

Effects of combining mental practice with electromyogram-triggered electrical stimulation for stroke patients with unilateral neglect

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Abstract. [Purpose] The aim of this study was to investigate the effect of mental practice combined with electromyogram-triggered electrical stimulation on neglect and activities of daily living in stroke patients with unilateral neglect. [Subjects and Methods] Thirty-three stroke patients with unilateral neglect were recruited from a local university hospital, and were divided into two groups. The experimental group received an intervention consisting of mental practice combined with electromyogram-triggered electrical stimulation on the neglected side, while the control group received cyclic electrical stimulation at the same site. In addition, both groups received an identical intervention of conventional occupational and physical therapy. [Results] After the intervention, the experimental group showed a statistically significant improvement in the line bisection test result, star cancellation test result, and Catherine Bergego Scale scores. The control group showed a significant improvement only in the line bisection test result. [Conclusion] These data suggest that mental practice combined with electromyogram-triggered electrical stimulation is an effective, novel treatment for reducing unilateral neglect in stroke patients.

Key words: Electromyogram-triggered electrical stimulation, Mental practice, Unilateral neglect

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INTRODUCTION

Unilateral neglect (UN) refers to the neuropsychological condition in which patients experience reduced orientation and concentration and response to stimuli on the contralateral side owing to behavioral problems that occur after brain injury, although these patients having sensorimotor abilities¹⁾. UN is caused by various forms of brain damage and has an especially high incidence in patients with stroke in the right inferior parietal lobe²⁾.

UN has important implications in the rehabilitation of patients with brain damage. It is negatively associated with the rehabilitation period because patients with UN show relatively poor functional recovery compared with those without UN³⁾. In addition, these patients experience difficulties in activities of daily living (ADL), including maintaining personal hygiene, eating, and dressing, and also are at increased

risk of falling because of gait disturbance⁴⁾. Therefore, having an appropriate treatment and strategy are important while treating this condition because it is essential to reduce UN to achieve effective rehabilitation in these patients.

We proposed a new treatment method for UN by modifying current treatment methods and combining them with mental practice and electromyogram-triggered electrical stimulation (MP-EMG ES). MP-EMG ES is a new, state-of-the-art rehabilitation treatment technology based on neurologic theories. MP-EMG ES involves only repetitive mental practice (for example, imagination of intense movement of the upper limbs on the neglected side), not voluntary muscular contraction. When the generated electric potential reaches a preset threshold, an electric stimulus is generated, resulting in actual muscular contraction and cortical activation⁵⁾. In other words, MP-EMG ES can produce a synergistic effect by combining two treatments (mental practice plus electrical stimulation) with proven efficacy in the alleviation of neglect. The purpose of this study was to identify the effects of this novel training method—MP combined with EMG ES—over a 6-week period of daily training in patients showing right brain damage with UN.

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SUBJECTS AND METHODS

The participants for this study were recruited from the rehabilitation center of a local university hospital. The inclusion criteria for participation were: (1) onset duration of >6 months, (2) right hemisphere stroke with UN, (3) minimal status examination score >24, (4) ability to imagine (average score on the vividness of Movement Imagery Questionnaire <3), and (5) active wrist muscle strength >2 on the Medical Research Council (MRC) scale. Exclusion criteria were: (1) an implanted cardiac pacemaker, (2) skin lesion on the affected side or hypersensitivity at the electrode site, (3) a history of seizure or epilepsy, and (4) unstable medical conditions. In total, thirty-three stroke patients with neglect were eligible for this study. All participants provided written informed consent, and this study was approved by the Inje University Institution Review Board.

This study was designed as a single-blind randomized control study and was scheduled to last for a total 6 weeks. Eligible participants were randomly allocated to the two groups by block randomization using opaque envelopes containing a code specifying the group. The experimental group (n=16) received MP-EMG ES in addition to conventional rehabilitation therapy (CRT: physical therapy and occupational therapy), whereas the control group (n=17) received cyclic ES in addition to the same CRT. Mentamove (Mentamove Deutschland GmbH, Munich, Germany) was used to apply MP-EMG ES in the experimental group. Surface electrodes were attached to the wrist extensor muscle and a reference electrode was attached at the lateral side of the forearm. The site of electrode placement was marked using a permanent marker throughout the intervention. During motor imagery training, electrical potentials were generated in the affected arm and were recorded using EMG. When the potentials reached a preset threshold, the induced electrical stimulation would contract the targeted muscle.

The Mentamove process consisted of three stages: (1) motor imagery (approximately 12 s), (2) electrical stimulation (approximately 6 s), and (3) relaxation (approximately 12 s). The motor imagery used in this study was a vigorous waving of the affected whole arm. This imagery was selected because the EMG was not able to detect electrical stimulation induced by motor imagery of simple extension of the wrist or elbow. The EMG pick-up threshold was set afresh for each subject in every session. If the subject repeatedly reached the threshold during the MP-EMGES, the threshold was automatically increased slightly. The instructions were as follows: First, relax in a comfortable position. Imagine that your left arm moves rapidly and intensely when you see “motor imagery” in the tool window. If your performance is successful, you will experience an electrical stimulation in your forearm. If your performance fails, maintain the relaxed state.

Cyclic ES (Mendel GmbH, Germany) without the EMG function was used to apply electrical stimulation in the control group. Electrodes also were attached to the wrist extensor muscle. In either instrument, biphasic pulses with a frequency of 35 Hz and pulse width of 200 μ S were applied for 12 s. Stimulation intensity led to a clear extension of the wrist (average 20–30 mA). Over a period of 6 weeks, both

Table 1. Baseline characteristics of the subjects included in the study

		Experimental group (N=16)	Control group (N=17)
Gender	Male	10	8
	Female	6	9
Age (years)		67.5±10.3	62.2±10.2
Time post stroke (months)		3.3±1.3	3.5±1.6
Stroke type	Hemorrhage	4	5
	Infarction	12	12

groups were treated 30 times in two 30-min sessions.

