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Effects of Motor Imagery Training on Gait Ability of Patients with Chronic Stroke

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Abstract. [Purpose] The purpose of this study was to investigate the effects of motor imagery training on improvement of gait ability of patients with chronic stroke. The motor imagery training was performed using imagination of normal gait movement. [Subjects] Participants were randomly allocated to two groups: a motor imagery training group (n=13) and a control group (n=11). [Methods] Both groups received treadmill training for 3 session 30 minutes per week for 6 weeks. The motor imagery training group practiced additional motor imagery training. Measures were evaluated by gait ability. [Results] The outcomes significantly improved by motor imagery training were gait speed, step length of paretic side, step length of non-paretic side, stride length of paretic side, stride length of non-paretic side, single limb support period of paretic side, and double limb support period of both sides. [Conclusion] The motor imagery training improved gait ability. These results suggest that motor imagery training is feasible and suitable for individuals with stroke.
Key words: Motor imagery, Gait ability, Stroke

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INTRODUCTION

Stroke is the second major cause of death except cancer in Korea. Stroke prevalence is 6.7 and the death rate is 0.6 per 1000 individuals[1)]. Stroke patients have functional limitations and disabilities[2)]. The causes of the functional limits and disabilities are various, and depend on the involved site and the extent of damage. Nevertheless, motor and sensory paralysis on one side of a victim's body is common symptom[3)]. Stroke causes depression among patients, creating problems with their interpersonal relationships and social lives, and lowering their quality of life[4)].

Hemiplegic people show asymmetrical body alignment because of different muscle tone between the affected and unaffected sides. These changes may result in gait deterioration[5)]. Generally, longer stance phase duration and shorter swing phase duration during gait on the affected side are shown, and the step length, gait cycle and velocity are changed[6)]. As stroke patients have decreased balance ability, they show an inefficient gait pattern through consumption of more energy[7)]. This abnormal gait pattern limits ADL and decreases independence of patients, restricting their participation in society[8)]. Restoration of normal gait ability is one of the most important goals of rehabilitation and many interventions have been used to improve this ability[9)].

Recently, many studies have investigated new interventions, and mental practice with motor imagery training has emerged as a technique showing particular promise. Mental practice with motor imagery training uses cognitive control to improve neurological activity of the brain circuit[10)]. The training goal is to develop learning ability for given tasks by repeatedly imagining the motion[11)]. The validity of motor imagery training has been proved by studies of brain imaging using PET or MRI[12)]. According to previous studies, the same brain area is activated when the same task is performed in real training or image training[13)], and the neural network is activated after performing motor imagery training in both healthy and chronic hemiplegic subjects[11)].

Motor imagery training has been well studied in sports and is effective at improving player's performance and the acquisition of new skills[14–15)]. Although the application of athletic imagery training to patients has not proven, it has been used as a primary method for rehabilitation[16)]. Since the positive effect of motor imagery training has been proved by many studies, the necessity of motor imagery training has gradually been recognized[17)]. Many studies[18–22)] have demonstrated that motor imagery training improves upper extremity function in hemiplegic patients. Research to date has provided varying results: upper extremity function in hemiplegic patients improved over that of a control group after motor imagery training[18)], and motor imagery training was effective for the improvement of hemiplegic patients with neglect[23)]. Gait ability of hemiplegic patients has also been improved after gait training with motor imagery of the normal gait pattern[24]. Some studies have suggested that a motor imagery home training exercise is effective at improving the motor function of hemiplegic patients, and have mentioned the necessity of continuing motor imagery studies[25–26]. However, motor imagery training studies of gait function are few, there is only one study of the lower extremity, and there have been no randomized controlled studies.

Thus, the aim of this study was to investigate whether gait training on a treadmill with motor imagery training of the normal gait pattern affected hemiplegic patients' gait ability.

SUBJECTS AND METHODS

The subjects of this study were 40 patients with stroke who were participating in a rehabilitation program of community center. Subjects were recruited according to the following inclusion criteria: hemiparetic from a single stroke occurring at least six months earlier; able to walk 10 m independently without an assistive device; Mini-Mental State Examination (MMSE)[27] scores of 24 or higher; no known musculoskeletal conditions that would affect the ability to safely walk repeatedly; and absence of serious visual impairment or hearing disorder. Four subjects were excluded because they failed to meet the inclusion criteria. Thirty-six subjects provided their written informed consent prior to participating in the study.

Subjects were randomly assigned to one of the two groups after initial evaluation using a simple random sampling method for minimizing the selection bias. After randomization, 18 patients were assigned to the experimental group (treadmill gait training plus motor imagery training) and the remaining 18 patients were assigned to the control group (treadmill gait training). Five patients from the experimental group and seven patients from the control group dropped out of the study due to health condition, loss of interesting, refusal to continue and individual circumstances. Hence, outcome data were obtained from 13 patients in the experimental group and 11 patients in the control group (Table 1).

