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ORIGINAL ARTICLE

The Effect of Partial Weight Support with Ground Walking Training on Temporal and Spatial Gait in Patients with Chronic Stroke

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ABSTRACT

Background. There have been many studies on partial weight support walking training. However, most studies have been performed in treadmill settings, not in actual walking environments. **Objectives.** This study aimed to investigate the effect of partial weight support ground walking training on the temporal and spatial gait parameters of chronic stroke patients. **Methods.** This study was designed as a single-blinded randomized controlled trial. The experimental group applied only 70% of its weight using partial weight support equipment. The experimental group underwent the 30 m ground track for 12 minutes, rested for 3 minutes, and then repeated twice in the same way to apply a total of 30 minutes of partial weight-supported ground walking training. In order to measure the temporal and spatial parameters of gait for walking training in stroke patients, a pre-and post-test was performed using GAIT RITE. An analysis of covariance (ANCOVA) was used to compare gait variables. **Results.** There was a significant improvement in walking speed in the experimental group compared to the control group. However, there was no significant difference between cadence and cycle time ($P < 0.05$). Step length, stride length, and swing rate were significantly improved in the experimental group compared to the control group ($P < 0.05$). **Conclusion.** Partial weight support walking training positively affects gait in chronic stroke patients. Thus, it is thought that partial weight support gait training can be used as an effective intervention method to improve gait in chronic stroke patients.

KEYWORDS: ***Hemiparesis, Partial Weight-Bearing, Gait Speed, Step Length, Stroke.***

INTRODUCTION

Stroke is a neurological condition caused by a decrease in the blood supply to the brain caused by a problem in the brain's blood circulation due to hemorrhage, embolism, or thrombus (1). Stroke can be either acute or chronic and is one of the leading causes of disability, with 40% of patients having moderate disabilities and 15%~30% having severe disabilities (2). These stroke patients require continuous rehabilitation for the remaining disorders (3). Clinically, motor defects caused by stroke are characterized by hemiplegia, which occurs in the body opposite the lesion site (4). Most stroke patients have problems with balance and walking due to hemiplegia (5). The loss of balance and walking ability of stroke patients reduces the quality of life and limits daily activities. Therefore, restoring balance and walking ability is the most important goal of the stroke patient rehabilitation program (6).

The walking patterns of stroke patients are characterized by slow-walking cycles and speed, a difference in the step length and stride length along the paraplegic side, a short stance phase on the paralyzed side, and a relatively long swing phase (7). These walking characteristics have a negative effect on functional levels of independence and

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outcomes. Indeed, only 37% of stroke survivors can walk in the first week after stroke (8), and 60%–80% of patients with independent walking walk below 0.8 m/s, which is insufficient to function effectively in the community (9). In order to function sufficiently by walking in a variety of environments, the speed of walking should be between 1.1 and 1.5 m/s. Only about 7% of patients who have been discharged from rehabilitation therapy satisfy these social walking standards (10). Thus, achieving normal walking patterns and speeds is the ultimate goal of walking training for stroke survivors.

The rapid improvement of proper posture control in stroke patients is important for their independence, social participation, and general health (10). Furthermore, repeated and intensive use of veterinary motor control is essential for the recovery of motion in stroke patients. Numerous mediation methods are being studied to address abnormal walking patterns in stroke patients. Intervention methods include treadmill training, weight support, partial weight support, ground walking, and task-specific walking training (11). Among the many ways to improve the walking ability of stroke patients, weight support is commonly used to aid with posture and walking patterns (12).

Moreover, body-weight support provided by the overhead suspension system provides additional support and positive reinforcement for patients. As a result, patients can practice walking in a stable environment without fear of falling (13). In addition, gait training using weight supports can show improved movement control and strength during the stance and phase of gait in patients with stroke. Harness and therapist assistance for weight support are important therapeutic factors that can lead to intensive tasks (14). Research on partial weight supporting walking exercises is steadily increasing. However, most studies have been performed in treadmill settings, not in actual walking environments, and research on partial weight support walking training in overground settings is insufficient. Therefore, this study aimed to investigate the effect of partial weight support walking training on a ground track similar to the actual walk environment on chronic stroke patients' temporal and spatial gait parameters.

