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Original Article

An efficacy study on improving balance and gait in subacute stroke patients by balance training with additional motor imagery: a pilot study

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Abstract. [Purpose] The few studies conducted on subacute stroke patients have focused only on gait function improvement. This study therefore aimed to confirm the effect of balance training with additional motor imagery on balance and gait improvement in subacute stroke patients. [Subjects and Methods] Participants were divided into an experimental or control group. The experimental group received balance training for 20 minutes/day with mental imagery for 10 minutes/day, three days/week, for four weeks. The control group received only balance training for 30 minutes. Before and after the 12 sessions, balance and gait ability were assessed by the researcher and a physical therapist. [Results] After completion of the 4-week intervention, Berg Balance Scale, Timed Up and Go test, Functional Reach Test, and Four Square Step test scores significantly increased in the experimental group. In the control group, Berg Balance Scale and Functional Reach Test scores significantly improved. Changes in the Timed Up and Go test, Functional Reach Test, and Four Square Step Test scores after intervention were significantly higher in the experimental than in the control group. [Conclusion] Specific balance training with additional motor imagery may result in better rehabilitation outcomes of gait and balance ability than balance training alone.
Key words: Balance, Gait, Motor imagery

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INTRODUCTION

Stroke can cause permanent disability in patients. Strokes can cause a combination of motor, sensory, cognitive and emotional impairments resulting in impairment of balance and gait ability in patients as well as impairment of the Activities of Daily Living (ADL)[1)]. The major goals of rehabilitation in stroke patients are improving balance and gait ability[2)]. Balance is the ability of an individual to maintain or move within a weight-bearing posture without falling[3)]. Balance ability requires the person to maintain their body's center of gravity within the base of support[4)]. Many research studies have demonstrated a relationship between balance ability and gait speed, independence, and appearance of an individual and have demonstrated abnormal patterns[5)]. Balance is an essential function in maintaining gait and normal movement in stroke patients[6)]. Accordingly, various therapeutic methods have been used for the improvement of balance, such as core strength exercises[7)], visual feedback training[8)], and task-related training[9)].

Recently, several studies about a mental practice for rehabilitation of stroke patients have been reported[10–12)]. Mental imagery (MI) is a rehabilitation method, which involves the use of motor imagery content with repetition of movement processes. Many previous research studies have reported that cortical functional reorganization following mental practice contributes to the improvement of hand function in stroke patients[10, 13, 14)]. Additionally several previous studies have shown that the MI in combination with physical therapy has been effective in improving balance and gait performance in stroke patients[12)]. However, there have been divergent opinions about the effectiveness of MI on balance and gait function. There have been a few studies, which have investigated the influence of specific balance training with additional MI in stroke patients.

The importance of effective rehabilitation in the early stages for stroke patients is increasing. MI is a clinically practicable and cost-effective supplement that may enhance outcome in acute stroke patients[15)]. However, most of the previous studies of MI training were conducted for chronic stroke patients[12–14)]. There have been a few studies of subacute stroke patients, which have only focused on an improvement in gait function[11)]. Therefore, this study was performed to confirm the effect of balance training with ad-

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ditional MI on balance and gait improvement in sub-acute stroke patients.

SUBJECTS AND METHODS

Twenty subacute stroke patients (10 males and 10 females) participated in the study in the rehabilitation unit. The inclusion criteria for the present study were as follows:

(1) A diagnosis of stroke (ischemic or hemorrhagic stroke) < 3 months after stroke onset

(2) Korean mini-mental state examination score > 24

(3) A capability to stand up, maintain standing balance, and walk more than 10 m independently.

We explained the purpose of this study to the patients and obtained their informed consent. The study was approved by the Human Ethics Committee of the Sahmyook University. All of the procedures in the study were conducted as per the Declaration of Helsinki.

