J. Phys. Ther. Sci. 30: 1241–1244, 2018

The Journal of Physical Therapy Science

Original Article

The effects of mirror neuron system-based self-observation training on lower limb muscle activity and dynamic balance in patients with chronic stroke

Young-Lan Son, MSc[1)], Jae-Woon Kim, MSc[1)*]

[1)] *Department of Physical Therapy, Graduate School, Nambu University: 214 Pungyeong-ro, Gwangsan-gu, Gwangju 6225, Republic of Korea*

Abstract. [Purpose] This study aimed to investigate the effects of mirror neuron system-based self-observation training on lower limb muscle activity and dynamic balance in patients with chronic stroke. [Participants and Methods] Twenty patients with chronic stroke were randomly assigned to a self-observation training group (n=10) or a control group (n=10). Both groups followed a routine 30-minute exercise therapy regimen five days a week for four weeks. The self-observation training group additionally watched video clips of their balance and functional gait training and performed physical training twice over a 10-minute time span. Each self-observation training session was performed for 30 minutes, three times a week for four weeks. Muscle activity was evaluated using surface electromyography; dynamic balance was evaluated using timed up and go and 10-meterwalk tests. [Results] Within-group comparisons showed significant differences in muscular activities of the rectus femoris, biceps femoris, tibialis anterior, and gastrocnemius and dynamic balance. Comparing between groups, the muscle activity of the rectus femoris, biceps femoris, tibialis anterior, and gastrocnemius and dynamic balance were significantly different between experimental and control groups. [Conclusion] Self-observation training improved lower limb muscle activity and dynamic balance in patients with chronic stroke.

Key words: Self-observation training, Muscle activity, Dynamic balance

(This article was submitted Apr. 29, 2018, and was accepted Jul. 20, 2018)

INTRODUCTION

Stroke refers to a group of diseases and incidents caused by a cerebrovascular disorder where in the blood supply in the brain is disrupted by a rupture or blockage of the cerebral vasculature[1)]. Although functional deficits vary by the site and severity of the stroke, these patients exhibit weakened muscle contractions, reduced motor unit activation during contractions, and a loss of the ability to control muscular activity in a timely manner[2)]. Specifically, limited lower limb movement increases the risk of fall and adversely affects balance and ambulation[3)]. Recently, multiple studies have investigated the effects of cranial nerve plasticity on functional recovery after stroke, and interventions based on the mirror-neuron system have been proposed as beneficial alternatives in stroke rehabilitation[4)]. One of these interventions, called self-observation, significantly improves motor skill acquisition[5)]. Self-observation involves recording and watching one's own activity and adjusting one's motions based on the video[6)]. While watching their own movements, the patients could visualize and appropriately alter their previously inappropriate actions[7)]. Identifying and adjusting motion errors is critical for improving motor functions[8)]. Existing observation training programs focus on physical training from the perspective of a third person[9, 10)]. Studies comparing the physical functions during self-observation training are lacking. Therefore, this study aimed to investigate the effects of

*Corresponding author. Jae-Woon Kim (E-mail: bomman16@naver.com)

self-observation training on muscle activity and dynamic balance in patients with chronic stroke. The goal was to ultimately provide clinical evidence and foundational data by administering a self-observation training program to patients and comparing their results with those of the control group.

PARTICIPANTS AND METHODS

Twenty patients diagnosed with stroke-related hemiplegia due to stroke were enrolled. The inclusion criteria comprised comprehension of the purpose of the study and provision of consent to participate, a diagnosis of stroke at least six months prior to the study, and patients who were capable of walking at least 10 m without assistance. The participants were randomly divided into an experimental group (n=10) and a control group (n=10). We used simple randomization and sealed envelopes with sequential numbers for allocation concealment. Patients with an orthopedic disease in the lower limb, visual impairment affecting study participation, and neurologic diseases other than stroke that may have affected the study were excluded. The purpose and methods of the study were explained to the participants, and written informed consent was obtained in keeping with the ethical principles of the Declaration of Helsinki. The mean age, weight, height, and the Korean version of the mini-mental status examination (MMSE-K) score of the experimental group were 67.6 ± 6.3 years, 66.9 ± 7.6 kg, 171.2 ± 5.8 cm, and a 26.9 ± 2.4 score, respectively. The mean age, weight, height, and MMSE-K score of the control group were 66.7 ± 6.8 years, 65.7 ± 9.6 kg, 173.3 ± 6.5 cm, and a 27.8 ± 2.9 score, respectively (Table 1). Both groups underwent general rehabilitation training for 30 minutes a day, 5 times a week, for 4 weeks. Additionally, the experimental group watched a video of their performance after walking 3 m or 10 m, walking on an unstable supporting surface, and walking away from block and walking over block tasks. After watching the video, the participants performed two trials of physical training for 10 minutes each, and the total duration of the intervention was 30 minutes. For the physical training after watching the video, the participants performed the same tasks in the video with an individual trainer. The self-observation program lasted 30 minutes a day, 3 times a week, for 4 weeks. Muscle activity was measured using surface electromyography (EMG) (EMG BTS300; BTS Company, Milano, Italy). The surface EMG electrodes were attached to the rectus femoris, biceps femoris, tibialis anterior, and gastrocnemius, representing muscles that substantially contribute to walking. The collected EMG signals were normalized to percentage of reference voluntary contraction (%RVC), and RVC was used. The root mean square (RMS) was computed for the analysis. To measure the baseline RVC value, the participants were instructed to maintain both feet on the ground for support as a preparatory motion for walking, for five seconds. RVC was measured from the mid-stance phase to the terminal-stance phase three times before and after, and the average value was used for analysis. The %RVC of the collected EMG signals were computed by dividing the mean RMS by the baseline RMS. Collected data were statistically processed using SPSS 22.0 (SPSS, IBM, USA) for Windows. Participants' overall characters were evaluated by descriptive statistics. The paired t-test was used to compare groups before and after the experiment. The independent t-test was conducted to assess difference in the degree of change between the two groups before and after the experiment. The significance level was set to α=0.05.

