Impact of PNF-based Walking Exercise on a Ramp on Gait Performance of Stroke Patients

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Abstract. [Purpose] The present study examines how PNF-based walking exercise on a ramp affects gait performance of stroke patients. [Methods] Forty stroke patients were randomly divided into an experiment group and a control group. For the former group, patients went through a half-hour of training therapy and a half-hour of PNF-based walking exercise on a ramp. For the latter group, patients went through 30 minutes of training therapy and a half-hour of walking exercise on a ramp. All participants had five training sessions each week for four weeks. For measurement, a GAITRite system was used to examine temporal parameters, spatial parameters, and functional ambulation performance before and after the training. [Results] Regarding temporal parameters, step time, double support, and stance phase decreased more significantly in the experiment group than in the control group after the walking exercise on a ramp, while mean velocity increased significantly. In terms of spatial parameters, step length, and heel-to-heel base of support increased significantly in the experiment group after the walking exercise, and step-to-extremity ratio decreased significantly in the same group. Lastly, FAP rose more significantly in the experiment group than in the control group following the walking exercise on a ramp. [Conclusion] The experiment results showed that PNF-based walking exercise on a ramp is effective in enhancing gait performance. It is expected that the same exercise can be applied to patients of other types of neurological disorders to improve their gait performances.

Key words: Strokes, Proprioceptive Neuromuscular Facilitation, Ramp gait

INTRODUCTION

Stroke patients’ gait requires high energy consumption and physiological burden indexes, and due to changes in movements coordinated among the head, trunk, and pelvis and stability1), plantar pressure caused by weight shifts of the paretic side increase in the lateral direction and decrease in the anteroposterior direction, significantly affecting the patients’ gait ability2). Therefore, gait ability is an important part of rehabilitation in stroke patients. Indeed, in elderly patients and hemiplegic patients, gait abilities become an important rating scale to see individuals’ functional conditions, and their disabilities are minimized through gait training3).

Treatment programs for active recovery of stroke patients’ functions considerably affect the improvement of their gait functions. These programs include slope way gait training. Slope ways are essential facilities used in place of stairways for disabled persons, elderly persons, and pregnant women who cannot use stairways, and they are in a trend of being universalized4). Slope way gait training is also provided as a program to prevent injuries by falls and as a rehabilitation exercise program after injuries5). In studies of slope way walking in normal adults, Yun et al.6) reported that lower extremity muscle activity increased and, Yi and Kim7) reported that walking speeds increased along with treadmill slope angles. In a study on stroke patients, Hesse et al.8) reported that strides and walking speeds increased along with treadmill slope angles.

Methods of improving stroke patients’ gait function include proprioceptive neuromuscular facilitation (PNF)9). This method stimulates proprioceptive organs in muscles and tendons to improve functions, increase muscle strength, flexibility, and balance, and increase coordination10), and thus this method is effective for training motor units to react maximally11). Thus far in studies of PNF in hemiplegic patients, PNF lower extremity patterns have been used to show improvement in step lengths, walking time, and walking speeds12–15).

The aim of the present study was intended to examine the effects of slope way gait training applied with the PNF technique, which is effective in reinforcing muscle strength and retraining muscles necessary for independent gaits in hemiplegic patients on gait ability in hemiplegic patients.

SUBJECTS AND METHODS

Subjects

This study was conducted in a hospital located in Daegu
Metropolitan City, from January 1 to January 31, 2012. Forty stroke patients who had been diagnosed with the disease by computed tomography (CT) or magnetic resonance imaging (MRI) at least six months previously were allocated randomly and equally to an experimental group and a control group. A sufficient explanation of this study was given to them, and they consented to participate in the study.

Only those whose mini-mental state examination Korean version (MMSE-K) scores were 24 or higher were selected, in order to recruit those patients who were able to walk independently, who did not need drug treatment to mitigate spasticity, who were without flexion contracture of the hip or knee joint, or lower-part flexion contracture of the ankle joint, and who could understand and follow the researchers’ instructions. The general characteristics of both groups are shown in Table 1.

**Methods**

The experiment group and control group went through the walking exercise five times a week for four weeks. The therapy room was kept soundproof, and the indoor temperature was kept at 26±1 °C to maintain a stable condition of paralysis. Participants of both groups had a 30-minute walking training each day on a specially designed ramp that was 10 m by 0.8 m and tilted 10°.

Prior to the walking exercise, participants in both groups received a half-hour of general physical therapy that consisted of a joint exercise, muscle strengthening exercise, and a stretching exercise. Then the experiment group went through a half-hour of PNF-based walking exercise on a ramp conducted by a therapist in the therapy room.

