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Clinical Feasibility of Action Observation Based on Mirror Neuron System on Walking Performance in Post Stroke Patients

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Abstract. [Purpose] The purpose of this study was to determine the effect of action observation on walking performance and its clinical feasibility for treatment of hemiparetic stroke. [Subjects] The subjects of the study were 30 stroke patients. [Methods] They were randomly allocated to two groups: an experimental group (n=15) which used the action observation training and the control group (n=15) which did no exercise. [Result] The results indicate that step length (cm), stride length (cm), single support time (%), double support time (%), gait velocity (m/s), and cadence (steps/min) significantly improved in the experimental group. In contrast, in the control group, the results indicate that step length, stride length, single support time, double support time, gait velocity, and cadence did not significantly change. There were significant differences in step length, stride length, single support time, double support time, gait velocity, and cadence between the experimental group and the control group after the intervention of action observation. [Conclusion] These findings suggest that the action observation can enhance the walking performance of patients with post stroke hemiparesis.
Key words: Action observation, Stroke, Gait

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INTRODUCTION

Walking impairments are one of the most severe disabilities associated with post-stroke hemiparesis. Therefore, complete recovery of walking function is ranked as a primary goal in stroke rehabilitation[1)]. Early physical therapy intervention in gait training is believed to be valuable for enhancing the walking function of post-stroke patients. Recently, various new methods have been recommended for improve gait, including virtual reality gait training[2)], task-oriented gait training[3)] and task-oriented biofeedback gait training[4)]. However, these trainings must be made independent walking. To overcome such disadvantages, several investigators have suggested the use of action observation in physical rehabilitation since it is easy to conduct and is a safe means of promoting motor recovery after stroke[5)]. Action observation can enhance the beneficial effects of motor training on motor memory formation after stroke[5)]. Functional-imaging studies of humans have further demonstrated that some motor cortical regions are active during observation of actions made by others, following the same rules of motor representation[6)]. However, only a few studies have demonstrated the effect of action observation on walking ability in Parkinson's disease[7)] or upper extremity ability in stroke[8)]. Therefore, the purpose of this study was to determine the effect of action observation on walking performance and its clinical feasibility for treatment of hemiparetic stroke.

SUBJECTS AND METHODS

The subjects of this study were 30 patients with post stroke hemiparesis who were recruited from a stroke rehabilitation center in the Republic of Korea. There were not significantly differences voluntarily between the action observation group and the control group (Table 1). The subjects voluntarily agreed to participate in the training including the exercise program. At the time of enrolment, patients were randomly assigned to the experimental or control groups by a computerized random-number generator performed by an independent researcher. All patients received 30 minutes of physical therapy training. Each session started with the observation of video clips projected on a large computer screen. Those in the action observation group were instructed to carefully watch 5 video clips (each clip lasting 2 minutes). The action observation video clips used in this study consisted of 5 video clips: (1) Anterior view of walking straight with long steps; (2) Side view of walking straight with long steps; (3) Posterior view of walking straight with long steps; (4) All direction view of walking straight with long steps in slow motion; (5) All direction view of walking straight with long steps in fast motion. To ensure proper attention during the video presentation, patients were explicitly asked to concentrate

Table 1. The general characteristics of the stroke patients

Group	Age (years)	Height (cm)	Weight (kg)	Onset time (month)	Stroke type (infarction/ Hemorrhage)	Affected side (right/left)	Brunnstrome (StagesIV/V)
Action observation	64.1 ± 8.3	164.7 ± 7.9	60.0 ± 8.9	4.6 ± 1.3	10/5	8/7	12/3
Control group	65.5 ± 7.7	162.2 ± 9.1	64.0 ± 8.1	4.1 ± 1.0	10/5	8/7	12/3

