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Home-Based Auditory Stimulation Training for Gait Rehabilitation of Chronic Stroke Patients

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Abstract. [Purpose] The purpose of this study was to examine the effect of home-based auditory stimulation on walking performance and to determine its clinical feasibility for chronic hemiparetic stroke patients. [Subjects] The subjects of this study were 20 chronic stroke patients. [Methods] The subjects were randomly divided into two groups: the experimental group (n=10) used over the ground gait training with a metronome beat, and the control group (n=10) which performed over the ground gait training. [Result] The affected side single support time, affected side single support time ratio, and gait velocity of both groups were significantly improved when compared with their respective values before the experiment. Affected side stride length, non-affected side stride length, and stride length ratio of the experimental group were significantly different between before and after the experiment. Comparison of the spatial-temporal gait parameters and symmetry ratios between the experimental group and the control group after the exercise showed a significant difference in affected stride length, non affected stride length, stride length ratio, affected single support time, non affected single support time, single support time ratio, and gait velocity. [Conclusion] These findings suggest that the home-based auditory stimulation training more effectively improves the walking performance of chronic stroke patients than gait training without auditory stimulation.
Key words: Auditory stimulation, Metronome beat, Stroke

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INTRODUCTION

Stroke is a major cause of disability and handicap in adults. Gait performance of patients with stroke is characterized by slower velocity and more asymmetrical gait patterns than healthy adults[1)]. Therefore, faster gait velocity and more symmetric gait patterns are perceived by many stroke patients as their ultimate goals of rehabilitation[2)]. The most widely applied method used for gait improvement consists of exercises that were developed for neurological rehabilitation, together with the practice of pre-walking functional tasks such as transfer activities, weight transfer in sitting and standing, and maintenance of stance[3, 4)]. However, the walking practices of patients with hemiparesis is usually limited by time, space, and cost. Especially, outpatients are unlikely to practice because resources provided in rehabilitation settings are not available in home exercise programs[5)]. As a result, stroke patients who live at home are often restricted to walking short distances, and their asymmetric gait and their already impaired walking performance further deteriorate because of a lack of practice. To overcome this problem, several investigators have suggested the use of auditory stimulation[6–8)]. A auditory stimulation can increase the excitability of spinal motor neurons via the reticulospinal pathway, decreasing the amount of time required for muscular response to a given motor command[9)]. However, only a few studies have considered the effect of auditory stimulation training on rehabilitation of the walking ability of indoor patients[6–8)]. In previous publications[7)], it was described studies of subjects with chronic post stroke hemiparesis who received a structured program of auditory stimulation training at home to improve their walking performances. The main objective of the current study was to confirm and extend the findings of the home-based auditory stimulation training on walking speed, related spatial temporal values and symmetry ratios of post stroke individuals in the chronic phase.

SUBJECTS AND METHODS

The subjects of this study were 20 patients with post stroke hemiparesis who were recruited from a community support group of people who had suffered a stroke. They volunteered to take part in the study and met the following inclusion criteria: unilateral stroke that occurred at least 3 months before joining the study, able to walk a total of 6 minute without a cane, able to maintain proper communication skills as determined by free conversation with each volunteer and by reports of relatives, and did not suffer from dementia as determined by a minimum score of 24 points in the Folstein Mini-Mental State Examination[10)]. None of the subjects received any kind of therapy during the study

Table 1. The general characteristics of the subjects

Group	Age (years)	Height (cm)	Weight (kg)	Onset time (month)	Stroke type (infarction/hemorrhage)	Affected side (right/left)	Brunnstrom (stage V/VI)
Auditory stimulation	65.2 ± 6.8	165.4 ± 7.7	63.0 ± 8.8	15.8 ± 2.3	7/3	6/4	8/2
Control group	64.5 ± 8.1	17.0 ± 8.4	64.1 ± 8.6	15.3 ± 3.0	7/3	6/4	8/2

Mean ± SD, *p<0.05

period, and their major demographic and clinical details are presented in Table 1. At the time of enrolment, the subjects were randomly assigned to the experimental or control groups by a computerized random-number generator supervised by an independent researcher. All the participants were living at home. They were provided 3 times a week for a total of 6 weeks, and each session lasted 10 minutes. Subjects were required to walk on an over the ground in both groups. In the control group, the subjects walked comfortably and safely over the ground for 10 minutes. In the experimental group, the subjects walked over the ground while listening to a metronome beat. The metronome beat began at 20 pulses per minute, and was incremented by 20 pulses per minute every 2 minutes: 20, 40, 60, 80, and 100 pulses per minute from 0, 2, 4, 6, and 8 minutes of training, respectively. As an option for auditory stimulation, the metronome beat could be listened to as a constant beat for the whole 10 minutes.

