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Research paper

Effects of side walking training using rhythmic auditory stimulation on plantar foot pressure sagittal distribution, body sway and gait in stroke patients

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Abstract

The purpose of this study was to evaluate the effect of side walking training using rhythmic auditory stimulation(RAS) on plantar foot pressure sagittal distribution(PFPSD), body sway and gait ability of stroke patients. Thirty patients with stroke patients participated in this study. Participants were randomly assignment to the side walking using RAS group(SWRASG, n=10), the side walking group(SWG, n=10), and the control group(CG, n=10). PFPSD, body sway, dynamic gait index(DGI) and 10m walking test(10 MWT) were performed for evaluate of pre-and post-intervention in balance and gait ability of participants. As a result, the pre- to post-test measures revealed a significant effect in each group on the PFPSD, body sway, DGI and 10 MWT($p<0.05$). The PFPSD, body sway, DGI and 10 MWT were higher in SWG($p<0.05$) than in CG and it was the highest in SWRASG($p<0.05$). The PFPSD, body sway balance and 10 MWT, DGI gait ability was higher in SWG and SWRASG than in CG($p<0.05$). In conclusion, for stroke patients, side walking training using RAS is effective on the balance and gait ability.

Keywords: *Balance; Gait ability; Rhythmic Auditory Stimulation (RAS); Side walking training; Stroke*

1. Introduction

Symptoms of stroke include movement disorders, cognitive and perceptual disorders, and speech disorders. These disorders limit daily activities and make walking especially difficult [1]. Walking refers to a series of exercises that occur rhythmically and alternately between the trunk and lower limb while moving the center of gravity of the body forward. If the both limb gait is functional as a means of transportation, safety should be maintained when standing upright and energy efficient [2]. According to several researchers, the cause of abnormal walking in patients with stroke was the inability to move the center of gravity to the paralyzed lower limb, and 80% of the total body weight was supported at the paraplegic limb during standing [3, 4]. The ideal goal in the functional rehabilitation of stroke patients is to reduce asymmetry, to make a balanced standing posture with equal weight load, and finally to restore symmetric walking by increasing the ability to move the weight on the paralyzed side [5]. In previous studies, side walking training was suggested as one of the methods to increase lateral stability of the body of stroke patients. The side walking training can increase the lateral stability more than the front and rear walking training and it is effective to improve the balance and walking ability by helping the weight shift and to reduce the asymmetric weight support time of the lower limb [6]. Recently, various studies have been actively attempted to improve walking ability using RAS. The RAS stimulates the rhythm sensation through a certain RAS using sound and influences the motor system and synchronizes the motor area and the perception area within a stable time to induce activation of each area of the brain [7]. Improve walking ability, improve mobility and flexibility, as well as improve mental problems and quality of life [8]. However, until now, most studies and treatments have been focused on the safety of stroke patients gait forward and backward gait in a limited environment. also, studies on plantar foot pressure sagittal distribution, body sway and gait using RAS are insufficient.

2. Experiments

2.1. Subject selection and Experiments procedure

The subjects of this study were 30 chronic stroke patients who were participating in outpatient B rehabilitation hospital. The criteria for selection of the study subjects were adult hemiplegia due to cerebral infarction or cerebral hemorrhage, who had an onset of 6 months or more, who had no history of orthopedic illness in the lower extremities, who had no consumable diseases such as diabetes or thyroid, He was able to walk independently for more than 20 minutes without any help, understand the contents of the experiment, communicate with him, and no limit hearing and hearing difficulties. A total of 30 subjects participated in this study. The subjects were divided into SWRASG(n=10), SWG(n=10) and CG(n=10). PFPSD test, body sway test, DGI test and 10 MWT test were measured before the experiment and after 8 weeks of intervention. All groups received 30 minutes of 3 times a week for a total of 8 weeks of central nervous system rehabilitation, and additionally SWG and SWRASG performed side walking training for 25 minutes a day, 3times a week for a total of a 8 weeks. All the subjects voluntarily agreed and participated in the experiment after receiving sufficient explanations about the purpose and method of the study, and there was no significant difference in the homogeneity test.

