Motor imagery training improves upper extremity performance in stroke patients

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Abstract. [Purpose] The purpose of this study was to investigate whether motor imagery training has a positive influence on upper extremity performance in stroke patients. [Subjects and Methods] Twenty-four patients were randomly assigned to one of the following two groups: motor imagery (n = 12) or control (n = 12). Over the course of 4 weeks, the motor imagery group participated in 30 minutes of motor imagery training on each of the 18 tasks (9 hours total) related to their daily living activities. After the 4-week intervention period, the Fugl-Meyer Assessment-Upper Extremity outcomes and Wolf Motor Function Test outcomes were compared. [Results] The post-test score of the motor imagery group on the Fugl-Meyer Assessment-Upper Extremity outcomes was significantly higher than that of the control group. In particular, the shoulder and wrist sub-items demonstrated improvement in the motor imagery group. [Conclusion] Motor imagery training has a positive influence on upper extremity performance by improving functional mobility during stroke rehabilitation. These results suggest that motor imagery training is feasible and beneficial for improving upper extremity function in stroke patients.

Key words: Stroke, Motor imagery training, Upper extremity performance

INTRODUCTION

Approximately 85% of patients who experience a stroke have a residual upper extremity (UE) disability, and 55–75% experience UE deficits that directly affect their quality of life that directly affects their quality of life1). Stroke patients commonly use the unaffected UE for performing daily living activities and avoid using the affected side, this leads to decreased UE muscle strength and movement and increased stiffness and can greatly affect independence in daily life2). Recovery of UE function is important for effective rehabilitation3, and the plasticity of neural networks is vital to recover damaged motor functions or acquire new motor functions. The plasticity of networks in the brain is extremely important, as it is the basis for recovery of cognitive function and motor learning4).

Motor imagery (MI) is a conscious process that induces muscle activity related to an actual motor output by creating a mental image of the action without the intent of performing it5). It is a cognitive method, which instead of forcing a patient to learn new techniques, causes neural changes in order to re-obtain motor techniques learned before the stroke damage or imitate the actions of others6).

Therefore, in this study, chronic stroke patients were monitored and examined to test the effect of MI on rehabilitation of UE function and brain activation. Motor imagery training (MIT) was designed to maximally activate the mirror neuron network during 18 specific daily activities. The study hypothesis was that MIT would provide sensory feedback and lead to improvement of UE function in patients recovering from a stroke.

SUBJECTS AND METHODS

Twenty-four first-time stroke survivors were included in this study. The inclusion criteria were as follows: (1) 6–12 months since stroke onset, (2) Mini-Mental State Examination (MMSE) score >24 points, and (3) able to sit independently for >30 minutes. Exclusion criteria were as follows: (1) severe cognitive disability such as unilateral neglect, dementia, depression, or seizure and (2) any musculoskeletal disorder including muscle contracture or limitation of joint motion. Prior to study initiation, the objectives and requirements were explained to all participants, who signed a written informed consent form. This study was approved by the Ethics Committee (KyungHee University Medical Center Institutional Review Board, KOMCIRB-2013-050).

All participants underwent an evaluation of UE function at the start of the study. Twenty-four participants were randomly assigned to either the MI or the control group. The following clinical measures were used for assessing UE performance: Fugl-Meyer Assessment-Upper Extremity component (FMA-UE) and Wolf Motor Function Test (WMFT).

Participants in both groups completed their training in 30-minute sessions, 3 times per week, for 4 weeks. In ad-
Motor imagery is a mental exercise that uses an internal stimulus to induce motor sensations from a psychological representation of action without the intent to perform that action. It is known to induce activation in brain areas and muscles similar to those involved in actual task performance. In addition, it mediates and accelerates learning of physical activities and changes in motor function; many studies have demonstrated the neurophysiological basis of MI exercises. Stippich observed localized stimulation of the precentral gyrus along the known somatotopic map when participants imagined moving different body parts such as the foot, hand, or tongue. Ehrsson observed the activation of corresponding areas within the primary motor cortex along the somatotopic map when participants imagined the movement of fingers, toes, and tongue. In the current study, a significant increase in FMA-UE score from 27.92 to 36.08 (8.17 points) was observed after MIT, during which the patients were asked to imagine 18 different daily living activities.

The shoulder, wrist, and hand scores of the FMA-UE were notably increased after the training. Thus, activities of daily living such as folding a towel, using scissors, opening and closing a square airtight container, using a wallet, plugging a cord into an outlet, and sorting chopsticks and spoons appear to improve strength in the muscles surrounding the shoulder, wrist, and hand. WMFT scores for the MI group also changed significantly, from 28.58 to 31.00 between pre- and post-tests. There was a significant difference in pre- and post-test FMA-UE improvement between the two groups (p < 0.05). In the MI group, the average WMFT score changed from 44.75 to 51.00 between pre- and post-tests. A significant increase of 6.25 points was observed (p < 0.05). In the control group, the average WMFT score changed from 35.08 to 40.17 between pre- and post-tests. There was no significant difference in pre- and post-test WMFT improvement between the two groups (Table 1).

DISCUSSION

Motor imagery is a mental exercise that uses an internal stimulus to induce motor sensations from a psychological representation of action without the intent to perform that action. It is known to induce activation in brain areas and muscles similar to those involved in actual task performance. In addition, it mediates and accelerates learning of physical activities and changes in motor function; many studies have demonstrated the neurophysiological basis of MI exercises. Stippich observed localized stimulation of the precentral gyrus along the known somatotopic map when participants imagined moving different body parts such as the foot, hand, or tongue. Ehrsson observed the activation of corresponding areas within the primary motor cortex along the somatotopic map when participants imagined the movement of fingers, toes, and tongue. In the current study, a significant increase in FMA-UE score from 27.92 to 36.08 (8.17 points) was observed after MIT, during which the patients were asked to imagine 18 different daily living activities.

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The MIT exercise used in this study involved repeatedly imagining a familiar motion and then imitating the motion with a therapist, leading to an improvement in UE perfor-
performance and improvement in activities of daily living. Celnik et al. showed that the daily task performance ability of 15 brain-injured patients increased as a result of conducting imitation exercises after watching a clip of a kitchen task such as opening and closing a refrigerator. The present study used an imagery exercise instead of an action-observation training exercise, and the effectiveness was found to be similar to results from the pilot study. The MIT used in the current study involved actions frequently used in daily living activities; thus, when coupled with the use of familiar objects to help trigger motivation through environmental cues relevant to the patient’s life, MIT can help to advance UE rehabilitation. Furthermore, MIT can improve the degree of UE motor performance in daily life as well as the patient’s functional abilities. It has been shown that the motor system of the brain becomes more active with increased similarity between an observed and performed motion [17], when performing goal-oriented rather than simple motions [18, 19] and when observing motion rather than a static image [20].

The results of this study indicate that rehabilitation with MIT combined with physical training improves recovery in stroke patients. The FMA-UE improvement was significantly higher in the MI group compared to the control group. In particular, the FMA-UE shoulder and wrist sub-items improved in the motor imagery group. Thus, MIT has a positive influence on UE performance by improving functional mobility in patients who have experienced a stroke. These results suggest that MIT is feasible and beneficial for improving UE function in stroke patients.

## References