Participants were divided into an experimental or control group (Table 1). The experimental group received balance training for 20 minutes/day with additional mental imagery for 10 minutes/day, three days/week, for a period of four weeks. The control group received balance training for 30 minutes/day. Before and after the 12 sessions, balance and gait ability were assessed by the researcher and a physical therapist. All participants received balance training, which consisted of four practices for 20 minutes as follows:

(1) Standing on an unstable balance pad and then implementing a head flexion and extension and rotation to the left and right

(2) Shifting the weight from left to right while standing on even floor

(3) Standing on one leg for 5 seconds

(4) Walking in a straight line.

After the balance training session, MI was implemented in subjects in the experimental group in an isolated, quiet room. The MI was recorded by a physical therapist using standard Korean language. The MI program was composed of guided balance training. The participants performed the MI while they were in a comfortable condition, sitting in a comfortable seat, with an armrest and backrest. Before the 10-minute MI, the participants were guided to a state of relaxation by deep breathing for 2 minutes.

Before and after training, balance ability was evaluated using the Berg Balance Scale (BBS). Since the BBS has been shown to have excellent validity and outstanding intra-rater and inter-rater reliability (interclass correlation = 0.99), it is extensively used as a measurement tool for balance function. BBS is correlated well with other clinical balance scales and with measurements of gait speed for stroke patients[16].

The Timed Up and Go test (TUG) is a clinical test of dynamic standing balance tasks. Patients were seated in a chair. They were then ordered to stand up and walk as quickly and safely as they could for a distance of 3 m, turn around, walk back to the chair, and sit down again. The time was recorded from the point at which the patient stood up from the chair until he or she returned to the same sitting position. The test was implemented thrice. The average time of the three tests was taken as the result of the test.

Table 1. General characteristics of the subjects

Parameters	Experimental group	Control group
Gender (male/female)	5/5	5/5
Age (years)	67.1 ± 9.2	67.2 ± 7.8
Height (cm)	170.0 ± 12.1	168.2 ± 12.2
Weight (kg)	73.6 ± 12.0	74.2 ± 10.7
Duration of onset (days)	13.4 ± 4.5	14.1 ± 4.8
Ischemic/Hemorrhagic stroke	5/5	5/5
Right sided lesion/Left sided lesion	5/5	5/5

Values are presented as the mean ± SD

Functional Reach Test (FRT) is an upper-extremity balance task used in this study. The subject stood comfortably and perpendicular to a wall. A yardstick, which was horizontally attached to the wall, was applied at the subject's acromion level. The subjects extended their fisted hands along the yardstick. The position of the third metacarpal was recorded before and after a maximal forward reach. The mean score of three successful trials was calculated.

The Four Square Step Test (FSST) is a clinical test of dynamic standing balance that measures the time taken to step over four walking sticks, which are placed in a cross-configuration on the ground by using a set movement sequence. The combination of cognitive and physical demands is a key attribute of this test. Scores on the FSST have been found to be reliable, valid, and sensitive to change post-stroke. A score of 15 s or more, or the inability to perform the FSST may also identify the risk of falls in people after stroke. In this study, the FSST was conducted as per a standardized protocol, which has been used previously in post-stroke patients.

We analyzed the data using SPSS version 21.0 software (SPSS for windows; SPSS Inc., Chicago, IL, USA). The Wilcoxon Signed-Rank test was used to compare the BBS, TUG, FRT, and FSST scores before and after the intervention. The Mann-Whitney U-test was used to compare the changes in the scores of the tests after the intervention between the groups. $P < 0.05$ was considered to indicate statistical significance.

RESULTS

The general characteristics of the participants, age, height, weight, duration after onset, and Mini Mental State Examination-Korean (MMSE-K) score, are described in Table 1. The comparison of BBS, TUG, FRT, and FSST scores between before and after the intervention within groups is summarized in Table 2. After the completion of the 4-week intervention, BBS, TUG, FRT, and FSST scores significantly increased in the MI group ($p < 0.05$). In the control group, BBS and FRT scores showed significant improvement ($p < 0.05$). Changes in the TUG, FRT, and FSST scores after the intervention were significantly higher in the MI group than in the control group ($p < 0.05$).

