Original Article

The effects of ramp gait exercise with PNF on stroke patients' dynamic balance

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J. Phys. Ther. Sci.
27: 1747–1749, 2015

Abstract. [Purpose] This study examined the effects of ramp gait training using lower extremity patterns of proprioceptive neuromuscular facilitation (PNF) on chronic stroke patients' dynamic balance ability. [Subjects and Methods] In total, 30 stroke patients participated in this study, and they were assigned randomly and equally to an experimental group and a control group. The experimental group received exercise treatment for 30 min and ramp gait training with PNF for 30 min. The control group received exercise treatment for 30 min and ground gait training for 30 min. The interventions were conducted in 30 min sessions, three times per week for four week. The subjects were assessed with the Berg balance scale test, timed up and go test, and functional reach test before and after the experiment and the results were compared. [Results] After the intervention, the BBS and FRT values had significantly increased and the TUG value had significantly decreased in the experimental group; however, the BBS, FRT, and TUG values showed no significant differences in the control group. In addition, differences between the two groups before the intervention and after the intervention were not significant. [Conclusion] In conclusion, ramp gait training with PNF improved stroke patients' dynamic balance ability, and a good outcome of ramp gait training with PNF is also expected for other neurological system disease patients.
Key words: Stroke, Proprioception, Ramp gait

(This article was submitted Jan. 16, 2015, and was accepted Feb. 14, 2015)

INTRODUCTION

Stroke patients have difficulty with balance and postural adjustments and increased postural sway. They also shift the center of gravity to the non-paretic lower limb causing asymmetric posture, decreased body balance, and reduced weight movement ability[1)]. The balance ability of hemiplegic patients suffering from stroke is the most important factor for them and their family members, and its improvement is the most important goal of rehabilitation[2)].

An active functional recovery treatment program for stroke patients is ramp gait training. A ramp is provided as a measure to prevent the risk of a fall, and as a rehabilitation program after injury, it is used as a substitute for stairs[3)]. A ramp is an essential facility for those who have difficulty with movement, such as the disabled who cannot use stairs, and elderly people and pregnant women who cannot move about freely[4)]. In a study of ramp use characteristics of healthy adults, Yun et al.[5)] reported that increases in angle height led to increased muscle activity in the lower limb muscles. Yi and Kim[6)] noted that increased ramp height in treadmill training resulted in increased gait speed, and in a study of stroke patients Hesse et al.[7)] observed that slope training using a treadmill improved their stride and gait speed.

A method of enhancing stroke patients' balance ability is proprioceptive neuromuscular facilitation (PNF)[8)]. PNF improves the functions of proprioceptors by stimulating them in the muscles and tendons. It also increases muscle strength, flexibility, and balance[9)], and enhances coordination[10)]. It is effective at eliciting the maximal responses of motor units. Based on theoretical grounds, this study examined the effects of ramp gait training with the PNF technique, which is an effective therapy for the muscle strengthening and retraining necessary for the independent gait of hemiplegic patients, as well as for stroke patients' balance.

SUBJECTS AND METHODS

This study was conducted from August 20 to September 30, 2014 in K hospital located in Daegu Metropolitan City. The criteria for inclusion were: chronic stroke patients who were diagnosed as having stroke resulting from a cerebral hemorrhage using magnetic resonance imaging or computed tomography, whose onset of stroke was at least six months or longer ability to maintain an independent standing posture for 30 s or longer; the ability to walk 30 m or longer alone indoors; the ability to communicate enough and to understand oral instructions given by the therapist; and patients who were not using assistive devices or receiving drug

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therapy of internal medicine for the alleviation of spasticity. The subjects voluntarily agreed to participate in this study, and a written agreement was obtained from them. This study was approved by the University institutional review board and was conducted in accordance with the ethical principles of the Declaration of Helsinki. The total number of subjects was 30 and they were assigned randomly and equally to a control group and an experimental group. