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The Effect of Dual Motor Task Training while Sitting on Trunk Control Ability and Balance of Patients with Chronic Stroke

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Abstract. [Purpose] The purpose of this study was to investigate the effect on chronic stroke patient's trunk control and dynamic balance ability in the sitting position of a dual motor task training program combined with a conventional training program. [Subjects] Twenty-eight subjects after twelve months post stroke participated. [Methods] The subjects were randomly divided into two groups: a dual motor task training group (n=14) and a control group (n=14). Both groups performed the conventional exercise program for 60 minutes per day, 5 times a week for six weeks. The dual motor task training group also performed dual motor task training in the sitting position for 30 minutes per day, 3 times a week for six weeks at a separate place from the control group. [Results] The dual motor task training group showed significant improvements in trunk control ability, and dynamic balance in the sitting position. [Conclusion] Dual motor task training combined with a conventional exercise program improves trunk control ability and sitting balance. These results suggest that dual motor task training is feasible and beneficial for individuals with chronic stroke.

Key words: Stroke, Dual motor task training, Balance

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INTRODUCTION

Stroke patients have impairments of cognition, sensory, or motor function. These physical and psychological impairments inhibit patients, ability to perform activities of daily living[1]. Especially, muscle atrophy, stiffness, and changes of muscle fibers cause problems such as a decrease of muscle strength, muscle endurance, or flexibility[2]. Muscle weakness which is the primary reason for physical functional disorder, leads to hypomobility of the pelvis. This hypomobility makes the trunk unstable, and causes problems with respiration, speaking, functional movement of the extremities, balance, and gait. Balance problems are serious[3–6]. Balance is defined as unrestricted locomotion of the center of gravity in sitting, standing, moving objects, or gait and the capacity for keeping posture in various surroundings. Balance is essential for all functional activities[7, 8].

Stroke patients tend to adapt themselves to their new circumstance, which is created by instability, leading to asymmetric posture of the trunk[1]. Perlmutter et al.[9] reported that the results of static balance in the sitting position show that chronic stroke patients have impairment of balance compared to normal people due to imperfect control of the trunk.

For stroke patients, exercise in the sitting position is one method of rehabilitation training. Balance training in the sitting position makes it easy for the paretic side to support weight and for the lower extremity of the paretic side to facilitate muscle activity. These effects continue even in the standing position[10, 11]. Verheyden et al.[12] reported that training in the sitting position aimed at improving control of the trunk is effective and recovered extremity functions, resulting in functional improvement of daily activities.

Recently various training exercises such as sitting on uneven ground[13], moving objects in the sitting position[10], and playing games in the sitting position[14] have been conducted to improve balance ability in the sitting position.

Situations requiring more than two activities conducted together in daily living are sometimes encountered[15]. Subjects who have impairment of cognitional or physical function, such as the elderly and stroke patients, are at high risk of physical injury or hurt from a fall in situations that require two more activities[16–18]. Both balance and stability are required together and functional training doing dual task at the same time is necessary[19]. Many studies of balance training with dual tasks for the elderly or stroke patients have been conducted for these reason[17, 18, 20].

Dual task training should be conducted to facilitate functional activities. Examples of this are balance training which is conducted with cognition training, such as calculating and naming a color at the same time, balance training which is conducted while moving an object or throwing-catching a ball[21–23].

Canning et al.[20] reported that dual task training should be conducted for complicated activities of daily living, and Yang et al.[18] reported that subjects who were trained in dual

Table 1. Characteristics of subjects

Group	N	Gender (male/female)	Hemiplegic side (right/left)	Age (years)	Height (cm)	Weight (kg)	Months since stroke	K-MMSE (points)
Dual motor task training	14	8/6	6/8	59.0 (11.0)	162.9 (7.2)	63.6 (10.4)	34.4 (25.4)	26.4 (1.6)
Control	14	10/4	8/6	62.3 (14.2)	164.1 (6.2)	65.1 (11.3)	33.6 (15.9)	26.1 (1.3)

Values are frequency or mean (SD). K-MMSE, Korean version of mini-mental state examination.

motor task training showed higher performance in the dual task situations compared to a control group.

Therefore, this study was conducted to see if training in the sitting position together with balance training, based on dual motor task training at the same time, is effective at enhancing trunk control ability and dynamic balance ability in sitting position.

SUBJECTS AND METHODS

Thirty individuals with chronic stroke receiving therapeutic exercise treatment at H rehabilitation center were enrolled in this randomized, controlled trial. Inclusion criteria were: more than a year from stroke onset, a score of more than 24 out of 30 points in the Korean version of the mini-mental state exam (K-MMSE), and ability to sit independently on an unstable disc for longer than 30 seconds. Exclusion criteria were: presence of musculoskeletal disorder, visual deficit, and a history of lower back pain. All subjects provided their written informed consent prior to participation in this study. Subjects were randomly allocated to one of two groups: the dual motor task training group and the control group. Two subjects dropped out of the study due to discharge. Hence, outcome data are available for only 14 subjects per group (Table 1).