The line bisection test (LBT), star cancellation test (SCT), and Catherine Bergego Scale (CBS) were used to quantify the severity of UN. The LBT was performed using Schenkenberg's method⁶. Twenty lines were drawn on an A4 sheet parallel to the long axis, and 18 of these lines were organized into 3 set of 6: 1 set lay primarily on the left, 1 at the center, and 1 on the right side of the sheet. The evaluator initially demonstrated the procedure by marking the 2,150-mm lines at the top and bottom of the sheet. Patients were asked to mark the center points of each of the 18 lines in order. Distances from the left of each line to patient's marks and to true line centers were measured. Deviations were measured using the formula: Percent deviation (%) = [(Marked left side distance-True half length)/True half length] × 100.

In SCT, 56 stars and other symbols were presented on an A4 sheet. The left and right halves of the sheet each contained 27 stars, and patients were asked to mark all of the stars. The scores range from 0 to 27, with lower scores indicating more severe UN. Assessment using CBS involved evaluating the performance of patients by directly observing them perform activities (e.g., dressing, grooming) in real-life situations, and consisted of 10 items. Each item was scored on a four-point scale as follows: 0: no neglect 1–10: mild neglect, 11–20: moderate neglect, and 21–30: severe neglect⁷.

Participant characteristics were analyzed using a statistical software program (SPSS Statistics 20) and descriptive statistics were presented as mean ± SD. The Shapiro-Wilk test was used to check normality of the outcome variables. To evaluate the intervention effects, measures before and after the intervention in each group were compared using a paired t-test. An independent t-test was used to compare changes in outcome measures between the two groups. Statistical significance was set at $p < 0.05$.

RESULTS

All demographic and clinical characteristics of the participants were comparable and are summarized in Table 1.

There were no significant differences in the baseline characteristics between the groups. The experimental group showed a significant improvement in the LBT ($p < 0.01$), CBS, and SCT ($p < 0.05$) scores after the intervention compared with the values obtained before the intervention (Table 2). On the other hand, no significant difference was observed in the control group, except in the LBT score ($p < 0.05$). No

Table 2. Clinical parameters before and after the treatment (N=33)

	Experimental group		Control group	
	Before	After	Before	After
CBS	12.1±4.2	10.1±4.6*	12.6±3.8	11.2±4.1
LBT	30.5±8.9	24.1±10.3*	32.6±9.1	27.7±10.6*
SCT	10.6±5.2	13.0±5.5*	9.2±5.2	11.0±4.6

The values are mean ± standard deviation. CBS: Catherine Bergego Scale, LBT: Line Bisection Test, SCT: Star Cancellation Test

*p<0.05 by paired t test between the initial and final scores in the group

†p<0.05 by independent t test between two groups

significant differences were observed in the LBT, CBS, and SCT scores between the two groups after treatment.

DISCUSSION

MP-EMG ES is a recently developed method that produces tiny electrical signals in the brain through mental practice, rather than through actual physical movements, and this method is used to induce muscle contraction in the upper extremity (U/E) on the neglected side. In other words, the aim of MP-EMG ES is to form sensorimotor circuits for movement through a repeated cycle of brain signal → transmission → muscle movement, which can be used to produce functional changes in the central nervous system and the body. The continual activation of these circuits helps reorganize the damaged areas of the cerebral cortex⁸⁾. It is thought that MP-EMG ES works by inducing neural and peripheral changes through activation of the cerebral cortex via mental practice and afferent stimulation of the neglected U/E via electrical stimulation.

Hong et al.⁵⁾ reported MP-EMG ES is more effective than cyclic ES for improving motor function on the affected side and improves cerebral glucose metabolism in supplementary motor, precentral and postcentral gyri on the contralesional side. However, there is little evidence about the effects of this treatment in cases of UN. In this study, we investigated the effects of MP-EMG ES on neglect in comparison with those of cyclic ES. CBS, LBT and SCT scores significantly improved after treatment in the experimental group. The control group received various CRT interventions that were the same as the experimental group. This control treatment was important because Cyclic ES has been proven to alleviate neglect to some extent by applying afferent stimulation to the neglected side. Therefore, while the control group only showed a significant improvement in LBT, they also showed a slight improvement in scores for CBS and SCT, and as a result, no significant differences were demonstrated between the two groups in any assessments.

The effect of MP-EMG ES is considered synergistic with mental practice. Some studies reported that mental practice is effective for rehabilitation in patients with contralesional neglect, but it is difficult to verify whether patients imagine the specific movement well⁹⁾. MP-EMG ES seems to remedy the deficiencies of mental practice alone.

In this study, patients were instructed to imagine a large and powerful movement of the neglected U/E during the

mental practice stage of MP-EMG ES treatment. When imagining the movement of the neglected U/E, the muscles in the U/E show dynamic regulation and changes⁵⁾. In this regard, when a participant imagined a complex and powerful movement instead of a simple movement, the motor-evoked potential and the excitation in the corticospinal tract increased¹⁰⁾.

This study showed that MP-EMG ES is an effective method for reducing unilateral neglect in stroke patients. However, several factors need to be considered when applying this method. Because MP-EMG ES requires the patient to be capable of imaging movement of the body on the neglect side, there are limitations in applying this method to patients with severe neglect. Active cooperation and good cognitive function also are required.

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