



Original Article

Effects of gait training with rhythmic auditory stimulation on gait ability in stroke patients

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Abstract. [Purpose] The purpose of this study was to compare the gait abilities and motor recovery abilities in stroke patients following overground gait training with or without rhythmic auditory stimulation. [Subjects and Methods] Forty patients with hemiplegia resulting from stroke were divided into a rhythmic auditory stimulation gait training group (n=20) and a gait training group (n=20). The rhythmic auditory stimulation gait group and gait training group both performed gait training. Rhythmic auditory stimulation was added during gait training in the rhythmic auditory stimulation gait training group. The gait training was performed in 30 minute sessions, five times a week, for a total four weeks. [Results] Gate ability significantly improved in both groups, and the rhythmic auditory stimulation gait training group showed more significant increases in cadence, step length, and Dynamic Gait Index. [Conclusion] The results of this study showed that gait training with rhythmic auditory stimulation was more effective at improving gait ability.

Key words: Stroke, Gait, Rhythmic auditory stimulation

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INTRODUCTION

Patients with stroke experience a number of physical disorders, including movement, cognitive, sensory, language, and visual disorders. Among them, movement disorders can limit muscle control and motion functions or mobility, as well as degrade balance control abilities. Hemiplegia is accompanied by an increase in postural instability, asymmetrical weight bearing, impairment of body weight transfer capabilities, and a decrease in postural stability¹⁾. Therefore, many patients with stroke experience problems with daily activities requiring functional movements such as balance, climbing stairs, gait, and walking^{2, 3)}.

For this reason, one of the primary goals of rehabilitation for stroke patients is to restore mobility through gait training⁴⁾. Various therapeutic approaches have been suggested for the improvement of gait ability of patients with stroke, such as neurodevelopmental treatment and sensory stimulation. Numerous studies of training using rhythmic auditory stimulation (RAS) have been conducted since its development in 1990 for gait training for patients with neurological damage⁵⁾. RAS is a training method that enhances motor skills by providing rhythmic stimulation to the motor center of the brain. The stride, gait speed, and symmetry of stroke patients trained with rhythmic auditory stimulation were found to increase. The effect of gait training with rhythmic auditory stimulation was proved through previous papers⁶⁾.

The purpose of this study was to compare the gait abilities and motor recovery abilities of stroke patients following either overground gait training with or without rhythmic auditory stimulation.

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SUBJECTS AND METHODS

The subjects of this study were 40 adult stroke inpatients of J Hospital located in Daegu, South Korea. They were randomly and equally divided into a rhythmic auditory stimulation gait training group (RASG) and a gait training group (GTG). There were no significant differences between the two groups in terms of their general characteristics (Table 1). The inclusion criteria were as follows: hemiplegic patients diagnosed with stroke; no cognitive impairment with MMSE scores of 24 or higher; those without visual, auditory, or orthopedic injuries that might influence balance; and understood and consented to the purpose of the study. This study was approved by the university's Institutional Review Board, and all of the subjects understood the purpose of the study and provided written informed consent prior to their participation in the study, in accordance with the ethical standards of the Declaration of Helsinki. The protocol for this study was approved by the local ethics committee.

The 20 patients in both groups performed 30 minutes of neurodevelopmental therapy for 30 minutes, five times a week for four weeks. In addition, the RASG patients performed gait training with a rhythmic auditory stimulation for 30 minutes, five times a week for four weeks, and the GTG patients performed gait training with a supervisor for 30 minutes, five times a week for four weeks.

For assessment of gait ability, a 10-meter walking test (10MWT) and a GAITRite analysis system were used to determine cadence and step length. The Dynamic Gait Index (DGI) was used to assess the participants' functional gait ability⁷⁾. This index consists of eight items: level walking, walking at different speeds, walking while turning the head horizontally, walking while turning the head vertically, walking and performing a pivot turn, crossing obstacles, walking around obstacles, and stair walking. Each item is assessed on a scale of 0 to 3 according to the presence of assistance and performance level. Total scores closer to 24 points, a perfect score, indicate higher levels of functional gait ability. The DGI has been shown to have good inter-rater reliability (ICC=0.96) and validity (r=0.837).

The experimental results were statistically analyzed using SPSS 12.0 KO (SPSS Inc., Chicago, IL, USA). After the general characteristics of the subjects were determined, their general characteristics were analyzed using descriptive statistics. A paired t-test was used to assess differences before and after the intervention. An independent t-test was used to assess differences between the two groups.

RESULTS

Both the RASG and GTG subjects exhibited significant improvements in gait ability after the intervention and DGI ($p < 0.05$). The subjects of both groups showed significant improvements in cadence, step length, 10-MWT, after the intervention ($p < 0.05$). In addition, comparison of the post-intervention improvements of the two groups revealed that the RASG showed a more significant increase in cadence, step length, 10-MWT, and DGI than the GTG ($p < 0.05$; Table 2).

