Drinking Behavior Training for Stroke Patients Using Action Observation and Practice of Upper Limb Function

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Abstract. [Purpose] This study examined the effects of action observation and action practice on stroke patients’ upper limb function. [Subjects and Methods] The subjects were 33 chronic stroke patients who were randomly assigned to four groups. The action observation group (5 males, 3 females) watched a video of the task, the action practice group (5 males, 4 females) performed the action, the combined action observation-action practice group (5 males, 4 females) watched the video of the task and practiced the action, and the control group (4 males, 3 females) did not perform either action observation or action practice. The video used in the action observational physical training comprised a scene of an adult male picking up a cup, bringing it to his mouth in order to touch his mouth, and then returning the cup to its initial position. [Results] Improvements in drinking behavior functions were observed immediately after the experiment and one week later. After the intervention, the number of drinking motions had increased the most in the combination group. One week after the experiment, there were increases in the action observation, action training, and combination groups. [Conclusion] A combination of action observation and action training is the most effective treatment method, and action training is a desirable second to combined therapy.

Key words: Action observation, Drinking behavior training, Upper limb function

INTRODUCTION

For patients such as those who have had a stroke or sustained a brain injury, rehabilitation conducted by a multidisciplinary team is effective1, 2). Recently, it was suggested that motor imagery practice may be effective at enhancing motor performance in sport and of patients who have had a stroke3). Since the purpose of rehabilitation is to recover motor skills that have previously been learned rather than learning new skills, motor imitation is frequently used for motor recovery in rehabilitation. Motor imitation is a cognitive process, which involves wide neural networks, and includes action observation, motor imagery, and motor execution as sub-processes4). Motor imagery refers to the process of obtaining indirect experiences of motor sensation by imagining the act of performance in the mind5). Action observation is a learning method using the visual and auditory effects of activities performed by others. It can be said to be a cognitive intervention technique for sportsmen or ordinary persons which can be used to enhance motor skill and motor learning6). In the case of mirror neurons, which are known to be activated during action observation or motor imagery, the same neural circuit that is activated during voluntary performance of an action is triggered when observing actions performed by other individuals. Therefore, motor imagery and action observation can be said to be useful for stroke patients who cannot voluntarily perform actions, since these methods can lead to the recovery of their damaged functions.

Mirror neurons are a particular class of visuomotor neurons. In order to be triggered by visual stimuli, mirror neurons require an interaction between a biological effector such as the hand or mouth and an object, which initiate interactions between biological effectors and the object. In terms of mirror neurons, effective observed and executed actions correspond to goals (e.g., grasping) and the means for reaching those goals (e.g., precision grip), respectively. The visual stimuli effective in triggering the neurons, indicate there are two classes of mouth mirror neurons: ingestive and communicative mirror neurons. Ingestive mirror neurons respond to the observation of actions related to ingestive functions, such as grasping food with the mouth, breaking it, or sucking7, 8).

Action practice is a conservative therapeutic method and requires the repeated practice of the same action many times. The upper extremities serve many functions in daily life. Therefore, if a person has functional disorders in the upper extremities due to stroke, it is important that those be dealt with and efforts are made to recover the relevant func-
tions. In particular, the drinking action—to stretch a hand to pick up a cup and bring it to the mouth—is similar to the eating action, and is the most essential action as humans do it frequently in daily life. The understanding and re-learning of this action are important for those who have upper extremity functional disorder, as its use provides independence and nutrition in daily life. Therefore, in the present study, drinking behavior training was conducted for stroke patients using action observation and action practice using the mirror neuron system. Using the results of the study, the effects of action observation and action practice were compared with other approaches to the treatment of stroke patients’ upper extremities, and their possible uses in rehabilitation therapy are discussed.

