients.

This study has some limitations in generalization because we cannot say this is the same case for all stroke patients. Also, we could not completely control the daily lives of the subjects, so we cannot exclude the possibility that other factors might have affected balance and attention in the subjects. In the future, it will be necessary to conduct various studies on such things as dual-task training methods, differences caused by level of difficulty, and brainwave tests when evaluating attention-related items.

In summary, it would be more effective to conduct dual-task training under both vision controlled and unstable supporting surface conditions compared with either vision control or unstable supporting plane conditions alone as a rehabilitation training program to improve balance and attention in chronic stroke patients.

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