MATERIALS AND METHODS

Participants. This study was designed as a single-blinded randomized controlled trial. This study was conducted on stroke subjects admitted to S rehabilitation hospital in Gyeongsangnam-do. The subjects were recruited through hospital advertisements and selected according to the following criteria:

Selection criteria: 1) Diagnosed with cerebral hemorrhage and infarction by computed tomography or magnetic resonance imaging; 2) 6 months or more after the onset of a stroke; 3) a Korean Simple Mental State Discrimination Test (MMSE-K) score of 24 or higher, and 4) a functional ambulation category (FAC) score of 2-3 points.

Exclusion criteria: 1) Visual or hearing impairment; 2) cardiovascular disease, kidney disease, liver disease, cognitive problems; 3) cerebellar disease, and 4) other diseases affecting walking ability. In the previous partial weight-supported gait study similar to this study, a total of 28 subjects were studied, and statistically significant results were obtained (15). In this study, the number of subjects was selected based on the previous study, and the final 30 subjects were selected considering the dropout rate of 10%. A total of 36 subjects were recruited, and 30 were selected following the exclusion of 4 patients below the required MMSE-k score and 2 below the required FAC score. All subjects were informed of the procedure and purpose of the study and agreed to participate. The Kyungnam University Research Ethics Committee approved all research protocols. The clinical research registration service registration number is KCT0005272.

Procedures. A total of 30 stroke patients participated in this study and were randomized to experimental (n = 15) or control (n = 15) groups using the drawing method. The experimental group wore a harness connected to the partial weight-supported gait training system and lifted the subject using a harness until it reached 70% of the subject's body weight using a scale. The experimental group underwent the 30 m ground track for 12 minutes under the supervision of a therapist, rested for 3 minutes, and then repeated twice in the same way to apply a total of 30 minutes of partial weight-supported ground walking training. Partial weight-bearing ground gait training was applied once for 30 minutes, 3 times a week, and 18 times for 6 weeks. In the control group, the patients walked on the 30 m track for 12 minutes without weight support under the therapist's supervision, rested for 3 minutes, and then repeated twice in the same way to apply a total of 30 minutes of general ground walking training. General ground gait training was also applied under the same conditions as part-weight-supported gait training, once for 30 minutes, 3 times a week, and 18 times for 6 weeks. Experimental and control groups performed the same general rehabilitation training consisting of physical and occupational therapy once for 30 minutes, 5 times a week, and 30 times for 6 weeks. Physical therapy was given to neuro developmental treatment and occupational therapy was trained in activities of daily living. In order to measure the temporal and spatial parameters of gait for walking training in stroke patients, a pre- and post-test was performed using GAITRITE. The same therapist conducted the assessment, blinded to group assignments and interventions.

Intervention. Partial weight support ground walking training system. The subjects wore a harness from the partial weight support walking training system and measured their weight using a scale. With the weight measured using a scale, the subject pulls the harness upwards so that only 70% of the body weight can be applied. Using partial weight support equipment, the subjects walked a 30 m ground track with the therapist for 12 minutes, followed by a rest for 3 minutes, with only 70% of their body weight applied. The same method was repeated twice for 30 minutes of partial weight support walking training. During partial weight support training, the subject was allowed to walk at a normal walking speed.

Conventional Over Ground Walking Training. Subjects were trained for 12 minutes on a 30 m track with a therapist without a supporting weight. Then, after resting for 3 minutes, the method was repeated twice for 30 minutes.

General Rehabilitation Program. The subjects in both the experimental group and the control group underwent personalized neurodevelopmental treatment and activities of daily living training once a day for 30 minutes, 5 times a week, for 6 weeks

Outcome Measures. This study used GAITRITE to measure stroke patients' temporal and spatial gait ability before and after the intervention. GAITRITE is a pad with a pressure sensor 461 cm long and 88 cm wide. The temporal parameters of gait were evaluated for gait speed, cadence, and cycle time. The spatial parameters of gait were evaluated for step time, stride length, step length, and swing rate. The reliability of GAITRITE is ICC = .91, which is very reliable. The subjects stood in front of the GAITRITE and were then allowed to walk at the most comfortable speed following an oral signal from the assessor. This test was conducted three times, and the average value was used for the final analysis.

Statistical Analysis. In this study, SPSS 18.0 was used for statistical analysis. All data were tested for normality using the Shapiro-Wilk test method. In order to compare the gait parameters according to training within the group, a paired t-test was conducted. An analysis of covariance (ANCOVA) was performed to compare the differences in gait parameters according to the inter-group intervention method. All statistical significance levels (α) were below 0.05.