2.2. Measurement Method

1) PFPSD test and body sway test: The subjects were taken off the shoes and puts foot on the foot sensor of the Gaitview system AFA-50(Alfoots Co., Korea), and the looking to the full-body mirror were standing for 10 seconds in a comfortable posture after standing. after measuring the PFPSD, body sway length and area, the stability score was scaled to 100 points. After a total of 3 measurements, the mean value was used and one minute of rest was taken between measurements. 2)10 MWT test: The walking speed was measured by walking the subject at a distance of 14 m, and the time was measured at a distance of 10 m from the center except for the acceleration and deceleration periods of 2 m. The test was performed three times in total, and the average time was obtained. The inter-rater reliability r=0.99 and the intra-rater reliability r=0.88. 3) DGI test: In order to evaluate the ability of the elderly people who can walk, the responding gait control ability is changed when the task of the external environment changes. Eight tasks are evaluated according to the degree of performance from 0 to 3 score. The reliability of the inter-rater and the intra-rater in the stroke patients was r=0.96. Intervention: 1) SWRAG: In this study, RAS was provided using the metronome application(Metronome: Tempo Lite 4.01, Frozen ape Co., Singapore) of the iPhone 8(A1905, Apple, California). As the patient's walking speed increased, the speed was increased by one-third of a minute. When the patient showed stable walking speed, he increased the RAS according to the patient's stance phase, but when the patient showed unstable gait or did not adapt he returned to the first beat [9]. In order to be able to walk on the sideways, a cheek tape was attached to the floor with an area of 5 cm and a length of 1 m, and a 3 m walking line was installed behind the mirror and a side walking training was performed along the walking line. The training frequency was 3 times a week 10 training sessions 2set by a 5minute break between sets for a total 25minutes and the experiment was conducted in the presence of one interventional physical therapist in preparation for the risk of falls. 2)SWG: Subjects underwent side walking without using RAS. The other conditions were the same as those of the SWRASG. 3) CG: In the CG, only the rehabilitation exercise treatment was performed without the side walking training. The collected data were analyzed using the SPSS 21.0 statistical program. One-way ANOVA was performed to compare the general characteristics of the subjects. To compare the pre- and post-intervention groups of each group, a t - test was conducted. Post-hoc test was performed by Tukey test. Statistical significance was 0.05 for all tests

3. Results and Discussion

The results of effects on the PFPSD and body sway dependent variables within and among the groups pre and post the experiment are shown in Table 1.

1) In order to evaluate the balance ability of each group, we measured the PFPSD and body sway test. The SWRASG, SWG and CG showed a statistically significant effect compared with before the intervention($p<0.05$), and there was also significant difference among the groups($p<0.05$). In the post-hoc test, the differences were statistically significant in the order of SWRASG, SWG and CG(Table 1).

2) In order to evaluate the gait ability of each group, we measured the 10 MWT and DGI test. In the 10 MWT, the SWRASG, SWG and CG showed a statistically significant effect compared with before the intervention ($p<0.05$), and there was also significant difference among the groups($p<0.05$). In the post-hoc test, the differences were statistically significant in the order of SWRASG, SWG and CG. and In the DGI test, the SWRASG, SWG and CG showed a statistically significant effect compared with before the intervention($p<0.05$), and there was also significant difference between the groups($p<0.05$). In the post-hoc test, the SWRASG and the SWG were significantly more significant than the CG (Table 2).

The results of effects on the gait ability variables within and among the groups pre and post the experiment are shown in Table 2.

