

Graded motor imagery training as a home exercise program for upper limb motor function in patients with chronic stroke

A randomized controlled trial

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Abstract

Purpose: Although several types of occupational therapy for motor recovery of the upper limb in patients with chronic stroke have been investigated, most treatments are performed in a hospital or clinic setting. We investigated the effect of graded motor imagery (GMI) training, as a home exercise program, on upper limb motor recovery and activities of daily living (ADL) in patients with stroke.

Methods: This prospective randomized controlled trial recruited 42 subjects with chronic stroke. The intervention group received instruction regarding the GMI program and performed it at home over 8 weeks (30 minutes a day). The primary outcome measure was the change in motor function between baseline and 8 weeks, assessed the Manual Function Test (MFT) and Fugl-Meyer Assessment (FMA). The secondary outcome measure was the change in ADL, assessed with the Modified Barthel Index (MBI).

Results: Of the 42 subjects, 37 completed the 8-week program (17 in the GMI group and 20 controls). All subjects showed significant improvements in the MFT, FMA, and MBI over time ($P < .05$). However, the improvements in the total scores for the MFT, FMA, and MBI did not differ between the GMI and control groups. The MFT arm motion score for the GMI group was significantly better than that of the controls ($P < .05$).

Conclusions: The GMI program may be useful for improving upper extremity function as an adjunct to conventional rehabilitation for patients with chronic stroke.

Abbreviations: ADL = activities of daily living, FMA = Fugl-Meyer Assessment, GMI = graded motor imagery, MBI = Modified Barthel Index, MFT = Manual Function Test.

Keywords: graded motor imagery, home exercise, motor recovery, occupational therapy, rehabilitation, stroke, upper limb

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1. Introduction

Following stroke, rehabilitation programs are needed to reduce disability. Most of the functional recovery is achieved within 3 months after onset.^[1–5] During the chronic stage, functional recovery is slow and then reaches a plateau.^[3,5] Thus, in-patient rehabilitation usually continues in the acute and subacute phases of stroke. Chronic stroke patients may undergo outpatient and community-based rehabilitation. However, there are few community-based rehabilitation programs. Graded motor imagery (GMI) was introduced to promote motor recovery in patients with complex regional pain syndrome.^[6,7] A non-randomized trial demonstrated some effect of GMI on motor function in patients with chronic stroke.^[8]

We hypothesized that GMI might improve motor function in patients with chronic stroke, and investigated the effects of home-based GMI on upper limb motor function in the patients over the 3-month period after stroke onset

2. Methods

2.1. Participants

This was a prospective randomized controlled trial. All subjects had suffered supratentorial strokes and met the following criteria:

1. first-ever unilateral stroke and over 3 months since onset^[9,10];
2. Mini-Mental State Examination score ≥ 24 ; and