RESULTS

The changes in the muscle activities and dynamic balance are shown in Table 2. The within-group comparison in the both the experimental and control groups showed significant differences in the muscle activities of the rectus femoris, biceps femoris, tibialis anterior, gastrocnemius and dynamic balance (TUG, 10MWT) ($p<0.05$). In a comparison between the groups, the muscle activities of the rectus femoris, biceps femoris, tibialis anterior, and gastrocnemius and dynamic balance (TUG, 10MWT) of the experimental group were significantly different compared to the control group ($p<0.05$).

DISCUSSION

The purpose of this research was to determine the effect of self-action observation training based on mirror neuron system on muscle activity and dynamic balance with chronic stroke patients. Both experimental group and control group showed a significant differences in muscle activity of rectus femoris, biceps femoris, tibialis anterior, gastrocnemius in the within group comparison. In a comparison between the groups, the experimental group showed significantly higher rectus femoris, biceps femoris, tibialis anterior, and gastrocnemius muscle activities than those of the control group. In a previous study, compared with the muscle activity of the affected lower extremities in the control group, the muscle activity in the action observation training group which was aimed at chronic stroke patients with affected lower extremities increased[11], where as another study reported that normal men who watched a video of hand gripping motions had a higher level of hand muscle activity than those who did not watch the video[12]. Additionally, patients that experienced stroke who underwent motion observation training had greater tibialis anterior and gastrocnemius muscle activities[13]. A previous study reported that patients who underwent mirror therapy after stroke showed an improvement in the step length and stride length compared to those of the control group[14]. The findings of this study are in line with those of previous studies, and we found that asymmetric walking had a positive effect on improvement of muscle activity by increasing the supported weight on the affect side.

Both experimental group and control group showed a significant differences in dynamic balance in the within group com-

Table 1. General characteristics of the study participants

	Experimetal group (n=10)	Control Group (n=10)
Gender (male/female)	4/6	5/5
Age (years)	67.6 ± 6.3[a]	66.7 ± 6.8
Weight (kg)	66.9 ± 7.6	65.7 ± 9.6
Height (cm)	171.2 ± 5.8	173.3 ± 6.5
MMSE-K (scores)	26.9 ± 2.4	27.8 ± 2.9

[a]Mean ± SD.
MMSE-K: Korean Mini-Mental Status Examination.

Table 2. Comparison of the muscle activity and dynamic balance results between the experimental and control groups

	Experimental group (N=10)			Control group (N=10)		
	Pre	Post	Post-Pre	Pre	Post	Post-Pre
RF (%RVC)	112.7 ± 9.2 [a]	134.6 ± 8.9*	22.0 ± 2.9#	112.7 ± 4.6	126.8 ± 5.4*	14.1 ± 2.3
BF (%RVC)	111.9 ± 7.1	137.1 ± 11.2*	25.2 ± 8.7#	109.3 ± 5.5	121.8 ± 5.4*	12.5 ± 2.6
TA (%RVC)	120.8 ± 8.6	145.3 ± 7.6*	24.5 ± 2.9#	125.2 ± 9.9	132.5 ± 9.8*	7.3 ± 1.4
G (%RVC)	121.9 ± 4.3	140.5 ± 5.6*	18.6 ± 2.2#	129.4 ± 11.1	136.0 ± 11.3*	6.6 ± 2.6
TUG (sec)	19.3 ± 1.3	17.8 ± 1.1*	−1.6 ± 0.4#	18.4 ± 0.9	17.9 ± 1.1*	−0.6 ± 0.2
10MWT (sec)	29.5 ± 1.1	27.1 ± 1.1*	−1.6 ± 0.4#	28.6 ± 1.5	28.1 ± 1.6*	−0.6 ± 0.3