To measure, stride length, single support time, and walking velocity of all subjects' paretic sides, we used the Rs scan system (Rs scan Ltd., German) with a 2 m long plate. The Rs scan system can analyze spatial and temporal coordinates by region while subjects are walking on the 2 m long plate[11]. Both the spatial and temporal values were collected three times under each condition and the mean values and standard deviation were used in the analysis. To quantify the extent of the temporal and spatial asymmetry of gait pattern, the single-support time asymmetry ratio and the stride length asymmetry ratio were calculated, as follows[1]. Stride length asymmetry ratio=1-(stride length <affected> / stride length <unaffected>). Single-support-time asymmetry ratio=1-(single support time <affected> / single support time <unaffected>). Greater ratios are indicative of greater asymmetry. A value of zero indicates perfect symmetry.

The collected data were analyzed using SPSS ver. 12.0. All the characteristics of the subjects were tested by the Kolmogorov-Smirnov test, which showed that the data were normally distributed. The repeated below. The paired t-test was performed to test within group differences between before and after the experiment, and the independent t-test was performed to test the differences between the groups before and after the experiment. The significance level, p, was chosen as 0.05.

RESULTS

The affected side single support time (ms), affected side single support time ratio, and gait velocity (km/h) of both groups after the training were significantly improved when compared with their respective values before the training. Affected side stride length (cm), non affected side stride length (cm), stride length ratio of the experimental group after the training were significantly different from their respective values before the training.

Comparison of the spatial-temporal gait parameters and symmetry ratios between the experimental group and the control group after the exercise showed a significant difference in affected stride length (cm), non affected stride length (cm), stride length ratio, affected single support time (ms), non affected single support time (ms), single support time ratio, and gait velocity (km/h) (Table 2).

DISCUSSION

The main purpose of this study was to determine the feasibility and efficacy of using home-based auditory stimulation training to improve the walking performance of people with chronic post stroke hemiparesis. The results show that the walking performance of the auditory stimulation training group after training was significantly better than that of the control group, indicating that the auditory stimulation training had a positive effect on the improvement of walking performance and gait symmetry of post-stroke hemiparesis patients. Our results show that affected side stride length, non- affected side stride length, stride length ratio, affected side single support time, single support time ratio, and gait velocity were significantly improved in the auditory stimulation group, while there were significant improvements in affected side single support time, single support time ratio, and gait velocity in the control group. Comparison of the two groups showed that affected side stride length, non-affected side stride length, stride length ratio, affected side single support time, single support time ratio, and gait velocity after auditory stimulation training improved more in the experimental group than in the control group. 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, e.g. in walking performance[6–8]. The key rationale for auditory stimulation in stroke rehabilitation is to provide 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 command[9]. In walking performance, sensory stimulation may be an effective means of strengthening functional movement when it is rhythmically performed in coordination with the motor response in an appropriate time relationship[12]. A similar positive impact of auditory stimulation was documented for the bilateral arm function of chronic stroke patients[13] and the walking performance of multiple sclerosis and stroke patients[6–8]. To our knowledge,

Table 2. The effect of metronome beat on the subjects

Gait parameters		Auditory stimulation group	Control group
Affected side Stride length (cm)*	pre	69.9 ± 8.9$^{\alpha}$	68.2 ± 7.2
	post	92.1 ± 3.2*	71.7 ± 6.0
Non affected side Stride length (cm)*	pre	65.1 ± 5.9	69.9 ± 10.4
	post	89.9 ± 2.4*	68.4 ± 5.8
Stride Length ratio*	pre	0.1 ± 0.1	0.1 ± 0.1
	post	0.0 ± 0.0*	0.1 ± 0.1
Affected side single Support time (ms)*	pre	373.0 ± 43.5	349.1 ± 70.9
	post	942.0 ± 87.0 *	549.0 ± 98.9*
Non affected side single Support time (ms)*	pre	843.0 ± 53.6	830.6 ± 62.5
	post	1005.0 ± 96.7*	849.0 ± 98.9
Single support Time ratio*	pre	0.6 ± 0.1	0.6 ± 0.1
	post	0.1 ± 0.1*	0.4 ± 0.0*
Gait velocity (km/h)*	pre	2.3 ± 0.5	2.2 ± 0.4
	post	3.7 ± 0.5*	2.9 ± 0.3*

$^{\alpha}$Mean ± Standerd deviation, *p<0.05

this is the first study to present data supporting the use of home-based auditory stimulation training for chronic post stroke hemiparesis. Our findings show that this training program, administered with a metronome beat, produced improvements in walking that were comparable to or better than the gains achieved by other intervention modes. In conclusion, home-based auditory stimulation training can improve the walking performance of chronic stroke patients. The limitations of this study were the lack of randomization and the relatively small numbers of subjects. Further studies with a much larger sample are required to establish the significance of this method.

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