

The effects of symmetric center of pressure displacement training with feedback on the gait of stroke patients

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Abstract. [Purpose] This study investigated the effects of COP displacement training using visual feedback had on the gait of patients with hemiplegia due to stroke. [Subjects and Methods] This study was conducted with 20 patients with hemiplegia due to stroke. The training consisted of five training sets repeated 10 times and the activity was conducted for 15 minutes each session, three times per week for six weeks immediately after completion of central nervous system developmental treatment. [Results] A comparison of the results of before and after the experiment found that the COP displacement training group showed significant improvements in step length, stride length, gait velocity, and the functional reach test, while the control group showed significant improvement only in the functional reach test. In the intergroup comparison, the COP displacement training group showed significant improvements in paretic side step length, paretic side stride length, gait velocity, and the functional reach test compared to the control group. [Conclusion] In conclusion, according to the results of this study, visual feedback training for COP displacement is more effective at enhancing the gait and balance of hemiplegic patients due to stroke than only performing feedback training for even weight distribution.

Key words: Stroke, Center of pressure, Feedback

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INTRODUCTION

Stroke is a major cause of death and disability among adults. Most cases of stroke bring about functional restriction and movement restriction due to motor impairment¹⁾. Among these restrictions, gait disturbance is one of the most serious problems experienced by patients with hemiplegia due to stroke²⁾. Diverse studies have been conducted investigating gait problems, and in particular, visual feedback training is commonly used in clinical settings. In particular, external visual feedback has been reported to facilitate learning about the spatial location and displacement of the body, and to be effective in the enhancement of balance control^{3, 4)}. For this reason, different forms of visual feedback have been investigated in recent studies, including visual feedback balance control training using a platform⁵⁾, gait training with visual signals for patients with Parkinson's disease⁶⁾, gait and balance training using 3D visual feedback⁷⁾, and spinal stabilization exercises using visual feedback⁸⁾. Training methods that require stroke patients to actually perform tasks along with visual feedback are quite rare. In particular, training of

center of pressure (COP) displacement has been reported to be effective at enhancing the balance and gait of hemiplegic patients⁹⁾. However, although most studies have used COP displacement to evaluate balance ability^{10, 11)}, the findings of studies of balance and gait training with visual feedback using COP displacement of patients with hemiplegia due to stroke are insufficient. Therefore, this study investigated the effects that COP displacement training using visual feedback has on the gait of patients with hemiplegia due to stroke.

SUBJECTS AND METHODS

The study subjects were 20 patients with hemiplegia due to stroke. The subjects were selected from among patients who received a clear explanation of this study and agreed to participate in it. All the participants signed an informed consent form (including consent for publication of the anonymized data) following the Declaration of Helsinki recommendations for investigations involving human subjects. The subjects of this study were chronic stroke patients (at least six months) who had no hemi-spatial neglect or cardiovascular dysfunction, who could walk independently, and who had a Mini-Mental Status Examination (MMSE-K) score that was not less than 25 points. In this study, dynamic balance was measured using the functional reach test (FRT), which is a commonly used clinical evaluation. Moreover, paretic side step length, paretic side stride length, and gait velocity were measured using a GAITrite walkway to examine the spatiotemporal variables of the participants' gait.

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Both the experimental group and the control group received central nervous system developmental treatment 30 minutes per day, five times per week. The gait training consisted of five sets repeated 10 times and the activity was conducted for 15 minutes each session, three times per week for six weeks immediately after completion of the central nervous system developmental treatment. For the training, each subject in the experimental group stood on both feet wearing an F-Scan system and looked at the monitor while the round pointer displayed on the monitor was displaced from the center of the heel to the center of the 1st metatarsal bone as real-time feedback. Each subject in the control group stood on both feet wearing an F-Scan system and looked at the monitor and performed lateral symmetry training while watching the COP displayed on the monitor in real time. The data were statistically analyzed using SPSS version 12.0. The paired t-tests was used to investigate the significance of difference between pre- and post-test outcome measures and independent t-test was used for intergroup comparison. The significance level was chosen as the 95% confidence level.