The experimental group stood in front of a gait training machine to receive knee joint flexion, hip joint flexion, adduction, and external rotation training of the affected side from the therapist as part of PNF gait pattern training. In this case, the therapist held the leg above the ankle in the experimental group with one hand and the anterior medial region with the other hand. Then, the therapist issued an oral instruction saying, “Raise your ankle and bend your lower extremity over the diagonal line.” Throughout the movement, the therapist continuously applied resistance against the movement\(^{16}\). The patient performed a walking exercise on the ramp in opposition to the therapist’s pressure. Meanwhile, the control group performed half-hour of walking exercise on the ramp without the PNF pattern.

To analyze temporal parameters, spatial parameters, and functional ambulation performance (FAP) of the patients, a GAITRite system (CIR Systems, Inc. Clifton, NJ, USA) was used, an electronic walking plate (8.3 m by 0.89 m) that has 13,824 sensors (Φ 1 cm) vertically installed at an interval of 1.27 cm to measure components of a gait in an objective and reliable manner\(^{17}\).

A sufficient explanation was given to participants of both groups, and the participant were given a 10-minute break before measurement. The participants stood upright to measure the length of the leg between the back of the major trochanter and the outer ankle bone. To ensure accuracy, the length was measured twice by different examiners, and the average value was used for the GAITRite software. Participants were asked to walk at a comfortable and constant pace. They started walking 3 m before the plate, following the assessor’s oral instruction, walked over the walking plate, and stopped 3 m after the plate. This was repeated three times to calculate the average. To prevent accidents, one of the assessors walked beside patients at a distance that did not affect the patient’s walking.

For data analysis, SPSS Win 12.0 was used. T-test for corresponding samples was conducted to compare temporal and spatial parameters and the FAPs of the two groups before and after the exercise. For comparative analysis between the groups before and after the training, a t-test for independent samples was also conducted. The significance level (α) was set at 0.05.

### RESULTS

Regarding the temporal parameters, both groups showed a significant decrease in step time after the exercise (p<0.05). Also a significant difference was observed between the two groups after the exercise (p<0.05). Regarding double support and the stance phase, only the experiment group showed a significant decrease following the exercise (p<0.05). The difference between the values of the two groups changed significantly after the exercise (p<0.05). In terms of mean velocity, only the experiment group showed a significant increase (p<0.05), and the difference between the values of the two groups changed significantly after the exercise (p<0.05) (Table 2).

Meanwhile, regarding the spatial parameters, both groups showed a significant increase in step length after the walking exercise (p<0.05). Also, significant change was observed in the difference of values between the two groups (p<0.05). The heel-to-toe base of support and the step-to-extremity ratio showed a significant decrease only in the experiment group after the walking exercise (p<0.05), and the difference between the values of the two groups showed a significant change after the training (p<0.05). In terms of FAP, only the experiment group showed a significant increase after the training (p<0.05), and significant change was observed in the difference between of the two groups (p<0.05) (Table 2).

### DISCUSSION

The present study applied a PNF-based walking exercise...
on a ramp for hemiplegia patients in two groups: an experiment group and a control group. The experiment lasted four weeks, and changes in the gait parameters between before and after the walking exercise were observed.

Regarding the temporal parameters, patients in the experiment group showed a significant decrease in step time, double support, and stance phase compared with the control group, and the mean velocity rose significantly following the exercise. Regarding the spatial parameters, patients in the experiment group showed a significant increase in step length and step-to-extremity ratio after the walking exercise, while the heel-to-heel base of support decreased significantly. It is attributed to that the use of lower-limb pattern promoted proprioceptive muscular nerves, which in turn, facilitated walking on the ramp and led to active muscular contraction of the lower limbs and the trunk. These enhanced temporal and spatial gait parameters and the overall gait performance. Holden et al. examined temporal and spatial parameters of the gait in 61 patients with neurological disorders, and reported a range of test-retest reliability between 0.95 and 0.97, and quite a high range of inter-subject correlation reliability (between 0.98 and 1.00).

Yun and Kim showed in a study that walking on a ramp decreased step length and widened step width in order to elderly people to maintain balance. Wall et al. claimed that in walking on an upward ramp, flexion of the hip and knee joint increased during a transition period between the last swing phase and the initial stance period. Also, walking on a ramp led to an increased chest wall in the frontal plane and cross section, and it also affected pace of walking.

Sun et al. reported that walking on a ramp leads to a slower reliability (between 0.98 and 1.00). Yun et al. reported a range of test-retest reliability between 0.95 and 1.00. The present study showed that the PNF-based walking exercise on a ramp enhanced gait performance of stroke patients. Data on temporal parameters and spatial parameters and FAP score could be useful for doctors in validating the effect of rehabilitation. Also, it could be used to estimate functional performance and living quality of stroke patients and provide objective data to evaluate training progress and treatment results of patients with gait disorders.

### REFERENCES

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