One of the activities most affected by stroke is gait, in which 80% of the initial stroke patients lose their ability to walk and begin to improve their ability to walk within the next six months. In stroke patients, restoration of balance and gait disturbance is considered to be the most important goal in the rehabilitation of patients because it is an important factor in maintaining daily life independently. Hemiplegic patients with stroke are characterized by asymmetric hemiparesis, which is due to a decrease in selective muscular control and a primitive reflex pattern, resulting in longer prolongation of the stance phase and double limb stance phase, and asymmetry of the non-affected limb stance phase relative to the affected limb [10]. Various approach has been attempted to support even weight of hemiplegic patients. The dual visual, auditory, and somatosensory feedback is to restore symmetrical gait by ultimately providing a balanced standing posture by providing visual, auditory, and somatosensory feedback to the patient's affected limbs. and weight-shifting therapy using visual and auditory feedbacks may improve sympathetic postural posture of adult hemiplegia and improve gait characteristics [4]. also visual biofeedback balance training is effective in improving standing stability and walking ability in hemiplegic patients with stroke [11]. The side walking training was found to be effective on the walking speed of the hemiplegic patient, on the non-affected side stride, on the affected side step, and on the non-affected side foot angle, and it was also found to have an effect on the increase of the weight load [1]. In a previous study on the effect of side walking training, Fujisawa and Takeda [6] reported that side walking for patients with cerebral palsy increased the stride length, walking speed, and time to support the palsy side. Kim [1] reported a significant increase in walking ability and weight loading gain in stroke patients by side walking. In addition, hip joint muscles during the gait control the lower limbs in the swing phase and stabilize the trunk in the stance phase [12]. Hip abductor and adductor muscles play an important role in stabilizing the trunk and stride length of the stance phase during gait, and weakening of the muscles of the hip abduction muscle causes the lateral bending of the trunk by reducing the stability at the frontal plane [13]. For this reason, we think that the side walking training of this study improved the stability of walking and improved the balance and walking ability after intervention. In previous studies, side walking training was reported to improve lower limb abilities and improve balance ability to prevent falls [14]. also strengthening of the hip joint abduction muscle of the stroke patient increases the lateral stability of the body and increases the dynamic balance ability [15]. This suggests that the hip joint abduction muscle is an important factor for lateral stability during walking of the stroke patients, which may affect lateral shift the center of gravity and balance ability. also It seems to play an important role in improvement of trunk control and balance and walking ability. RAS one of the therapeutic strategies used in gait training, has been repeatedly reported to be effective in improving gait function in patients with various neurological impairments. RAS, which repeatedly provides a regular interval of rhythm, can be traced back to the lower motor neurons by creating a pathway that directs the lowering signal that begins to walk through the reticulospinal tracts, to execute walking without any limitation of neurological impairment and to control walking speed [16]. As a result, it has been reported that inducing an entrainment of movement and assisting sequential movement according to the gait cycle induces an efficient gait pattern [17]. Thaut et al [18] divided the walking training group with RAS, and the conservative physical therapy group based on the Bobath therapy of stroke patients, walking training was performed for 30 minutes a day, 5 times a week for a total of 3 weeks. In the RAS walking training group, patients who had comfortable walking and improved walking speed increased the speed by 5% during walking training. As a result, significant improvement was observed in the walking speed, cadence, stride length, and the walking symmetry in the RAS walking training group. The limitation of this study was that it could not completely rule out that everyday life could affect walking and balance ability because the subjects could not control their daily life during the study. In addition, the number of subjects is low and the intervention period is short, making it difficult to generalize to all stroke patients. Therefore, further study should be carried out through various brain injury diseases and intervention time during side walking training using RAS.

4. Conclusion

In this study, the side walking training using RAS improved the PFPSD, body sway and walking ability of the stroke patients. These results can be expected to contribute to the independent daily life of stroke patients and to their quality of life. Therefore, side walking training using rhythmic auditory stimulation is considered to be helpful in improving the PFPSD, body sway and walking ability of stroke patients.

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Table 1. The results of effects on the PFPSD and body sway within and among the groups pre and post the experiment

	GROUP	Pre-Test(M±SD)	Post-Test(M±SD)	F	Post-hoc
PFPSD Difference (%)	SWRASG[a]	22.60±2.35	14.60±0.87*	15.39†	a>b, a>c
	SWG[b]	21.76±2.20	16.92±1.06*		b>c
	CG[c]	22.40±1.79	19.84±1.71*		
Body Sway (Cm^2)	SWRASG[a]	4.92±0.38	2.63±0.32*	11.90†	a>b, a>c
	SWG[b]	4.94±0.32	3.26±0.35*		b>c
	CG[c]	4.70±0.62	4.08±0.38*		

* significant difference within groups, †significant difference among groups.

Table 2. The results of effects on the 10MWT and DGI within and among the groups pre and post the experiment

	GROUP	Pre-Test(M±SD)	Post-Test(M±SD)	F	Post-hoc
10MWT (sec)	SWRASG[a]	16.92±1.12	12.98±0.61*	9.88†	a>b, a>c
	SWG[b]	16.54±0.40	14.27±0.64*		b>c
	CG[c]	15.96±0.95	15.55±0.81*		
DGI (score)	SWRASG[a]	11.12±0.61	14.15±0.21	11.32†	a>c
	SWG[b]	10.91±0.21	13.61±0.87		b>c
	CG[c]	10.97±0.82	11.15±0.18		

* significant difference within groups, †significant difference among groups.