RESULTS

The general characteristics of the participants in this study are as shown in Table 1. According to the comparison of the results between before and after the experiment, the COP displacement training group showed significant improvements in step length, stride length, gait velocity, and the functional reach test ($p<0.05$), and the control group

showed a significant improvement only in the functional reach test ($p<0.05$). In the intergroup comparison, the COP displacement training group showed significant improvements in paretic side step length, paretic side stride length, gait velocity, and the functional reach test compared to the control group ($p<0.05$) (Table 2).

DISCUSSION

This study compared COP displacement training using visual feedback and feedback training using symmetric pressure for patients with hemiplegia due to stroke. The feedback training used in this study is a method that has been shown to be useful for improving the motor learning of healthy people and stroke patients¹². In particular, extrinsic feedback facilitates the correction of impaired limbs and enables faster learning when physical skills are taught¹³. Therefore, the experimental group and the control group in this study were trained using extrinsic feedback. In particular, COP displacement is clinically and directly related to balance and gait disturbance⁹. In this study, the COP displacement training group showed improvements in their step length, stride length, gait velocity, and dynamic balance results after the intervention in comparison to before the intervention, while the control group showed an improvement only in dynamic balance. In the intergroup comparison, the COP displacement training group showed significant improvements in step length, stride length, gait velocity, and dynamic balance in comparison to the control group. Patients with hemiplegia due to stroke have increased ranges of lateral and anterior/posterior displacement during standing¹⁴, and they more easily fall when COP displacement velocity increases abnormally¹⁵. For this reason, in this study, it was possible to significantly improve the dynamic balance in the COP displacement of the training group, in comparison to the control group, using visual feedback training. This enabled the slow COP displacement from the heel to the 1st metatarsal bone so that the lateral and antero/posterior COP displacement velocities could be adjusted to ensure that they were not too high. In addition, the COP displacement training group showed significant increases in step length, stride length, and gait velocity in comparison to the control group. One study reported that a reason for this finding could be the fact that the ability to bear weight is significantly

Table 1. The general characteristics of subjects (n=20)

	Experimental group (n=10)	Control group (n=10)
Sex (F/M)	6/4	6/4
Type (H/I)	4/6	4/6
Age (years)	60.8±6.1 ^a	61.4±9.5
Height (cm)	160.8±9.7	164.9±8.4
Weight (kg)	63.8±9.5	62.2±10.8
Duration (month)	9.2±1.8	8.7±2.6

* $p<0.05$; ^amean±SD; F: female; M: male; H: hemorrhage; I: ischemic

Table 2. The result of COP visual feedback training for the hemiparesis patients (n=20)

		Experimental group (n=10)	Control group (n=10)
Step length (cm)*	pre test	31.8±12.2 ^a	30.2±6.7
	post test	44.2±11.2*	33.0±9.6
Stride length (cm)*	pre test	62.0±24.9	65.3±17.4
	post test	87.3±18.1*	64.7±13.1
Gait velocity (m/s)*	pre test	0.7±0.1	0.8±0.2
	post test	1.0±0.3*	0.8±0.2
Functional reach test (cm)*	pre test	18.6±1.9	17.4±1.5
	post test	26.2±2.5*	23.0±2.2*

* $p<0.05$; ^amean±SD

related to the strength required for walking¹⁶). In addition, it has been reported that when stroke patients walk, the COP displacement distances are shortened on the paretic side¹⁷. Therefore, we think the experimental group's gait improved in comparison to the control group because the training used an ankle strategy to distribute weight evenly between the left and right side and to displace the COP laterally, and antero/posteriorly increased the COP displacement lengths that had been shortened. Yang et al.¹⁸ reported that patients with hemiplegia due to stroke showed improvement in their gait index after gait training using robots. In that study, the patients' COP displacement increased a finding that is similar to the results obtained in the present study. The control group showed improvement in dynamic balance but not in the gait index. We consider this is because the control group simply aimed to bear weight evenly, aiming at equal weight distribution. This study had several limitations that prevent a generalization of its results. First, the number of subjects was not large enough and the intervention period was short. In future studies, more subjects should be included and the intervention period should be increased for more effective COP displacement feedback training. In conclusion, according to the results of this study, visual feedback training for COP displacement is more effective at enhancing the gait and balance of hemiplegic patients due to stroke than simply performing feedback training for even weight distribution.

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