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The Effect of Treadmill-based Incremental Leg Weight Loading Training on the Balance of Stroke Patients

Jae Hyo Park, MS, PT[1)], Gak Hwangbo, PhD, PT[1)], Jun Soo Kim, MS, PT[2)*]

[1)] *Department of Physical Therapy, College of Rehabilitation Science, Daegu University, Republic of Korea*
[2)] *Department of Rehabilitation Medicine, Daegu Catholic University Hospital: 4 Daemyeong, Nam-gu, Daegu 705-718, Republic of Korea*

Abstract. [Purpose] The purpose of this study was to examine the effect of treadmill-based gait training using incremental weight loading on the ankle of the affected side on hemiplegic stroke patients' balance. [Subjects] In this study, 30 hemiplegic stroke patients were randomly divided into an incremental weight load group (IWLG, n=15) and a no-load group (NLG, n=15). [Methods] The IWLG performed gait training on treadmills for four weeks wearing a sandbag weighing 3% of the body weight on the affected side ankle, followed by wearing a sandbag weighing 5% of the body weight from the 5th week. The NLG performed similar training without sandbags. [Results] Both the IWLG and the NLG showed significant improvements in balance ability. The IWLG showed a larger decrease in the area and length of movement of the center of pressure in static standing positions after the experiment although the difference was not significant. [Conclusion] We recommend, utilizing the treadmill-based gait training using incremental weight loading on the affected side ankle as a clinical intervention for improving hemiplegic stroke patients' balance ability.

Key words: Stroke, Incremental weight load, Treadmill

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INTRODUCTION

Hemiplegic stroke patients support only 25:43% of their body weight on their affected side lower extremity in standing positions. As a result, asymmetric positions occur. Accordingly, their balancing ability and ambulatory ability, which are among the most basic abilities needed for maintaining daily living, are remarkably reduced. This significantly deteriorates their quality of life, as it limits their activities of daily living[1)].

Treadmill gait training, which simulates walking on flat land[2)], is prescribed in hemiplegic stroke patients' rehabilitation to improve their balance and/or to reduce their gait disturbance[3)]. Treadmill gait training supporting the body weight has been reported to improve the symmetry of gait and reduce ankylosis, and enable more effective improvement of stroke patients' ambulatory ability than walking on flat land alone[4)]. Additionally, it has been reported to not only improve standing balance, but also to reinforce muscle strength, improve balance, and enable motor control in gait patterns to be newly recognized[5)].

In a study in which weight was loaded on stroke patients' affected side lower extremity to examine the effect of load on walking speed, it was reported that although the effect was not significant, the weight increased the muscle strength of the flexor muscles and improved the toe-off action[6)]. Additionally, in a study in which weight was loaded on the affected side lower extremity during treadmill gait training, increases in the swing phase time and improvement s in of ambulatory ability, such as stair climbing, were found[7)].

Although diverse studies have been conducted on treadmill training for improvement of hemiplegic stroke patients' balance and ambulatory ability, studies of incremental weight loading in gait training involving a treadmill are lacking. Therefore, this study examined the effects of treadmill-based gait training with incremental weight loading on the affected side ankle with respect to the improvement of hemiplegic stroke patients' balance.

SUBJECTS AND METHODS

The study subjects were inpatients who were being treated at D Hospital, Daegu, South Korea who were diagnosed with hemiplegia due to stroke by specialists in rehabilitative medicine. They were randomly assigned to an IWLG (8 males, 7 females) or an NLG (9 males, 6 females). The IWLG subjects' age was 55.07±15.14 years(mean±SD),

*Corresponding author. Jun Soo Kim (E-mail: sesseafan@gmail.com)

Table 1. Comparison of the COP sway area and the length following quiet standing between pre- and post-intervention (mean ± SD)

Group		Experimental group	Control group
SA (Unit: mm^2)*	Pre-intervention	109.06 ± 31.65	105.33 ± 20.11
	Post-intervention	94.00 ± 26.33	96.53 ± 23.01
SL (Unit: cm)*	Pre-intervention	29.47 ± 6.37	30.00 ± 4.47
	Post-intervention	19.91 ± 4.30	24.39 ± 4.14

*p<0.05, SA, sway area; SL, sway length

Table 2. Comparison of the variation in the COP sway area and length following quiet standing between the experimental group and the control group (mean ± SD)

Group		Experimental group	Control group
SA (Unit: mm^2)	Pre-intervention	109.06 ± 31.65	105.33 ± 20.11
	Post-intervention	94.00 ± 26.33	96.53 ± 23.01
	Change between pre- and post-	−15.06 ± 10.25	−8.80 ± 6.55
SL (Unit: cm)	Pre-intervention	29.47 ± 6.37	30.00 ± 4.47
	Post-intervention	19.91 ± 4.30	24.39 ± 4.14
	Change between pre- and post-	−9.56 ± 3.97	−5.60 ± 1.66

*p<0.05, SA, sway area; SL, sway length

their height was 164.20±7.86 cm, and their weight was 61.93±10.40 kg. There were 9 cases of left hemiplegia and 6 cases of right hemiplegia, and the mean time since onset of stroke was 13.47±16.26 months. The NLG subjects' age was 50.00±13.33 years(mean±SD), their height was 164.20±7.91 cm, and their weight was 60.67±6.81 kg. There were 6 cases of left hemiplegia and 9 cases of right hemiplegia, and the mean time since onset of stroke was 17.86±16.15 months.

