

Original Article

Effects of auditory feedback during gait training on hemiplegic patients' weight bearing and dynamic balance ability

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Abstract. [Purpose] This study examined the effects of auditory feedback during gait on the weight bearing of patients with hemiplegia resulting from a stroke. [Subjects] Thirty hemiplegic patients participated in this experiment and they were randomly allocated to an experimental group and a control group. [Methods] Both groups received neuro-developmental treatment for four weeks and the experimental group additionally received auditory feedback during gait training. In order to examine auditory feedback effects on weight bearing during gait, a motion analysis system GAITRite was used to measure the duration of the stance phase and single limb stance phase of the subjects. [Results] The experimental group showed statistically significant improvements in the duration of the stance phase and single limb stance phase of the paretic side and the results of the Timed Up and Go Test after the training. [Conclusion] Auditory feedback during gait training significantly improved the duration of the stance phase and single limb stance phase of hemiplegic stroke patients.

Key words: Auditory feedback, Gait, Hemiplegic patients

(This article was submitted Dec. 2, 2014, and was accepted Jan. 7, 2015)

INTRODUCTION

Hemiplegic patients' amplitude of postural sway is twice as large as that of healthy people of a similar age¹⁾. Impaired balance and increased postural sway reduces hemiplegic patients' ability to maintain their body in a stable state^{2, 3)}. Hemiplegia is the main symptom of stroke and causes asymmetric posture and weight bearing. Hemiplegic patients weight bearing by the paretic side lower limb decreases to 25–38% in the sit-to-stand task^{4, 5)}. In a static standing position, weight bearing by the paretic side lower extremity goes down to 25–43%^{6–8)}.

For the improvement of hemiplegic patients' balance and gait abilities, training for symmetric weight support is emphasized. Many previous studies have employed biofeedback as a training method for weight bearing. Huang et al.⁹⁾ noted that biofeedback training is a valid tool as physical therapy for the neurological system.

Gait assessments during rehabilitation programs for hemiplegic patients are important for evaluating their motor function recovery. In order to improve gait, weight bearing training should be given importance. Biofeedback training is

known to be very effective in the treatment of neurological system disorders. In the clinical field, various biofeedback systems are in use. However, existing systems are limited because they cannot be applied to dynamic gait. Accordingly, this study clarified the effects of providing auditory feedback during gait training on hemiplegic patients' weight bearing.

SUBJECTS AND METHODS

The subjects of this study were 30 hemiplegic patients who had been diagnosed as having a stroke six months or more ago. They were randomly assigned to an experimental group and a control group. The criteria for the selection of the subjects were: a mini-mental state examination score of 24 points or higher; the ability to walk independently or with an aid for 10 m or further; and the absence of orthopedic disease (Table 1). All of the protocols used in this study were approved by the University of Daejeon. Before participation, the procedures, risks, and benefits were explained to all the participants, who gave their informed consent. The participants' rights were protected according to the guidelines of the University of Daejeon.

A GAITRite (CIR system Inc, USA) was employed to measure the stance phase and single limb stance phase of the paretic lower limb during gait. The collected data was processed using GAITRite GOLD, Version 3.2b (CIR system Inc, USA). The gait mat was placed at the middle of 10-meter walkway, and the measurer trained the subjects to walk the determined section at their most comfortable speed.

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Measurements were taken three times and their average values were used in the data analysis.

In the present study, the training period was a total of four weeks and neuro-developmental treatment was conducted for both the groups. The experimental group additionally received auditory feedback during gait training. In order to collect information on hemiplegic patients' weight bearing during gait with auditory feedback, a pressure gauge Ped-AlertTM120 (ORBITEC, USA) was employed. The gauge was set to emit a beep sound, when it exceeded 50% of an individual subject's weight. When a beep sound was made after weight had moved to the paretic side during gait, the subject stepped forward with the non-paretic side leg.

The data collected in the present study was statistically processed using SPSS version 19.0. Frequency and cross analyses of the subject's general characteristics were conducted using descriptive statistics and the independent t-test. In order to compare differences between prior to and after the intervention in each group, the paired t-test was performed and in order to compare changes between the two groups after the intervention, the independent t-test was performed. A significance level of 0.05 was chosen.