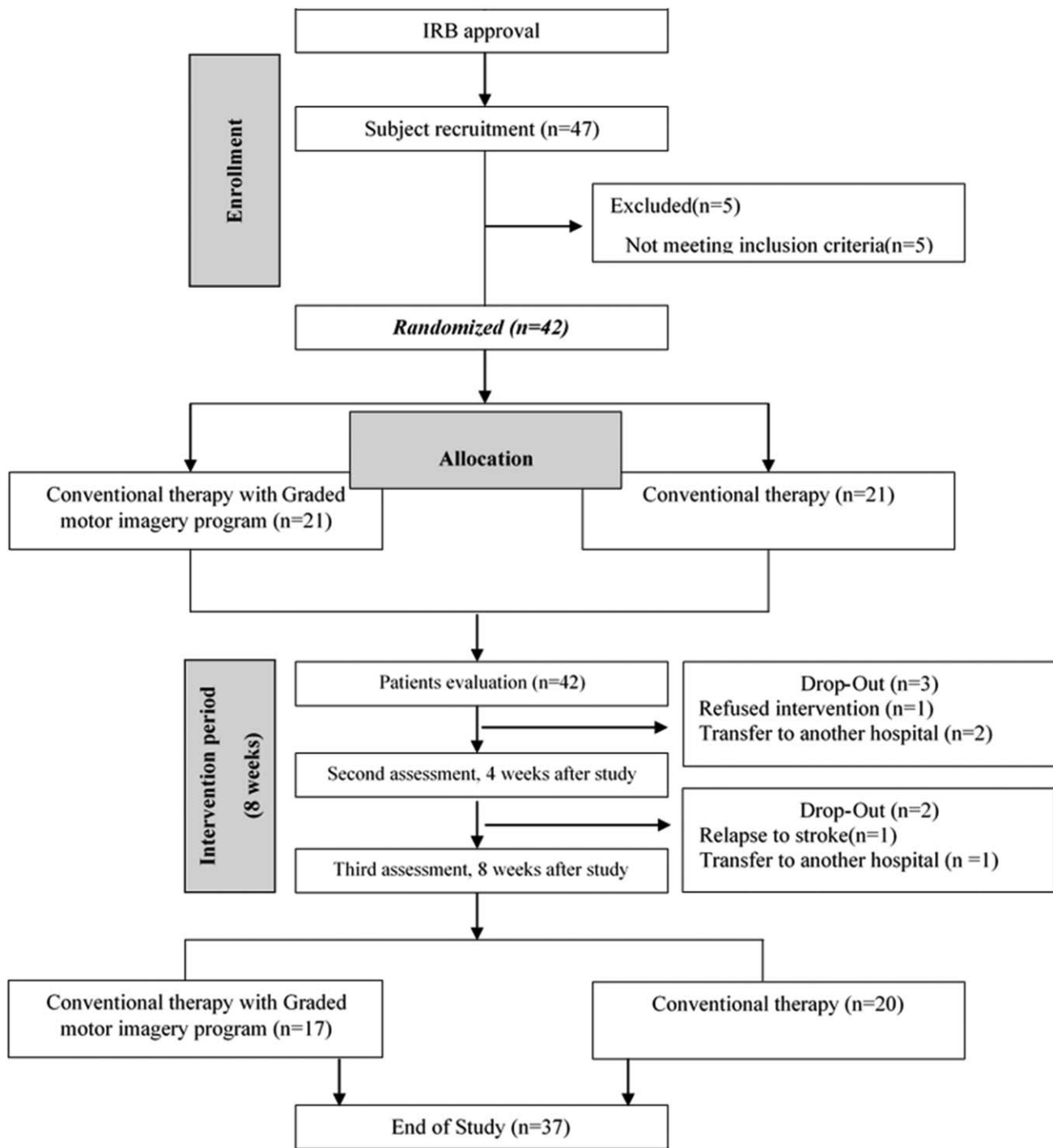


Figure 1. Flow diagram of the study.

3. Fugl-Meyer Assessment (FMA) score <60 for the upper extremity.^[11,12]

The exclusion criteria were

1. musculoskeletal disorders hindering routine activities of daily living (ADL) and
2. other neurological disorders affecting ADL or mood.

We screened 47 right-handed subjects with first-ever stroke; 42 subjects were enrolled and randomly assigned to the control (n = 21) or GMI (experimental) (n=21) group (randomized block design). All subjects were tested 3 times: at baseline (0 weeks), and at 4, and 8 weeks (Fig. 1).

The study was approved by the Ethics Committee of the Catholic University of Korea (VC18EESI0226). Informed

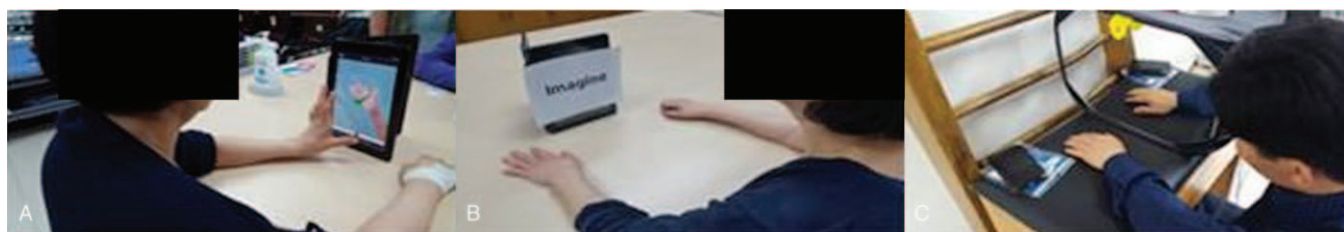


Figure 2. The application of graded motor imagery (GMI) training. A; implicit motor imagery, B; explicit motor imagery, C; mirror therapy.

consent was obtained from all subjects according to the Declaration of Helsinki.

2.2. GMI intervention

GMI training involves implicit motor imagery, explicit motor imagery, and mirror therapy (Fig. 2).^[6,8] Regarding the implicit motor imagery, a discrimination task (left vs right) was conducted using an Android smartphone and Orientate software (Reflex Pain Management Ltd.). Twenty five photographs of the right or left hand were presented at random, and the participant pressed the screen as soon as possible to indicate which hand was shown. Regarding the explicit motor imagery, 25 photographs were again randomly displayed on the smartphone screen. The subjects were asked to imagine that they were working without any movement on the injured side.^[13] Regarding the mirror therapy, a 24 × 24 × 35 cm³ mirror (Folding Mirror Therapy Box; Reflex Pain Management Ltd.) was placed directly in front of the subject,^[14] who confirmed that the hand on the affected side was reflected in the mirror. They were then instructed to move the hand on the unaffected side (grasp/release the hand and supinate/pronate the forearm), and to try to emulate that movement with the hand on the affected side. The control group exercised the upper limb for the same amount of time. All 3 tasks were repeated 3 times, with rest periods provided between sessions.