Both groups performed 60 minutes of conventional exercise 5 times a week for 6 weeks. In addition to conventional exercise, the dual motor training group performed 30 minutes of dual motor training in the sitting position 3 times a week for 6 weeks at a separate place from the control group. The conventional exercise was conducted for 30 minute each by a physical therapist and an occupational therapist who worked at the H rehabilitation hospital. The physical and occupational therapists carried out the general exercise program which consisted of Brunnstrom motion therapy, Bobath neurological development therapy, and proprioceptive neuromuscular facilitation. The physical therapist spent 10 minutes each conducting: flexibility training, resistance exercise for muscle strengthening, and pelvic tilting exercise focused on trunk control ability. The occupational therapist carried out activities of daily living training focused on functional activities for 30 minutes.

The dual motor task training group performed 5 minutes of warm-up exercise before the start of training such as raising the upper extremities, trunk flexion and rotation for range of motion and flexibility. The therapist supported the patients if they couldn't perform the movements actively. The dual motor task training was performed using the upper extremities while sitting on unstable ground to stimulate active balance. A 50 cm diameter disk was used as unstable ground. Subjects sat on the disk with their knee and hip joints flexed at 90° and with their feet touching the ground. The training was administered in three steps, 2 weeks for each step, for a total of 6 weeks to motivate patients. Patients moved a cup forward and from the coronal plane to the diagonal side while keeping balance in the sitting position on unstable ground for the first step. For the second step, patients performed targeting with a ball and tossing a balloon. In the third step, patients did fishing and played badminton while keeping balance in the sitting position on unstable ground. Each step was performed for 12 minutes and one minute of resting time was given between each step.

All outcome measures were assessed prior to the start of the intervention and then again after 6 weeks. The outcome measures included trunk control ability, and dynamic balance ability in the sitting position. All tests were performed by a skilled physical therapist who did not participate in the training program.

The trunk impairment scale (TIS) was used to check trunk control ability. The TIS is a clinical test that assesses trunk motor impairment of stroke patients and evaluates static and dynamic balance in the sitting position and trunk coordination ability. The TIS includes three items of static balance, 10 items of dynamic balance, and 4 items of trunk coordination and total scores range between 0 and 23 points, with a higher score denoting better trunk control ability[6]. The reliability and internal validity of TIS of stroke patients are high[24].

The modified functional reach test (MFRT), modified and compensated Duncan's functional reach test[25], was used to evaluate dynamic balance in the sitting position. Patients sat comfortably on a chair without back-support and a standard scale was fixed to the wall at the height of the acromion. Abdominal support was applied as a needed[26]. In order to check the forward direction, patients flexed the shoulder at 90° and extended the hand as far as possible in a straight line, moving the upper extremity and trunk forward as far as possible, and we measured the distance moved by the end of middle finger. Patients abducted the arm at 90° and fully extended the elbow to position it parallel with the hand for measurement of the non-paretic side, then moved the upper extremity and trunk laterally and the distance was moved by end of the middle finger was measured. The measurement of the paretic side was made from the acromion to the end of middle finger. All evaluations were conducted for the three times and the average value was recorded. The MFRT while sitting has high reliability for the evaluation of individuals with stroke[27].

Table 2. Comparison of trunk control ability

Measures		Dual motor task training (n=14)	Control (n=14)
TIS (point)	Pre-intervention	8.9 (4.0)	8.2 (2.7)
	Post-intervention	12.6 (5.2)*	9.1 (2.8)*
	Change	3.7 (2.3)	0.9 (1.4)†

Values are mean (SD). TIS: trunk impairment scale, Change: post-pre-intervention. *p<0.05 from pre-intervention, †p<0.05 from dual motor task training

Table 3. Comparison of dynamic balance

Measures			Dual motor task training (n=14)	Control (n=14)
MFRT (cm)	Forward	Pre-intervention	90.9 (16.6)	91.2 (10.7)
		Post-intervention	107.4 (11.1)*	95.3 (11.0)*
		Change	16.4 (9.7)	4.1 (5.6)†
	NP side	Pre-intervention	71.5 (8.2)	72.5 (5.9)
		Post-intervention	80.2 (6.7)*	74.3 (6.0)*
		Change	8.71 (5.2)	1.8 (2.8)†
	P side	Pre-intervention	8.6 (3.6)	7.4 (3.1)
		Post-intervention	13.9 (5.6)*	9.1* (3.5)*
		Change	5.3 (4.4)	1.7 (2.1)†

Values are mean (SD). MFRT: modified functional reach test, NP side: non paretic side, P side: paretic side; Change: post-pre-intervention. *p<0.05 from pre-intervention, †p<0.05 from dual motor task training

Statistical analysis was performed using SPSS 15.0 (SPSS Inc, Chicago, IL, USA). The data distribution was evaluated with the Kolmogorov-Smirnov test. Differences of all variables between the dual motor task training and control groups were examined by the independent t test or the χ^2 test for continuous or dichotomous data. Two-way repeated measure ANOVA was performed to compare the effects of the intervention and subject groups (dual motor task training and control). Statistical significance was accepted for value less than 0.05.

