

# Effect of rehabilitational sliding machine and ergometer bicycle training on patients with hemiplegia

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**Abstract.** [Purpose] The purpose of the study was to investigate the effects of exercise using rehabilitational sliding machine training and ergometer bicycle training on the balance and gait of patients with stroke. [Subjects] Forty patients with hemiplegia resulting from stroke were divided into a sliding training group (STG, n=20) and ergometer bicycle training group (ETG, n=20). [Methods] STG and ETG respectively performed rehabilitational sliding training and cycle ergometer training in 30 minute sessions, five times a week, for a total of eight weeks. [Results] The balance and gait ability of both groups significantly improved. Both groups showed improvements in balance and gait ability, and the ETG showed anterior and posterior ranges of the limit of stability following standing. [Conclusion] Training on a rehabilitational sliding machine and an ergometer is effective at increasing a patient's balance and gait ability during nontreatment time in their daily time without therapist.

**Key words:** Hemiplegia, Rehabilitational sliding training, Ergometer bicycle training

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## INTRODUCTION

Patients with hemiplegia resulting from stroke adopt an asymmetric position that places a smaller load on the lower extremity of the paretic side in a standing position due to factors such as reduction of muscle strength, impaired sense of balance, excessive stretch reflex, joint contraction of the antagonistic muscles, and decrease in motor control ability. An asymmetric posture triggers gait disturbance<sup>1)</sup>. In particular, patients who are hemiplegic resulting from stroke have difficulty with balance and gait because of problems with the lower extremities. As a result, they have disability in standing and in their gait, and their postural sway in a standing posture is twice as high as that of healthy people of the same age range<sup>2)</sup>. Also their limit of stability, defined as the maximal distance the center of gravity and move while maintaining balance without detaching the feet from the ground, decreases<sup>3)</sup>.

It is essential to increase the lower extremity muscle strength in order to maximize the functional recovery of stroke patients and heighten their quality of life<sup>4)</sup>. There has been much research on the balance and gait ability of patients related to their lower extremity muscle strength, movement, and function. In order to increase the muscle

strength of stroke patients' lower extremities, weight equipment<sup>5)</sup>, an elastic band<sup>6)</sup>, and isometric equipment<sup>7)</sup> have been employed. Using a tilt table composed of a rail system and a carriage with wheels, Trees et al.<sup>8)</sup> conducted a weight load exercise for four burn patients who had difficulty with weight load training in a standing position, and reported improvement in their lower extremity muscle strength. Byun et al.<sup>9)</sup> used a sliding rehabilitation machine to treat patients with hemiplegia resulting from a stroke and reported that the patients' muscle strength, spasticity, gait ability, balance ability, and activities of daily living improved. Bicycle exercise, which is a cyclic leg exercise, enhances leg muscle strength, and this increase in muscle strength improves the body's activity ability and elicits a balanced development of the body<sup>10)</sup>. Leg exercise using a bicycle in a sitting position is a bilateral method, which integrates assistive positive training, and induces alternating movement of the paretic side leg with the help of the nonparetic lower limb<sup>11)</sup>. Limb-loaded cycling demands the coordinated movement of a weight between the paretic and nonparetic sides and the generation of physical strength by the lower limbs during an extended period, and it provides weight load ability through the practice of gait techniques<sup>12)</sup>.

This study examined the effects of training using a sliding rehabilitation machine, that enhances lower leg function, which is important for stroke patients' balance and gait performance, and the effects of ergometer bicycle exercise, similar to the basic rhythmic gait pattern, one of the important conditions for gait by stroke patients.

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**Table 1.** Comparison of change in the balance function of the training groups with values presented as mean  $\pm$  standard deviation (unit: cm<sup>2</sup>)

	STG		ETG	
	Pretest	Posttest	Pretest	Posttest
AL	680.8 $\pm$ 186.2	920.6 $\pm$ 210.1*	832.9 $\pm$ 211.9	1338.2 $\pm$ 287.4* <sup>a</sup>
PL	514.9 $\pm$ 139.5	592.3 $\pm$ 141.7*	629.2 $\pm$ 177.8	966.3 $\pm$ 221.3* <sup>a</sup>

\*Significant difference from pre-test <0.05. <sup>a</sup>Significant difference in the improvements of the two groups <0.05. M $\pm$ SE: Mean  $\pm$  standard error. STG: sliding training group; ETG: ergometer training group; AL: anterior range of the limit of stability during on standing; PL: posterior range of the limit of stability during standing

## SUBJECTS AND METHODS

The subjects of this study were 40 patients of a rehabilitation doctor practicing at N Hospital located in Daegu, South Korea, who were diagnosed with hemiplegia resulting from stroke. They were randomly and equally assigned to a rehabilitational sliding machine training group (STG: 10 males, 10 females) or an ergometer bicycle training group (ETG: 12 males, 8 females). The mean  $\pm$  SD age, height, and weight of the STG were 51.4 $\pm$ 40.6 years, 167.0 $\pm$ 9.5 cm, and 64.1 $\pm$ 13.1 kg, respectively. Eleven of the patients had right hemiplegia, and nine had left hemiplegia. The onset period was 14.8 $\pm$ 6.1 months. The mean  $\pm$  SD age, height, and weight of the ETG were 50.1 $\pm$ 7.8 years, 169.2 $\pm$ 9.2 cm, and 65.2 $\pm$ 11.3 kg, respectively. Eight of the patients had right hemiplegia, and 12 had left hemiplegia. The onset period was 14.3 $\pm$ 3.4 months.

