The effects of intensive gait training with body weight support treadmill training on gait and balance in stroke disability patients: a randomized controlled trial

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Objective: The purpose of this study was to investigate the effects of intensive gait training with body weight support treadmill training on gait and balance in stroke disability patients.

Design: Randomized controlled trial.

Methods: Twenty-six stroke patients (20 men and 6 women) participated in this study. All subjects were hospitalized patients. They were randomly divided into two groups: the experimental group (body weight supported treadmill training group, n=14) and control group (treadmill group, n=12). The mean ages were 52.07 years (experimental group) and 53.83 years (control group). Subjects in both groups received conventional training 10 times/wk. Subjects in the experimental group practiced body weight supported treadmill training for 30 minutes a day, 3 day/wk. Subjects in the control group practiced treadmill training for 30 minutes. The Berg Balance Scale (BBS) and GAITRite were used to evaluate balance and gait parameters (step length, cadence, and gait speed) before and after the intervention.

Results: BBS scores in the experimental group showed significantly greater improvement (4.33±1.54), compared with the control group (p<0.05). Significantly greater improvement in the gait speed (24.13±4.53 cm/s), affected side step length (10.40±3.42 cm), sound side step length (11.97±3.29 cm), and cadence (23.88±5.52 step/min), compared with the control group (p<0.05).

Conclusions: Intensive gait training with Body Weight Support Treadmill Training may improve gait and balance in subacute stroke.

Key Words: Gait, Postural balance, Stroke, Weight bearing

Introduction

Stroke is one of the main causes of acquired adult disability in most countries [1]. A patient acquires a disability depending on the position of damage from a stroke. Gait disturbance and balance disorders affect the quality of life and independent activity of daily living. Therefore, there are many attempts to improve gait disturbance and balance disorders of stroke patients [2-6]. Among them, gait training with a treadmill is a task oriented approach that can be trained to operate the walking exercise. It can be adjusted to maintain a constant walking speed of a patient. Therefore, treadmill gait training was used for gait training of stroke patients.

It is the best intervention that should begin as quickly as possible for functional recovery [7,8]. More recently, Body Weight Support Treadmill Training (BWSTT) has been tried for patients who were unable to cope with full weight bearing on their lower limbs. This training consists of using an overhead suspension system and harness to support the body
Intensive and graded locomotor activities increased recovery of functional activity [10]. Therefore, intensive gait training is necessary to further improve walking in stroke patients. However, stroke patients cannot be subjected to intensive gait training due to high risk of falls, poor coordination and weakness.

BWSTT provides support to the patient and reduces the loading weight. This study intends to investigate the effects of intensive treadmill training with body weight support on gait and balance for stroke patients who can walk.

**Methods**

**Subjects**

The subjects were recruited from M Rehabilitation Hospital in Seoul. Twenty-eight subjects (21 men and 7 women) were enrolled in the study. Two subjects from the control group did not complete the study. Table 1 shows the general characteristics of subjects who completed the study.

Inclusion criteria [11,12] were (1) those who were diagnosed stroke shown by computed tomography or magnetic resonance imaging; (2) those who had independent gait ability with or without a walking aid for a minimum of 10 m; (3) no abnormality in the visual and auditory system; and (4) a mini-mental state examination (MMSE-K) score of greater than 24.

Exclusion criteria [12,13] were (1) those who had a history of other neurologic diseases or disorders; (2) abnormality in the cardiovascular system; (3) pain or limited motion of the lower extremity; and (4) could not understand verbal instruction.

This study was approved by the Sahmyook University’s institutional review board. All subjects signed a written informed consent prior to participation.

**Procedures**

Twenty-eight subjects were randomized into one of the two groups, the experimental group (n=14) and control group (n=14). Randomization was computer generated using a basic random number generator. Pre-tests were performed with measurements of balance (Berg Balance Scale [BBS]) and gait (step length, cadence and gait speed). Subjects in both groups participated in a conventional training program twice a day, 5 day/wk for 4 weeks. Subjects in the experimental group practiced BWSTT 30 minutes a day, 3 day/wk for 4 weeks [14,15]. Subjects in the control group practiced treadmill training without body weight support. Frequency was the same as the experimental group. All subjects from the experimental group completed the study. However, two subjects of control group did not complete the study.