Subjects in the experimental group underwent 30 minutes of motor imagery (MI) training and 30 minutes of treadmill gait training 3 times a week for 6 weeks. Subjects in the control group only participated in the 30 minutes of treadmill gait training.

MI training was composed of imagination of normal gait movement. It was carried out for 15 minutes after provision of visual and auditory information for 15 minutes. The provision of visual and auditory information was composed of: watching a video clip of normal gait movement being performed by normal people, and listening to a researcher's explanation of normal gait movement. MI training was performed utilizing a method used in prior studies[24–26]. In the MI training, subjects figured out for themselves the movement while listening to a researcher describe normal gait movement. MI training was divided between visual imagery and kinematic imagery. Visual imagery is the imagination of one's body movement from an external point of view and kinematic imagery is an imagination of internal sensory information while the body is moving. In the visual imagery of this study, subjects imagined affected leg movement as if it were the unaffected leg after imagining the normal movement of the unaffected side from an external point of view. In the kinematic imagery of this study, subjects imagined body moving on the affected side as if it were the unaffected side after imagining the sensory information felt during the movement of the unaffected side.

MI training was executed in a quiet place during the afternoon and subjects sat on a chair with maintaining the most comfortable position to relax their heart and body to increase the effect of MI training. A proper temperature for MI training was maintained. MI training was performed by a researcher who had sufficient experience of MI training and was carried out using the same protocol by the same researcher from start to finish.

Treadmill gait training was carried out using a treadmill (Health Trac S990, Gymtech, Korea). The gait speed for all subjects was determined using the self-paced capability of the treadmill. Then, the subjects were able to modify gait speed at will[28].

Gait abilities were measured using an electrical walkway system (GAITRite, CIR system inc., USA). The system captures temporal and spatial gait parameters and connects to the serial port of a personal computer. It consists of an 810 × 89 × 0.625 cm (length × width × height) instrumented mat with 27,648 embedded pressure sensitive sensors spaced at 1.27 cm arranged in a 48 × 576 grid. The sampling rate was 80 Hz and the obtained data were analyzed using gait analysis software (GAITRite GOLD, version 3.2b). Subjects walked at their comfortable gait speed over 3 trials. Subjects initiated and terminated walking a minimum of 3 m from the start and end of the walkway to maintain the gait speed on the mat. A verbal command was given to initiate walking and one of the examiners accompanied the subject to prevent a fall during walking. Gait speed, cadence, step length, stride length, single limb support for both the affected and unaffected legs, and double limb support were measured.

Statistical analyses were performed using SPSS version 15.0 software. After confirming the normality of the data by

Table 1. Subject characteristics

Group	N	Sex (male/female)	Age (years)	Height (cm)	Weight (kg)
Experimental	13	6/7	60.7 (7.53)	160.5 (8.6)	66.3 (7.8)
Control	11	4/7	61.9 (11.26)	163.8 (8.0)	67.0 (5.9)

NOTE. Values are frequency or mean (SD).

using the Shapiro-Wilks test, pre and post-intervention data were examined with the paired t-test for each group of subjects and the independent t-test for both groups. The level of significance was chosen as 5% for all statistical analyses.

RESULTS

After completion of 8 weeks intervention, gait speed among the temporal parameters, and paretic step length, non-paretic step length, paretic stride length, non-paretic stride length, and paretic single limb support period among the spatial parameters had significantly increased in the MI training group, compared to pre-intervention ($p<0.05$). However, between the MI training group and the control group, there was no significant difference in the change of gait speed at 8 weeks post-intervention. After intervention, the MI training group showed a significant reduction in the double limb support period on both sides compared to pre-intervention ($p<0.05$), whereas in the control group, there was no significant change (Table 2, 3).

DISCUSSION

In the case of instability of gait ability, a shortening stride length and an increasing interval between each step bring about a reduction cadence, and the single limb support period is decreased and the double limb support period is increased[29]. A decrease of weight bearing time and an increase double limb support period of a hemiplegic patient slows the gait cycle, and the stride and step length of the paretic side increase[6].

Gait speed is a clinical criterion for assessing an independent gait ability and function-recovery ability[30]. Many previous studies[31,32] have researched the relationship between gait speed and activities of daily living in hemiplegic patients. In general, gait speeds of 0.4 m/s for living at home, 0.58–0.8 m/s for restricted social activities, and above 0.8 m/s for social activities are required. This study showed that gait speed was increased by 0.17 m/s in the MI training group and by 0.10 m/s in the control group.