Table 1. Characteristics of the study participants

	Experimental group (n=12)	Control group (n=13)
Gender		
Male	8 (66.7) ^a	11 (84.6)
Female	4 (33.3)	2 (15.4)
Age (yrs)	55.3±9.2 ^b	60.1±12.3
Height (cm)	166.0±7.8	166.8±10.0
Weight (kg)	66.2±7.8	65.7±8.8
Stroke type		
Infarction	7 (58.3)	3 (23.1)
Hemorrhage	5 (41.7)	10 (76.9)
Paretic side		
Left	7 (58.3)	5 (38.5)
Right	5 (41.7)	8 (61.5)
Duration (month)	19.1±8.2	22.0±9.9
MMSE-K ^c	26.2±2.0	25.8±1.6

^an (%); ^bMean±SD; ^cMMSE-K: Mini-Mental State Examination-Korea

RESULTS

In order to examine changes in weight bearing elicited by auditory feedback training, the duration of the stance phase and single limb stance phase of the paretic side were compared between the experimental group and the control group. In order to compare their dynamic balance abilities, the results of the Timed Up and Go test were compared (Table 2).

In the experimental group, the duration of the stance phase significantly increased from 64.6% prior to the training to 72.2% after the training and the duration of the single limb stance phase significantly increased from 24.5% prior to the training to 29.1% after the training ($p<0.01$). In the experimental group, the Timed Up and Go test result was 22.5 seconds prior to the training to 20.3 seconds after the training, a significant improvement ($p<0.01$).

DISCUSSION

Training for balance and asymmetric weight bearing is emphasized for the improvement of hemiplegic patients gait ability. Shumway-Cook¹⁰ noted that biofeedback training decreased the asymmetric posture of hemiplegic patients, and that it was more effective than traditional physical therapy. Many studies have used force plates and visual feedback training for hemiplegic patients and verified that such training is effective at improving their weight-bearing symmetry and dynamic stability^{8, 11, 12}. Feedback is known to be a valid tool in neurological physical therapy⁹. Nonetheless, research involving biofeedback systems and stroke patients has not been sufficient enough to draw conclusions about their effects on gait, and additional research is necessary. Accordingly, this study was conducted in order to clarify the effects of the provision of weight-bearing information through auditory feedback on hemiplegic patients.

In order to evaluate changes in weight bearing elicited by auditory feedback during gait, the duration of the stance phase and single limb stance phase of the paretic side lower limb were measured and compared. In a comparison of gait cycle of hemiplegic patients and healthy people, the duration of the swing phase of the paretic side was relatively higher than that of the non-paretic side and the duration of the stance phase of the paretic side was relatively lower than that of the non-paretic side¹³. According to the results of

Table 2. Comparison of stance, single limb stance, and the Timed Up and Go test prior to and after gait training

		Experimental group (n=12)	Control group (n=13)
Stance (%)	Pre-test	64.6±5.4	63.6±4.9
	Post-test	72.2±9.7*	64.8±3.9
Single Limb Stance (%)	Pre-test	24.5±8.0	26.6±5.2
	Post-test	29.1±5.9**	26.4±5.9
TUG (sec)	Pre-test	22.5±7.0	25.2±6.0
	Post-test	20.3±6.1**	22.2±4.2

Mean±SD

* $p<0.05$, ** $p<0.01$

present study, the duration of the stance phase of the paretic side significantly increased by 6.9% from 63.6% to 70.6%.

Many studies have reported that hemiplegic patients have difficulty in supporting weight and maintaining balance with their paretic side lower limb, and therefore the duration of their single limb stance phase becomes short¹⁴⁻¹⁶. The results of the present study show that the duration of the single limb stance phase of the experimental group's paretic side limb significantly increased by 3.1% from 26.1% to 29.2%. To sum up the results of the present study, auditory feedback provided during gait training conducted for hemiplegic stroke patients elicited the significant improvements in the duration of the stance phase and single limb stance phase of the paretic side.

There are some limitations to the interpretation of the present study's result. First, the number of subjects was small making generalization of the results to all hemiplegic patients difficult. Second, the overall physical characteristics of individual patients, such as muscle strength and muscle tone of their paretic side lower limb, were not taken into account.

Auditory feedback provided during hemiplegic patients' gait training significantly enhanced the duration of their paretic side stance phase and single limb stance phase. Thus, its efficacy as an intervention program was verified, and it should be useful as a method for improving the duration of the stance phase and single limb stance phase of the paretic side of hemiplegic stroke patients.

ACKNOWLEDGEMENTS

This work (Grants No. C0142214) was supported by Business for Cooperative R&D between Industry, Academy, and Research Institute funded Korea Small and Medium Business Administration in 2013.

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