J. Phys. Ther. Sci.
27: 2303–2305, 2015

Original Article

Effects of ankle strengthening exercises combined with motor imagery training on the timed up and go test score and weight bearing ratio in stroke patients

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Abstract. [Purpose] The purpose of the present study was to compare the effects of ankle strengthening exercises combined with motor imagery training and those of ankle strengthening exercises alone in stroke patients. [Subjects and Methods] Thirty stroke patients were randomly assigned to one of the following two groups: experimental group (15 patients) and control group (15 patients). The experimental group underwent motor imagery training for 15 minutes and ankle joint strengthening exercises for 15 minutes, while the control group underwent only ankle joint strengthening exercises for 30 minutes. Each session and training program was implemented four times a week for 4 weeks. The timed up and go (TUG) test score, affected-side weight bearing ratio, and affected-side front/rear weight bearing ratio were assessed. [Results] Both groups demonstrated improvement on the TUG test, and in the affected-side weight bearing ratios, affected-side front/rear weight bearing ratios, and balance errors. The experimental group demonstrated greater improvement than the control group in all variables. [Conclusion] Motor imagery training is an effective treatment method for improving static balance ability in stroke patients.
Key words: Motor imagery training, Stroke, Balance

(This article was submitted Mar. 9, 2015, and was accepted Apr. 16, 2015)

INTRODUCTION

Stroke patients present with motor disturbances, impaired cognition, and a speech impediment. Approximately, 74% of stroke patients are not independent in daily activities; 50% experience sustained hemiplegia symptoms; and 30% are unable to walk without aid[1)].

Stroke patients have a right-left imbalance and an asymmetric posture due to decreased mobility. The center of mass in these patients shifts toward the affected lower extremity, which worsens balance ability and has a negative impact on balance control in the standing position as well[2)].

Moreover, the foot center of pressure has a noticeable front and lateral tendency during balance control in static conditions. A compensatory ankle strategy is used to maintain balance such that the ground reaction force acts largely on the non-paralyzed foot; this along with diminishing muscle strength on the paralyzed side lead to an asymmetric posture. Limitations in ankle movement are explained by the lack of weight-supporting ability due to the muscle control disorder in the paralyzed lower limb[3)]. This results in changes in muscle recruitment and delayed contraction of paralyzed muscles[4)].

The ankle joint is important for the balancing strategy of the body. During walking, the ankle joint absorbs the impact of the ground reaction force, supports body weight, and propels the lower limb[5)].

According to Lin, in hemiplegic patients, the plantar pressure on the affected side increased laterally and decreased in the front and back; the walking velocity and step length tended to increase following enhanced mobility of the ankle[6)].

Balance control ability is important in stroke rehabilitation as it enables independent participation in the program and predicts recovery[7)].

Therapeutic interventions such as feedback training using a force plate and rhythmic auditory stimulation training are diverse methods, which enhance balance ability in stroke patients. However, these methods have time and space limitations and also require many therapists. Several new interventions using imagery training have been introduced to address these issues[8)].

Motor imagery training is a cognitive process which refers to the mental performance of a specific movement without any kind of muscular activity; it accelerates exercise function learning using information processing activities that are similar to the task to be performed[9)].

This study investigated the effects of ankle strengthening

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Table 1. General characteristics of subjects (n=26)

		Experimental (n=13)	Control (n=13)
Gender	Male	6	8
	Female	7	5
Age	≤65 years	10	9
	>65 years	3	4
Diagnosis	Infarction	11	12
	Hemorrhage	2	1
Affected side	Left	6	8
	Right	7	5

Table 2. Comparison of parameters between the groups (n=26)

Variables		Experimental (n=13)	Control (n=13)
Timed up and go test (sec)	Before	25.28 (±9.05)	26.11 (±7.34)
	After	19.39 (±7.08)	21.29 (±6.67)
Affected side weight bearing (%)	Before	10.12 (±7.12)	12.97 (±7.34)
	After	17.28 (±6.92)*	15.89 (±6.33)
Front/rear weight bearing ratio (%)	Before	8.48 (±3.34)	9.20 (±5.44)
	After	4.34 (±1.52)*	7.31 (±4.25)

Values are shown as mean (±SD); *p<0.05

exercises combined with motor imagery training on balance ability in stroke patients.

SUBJECTS AND METHODS

Subjects

This study included 30 hemiplegic stroke patients who were hospitalized in Hospital B located in Gyeounggi-do in Korea. All patients had intact sensation in ankles and any sensory impairment. All patients and their guardians provided written informed consent, and research ethics in accordance with the Declaration of Helsinki were followed. The research subjects were divided into two groups: an experimental group (n=15) that underwent ankle strengthening exercises combined with motor imagery training and a control group (n=15) that underwent only ankle strengthening exercises. The general characteristics of the subjects and equivalence test results are summarized in Table 1. The final number of subjects included in the study was 26; they were assigned to the experimental group (n=13) and control group (n=13). The research period was from July 2014 to August 2014. Prior to the therapeutic intervention, data were collected on the clinical characteristics of the subjects.