RESULTS

The homogeneity test for the general characteristics of the subject is as follows (Table 1).

Gait speed, a temporal gait parameter, was significantly improved after intervention in the partial weight support walking training group ($P < 0.05$). However, the control group showed no statistically significant difference after intervention ($P > 0.05$). Comparing gait speed between groups showed a statistically significant difference in the partial weight support walking training group compared to the control group ($P < 0.05$). There were no statistically significant differences in the cadence and the cycle time in both experimental and control groups ($P > 0.05$). There was also no statistically significant difference between the experimental group and the control group ($P > 0.05$) (Table 2).

Table 1. Homogeneity test for general characteristics of subjects

	Experimental Group (n=15)	Control Group (n=15)	χ^2/t
Age (years)	50.80 ± 9.00	50.13 ± 6.53	0.232
Weight (kg)	65.73 ± 9.12	63.67 ± 7.83	0.557
Height (cm)	168.60 ± 6.11	161.5 ± 7.83	0.597
Paretic side			0.000
Right	10	7	
Left	5	8	
Onset period (months)	41.33 ± 30.61	44.87 ± 31.32	0.312
MMSE-K (score)	27.37 ± 2.09	27.2 ± 2.18	0.598

Values are expressed as mean (standard deviation)

Table 2. Comparison of Temporal Gait Parameters within Group and between Groups

	Experimental Group (n=15)	Control Group (n=15)	F	P
Gait speed (cm/s)			6.934	0.018†
Pre	41.41 ± 11.49	55.80 ± 22.33		
Post	69.15 ± 29.61	56.06 ± 20.03		
Pre-Post	-18.98 ± 16.78	-1.97 ± 1.83		
t	-3.556	-2.060		
p	0.009*	0.058		
Cadence (step/min)			2.453	0.221
Pre	69.62 ± 25.99	75.62 ± 22.74		
Post	72.60 ± 27.16	77.68 ± 23.20		
Pre-Post	-2.97 ± 10.26	-2.05 ± 4.71		
t	-2.450	-2.337		
p	0.051	0.058		
Cycle Time (sec) paralyzed side			1.352	0.071
Pre	1.61 ± 0.22	1.71 ± 0.23		
Post	1.50 ± 0.23	1.70 ± 0.25		
Pre-Post	-0.08 ± 0.03	0.01 ± 0.01		
t	2.247	2.162		
p	0.063	0.065		
Cycle Time (sec) non-paralyzed side			1.356	0.072
Pre	1.64 ± 0.18	1.60 ± 0.16		
Post	1.55 ± 0.15	1.53 ± 0.13		
Pre-Post	0.07 ± 0.05	0.02 ± 0.01		
t	2.312	2.142		
p	0.051	0.065		

Values are expressed as mean (standard deviation), *means significant difference within the group; †means significant difference between groups

Table 3. Comparison of Spatial Gait Parameters within Group and between Groups

	Experimental Group (n=15)	Control Group (n=15)	F	P
Step Length (cm) paralyzed side			0.403	0.042†
Pre	34.47 ± 6.62	35.92 ± 10.24		
Post	43.66 ± 8.83	40.48 ± 10.57		
Pre-Post	-8.78 ± 6.14	-1.25 ± 3.87		
t	-3.764	-2.156		
p	0.005*	0.061		
Step Lengt (cm) non-paralyzed side			0.408	0.043†
Pre	32.58 ± 8.44	36.91 ± 9.22		
Post	46.11 ± 7.42	43.85 ± 7.28		
Pre-Post	-10.54 ± 3.34	-1.58 ± 3.12		
t	-4.209	-1.597		
p	0.004*	0.141		
Stride Length (cm) paralyzed side			4.134	0.021†
Pre	69.96 ± 12.77	74.06 ± 16.08		
Post	84.02 ± 11.93	76.02 ± 15.99		
Pre-Post	14.06 ± 1.06	1.96 ± 2.04		
t	-27.774	-25.542		
p	0.000*	0.000*		
Stride Length (cm) non-paralyzed Side			4.122	0.020†
Pre	69.97 ± 12.45	74.53 ± 15.30		
Post	85.45 ± 11.93	75.78 ± 15.60		
Pre-Post	15.48 ± 1.45	1.24 ± 0.77		
t	-33.641	-5.083		
p	0.000*	0.001*		
Swing rate (%) paralyzed side			0.407	0.043†
Pre	27.30 ± 7.65	26.88 ± 5.53		
Post	31.69 ± 5.76	28.94 ± 6.03		
Pre-Post	-4.39 ± 5.20	2.06 ± 4.96		
t	-3.050	1.568		
p	0.010*	0.115		
Swing rate (%) non-paralyzed side			0.421	0.047†
Pre	25.43 ± 7.54	25.74 ± 7.27		
Post	28.54 ± 8.34	27.03 ± 7.95		
Pre-Post	-3.11 ± 5.65	-1.29 ± 5.23		
t	3.040	1.668		
p	0.012*	0.120		