**SUBJECTS AND METHODS**

The subjects of the present study were 33 chronic stroke patients who were hospitalized and treated in Daejon, Korea. They had stroke at least six months earlier and were assessed as having recovered to Brunnstrom stage 5. Pursuant to the Helsinki Declaration, the procedure and purpose of the present study were explained to the prospective subjects and their family members, and only those who voluntarily agreed to participate in the study became the subjects of the present study. The subjects were those who scored at least 20 points in the Korean Mini-Mental Status examination, were able to understand and perform instructions, and had visual acuity that was sufficient for watching videos. Since most Koreans’ dominant hand is the right hand, only right hemiplegic patients were selected. The study period was from November 2011 to March 2012, and the subjects were trained for 10 minutes per day for three weeks (i.e., 15 days in total) using the training methods of their respective groups. The patients selected as the subjects were randomly assigned to four groups. The first group was an action observation group (5 males, 3 females, mean age: 63±3.7 years, mean height: 162±8.1 cm) that watched a task video made to fit the purpose of the experiment. The second group was an action practice group (5 males, 4 females, mean age: 62±1.5 years, mean height: 160±5.3 cm) that repeatedly practiced the actions performed during the preliminary test for 10 minutes. The third group was a combined action observation and action practice group (5 males, 4 females, mean age: 61±2.3 years, mean height: 161±3.7 cm) that watched the task video for five minutes and practiced the actions for five minutes. The fourth group was a control group (4 males, 3 females, mean age: 60±5.9 years, mean height: 159±8.1 cm) that neither watched the video nor practiced the actions.

The study used in the present experiment was the action of stretching out the right hand to pick up a cup, bringing the cup to the mouth in order to touch the mouth, and then returning the cup to its initial position. The video used in the action observational physical training comprised a scene of an adult male picking up a cup, bringing it to his mouth in order to touch his mouth, and then returning the cup to its initial position. The video was taken from the front of the model. The cup used in the video scene was an empty paper cup without any handle. The position of the cup was 5 cm away from the edge of the table at the side where the patient was sitting and 45° from the affected hand. The action observation group watched the video of the task on a large screen for 10 minutes in a quiet room. The subjects were instructed to observe the action 20 times in 10 minutes. They were instructed to imagine they were performing the same task as that performed by the model at the same time as they watched the video. An oral instruction, “Please imagine that you the activities are identically copying”, was given every time the motions started and again after one set of the motions had been completed so that the subjects would concentrate on the video. The action practice group performed the action of picking up an empty cup, bringing it to their mouths in order to touch their mouths, and then returning the cup to its original position repeatedly for 10 minutes as instructed by the therapist, without watching the video. The combined action observation–action practice group observed the task video for five minutes and practiced the action for five minutes. The control group did not perform either action observation or action practice, or any task-related activities during the training period. However, this group was assessed for their performance of the task in the same way as the other groups.

The assessment was performed three times: before the intervention, immediately after the completion of the intervention, and one week later. In the assessment, the number of times the full drinking action was performed in one minute was measured. Only complete actions within the measuring time were counted, and those that were not completed were excluded from the measurement. The position and shape of the cup used in the experiment were the same as those presented in the video. Before the experiment, the physical therapist sufficiently explained the details and methods of the task to be performed to the study subjects, elucidating basic postures, technical details, and matters to be noted for the performance of the drinking action. The action was then demonstrated two times. The physical therapist performed the assessments one subject at a time, in an independent space. The physical therapist who conducted the assessments did not have any information about the experimental group of the subjects.

We employed SPSS 19.0 for data analysis examining the effects of action observation on the task performance of drinking. A repeated one-way analysis of variance was conducted in order to compare the number of drinking motions among the groups. Mauchly’s sphericity hypothesis was not satisfied; therefore, a modified version of the Greenhouse-Geisser degree of freedom correction was used in the analysis. For significant differences, a post hoc test was performed with the Bonferroni method. To test the statistical significance, the significance level was chosen as $\alpha = 0.05$.

**RESULTS**

The present study examined the effects of action observation and action practice on stroke patients’ drinking behavior using the upper limb. The action observation, combination, and action training groups showed statisti-
cally significant improvements compared to the control group (p<0.01). There were significant differences in respect of the passage of time (prior to the experiment, after the experiment, and one week after the experiment), in improvements in drinking function immediately after the experiment and one week after the experiment compared to prior to the experiment. The posthoc test results indicate that there were differences between prior to and after the experiment, and between prior to and one week after the experiment (p<0.01). There were no differences between the period after the experiment and one week after the experiment, suggesting that the enhanced function was maintained (Table 1).

