J. Phys. Ther. Sci.
25: 1173–1175, 2013

The Effects of Additional Action Observational Training for Functional Electrical Stimulation Treatment on Weight Bearing, Stability and Gait Velocity of Hemiplegic Patients

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Abstract. [Purpose] The purpose of this study was to evaluate the functional effects of additional action observational training for functional electrical stimulation treatment on weight bearing, stability and gait velocity of hemiplegic patients. [Subjects and Methods] Twenty subjects were randomized into two groups. Subjects more than six months post-stroke participated. Balance and gait velocity were measured at the baseline, and after six weeks of treatment. Both groups received functional electrical stimulation treatment. The experimental group additionally received action observational training. The paired t-test was used to analyze differences in the outcome measures between before and after the intervention. The difference between the groups was compared using the independent t-test. [Results] The experimental group showed significant increases in weight bearing (anterior·posterior, right·left) on the affected side, stability index and gait velocity. The control group showed only a significant increase in anterior·posterior weight bearing on the affected side. Moreover, according to the comparison of training effects between in the two groups, the variables of anterior·posterior weight bearing, stability index and gait velocity revealed a statistically significant difference. [Conclusion] Additional action observational training for functional electrical stimulation treatment should be considered as a therapeutic method in physical therapy for the improvement of weight bearing, stability index and gait velocity of hemiplegic patients.
Key words: Action observational training, Functional electrical stimulation, Hemiplegia

(This article was submitted Mar. 28, 2013, and was accepted May 4, 2013)

INTRODUCTION

Although studies of functional electrical stimulation treatment, one of the rehabilitation programs used to resolve problems related to the balance and gait of hemiplegic patients, are being actively carried out, the method that is generally used in clinics is executed in limited space or in wheelchairs. Thus, a decrease in the focus of research involving patients is being witnessed. Therefore, it is necessary to propose additional treatment programs or seek improvements in treatment methods in order to induce active movement.

Most training programs aim to generate adaptive reversibility in function and structures of the undamaged brain, and training is executed with that as the focus[1)]. However, there are limitations to the ability of hemiplegic patients with damaged mobility to participate in such training programs, and it is not easy to activate the brain through sensory and kinesthetic stimulation to revive the neuroplasticity. Action observational training is based on the mirror neuron system, and can overcome the ability limitations of hemiplegic patients. Action observational training is a method in which an action is observed, then imitated, and executed in repetitive training. Its theoretical base lies in the mirror neuron system[2)].

Although direct stimulation to the damaged brain is executed through exercise programs for paralyzed limbs, action observation training can also stimulate the part of the brain that is activated during the action training. It can also assist in the reorganization of the damaged part of the brain[3)]. Although studies of action observational training are currently being carried out with healthy people and athletes as subjects, and present outstanding results[4, 5)], there is lack of studies including patients with damaged nervous systems. If action observational training for hemiplegic patients could induce continuous activation of the brain, the maximization of functional movement in daily life could be achieved through imitation of the observed action. Furthermore, it could be used as a new method to treat neurologic patients.

SUBJECTS AND METHODS

Subjects

The subjects of this study were patients diagnosed with

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stroke at C University Hospital, Gyeonggi-do. Twenty patients who consented to participate in this study were chosen after an explanation of its purpose had been given to them and their guardians.

The subjects were hemiplegic patients more than 6 months from stroke onset who, scored over 25 points on the K-MMSE[6] and were capable of gait over 15 m.

The general characteristics of the subjects are shown in Table 1. Regarding the ages of the experimental group, there were 2 patients aged in their 30s, 1 in the 40s, 3 in their 50s, 2 in their 60s, and 2 in their 70s. There were 6 males and 4 females, and there were 4 and 6 patients with paralysis on the right and left sides respectively. In the control group, there were 1 in the 30s, 2 in their 40s, 3 in their 50s, 2 in their 60s, and 2 in their 70s. There were 5 males and 5 females, and there were 4 and 6 patients with paralysis on the right and left sides, respectively.

Methods

The experimental group received functional electrical stimulation treatment. They were asked to watch a video on gait for 15 minutes. The video on gait showed walking on flat ground, slopes, and stairs, and was watched 5 times a week for 6 weeks. The control group received only functional electrical stimulation treatment.

The functional electrical stimulator used in this study was Microstim (Medel GmBH, Berlin, Germany) which has adjustable frequency, contraction time, relaxation time, and on-time. The electrodes used were single-use surface electrodes (0.5×0.5 cm). Referring to the studies by Lindquist et al.[7], the active electrode was attached to the head of the fibula and the reference electrode was placed between the peroneus longus below the head of the fibula and the tibialis anterior to selectively stimulate the deep peroneal nerve. A biphasic rectangular wave was used for the waveform, and pulse rate, pulse width, and on-time were set as 35 pps, 250 μV, and 0.3 sec, respectively.