RESULTS

There were no differences between the 2 groups in the demographic variables, stroke-related parameters or the pre-intervention outcome measures. After completion of 6 weeks intervention, the TIS showed significant improvements in the both groups ($p<0.05$). A significant 2-way interaction between the intervention and group effect was found the TIS ($p<0.05$). There was a change in TIS in the dual motor task training group of 3.7 ± 2.3 points compared with the change in the control group of 0.9 ± 1.4 points (Table 2). In the MFRT, forward reach (90.9 to 107.4 cm vs 91.2 to 95.3 cm) and non-paretic side reach (71.5 to 80.2 cm vs 72.5 to 74.3 cm) of both groups increased significantly ($p<0.05$). The paretic side reach in the dual motor task training group increased and was higher than that of the control group. The effects of intervention and of group on paretic side reach were significant ($p<0.05$), as was the interaction between these effects ($p<0.05$) (Table 3).

DISCUSSION

This study studied the effect on trunk control ability, and dynamic balance ability after dual motor task training for chronic stroke patients.

Trunk control ability, which was analyzed using the trunk impairment scale, was increased in both the dual motor task training group and the control group ($p<0.05$). Conventional exercise treatments which were performed together with dual motor task training increased physical functions.

Verheyden et al.[12)] reported that exercises with pelvic movement significantly increased the trunk impairment scale by 1.01 ($p<0.001$) in their study of stroke patients' trunk control ability improvement. In our present study the trunk impairment scale of the dual motor task training group increased by 3.71 compared to before exercise.

The dual motor task training was conducted by controlling posture on uneven ground without back-support and activating upper extremity movements at the same time. Controlling posture on uneven ground stimulates proprioceptive receptors and the somatic senses. This kind of training has been used to enhance body balance control ability[28, 29)]. In a study evaluating muscle activity of multi-segments on various grounds, more muscle activities were shown on stable ground than on unstable ground[30)]. Also in a study of task performance training of chronic spinal cord injury patients, the patients showed positive results in the functional reach test, posture control, and stability with support of the lower extremities while using the upper extremities[31)].

Based on the above-mentioned studies, moving an object, targeting, tossing a balloon, fishing, and playing a badminton in the sitting position on uneven ground are considered to increase trunk control ability.

In activities of daily living, trunk control ability for functional activities is closely related to keeping balance in the sitting position[6, 12]. In this study of dual motor task training, trunk control ability and dynamic balance ability in the sitting position were evaluated.

Genthon et al.[32] reported that in a study of stroke patients, biomechanical evaluation showed that cooperative contractions of the abdominalis and latissimus dorsi, which control flexion and extension of trunk, were damaged more than of the internal and external oblique abdominal muscles, which control lateral movement ($p<0.05$)[32, 33]. Van Nes et al.[34] reported that forward-backward balance control in the sitting position was compensated by the lower extremities, and right-left balance control in the sitting position was solely dependent on trunk control.

Based on the results of these studies, dual motor tasks training may elevate the activation of trunk muscles by forward movement of the trunk increasing spinal erector muscles' activation[13]. Davies[35] said that more muscles were activated in 3-dimensional movement than in 1-dimensional movement because 3-dimensional movement, such as extension, lateral flexion, and rotation of upper trunk, demands greater stability. In a previous study, large movements facilitated greater improvement in postural control[36]. Similarly, in this study moving a cup in the diagonal direction in the sitting position increased balance ability.

The modified functional reach test was conducted to evaluate dynamic balance movement. This method evaluates the erect trunk's maximum forward or lateral movement. It measures the distance of dynamic movement of the trunk, and it is suitable for assessing dynamic balance ability. It also has the advantage of being a quick and easily conducted test[26, 27].

In Dean and Shepherd[11]'s study, task training for stroke patients increased the functional reach test distance by 9 cm in the sitting position ($p<0.01$), by 8 cm on the non-paretic side ($p<0.001$), and by 12 cm on the paretic side ($p<0.001$). Dean et al.[10] reported that in a study of sitting ability and quality of 12 stroke patients, the functional reach test distance was increased by 14 cm (11%).

In this study forward, lateral movement of the non-paretic side, and lateral movement of the paretic side were evaluated. Directional movement training with dual motor task training resulted in significant differences ($p<0.05$) on both sides. In dual motor task training, forward reach was increased by 16.43 cm, non-paretic side reach was increased by 8.71 cm, and paretic side reach was increased by 5.29 cm.

Dual motor task training using the upper extremities for trunk control ability on uneven ground was performed with the lower extremities in contact with the ground so that the lower extremity extensor muscles were strengthened together.

Conventional exercise together with dual motor task training for 6 weeks improved trunk control ability and balance control ability in the sitting position, however, the effect on gait which has many roles in activities of daily living were not studied. Therefore, we consider that the influence of dual motor task training on gait should be studied.

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