Mean ± SD, *p<0.05

Table 2. Comparison of the action observation effect

Gait parameters		Action observation	Control group
Affected side step length (cm)*	pre	34.52 ± 11.69	34.29 ± 12.73
	post	41.55 ± 9.12*	34.37 ± 8.61
Affected side stride length (cm)*	pre	75.14 ± 11.67	72.41 ± 14.76
	post	89.23 ± 8.45*	73.74 ± 14.42
Affected side single support time (%)*	pre	31.65 ± 9.77	29.85 ± 10.45
	post	38.52 ± 3.75*	30.65 ± 9.45
Double support time (%)*	pre	36.78 ± 10.61	37.11 ± 10.65
	post	27.21 ± 6.43*	33.21 ± 6.18
Gait velocity (m/s)*	pre	0.53 ± 0.17	0.48 ± 0.26
	post	0.73 ± 0.20*	0.53 ± 0.15
Cadence (step/min)*	pre	73.49 ± 13.78	66.27 ± 16.41
	post	90.36 ± 13.82*	75.49 ± 15.72

Mean ± SD, *p<0.05

on how the actions were performed and were not allowed to imitate any movement. After video clip observation, patients remained to walking performance scene during 10 minutes. In the control group, directly following each therapy session, each subject watched a 10-minute video in which they were taken through a progressive relaxation program (stretching). This regimen required subjects to flex different muscles in the body, and then relax them. The spatiotemporal gait parameters were measured by the GAITRite system(SMS Technologies Ltd, UK), which included the calculation of step length (cm), stride length (cm), single support time (%), double support time (%), gait velocity (m/s), and cadence (steps/mim). Three walking trials were conducted at a self-selected. Speed and the values were averaged. The GAITRite system has 2 main components: a pressure-sensitive mat (61 × 366 cm) and a personal computer (PC). The mat is composed of a series of sensors, organized in a 48 × 288 grid pattern sandwiched between 2 layers of vinyl. The mat gives the visual impression of a carpet. For the first analysis, a paper walkway was placed over the mat to record footfalls by the pencil-and-paper method concurrent with GAITRite recordings on a straight 6-m path. The collected data were analyzed using SPSS ver. 12.0. All the parameters for all the subjects were tested by the Kolmogorov-Smirnov test, which showed that the data were normally distributed. The paired t-test was performed to examine differences between before and after the intervention, and the independent t-test was performed to test the difference between the groups before and after the intervention. Significance was accepted for values of $p<0.05$.

RESULTS

The step length, stride length, single support time, double support time, gait velocity, and cadence of the action observation group were significantly improved when compared with those before the experiment; however, those of the control group were not significantly different. Comparison of the spatial-temporal gait parameters between the action observation group and the control group after the intervention showed significant differences in step length, stride length, single support time, double support time, gait velocity, and cadence (Table 2).

DISCUSSION

The purpose of this study was to determine the feasibility and the immediate effect of using action observation training to improve the walking performance of post-stroke hemiparesis patients. The results show that the walking performance of the action observation training group was significantly better than that of the control group, indicating that action observation training had a positive effect on the improvement of walking performance of post stroke hemiparesis patients. Step length, stride length, single support time, double support time, gait velocity, and cadence were significantly improved in the action observation group, while there were no significant changes in the control group. Comparison between the two groups showed that the step length, stride length, single support time, double support time, gait velocity, and cadence after action observation training were more positively affected in the action observation group than in the control group. Previous studies have shown that action observation appears to activate the motor system similar to execution by generating an internal representation of action that may be a goal for motor relearning[9]. The neural circuits involved constitute a mirror neuron system that maps the sensory signals of action observation onto a similar neuronal substrate involved in motor programming and execution of what had been observed[10]. The key rationale for action observation in stroke rehabilitation is to provide a means to recover lost function within the damaged motor network; so the critical condition is observation with intent to imitate the observed action[11]. A similar positive impact of action observation has been documented for both upper-limb function of stroke patients[8], and walking performance of Parkinson's disease patients[7]. The results of the present study suggest that the observation of specific actions belonging to participants' motor repertoire and linked to gait performance can enhance improvement of the walking ability of patients with post-stroke hemiparesis. In conclusion, action observation can enhance the walking performance of patients with post-stroke hemiparesis. There were some limitations of this study that can be addressed by further studies. The small sample size is a factor limiting the generalizability of the results. Further, we did not determine effect of action observation training on patients with severe hemiplegia. Therefore, further controlled studies with greater sample sizes including severe hemiplegia patients will be necessary to determine the clinical benefits of action observation as a walking training for patients with post stroke hemiparesis.

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