**Treadmill training program**

Subjects underwent gait training using a treadmill (FITEX T-5050; Fitex, Gwangju, Korea, 2007; Figure 1). Physical therapists observed the training process for patient safety. If patients felt pain or discomfort, dragged their feet, lost their balance, and/or experienced fatigue, a physical therapist immediately stopped the treadmill.

Subjects walked as fast as possible while maintaining a walking pattern close to normal and the initial speed of the

**Table 1. General characteristics of the subjects**

<table>
<thead>
<tr>
<th>Variable</th>
<th>BWSTT group (n=14)</th>
<th>Control group (n=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, male/female</td>
<td>11/3 (78.6/21.4)</td>
<td>9/3 (75/25)</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>52.07 (9.64)</td>
<td>53.83 (7.40)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64.45 (9.50)</td>
<td>67.10 (10.35)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>169.26 (8.21)</td>
<td>164.48 (9.10)</td>
</tr>
<tr>
<td>Month of post stroke</td>
<td>4 (1.18)</td>
<td>6 (1.76)</td>
</tr>
<tr>
<td>Side of lesion, right/left</td>
<td>7/7 (50/50)</td>
<td>4/8 (33.3/66.7)</td>
</tr>
<tr>
<td>Infarction/haemorrhage</td>
<td>9/5 (64.3/35.7)</td>
<td>9/3 (75/25)</td>
</tr>
<tr>
<td>MMSE</td>
<td>26.57 (2.03)</td>
<td>27.42 (1.78)</td>
</tr>
<tr>
<td>BBS</td>
<td>34.43 (3.78)</td>
<td>34.75 (2.56)</td>
</tr>
<tr>
<td>Affect side step length (cm)</td>
<td>32.07 (9.48)</td>
<td>35.49 (10.45)</td>
</tr>
<tr>
<td>Sound side step length (cm)</td>
<td>31.21 (9.41)</td>
<td>31.54 (13.39)</td>
</tr>
<tr>
<td>Gait speed (cm/s)</td>
<td>35.14 (20.59)</td>
<td>38.40 (19.86)</td>
</tr>
<tr>
<td>Cadence (step/min)</td>
<td>61.03 (21.48)</td>
<td>69.65 (17.92)</td>
</tr>
</tbody>
</table>

Values are presented as n (%) or mean (SD).

treadmill was decided at this speed [16]. The gait speed was increased in the experimental group [12].

**Body weight support treadmill training program**

Gait training using a treadmill was equivalent to the treadmill training program. Subjects walked with body weight support (LINAK, Silkeborg, Denmark, 2009; Figure 1). The body weight support device supported 40% of the patient’s weight [9, 17]. Body weight support was reduced by 5% and gait speed was increased by 0.2 km/h when patients stably walked for 3 minutes [12].

**Conventional training program**

Both groups were treated with conventional therapy. Conventional training was composed of range of motion exercise, strengthening exercise, functional movement re-education, and mat exercise.

**Outcome measures**

At pre- and post-test, BBS and GAITRite (CIR Systems, Sparta, NJ, USA) tests were used in assessment of balance and gait function of subjects.

BBS is identified as the most commonly used assessment tool in stroke rehabilitation [18-20]. BBS is performed with 14 subcategories. The subcategories are sitting to standing, standing unsupported, sitting unsupported, standing to sitting, transfers, standing with eyes closed, standing with feet together, reaching forward with outstretched arm, retrieving...
object from floor, turning to look behind, turning 360 degrees, placing alternate foot on stool, standing with one foot in front, and standing on one foot. An agreement between the raters was excellent (intraclass correlation coefficient [ICC]=0.98), and consistency was also excellent within the same rater at two points in time (ICC=0.97) [20].