Methods

The ankle strengthening exercise program used in this study was a modified version of the original program for elderly patients, and it was tailored to the functional abilities of hemiplegic patients[10]. A balancing pad (Balance pad, Airex, Swiss) was used for 2 weeks, and this was followed by application of a balancing board (Dynair allkissen, Togu, Germany) for the next 2 weeks. The exercises were performed with the assistance of a therapist and considering the difficulty level of the training as well as the patient's safety awareness. Motor imagery training was performed in the room for improving concentration on the task. The patient was comfortably seated in a chair with armrests and a back support, with eyes closed to decrease stress and anxiety[11]. Motor imagery training was performed for 15 minutes. During the training, the subject imagined feeling the sensation of the ankle joint, knee joint, hip joint, and their surrounding muscles moving and maintaining balance during this movement.

To assess the patient's pre- and post-intervention balance ability, the timed up and go (TUG) test score[12], weight bearing ratio and front/rear weight bearing ratio were assessed. The weight distribution on both soles in the standing position was assessed using the Gaitview System (AFA-50, Alfoots Inc., Korea), which is equipped with a 0.15-cm-thick, 2,304 (48×48) pressure sensor. The subject was verbally instructed to maintain an erect posture, and the weight bearing ratio from the pressure on both lower limbs was measured for 10 sec. The ratio was measured three times, and the average of the three measurements was used[13]. The experimental group underwent ankle strengthening exercises and motor imagery training times a week for weeks. The control group underwent ankle strengthening exercises times a week for weeks. Two patients from the experimental group were excluded; the final number of participants included in this group was 13. An independent t-test was used for analysis of data between the groups.

RESULTS

Both groups showed improvement on the TUG test and in the weight bearing ratio and front/rear weight bearing ratio after the exercises ($p<0.05$). A comparison between the two groups revealed the weight bearing ratio between the front and back increased in experiment group than control group ($p<0.05$) (Table2).

DISCUSSION

In this study, the impact of a 4-week program of ankle strengthening exercises and motor imagery training on balance ability was assessed in hemiplegic stroke patients.

The TUG test score was significantly decreased after the exercises in both groups, and the difference between the groups was not significant.

A study by Saito[14] reported that motor imagery training could improve balance ability in the sitting position, and Lee[15] reported significant improvement in walking velocity following motor imagery training of the paralyzed side.

Another previous study reported significant improvement in walking velocity[16], but in this study, there are any significant difference between groups in the TUG. Since the subjects in this study were chronic hemiplegic patients, the treatment was less effective in terms of balance improvement.

It is relevant to the fact that in order to maintain balancing ability and body stability, the ankle usually acts in case of

small disturbance which results in a faster walking velocity and a shorter TUG time[17].

Nyberg and Gustafson[18] reported that due to the asymmetric weight support on the left and right sides among hemiplegic patients, excess energy is required for overall body movement and walking. Decreased weight support on the paralyzed side increases the frequency of falls in patients. Hence, they argued that it was important for both lower limbs to have the same weight-support ratio. Their study suggested that this could be achieved in the standing position or during walking by increasing the ratio of weight support on the paralyzed lower limb. In this study, we calculated the weight bearing ratio and the front/rear weight bearing ratio in the standing position. According to the study results, the weight bearing ratio increased significantly and the front/rear weight bearing ratio of the affected side decreased significantly in the experimental group. The results of this study were consistent with those of a previous study, which reported that prior practice through motor imagery for changing movement has sustained effects in improving balance and posture control ability in the standing position[19].

In this study, ankle strengthening exercises combined with motor imagery training improved the weight-bearing ratio and the front/rear weight bearing ratio in hemiplegic patients.

In a previous brain imagery study, similar responses showed in premotor, parietal lobe, basal ganglia and cerebellum after motor imagery training, which compared to actual movement[20]. Motor imagery training build a nerve network, therefor motor images enhance dynamic balancing ability by facilitation the proprioceptive sense, kinesthesia and coordination capability[21]. Based on previous literature, strengthening exercises had an impact on balance ability, as the activation of cerebrum and cerebellum during motor imagery training affects the proprioceptive, visual, and vestibular senses, which affect balance ability, especially in terms of detection of movement and joint position.

This study has limitations that should be considered; generalization of our study results is difficult due to the small sample size and except for the training time. Future systematic and continuous studies on the effects of motor imagery training on balance ability in hemiplegic stroke patients are needed.

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