The subjects were selected from among those who had no visual field defect or abnormality in the vestibular organs, no orthopedic disease of the trunk or the lower extremities, were not limited in their range of motion of the joints, had the cognitive ability to understand and follow the researchers' instructions, and scored 24 points or higher on the Mini-Mental Status Examination-Korea (MMSE-K). All the subjects understood the purpose of this study and provided their written informed consent prior to their participation in the study in accordance with the ethical standards of the Declaration of Helsinki.

The IWLG engaged in gait training on motor-operated treadmills with a sandbag weighing 3–>5% of body weight attached to the affected side ankle. During treadmill gait training, one therapist assisted the subject when necessary by standing next to the affected side and helping the patient with steps and lower extremity control during the swing and stance phases. The treadmill speed was selected by the patient for walking on level ground, and was increased by 0.1 km/hr when the patient had walked for 20s or longer[8, 9]. For four weeks from the beginning of the intervention, each patient wore a sandbag weighing 3% of body weight on the affected side ankle, and from the fifth week onward, the patient wore a sandbag weighing 5% of body weight during the gait training. The NLG engaged in gait training without sandbags on motor-operated treadmills. Both groups engaged in the training for 30 minutes per session, 5 times per week, for 8 weeks. Warm-up exercises and cooling-down exercises were implemented before and after the gait training, respectively. The outcome measures were measured twice, once, before the intervention, and again on the completion of the 8-weeks intervention.

To measure the patients' ability to balance, center of pressure sway areas (SA) and sway length (SL) in the static standing position were measured.

The experimental results were statistically analyzed using SPSS 20.0 KO (IBM, IL, USA). After the general characteristics of the subjects were determined, the paired t-test was used to compare the sway area and length following quiet standing between pre- and post-intervention within each group. The significance of the differences in sway area and length between the two groups were investigated using the independent t-test. The statistical significance level, α, was chosen as 0.05.

RESULTS

The IWLG showed significant decreases in center of pressure SA and SL in the static standing position between before and after the intervention (p<0.05). The NLG also showed significant decreases in center of pressure SA and SL in the static standing position between before and after the intervention (p<0.05) (Table 1).

The differences in center of pressure SA and SL in the static standing positions between before and after the intervention of the two groups were compared. The IWLG showed larger decreases than the NLG, but the differences between the two groups were not significant (Table 2).

DISCUSSION

In this study, the IWLG showed larger decreases than the NLG, although the differences were not significant, in a comparison of the differences in center of pressure SA and SL in a static standing position between before and after the experiment. Given this result, the muscle strength of the affected side lower extremity seems to have been increased in the IWLG because of the repetitive weight loading gait training. Thus, this group's ability to bear weight increased. Additionally, the ability to shift weight improved, improving ankle stability which in turn improved balance ability.

Frenceschini et al.[10] reported that treadmill gait training improved stroke patients' trunk control ability such that their balance ability was improve. Also, studies conducted by Laufer et al.[11] and Lin et al.[12] reported that reinforced muscle strength, such as those of the dorsal flexor of the ankle joint and the flexor of the hip joint on the affected side lower extremity, reduced the phenomenon of foot dragging during the swing phase. As a result, the affected side lower extremity's time in the air was reduced, enabling weight shifting, and improving balance, witch resulted in a faster walking speed. In recent studies, Raymond et al.[13] indicated that incremental weight loading training seemed to be a safe exercise method for elderly persons, and Hass et al.[14] reported that incremental weight loading training for Parkinson's disease patients showed good effects on the movement of the center of pressure in the standing position, and the length and speed of the first step.

As in these previous studies, both groups in our present study showed improvement in balance. However, when compared to the NLG, the IWLG showed a little more improvement in balance ability. We infer, that the incremental weight loading gait training additionally implemented on a treadmill increased the hemiplegic stroke patients' lower extremity stability and lower extremity flexor strength more, thereby contributing to the greater improvement in balance. Therefore, treadmill gait training with incremental weight loading on the affected side lower extremity can be recommended as a clinical intervention for stroke patients.

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