[a]Mean ± SD.
RF: Rectus Femoris; BF: Biceps Femoris; TA: Tibialis Anterior; G: Gastrocnemius; TUG: Timed Up and Go; 10MWT: 10 M Walk Test.
*$p<0.05$: significant difference within group, # $p<0.05$: significant difference between groups.

parison. In a comparison between the two groups, the experimental group showed a significantly greater TUG and 10MWT (dynamic balance indicators) than the control group. A previous study reported that patients after stroke who underwent action observation training showed an improvement of dynamic balance and ambulatory ability[15)]. In another study, the participants were divided into a self-observation followed by physical training group, a physical training after observing healthy adults' motions group, and a physical training without observation group. The three groups underwent balance training on a horizontal surface, and the results showed that the self-observation group showed a significant improvement of balance[16)]. The results of the present study were consistent with those of the abovementioned prior study, self-observation training improves the asymmetric gait pattern. In addition, it was found that moving the center of gravity from the non-affected side slightly toward the affected side contributes to improving dynamic balance. This research has a limitation with respect to generalization on the findings to all stroke patients, since it was conducted in a small group. In addition, follow-up was not performed, so the duration of the effect is unknown. Further study is needed with a larger number of patients for a longer time period of follow-up.

Conflict of interest

None.

REFERENCES

1) Sullivan KJ, Brown DA, Klassen T, et al. Physical Therapy Clinical Research Network (PTClinResNet): Effects of task-specific locomotor and strength training in adults who were ambulatory after stroke: results of the STEPS randomized clinical trial. Phys Ther, 2007, 87: 1580–1602. [Medline] [CrossRef]
2) Patterson KK, Parafianowicz I, Danells CJ, et al.: Gait asymmetry in community-ambulating stroke survivors. Arch Phys Med Rehabil, 2008, 89: 304–310. [Medline] [CrossRef]
3) Liepert J, Graef S, Uhde I, et al.: Training-induced changes of motor cortex representations in stroke patients. Acta Neurol Scand, 2000, 101: 321–326. [Medline] [CrossRef]
4) Garrison KA, Winstein CJ, Aziz-Zadeh L: The mirror neuron system: a neural substrate for methods in stroke rehabilitation. Neurorehabil Neural Repair, 2010, 24: 404–412. [Medline] [CrossRef]
5) Besharati S, Kopelman M, Avesani R, et al.: Another perspective on anosognosia: self-observation in video replay improves motor awareness. Neuropsychol Rehabil, 2015, 25: 319–352. [Medline] [CrossRef]
6) Lee GJ, An HJ: The effects of videotaped self-observation on the development of insight among schizophrenic clients. J Kor Acad Phych Ment Health Nurs,

2002, 11: 89–97.
7) Wulfert E: Social learning theory: Albert Bandura, in NA Piotrowski (ed.) Psychology Basics. Pasadena: Salem Press, 2005, pp 787–793.
8) Thomas G, Morgan K, Harris K: Observational learning in coaching. Learn Sports Coach, 2016, 3: 22–23.
9) Choi HS, Nam GW: The effect of action observation training on balance in patients with chronic stroke. J Kor Acad Ind Coop Soc, 2014, 15: 3759–3765.
10) Gurbuz N, Afsar SI, Ayaş S, et al.: Effect of mirror therapy on upper extremity motor function in stroke patients: a randomized controlled trial. J Phys Ther Sci, 2016, 28: 2501–2506. [Medline] [CrossRef]
11) Lee HJ, Kim YM, Lee DK: The effects of action observation training and mirror therapy on gait and balance in stroke patients. J Phys Ther Sci, 2017, 29: 523–526. [Medline] [CrossRef]
12) Losana-Ferrer A, Manzanas-López S, Cuenca-Martínez F, et al.: Effects of motor imagery and action observation on hand grip strength, electromyographic activity and intramuscular oxygenation in the hand gripping gesture: a randomized controlled trial. Hum Mov Sci, 2018, 58: 119–131. [Medline] [CrossRef]
13) Bae S, Kim KY: Dual-afferent sensory input training for voluntary movement after stroke: a pilot randomized controlled study. NeuroRehabilitation, 2017, 40: 293–300. [Medline] [CrossRef]
14) Ji SG, Kim MK: The effects of mirror therapy on the gait of subacute stroke patients: a randomized controlled trial. Clin Rehabil, 2015, 29: 348–354. [Medline] [CrossRef]
15) Kim JS, Kim K: Clinical feasibility of action observation based on mirror neuron system on walking performance in post stroke patients. J Phys Ther Sci, 2012, 24: 597–599. [CrossRef]
16) Hiyamizu M, Maeoka H, Matsuo A, et al.: Effects of self-action observation on standing balance learning: a change of brain activity detected using functional near-infrared spectroscopy. NeuroRehabilitation, 2014, 35: 579–585. [Medline]