DISCUSSION

Patients with stroke experience a number of physical disorders, including movement, cognitive, sensory, language, and visual disorders. Among them, movement disorders can bring about limitations in muscle control and motion functions or mobility, as well as degradation of balance control abilities. Hemiplegia is accompanied by increase in posture instability, asymmetrical weight bearing, impairment of body weight transfer capabilities, and a decrease in postural stability^{1, 8)}. As a result, many patients with stroke experience problems in daily activities requiring functional movements such as balance, climbing stairs, gait, and walking^{2, 9)}.

This study compared the effects of two training programs—rhythmic auditory stimulation gait training and gait training on gait abilities in stroke patients. To determine gait abilities, the 10-meter walking test, cadence, step length, and DGI were assessed, and the test results showed that both the RASG and GTG had significant improvements in gait abilities. The results also showed that the walking performance of the auditory stimulation training group after training was significantly better than that of the gait training group, indicating that the auditory stimulation training had a positive effect on the improvement of gait performance.

Rhythmic auditory stimulation is known to stimulate motor neurons in the brainstem and at the spinal level¹⁰⁾. Auditory stimulation in stroke rehabilitation is provided as a means of increasing the excitability of spinal motor neurons via the reticulospinal pathway, thus decreasing the amount of time required for muscular response to a given motor command¹¹⁾. Regarding walking performance, sensory stimulation may be an effective means of strengthening functional movement when it is rhythmically performed in coordination with the motor response with an appropriate time relationship¹²⁾. According to a study by Roerdink in stroke patients, a treadmill training group that received rhythmic auditory cueing showed an improvement in stride length, which is shorter in stroke patients than in individuals without stroke⁵⁾. Our results show that cadence and stride length on the affected side were significantly improved in the RASG and that there were significant improvements compared with the GTG. A metronome beat assists the coordination of rhythmic or sequential movements. Regular application of auditory cueing over a suitable time frame may reinforce the coordinated motor response during

Table 1. General characteristics of the subjects

	RASG	GTG
Gender (M/F)	12/8	9/11
Age (yrs)	57.10 ± 7.8	60.10 ± 6.8
Height (cm)	162.20 ± 9.2	165.00 ± 9.5
Weight (kg)	63.20 ± 11.2	61.20 ± 9.2
Paretic side (Rt/Lt)	8/12	9/11
Onset period (mo)	12.30 ± 3.4	14.75 ± 6.0
K-MMSE (score)	25.30 ± 1.2	25.18 ± 0.8

RASG: rhythmic auditory stimulation gait training group; GTG: gait training group; K-MMSE: Mini-Mental State Examination-Korean version

Table 2. Comparison of changes in gait function in the training groups

	RASG		GTG	
	Before	After	Before	After
Cadence (steps/min)	75.6 ± 6.4	102.5 ± 6.2 ^a	78.6 ± 3.4	92.2 ± 4.3 [*]
Step length (cm)	53.7 ± 5.4	59.6 ± 4.5 ^a	52.3 ± 5.7	56.5 ± 6.7 [*]
10MWT (m/sec)	22.7 ± 2.2	16.7 ± 8.9 ^a	18.9 ± 2.1	14.3 ± 9.3 [*]
DIG (score)	12.3 ± 4.5	20.7 ± 7.9 ^a	13.4 ± 5.2	17.6 ± 2.4 [*]

Values are shown as the mean ± standard deviation. ^{*}Significant difference compared with before therapy at <0.05. ^aSignificant difference in gains between the two groups at <0.05. RASG: rhythmic auditory stimulation gait training group; GTG: gait training group; 10MWT: 10-meter walking test; DIG: Dynamic Gait Index

walking^{10, 13}). During walking, sensory stimulation may be an effective means of strengthening functional movement when it is rhythmically performed in coordination with the motor response with an appropriate time relationship⁶). A similar positive impact of auditory stimulation was documented for the bilateral arm function of chronic stroke patients¹⁴). The DGI is an index that classifies a subject's level of functional gait ability. It requires them to perform gait tasks that demand a high level of balance, including level walking, changing speeds during walking, and crossing obstacles; scores closer to 24 points, a perfect score, indicate higher levels of gait ability⁷). In this study, the RASG showed an increase in DGI score of 8.41 points, a more significant increase than that of the GT group, whose DGI score increased by 4.22 points. This result suggests that participants in the RASG achieved greater improvement in functional gait ability compared with those in the GTG.

The results of this study showed that gait training with rhythmic auditory stimulation was more effective at improving gait ability than overground gait training without rhythmic auditory stimulation. Therefore, rhythmic auditory stimulation may be useful for rehabilitation of patients with stroke.

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