Values are expressed as mean (standard deviation); *means significant difference within the group; †means significant difference between groups

The step length of the paralyzed/non-paralyzed side was significantly different after the intervention in the partial weight support walking training group ($P < 0.05$). The experimental group showed a significant difference compared to the control group in the comparison between the groups on the paralyzed/non-paralyzed step length ($P < 0.05$).

The paralytic/non-paralytic stride length was significantly different following intervention in the partial weight support walking training group and the control group. In addition, in the comparison between groups, the partial weight support weight walking training group showed a significant difference compared to the control group ($P < 0.05$).

The paralyzed/non-paralyzed swing rate, a spatial parameter of gait, showed a statistically significant difference after intervention in the partial weight support walking training group ($P < 0.05$). In addition, in the comparison between groups, the partial weight support weight walking training group showed a significant difference compared to the control group ($P < 0.05$) (Table 3).

DISCUSSION

This study investigated the effects of partial weight support ground walking training on chronic stroke patients' temporal and spatial gait parameters. The experimental group underwent partial weight support ground walking training, while the control group underwent general ground walking training without weight support for 6 weeks each.

In the temporal parameters of gait, the partial weight support walking training group had a statistically significant difference in gait speed; however, there was no statistically significant difference in the cadence and the cycle time. Furthermore, the control groups had no significant differences in the temporal parameters of gait. In the group comparison of the temporal parameters of gait, the gait speed of the partial weight support walking training group was significantly different from those of the control group, but cadence and cycle time was not significantly different. Gait is the ability to integrate walking with different tasks in a complex environment. However, stroke patients experience reduced walking and movement due to impaired motor skills (16). People with hemiplegia have asymmetry because they support less than 25%-40% of their body weight in the damaged lower limbs in a standing position (17). Partial weight support training can increase walking speed by improving weight-bearing ability and reducing patients' fear of falling (18). Lindquist et al. suggested that by combining dual tasks and partial weight support, treadmill training can improve motor recovery and gait patterns in hemiplegic patients (19). This study also showed that partial weight support ground walking training could increase gait speed, thought to be because partial weight support ground walking training provides a more physically normal stimulation for stance and swing phase of gait, and harness support can better control the movement of the center of gravity of stroke patients.

However, there was no statistically significant difference between the cadence and cycle time after intervention in the partial weight support walking training group. Stroke patients have a slower cycle time and cadence due to a shorter weight support time on the paralyzed side, which increases limb support time due to unilateral paralyzed (20).

Stroke patients also have weak momentum in the terminal stance phase and before the swing phase due to weakening the ankle plantar flexor (12). However, these are not believed to have made a statistically significant difference in the cadence and cycle time.

There was no statistically significant difference in the temporal parameters of gait in the control group.

In this study, subjects who performed partial weight-supported gait training reduced the load by 30% of their body weight, thereby reducing the asymmetry of the left and right by walking training with only 70% of the body weight. However, the control group performed walking training without weight support, and normal walking training without weight support is still subject to fear of falling as a result of the asymmetry due to hemiplegia (21).