Table 2. Comparison of changes in each score between the two groups

Test		Experimental group	Control group
BBS (score)	before	36.2 ± 14.8	32.5 ± 10.2
	after	44.2 ± 12.6*	34.9 ± 10.1*
TUG (sec)	before	18.5 ± 6.2	20.8 ± 4.8
	after	14.7 ± 4.7*	19.5 ± 5.2#
FRT (cm)	before	24.5 ± 7.2	23.1 ± 6.2
	after	32.4 ± 7.1*	25.9 ± 6.5*,#
FSST (sec)	before	24.8 ± 8.1	30.2 ± 7.1
	after	18.8 ± 7.1*	27.9 ± 6.9#

Values are presented as the mean ± SD
*indicates significant difference between the values before and after the interventions ($p<0.05$)
#indicates significant difference between the values of the two groups ($p<0.05$)
BBS: Berg Balance Scale; TUG: Timed Up and Go test; FRT: Functional Reach Test; FSST- Four Square Step Test

DISCUSSION

Physical therapy with additional MI may have a beneficial task-specific influence on gait function in patients with subacute stroke[11]. However, there have been very few studies that have evaluated the influence of balance training with additional MI on balance in the subacute stage of stroke. Thus, our study aimed to confirm the effect of balance training with additional MI on balance and gait improvement in sub-acute stroke patients.

Our results showed that the balance training with additional MI produced a significant improvement, which was greater than balance training alone in enhancing the balance and gait abilities of subacute stroke patients. However, there was no significant difference in the BBS score in subacute stroke patients.

In previous research studies on chronic stroke patients, additional MI produced a greater positive influence on balance recovery[17]. In a study on chronic stroke patients, Yoo et al. demonstrated that physical therapy with additional MI had an additional positive effect on improving and maintaining a symmetrical stance posture[18]. Additionally, many previous studies have reported the effectiveness of physical therapy with additional MI on balance and gait ability[12, 19, 20]. Although the subjects of the previous studies were in a different stage of recovery, our results were similar, with the FRT and FSST scores showing a significant improvement in the balance training with MI group compared to the balance training alone group in subacute stroke patients. Hwang et al. also reported that the BBS score of chronic stroke patients improved by 69% after physical therapy with additional MI in chronic stroke patients[21]. In our study, the BBS scores increased after the intervention, but this was not significant. The reason for this outcome may be due to a small number of subjects and a short- term duration of training. In addition, the specific balance training with additional MI was applied in a different stage of recovery as compared with previous studies of general physical therapy with additional MI.

In our study, the change in the TUG test score was greater in the balance training with additional MI group than in the balance training alone group in subacute stroke patients. Similar to the previous studies on subacute stroke patients, significant differences were found in the scores between the two groups. The results of the walking test showed greater improvement in the physical therapy with additional MI group, who were guided with vivid kinesthetic imagery, than in the patients of the muscle relaxation group. In another study, gait training with additional MI improved balance and gait abilities significantly more than only gait training in subacute stroke patients. Engagement in gait training with additional MI may increase self-efficacy, thus having a positive influence on motivation and self-confidence[11]. In a previous study on chronic stroke patients, Dickstein et al. reported that gait speed was enhanced in the 6 weeks physical therapy with additional MI group[22]. In addition, Hwang et al., demonstrated that the walking velocity increased after MI training for 4 weeks[21].

The current study found that specific balance training with additional MI may have a better effect than balance training alone on gait and balance ability. These findings almost coincide with previous studies that have investigated the influences of balance training with additional MI on gait and balance ability in chronic and subacute stroke patients. Balance training with additional MI may therefore have the effect of enhancing gait and balance ability. This study has some limitations. First, this study only involved a small number of subjects. Second, the severity of the condition of the subjects was relatively mild as the subjects in this study were able to walk more than 10 m independently. Third, this study used a short-term duration of training. Further studies with a greater number of subjects and long-term follow-up will be required to investigate the effects of balance training with additional MI.

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