Tetrax, developed by Sunlight of Israel, was used for to evaluate subjects' weight bearing and stability. Since the force plates of Tetrax are positioned under the front and rear of the left foot, and the front and rear of the right foot, it is possible to carry out weight bearing and balance test on each foot region, and to provide feedback training with a monitor placed at the front. Measures of weight bearing on the front and rear of the right and left feet were used in this study. The stability index measures the sway in the posture using 4 force plates, and the overall stability is calculated from measures of the area, length, and speed of the sway and gravity center; lower scores indicate better subject stability.

SPSS version 12.0 was used for the statistical analysis. The paired t-test was performed to examine changes within each group after the treatment. The independent t-test was used for inter-group comparison. The level of statistical significance was chosen as $\alpha=0.05$.

Table 1. General characteristics

Characteristics		Experimental group (n=10)	Control group (n=10)
Age (yr)	30–39	2	1
	40–49	1	2
	50–59	3	3
	60–69	2	2
	70–79	2	2
Sex	Male	6	5
	Female	4	5
Affected Side	Right	4	4
	Left	6	6

RESULTS

The experimental group showed statistically significant post-intervention changes in front and rear foot weight bearing, left and right foot weight bearing, stability index and gait velocity ($p<0.05$). The control group only showed a significant difference in anterior and posterior weight bearing ($p<0.05$). According to the comparison of training effects between in the two groups, the variables of anterior.posterior weight bearing, stability index and gait velocity revealed a statistically significant difference ($p<0.05$) (Table 2).

DISCUSSION

Functional electrical stimulation treatment is currently used in clinics and is considered to be an adjunctive treatment which is carried out during rest after exercise therapy. In action observational training subjects imitate an action through continuous observation regardless of whether the exercise had been learned or forgotten. Action imitation is a process comprised of action observation, motor imagery,

Table 2. Comparison of the groups

Variables		Experimental group (n=10)		Control group (n=10)	
		before	after	before	after
WD (%)	AP	36.15±6.56[ι]	40.35±4.28*	37.23±10.37	40.16±6.97*
	RL[§]	29.87±5.48	32.57±4.49*	28.26±9.20	28.73±9.05
	SI[§]	23.23±4.54	19.11±5.32*	22.45±6.55	21.69±5.96
GV (m/s)[§]		0.47±1.52	0.60±1.36*	0.39±2.18	0.42±2.26

[ι] Mean±SD, WD: Weight Distribution, AP: Anterior· Posterior, RL: Right ·Left, SI: Stability Index, GV: Gait Velocity
*significant difference from before at $p<0.05$, [§]significant difference between the groups

and action execution[8]. It is achieved through perception that comprehensively reproduces the observed action and stores it in the memory. Hemiplegic patients improve their balance and gait velocity by imitating the action in the part that is not functional through action observation. Lee and Lee[9] reported there was significant improvement in both static balance capacity and dynamic balance. This result supports the results of our present study which suggest that gait velocity increases with improvement in stability due to improvement in weight bearing. Choi and Park[10] reported that a group which performed actual training and motor imagery simultaneously displayed improvement in functional activity, a result which is also in agreement with the results of our present study. One study has suggested that action observation and exercise therapy, in which participants repetitively practice the observed action, may elicit improvement in the function of damaged brains[2]. It has also been reported that motor imagery may assist in the recovery of motor functions after stroke[11]. In addition, it has been reported that motor systems of stroke patients without good motor ability can be activated through dynamic introjection of action with motor imagery regardless of the fact that actual exercise has not been carried out[12]. In contrast, it has also been reported that there wasn't as much improvement in stroke patients as healthy people in cortical activation[13]. Another study has suggested that damage in certain parts of the brain not only reduces motor skill, but also the capacity for motor imagery[14]. Dijkerman et al.[15] proposed that passive observation can be performed to treat cognitive problems caused by a damaged brain, but it may not induce the activation of the brain with image reproduction through observation, making difficult to accurately evaluate whether or not the imagery training has been properly executed. However, the experiment carried out in this study selected only subjects who displayed no abnormalities in cognitive tests.

In conclusion, functional electrical stimulation treatment was proven to be effective when action observational training was added to improve weight bearing, stability, and gait velocity of stroke patients. We consider various attempts should be made to improve the gait functions of neurologic patients by developing more diverse action observational training methods and action observational training methods.

ACKNOWLEDGEMENT

This work was supported by the Howon University Research Fund.

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