Both groups received conventional therapy (task-oriented active/passive range of motion training) to improve upper extremity function. This training included weight support training, stretching, grasping, holding, and placing objects on the injured side.

2.3. Assessment

The primary outcome measure was the change in motor function, assessed using the Manual Function Test (MFT) and Fugl-Meyer Assessment (FMA), between baseline and 4 and 8 weeks.^[15,16] The secondary outcome measure was the change in ADL, assessed by the Korean version of the Modified Barthel Index (MBI).^[1,17,18]

2.4. Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics (ver. 21.0; IBM Corp., Armonk, NY). The patients’ demographic and clinical characteristics were compared using the Chi-Squared test for categorical variables and the Mann-Whitney U test for continuous variables. Two-factor (GMI × time) repeated-measures analysis of variance was performed to determine the

effects of GMI on the FMA, MFT, and MBI scores. All tests were two-tailed and P values ≤.05 were considered statistically significant. Based on a case-control trial (n = 28),^[8] we calculated that a sample size of 42 (n = 21 subjects per group) was required to observe a 50% increase in the primary outcome measure.

3. Results

Twenty one patients each were assigned to the GMI and conventional therapy only (control) groups. In total, 5 patients dropped out over the 8-week period, leaving 17 in the GMI group and 20 controls (Fig. 1). Table 1 presents the patients’ demographic and clinical characteristics. Table 2 shows the results of the functional assessments. The FMA and MFT scores increased significantly with time. The upper limb MFT score was significantly increased in the GMI group compared with the control (Fig. 3). All other functional results did not differ significantly between the 2 groups.

4. Discussion

We hypothesized that home GMI training would improve upper limb motor function in patients with chronic stroke: a small but significant increase was observed. The effect size was smaller than that reported in a non-randomized trial, but was in the same direction.^[8]

GMI consist of 3 main treatment strategies: implicit motor imagery, explicit motor imagery, and mirror therapy. These main treatment strategies would be used for routine occupational treatment for stroke patients.^[7,13,19,20] GMI programs are suitable for home use.^[21,22] A recent non-randomized controlled

Table 1
General characteristics of the groups.

Characteristic	Control group (n=20)	GMI group (n=17)	P value
Sex (male/female)	13/7	9/8	.25
Affected side (right/left)	13/7	9/8	.25
Stroke type (hemorrhage/infarction)	9/11	7/10	.41
Area affected by stroke			
Cerebral cortex	8	9	
Subcortex	9	7	
Cerebellum	2	0	
Mixed	1	1	
Age (years)	61.75 ± 11.59	53.29 ± 17.09	.08
Months since stroke	62.70 ± 64.24	46.29 ± 40.96	.37

GMI = graded motor imagery.

Table 2
Functional recovery over time in the 2 control and GMI groups.

	Controls (n=20)				GMI group (n=17)				P values for time × group interaction
	Baseline	4 weeks	8 weeks	P values for time	Baseline	4 weeks	8 weeks	P values for time	
FMA-upper extremity									
Shoulder/Elbow/Forearm	18.50 ± 8.95	20.40 ± 9.57	21.05 ± 9.90	.005	20.41 ± 11.44	21.71 ± 11.08	22.59 ± 11.26	.012	.403
Wrist	3.80 ± 3.51	4.30 ± 3.75	4.50 ± 3.77	.001	3.47 ± 3.46	3.88 ± 3.58	4.18 ± 3.54	.008	.889
Hand	5.00 ± 5.02	5.15 ± 5.18	5.35 ± 5.14	.054	4.29 ± 4.93	4.65 ± 5.09	4.47 ± 4.98	.152	.359
Total	27.30 ± 16.48	29.85 ± 17.50	30.80 ± 17.60	.001	28.18 ± 18.42	30.24 ± 18.32	31.24 ± 18.30	.001	.811
MFT									
Arm motion	9.00 ± 4.54	9.25 ± 4.55	9.35 ± 4.56	.162	9.71 ± 4.98	10.29 ± 4.49	10.88 ± 4.25	.020	.042
Grasping	2.35 ± 2.18	2.65 ± 2.25	2.55 ± 2.16	.006	2.47 ± 2.32	2.88 ± 2.11	2.82 ± 2.15	.044	.758
Manipulation	1.40 ± 1.87	2.00 ± 2.67	1.90 ± 2.49	.083	1.06 ± 1.47	1.41 ± 2.21	1.71 ± 2.25	.114	.173
Total	39.53 ± 24.50	43.43 ± 27.39	43.12 ± 26.48	.009	41.36 ± 26.36	45.59 ± 25.89	48.16 ± 25.17	.016	.162
MBI									
Total	62.25 ± 23.67	67.65 ± 22.83	68.55 ± 22.79	.011	76.12 ± 18.84	80.76 ± 16.67	82.18 ± 15.13	.002	.882