In this study, it is believed that control group subjects had asymmetry due to fear of falling and hemi paralyzed. In the spatial parameters of gait, the partial weight support walking training group showed a statistically significant difference in all parameters, including stride length, step time, and swing rate. The control group demonstrated a statistically significant difference in stride length and step length but no difference in step time and swing rate. In addition, all spatial parameters of gait were statistically significant between groups according to the intervention. Most stroke patients have proprioceptive sense impairment (22); in addition, the weight support of the paraplegic limb is reduced, resulting in asymmetric walking (23). In this study, the subjects who conducted partial weight support walking training reduced the weight load by 30%, which consequently reduced left-right asymmetry; this functioned to increase the weight support time of the paralyzed side, so the sense of proprioceptive acceptance was improved. It is thought that increased spatial parameters of gait. In the control group, there was an improvement in the stride length and step length, but there was no significant change in the step time and swing rate. It is thought to be the result of typical walking training without weight support, which can increase the stride, but is not sufficient to improve asymmetry due to abnormal weight distribution and abnormal posture control (14).

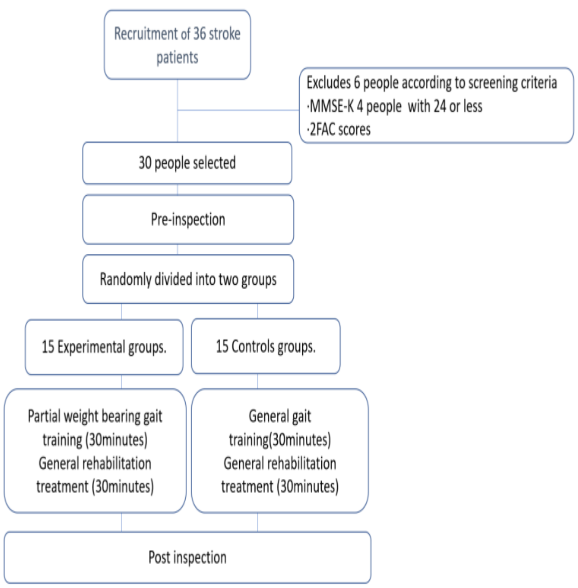

Figure 1. Flow Chart of this Study

The majority of the previous partial weight-supporting walking training studies were conducted passively on treadmills, although there was not much improvement in the ground walking ability (24). The partial weight support ground walking training applied in this study was able to identify improvements in walking parameters that were improved over previous treadmill-oriented weight support walking training. Hall AL studies related to partial weight support walking training after stroke found no significant difference in gait speed (25). However, in the current study, gait speed was increased in the partial weight support ground walking training group. Mehrholz J et al. conducted partial weight support trade-mill walking training on 39 chronic stroke patients and reported no change in gait symmetry (26). However, in the current study, gait symmetry improved because of the statistically significant differences in step time, stride length, step length, and swing rate.

Figure 2. Partial Weight Support Ground Walking Training System.

The results of this study confirmed that partial weight support ground walking training has a positive effect on walking ability. Moreover, the significant improvement in partial weight support ground walking training, temporal and spatial parameters, such as gait velocity, step length (parasite, non-parasitic), stride length (parasite, non-parasitic), and swing rate, further supports the results of this study.

This study used the G-power program to obtain the effect size and power of the partial weight support ground walking training. The effect size for gait speed in this study was 1.43, and the power was 0.985, which was high. The effect size for the step length was 1.47 for the paralyzed side and 2.77 for the non-paraplegic side, and the powers were 0.989 and 1.0, respectively. The effect size for stride length was 7.44 for the paralyzed side and 12.27 for the non-paretic side. The stride length power was as high as 1.0 on both the paralyzed and non-paralyzed sides. Also, the effect size for swing rate was 1.27 for the paralyzed side and 0.33 for the non-paralyzed side. The power according to the effect size of the swing rate is 0.96 and 0.27, respectively. The effect size and power of the partial weight support ground gait training used in this study were overall very large. These results of this study suggest that the partial weight-support ground gait training used in this study can be highly utilized for gait training in stroke patients.

There are several limitations of the current study. The track used for walking training was a simple circular track with no obstacles or heights; therefore, it is not known what effect it will have on gait in daily living. In order to clarify the effectiveness of the partial weight support ground walking training, further study is required to include more subjects and determine its effect on gait in daily living.

CONCLUSIONS

This study's results demonstrated a statistically significant difference in step time, stride length, step length, and swing rate in partial weight support training compared to general gait training. These results confirm that partial weight-supported gait training positively affects gait in chronic stroke patients. Thus, it is thought that partial weight support gait training can be used as an effective intervention method to improve gait in chronic stroke patients.

APPLICABLE REMARKS

- This study supports that partial weight-bearing ground gait training in chronic stroke patients can improve the patients' walking ability.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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