The inclusion criteria were as follows: no visual field defect, no abnormality of the vestibular organs, no orthopedic disease, an unrestricted range of motion, the ability to understand and perform the exercise as instructed by the researcher, and a score of 24 or higher on the Mini-Mental State Examination–Korean version. 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 principles of the Declaration of Helsinki.

The STG performed rehabilitational sliding machine training, 30 minutes per session, five times per week, for a total of eight weeks, according to a researcher's instruction. For the experiment, their weight was propped up by a lower limb support, and knee joint flexion and extension exercise was made possible with friction at a minimal level. In addition, for the stability of the patients, their ankles and body were fixed with safety belts. The slope of the tilt table was fixed at 30°, before training was conducted.

The ETG performed ergometer bicycle training 30 minutes per session, five times per week, for a total of eight weeks. Training was conducted for 30 minutes, so as not to exceed 40% of subjects' heart rate reserve, using a MOTomed Viva 2. MOTomed features are detailed biofeedback, software controlled therapy programs, and motivation and training games.

The subjects of the two experimental groups received training after hearing the order, "Please start". At an early stage of training, the researcher provided help to ensure that the subjects maintained a proper posture during the train-

ing. If a subject showed a sense of fatigue, abnormalities of breathing, or changes in facial complexion, or complained of pain, training was immediately stopped.

For the measurement of balance ability, a biofeedback analysis system (AP1153 Biorescue, France) was used to determine the anterior. And posterior ranges of the limit of stability during standing. The time required to walk 10 meters was measured using the 10-meter walking time test in order to assess the subjects' gait ability.

The experimental results were statistically analyzed using SPSS 12.0 KO (IBM, IL, USA). After the general characteristics of the subjects had been determined, the paired t-test was used to compare the differences in the anterior. And posterior ranges of the limit of stability during standing, and the 10-meter walking times between pre- and post-intervention within each group. The significance of the difference between the two groups was investigated using the independent t-test. Statistical significance was accepted for values of  $p < 0.05$ .

## RESULTS

The anterior and posterior ranges of the limit of stability during standing, their improvements in showed significant differences within each group, between pre and post-intervention, and there were also significant differences between the two groups in the anterior and posterior ranges of the limit of stability ( $p < 0.05$ ) (Table 1).

Time required to walk 10 meters by each group. Showed significant differences within each group between pre and post-intervention, but there was no significant difference between the two groups their improvements in the time required to walk 10 meters ( $p < 0.05$ ) (Table 2).

## DISCUSSION

Perry et al.<sup>13)</sup> reported that there were significant correlations between gait ability and the senses related to balance and balance ability. A decrease in postural sway observed in some patients with brain damage did not reflect that they had a good balance ability, but was the result of fear of falls after brain damage, and was an adaptive response to unstable balance. Stroke patients with a small range of postural sway in static standing balance have low stability and a high risk of falling<sup>14)</sup>. Accordingly, this study aimed to look at the effects of lower limb training using sliding and ergometer bicycle training on balance in a standing position. According

**Table 2.** Comparison of the 10-meter walking times of test in the training groups with values presented as mean  $\pm$  standard deviation (unit: sec)

	STG		ETG	
	Pretest	Posttest	Pretest	Posttest
10MWT	20.1 $\pm$ 2.3	14.3 $\pm$ 1.3*	20.1 $\pm$ 2.2	16.3 $\pm$ 1.4*

\*Significant difference from pre-test  $<0.05$ . M $\pm$ SE: Mean  $\pm$  standard error. STG: Sliding training group; ETG: Ergometer training group; 10MWT: 10-meter walking time

to the analysis of anterior and posterior ranges of the limit of stability in a standing position, STG and ETG showed significant differences within group from the pre intervention values at post intervention, and there were significant differences ( $p < 0.05$ ).

Enhancement of stroke patients' gait ability in the process of recovering their function is a major goal of physical therapy, because gait is a crucial requirement for functional independence. Stroke patients' gait is generally slow, requires excessive effort, and exhibits difficulties with coordination. Gait speed can not only be used to measure gait ability but also to evaluate independence and physical function, independent life, social activities, and functional health. This study carried out 10-meter walking to measure stroke patients' gait. According to the analysis of the time required to walk 10 meters from the pre intervention values at post intervention, STG and ETG showed within group significant in the 10 meters walking time improvements differences but there was no significant difference between the two groups.

Ergometer bicycle exercise is similar to walking in that it involves repetitive alternating flexion and extension as well as alternating contraction of the antagonistic muscles, and it enhances muscle strength. Lower limb muscle training was conducted for stroke patients for three weeks, and it was effective at improving their balance and gait performance<sup>(11)</sup>.

We consider training using a sliding rehabilitation machine and an ergometer effective at increasing a patients' balance and gait ability during day time and nontreatment time without their therapist. If research is proceeded with that applies diverse training methods focusing on stroke patients' muscle strength, initiation, timing, the order of exerting muscle strength, ability to swiftly produce force so as to affect their maintenance of force and balance, and coordination, and compares the results, it will provide diverse grounds for patients with stroke.

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