Reciprocal action between time and groups was identified; therefore, changes among the groups according to the passage of time were examined (Table 2). According to the comparison of the control group with the other groups, the increase in the number of drinking behaviors was significantly higher in the order of the combined group, the motion exercise group, and the motion observation group (p<0.05). According to the comparison of the motion observation group with the other groups, the increase in the number of drinking behaviors was significantly higher immediately after the experiment and one week after the experiment in the order of the control group and the motion observation group. There was no statistically significant difference between the combined group and the motion training group. According to the comparison of the motion exercise group with the other groups, the increase in the number of drinking behaviors was significantly lower in the control group. There was no statistically significant difference between the motion observation group and the combined group. After the experiment and one week after the experiment, the number of drinking motions had increased most in the combination group (p<0.05).

**DISCUSSION**

This study was conducted in order to examine the effects of action observance and action training on stroke patients’ drinking behavior as a proxy of upper limb function. According to our results, the drinking behavior function of the action observance, combination, and action training groups improved compared to the control group. The result was maintained in the delayed post-test, suggesting maintenance of the improvement. The action observation group’s drinking behavior function improved, a result similar to those of the combination and the action training groups. It can therefore be surmised that action observation through the activation of the mirror neurons produces effects analogous to actual action training. The number of drinking behavior motions was maintained in the delayed post-test, suggesting that action observation in the learning stage may promote stroke patients’ motor function learning. In this study, the

### Table 1. Number of drinking motions by each group in each period (unit: time)

| Group          | Before | After**† | After one week**‡ |
|----------------|--------|----------|-------------------|
| Control        | 15.1±2.6 | 14.6±2.7 | 14.1±2.0          |
| Action observation | 15.1±2.6 | 20.1±2.9 | 20.1±4.1          |
| Combination    | 16.1±3.0 | 25.1±1.1 | 25.1±5.9          |
| Action training| 16.0±4.2 | 23.3±3.7 | 22.1±3.1          |

**p <0.01, †Before experiment − After experiment: p < 0.01, ‡Before experiment − One week after experiment: p < 0.01.

### Table 2. Changes in the number of drinking motions in each group

| Group          | Group          | Before | After | After one week |
|----------------|----------------|--------|-------|---------------|
| Control        | Action observation | −0.0   | −5.5* | −6.0*         |
| Action observation | Combination | −1.0   | −11.0* | −11.0*       |
| Action training | Control        | −0.9   | −8.6* | −8.0*         |
| Action observation | Combination | −1.0   | −5.0* | −5.0         |
| Action training | Control        | −0.9   | −3.1  | −2.0         |
| Action training | Action observation | 1.0    | 5.0*  | 5.0          |
| Action training | Action training | 0.1    | 1.9   | 3.0          |
| Action training | Control        | 0.9    | 8.6*  | 8.0*         |
| Action training | Combination    | −0.1   | −1.9  | −3.0         |

*p <0.05, †Mean difference
combination group’s drinking behavior functions were better than those of the action training and action observation groups, and the action training group’s number of drinking behavior motions increased more than those of the action observation group after the experiment and one week after the experiment, though not significantly.

The results of the present study are similar to those of Kim7). In that study, mentally retarded middle-school girls obtained high scores for golf putting in the delayed post test after a combined therapy of action observation and action practice. Lee et al.9) observed that learning through actual performance resulted in somatic sense learning, and concluded that it is the best learning method. It was further observed that under circumstances when no actual performance was possible, action observation had similar effects to actual performance. The results of Sakamoto et al.10) support the results of the present study in that a combination of action observation and action training enhanced corticospinal excitability. In a motor-evoked potential test of stroke patients’ hand functions, motor-evoked potential after action observation and action training was high, which again agrees with the results of the present study11).

In the present study, a combination of action observation and action training was the most effective treatment method, and action training was a desirable second to combined therapy. In circumstances where no actual performance is possible, action observation has similar effects to actual performance. In the event that stroke patients can actually perform motions, the most effective method of rehabilitation treatment would be to induce the activation of mirror neurons through action observation and have them practice the motions. In order to generalize the results of the present study, future research should enroll a larger number of subjects, and should consider the time needed for action observation and the degree of changes according to the onset time. In the planning of physical therapy and occupational therapy training, the application of a combined therapy of action observation and action practice is necessary. For those patients who cannot actually perform motions, an action observation program needs to be conducted.

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