A study of gait training for 4 weeks based on the Bobath theory involving chronic stoke patients showed a significant increase in gait speed[33]. After walking exercise using a treadmill and computer instruments in real time, gait speed and strides of people with stroke improved significantly[34]. In a virtual reality gait training study, gait speed was increased[35]. MI training studies for hemi-paretic patients have reported improvements in gait speed[24,26]. Those previous studies reported results similar to this study: the improvement of gait speed was due to an increase of stride length in the paretic side.

In the present study, cadence of the MI training group increased insignificantly, and step length and stride length significantly increased. The normal cadence of adults is 113 steps/min and the stride length is 1.41–1.46 m, of men is longer than that, 1.28 m, of women by 14 %[36]. The average gain of stride length in MI training group was 0.19 m, and in the control group it was 0.15 m. Although there was no significant difference in stride length between the MI

Table 2. Comparison of Temporal Gait Measures Within Groups and Between Groups

Measures	Values				Change Values	
	MI training (n=13)		Control (n=11)		Experimental (n=13)	Control (n=11)
	Pretest	Posttest	Pretest	Posttest	Post-Pre	Post-Pre
Speed (cm/s)	39.28 (13.77)	55.68 (17.72)**	41.82 (19.96)	51.50(19.73)*	16.40 (15.66)	9.69 (15.60)
Cadence (step/min)	80.02 (11.13)	84.86 (15.87)	73.61 (17.15)	74.32(20.25)	4.84 (13.55)	0.71 (11.48)

NOTE. Values are mean(SD). Abbreviation: P; paretic side, NP; non-paretic side, Post-Pre; posttest-pretest. *p<0.05, **p<0.01 by paired t-test.

Table 3. Comparison of Spatial Gait Measures Within Groups and Between Groups

Measures		Values				Change Values	
		Experimental (n=13)		Control (n=11)		Experimental (n=13)	Control (n=11)
		Pretest	Posttest	Pretest	Posttest	Post-Pre	Post-Pre
Step length (cm)	P	32.15 (11.64)	41.86(8.98)**	34.10 (13.02)	42.87 (8.74)***	9.71 (2.66)	8.77 (4.24)
	NP	26.18 (8.97)	35.26(6.92)***	32.39 (11.49)	38.66 (7.53)**	9.07 (2.05)	6.27 (3.96)
Stride length (cm)	P	58.69 (15.55)	77.20 (13.48)***	66.58 (19.66)	81.48 (11.93)***	18.51 (12.68)	14.90 (13.63)
	NP	58.42 (15.62)	77.63 (13.66)***	66.99 (19.98)	82.07 (11.98)**	19.21 (13.66)	15.08 (14.72)
Single limb support (%)	P	20.14 (5.96)	25.37 (6.27)***	21.55 (7.51)	24.94(6.39)**	5.23 (3.31)	3.40 (3.87)
	NP	35.50 (6.03)	36.88 (5.78)	34.05 (7.29)	34.79 (6.56)	1.38 (3.40)	0.74 (4.52)
Double limb support (%)	P	44.17 (10.05)	38.04 (9.29)**	44.35(12.59)	40.44 (10.20)	–6.14 (5.51)	–3.91 (8.58)
	NP	43.95 (11.11)	38.17 (9.43)**	44.58 (14.43)	40.86 (10.55)	–5.78 (6.58)	–3.73 (9.31)

NOTE. Values are mean (SD). Abbreviation: P; paretic side, NP; non-paretic side, Post-Pre; posttest-pretest. *p<0.05, **p<0.01, ***p<0.001 by paired t-test.

training and control groups, the MI training group showed greater improvement than the control group. This result demonstrates that MI training improved the accuracy of movement, thereby increasing stride length.

In both groups of this study, the single limb support period on the non-paretic side showed no significant difference, but on the paretic side the differences were significant. The improvement on the paretic side is a mark of better symmetry in the gait pattern. In the MI training group, the double limb support period on both sides was significantly decreased, which is in agreement with the results of previous studies[24–26]. However there was no significant change in the control group. These results show that the shortening of the double limb support period is evidence of increasing gait speed and an improvement of the single limb support period on the paretic side. Furthermore, treadmill exercise with MI training was more effective than treadmill gait training only for gait ability.

The results of this study imply that activation of neural tracts and reorganization of the side of the brain contralateral to the affected side contributed to the improvement in gait ability[25].

In conclusion, 8-week MI training resulted in an improvement in the gait ability of people with chronic stroke. Perhaps greater benefits could be gained by focusing more heavily on imagery of impairments on the affected side. Motor training performed using imagery is a low-cost and low-risk motor rehabilitation intervention for individuals with stroke. Further study is needed to modify and optimize the present program and should be focused on MI training for various functions for stroke patients.

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