GAITRite is a portable gait analysis tool for automated measurement of spatiotemporal gait parameters [21]. As subjects walked along the GAITRite walkway, the sensors captured gait parameters. The gait parameters were transferred to a personal computer for processing. The reliability of walking speed, cadence and step length were excellent (ICCs between 0.82 and 0.92 and coefficients of variations between 1.4 and 3.5%) [22]. Subjects went through 3 trials and all values were averaged. The gait parameter were step length, cadence and gait speed.

Data analysis

Statistical analyses were performed using PASW Statistics version 18.0 (IBM Co., Armonk, NY, USA). Data of the subject who completed the study were analysed. Descriptive statistics were used to compare the general characteristics and pre-test score of the two study groups. A paired t-test was used to assess the significant difference between the pre-test and post-test. An independent t-test was used to assess the significant difference between the experimental group and control group. The level of statistical significance was set at a $p$ level of 0.05.

Results

There was a significant difference between the pre-test and post-test for gait variable and balance in both groups.

BBS score, 10.50 (4.6); affect side step length, 19.59 (8.06) cm; sound side step length, 21.63 (8.86) cm; cadence, 40.21 (13.93) step/min; and gait speed, 41.42 (10.69) cm/s were increased in the BWSTT group ($p<0.05$; Figure 2).

BBS score, 6.16 (2.89); affect side step length, 9.19 (9.39) cm; sound side step length, 9.66 (7.71) cm; cadence, 16.34 (14.13) step/min; and gait speed, 17.29 (12.43) cm/s were increased in the control group ($p<0.05$; Figure 3).

There was a significant difference in the amount of

![Figure 3](image-url) The differences within the control group after intervention ($n=12$). Data shown in the figure are the mean (SD). (A) Berg Balance Scale (BBS) score, (B) hemi-side step length, (C) sound side step length, (D) cadence, (E) gait speed. $p<0.05$. 
change in the BWSTT group and control group ($p < 0.05$; Figure 4). In the BWSTT group, BBS score, 4.33 (1.54); affect side step length, 10.40 (3.42) cm; sound side step length, 11.97 (3.29) cm; cadence, 23.88 (5.52) step/min; and gait speed, 24.13 (4.53) cm/s were higher than the control group mean (SD).

**Discussion**

This study aimed to determine the effect of intensive gait training with BWSTT on gait and balance in ambulatory stroke patients and to be used as basic materials for application to the clinical effect.

Improved results were visible in both the experimental group and control group after 4 weeks of intervention (Figures 2, 3). However, the amount of change was higher in the BWSTT group than in the control group (Figure 4). These results are in accordance with the results of previous studies [9,17,23-25].

Balance, coordination and muscle power is required for the process of walking [26-28]. The decrease of coordination and muscle weakness is one of the reasons that patients are unable to walk after stroke. Stroke patient have a high risk of falling and short walking distances.

Patients with the body weight support device may increase the walking speed and walking distance than those without the body weight support device [13,15]. In the current study, Body Weight Support device played a role in providing stability and created the movements necessary for walking with more ease through reduced loading to the lower extremity. Experimental group can be repeatedly walking training at a faster rate than control group. The repetitive training will help to achieve functional activity again [29-31]. Therefore, it can be speculated that BWSTT had a rapid and repetitive treadmill training effect, leading to improvement of the experimental group.

Balance training was possible by giving the opportunity to maintain the balance required for fast walking. The effect of BWSTT is better in more severely impaired or older patients [32]. However, this part could not be confirmed in this study because patients who attended this study could walk.

![Figure 4](image-url)
The effect of BWSTT transfers over to ground locomotion [24,32]. It is believed that the results of this study may have implications to real life.

The limitation of this study was that any effect in chronic stroke patient could not be for certain because subjects were subacute patients. The lasting effect of BWSTT after training was unclear since there was no follow-up. The treadmill speed had been increased to subjective judgment of the patient. Further research is required with the use of heart rate monitoring for deciding treadmill speed and to generalize these findings.

References

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