FMA = Fugl-Meyer Assessment; MBI = Modified Barthel Index; MFT = Manual Function Test.

trial of GMI consisting of mental practice and mirror therapy demonstrated beneficial effects in chronic stroke patients.^[8] We noted improvements in total FMA and MFT scores, and MBI scores, in both groups over time. However, the MFT score of the upper limb was improved significantly more in the GMI group compared with the control. Thus, GMI might confer additional benefits on upper limb motor function in patients with chronic stroke performing routine exercises.

The restoration of the function for upper limbs would be an essential issue in patients with chronic stroke. Many researchers have investigated for uncovering culprit lesion related to upper limb function or establishing the therapeutic methods for recovery of the upper limb.^[8,20,23–25] According to a previous study, the mental practice in chronic stroke patients provided

significant reductions in affected arm impairment and significant increases in daily arm function.^[13] The mirror therapy was introduced as 1 component of a home exercise program for chronic stroke patients with task-specific training.^[21] And then, the GMI was developed for motor recovery in patients with complex regional pain syndrome or chronic stroke.^[6–8] However, the effects did not reveal in randomized controlled trials. Thus, we demonstrated the therapeutic effects of GMI in patients with chronic stroke in a randomized controlled trial.

The GMI program has several clinical advantages. Mirror therapy and mental practice have therapeutic efficacy, require minimal equipment, and confer minimal risk. Thus, GMI programs are recommended, despite the small effect size in this study.

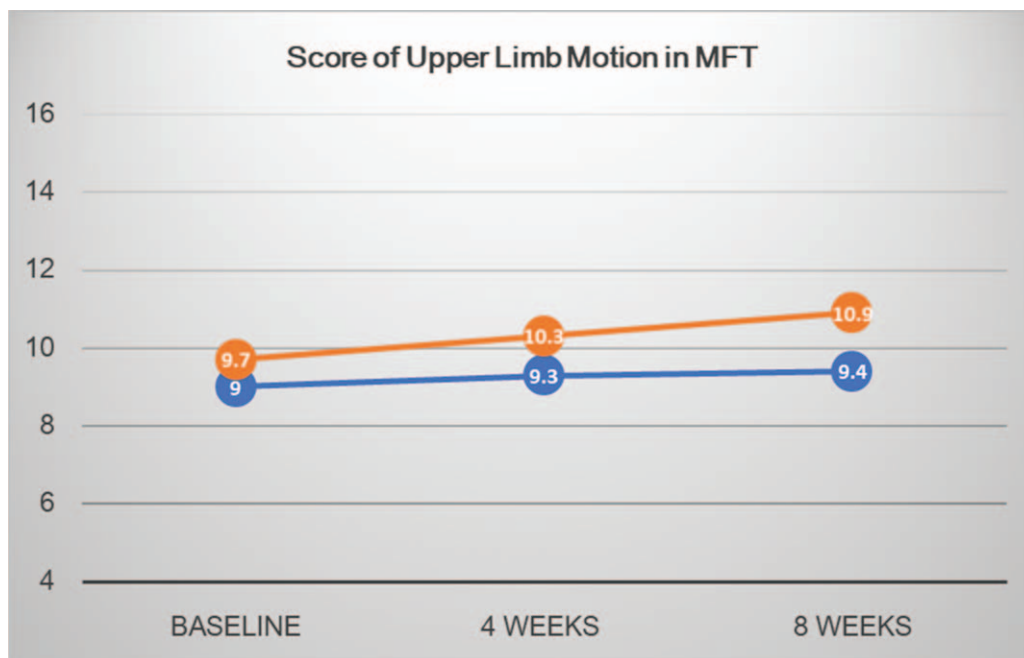


Figure 3. Functional recovery of the upper limb after MFT. The scores of the GMI group were significantly higher than those of the controls.

This study was limited by the heterogeneity of the patient group. We could not determine the subtypes of stroke that might benefit most from the GMI program. Also, we did not examine physiological changes in the brain that may have occurred in response to the GMI program. Thus, further research should determine the most suitable stroke types for GMI training and assess neurophysiological changes in the brain.

In conclusion, the implementation of a home-based stroke rehabilitation intervention with the GMI program resulted in favorable outcomes for the motor function of the upper limb. The home-based GMI programs may be useful adjuncts to conventional rehabilitation for improving upper extremity function in patients with chronic stroke.

Author contributions

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Writing – review & editing: Seong Hoon Lim.

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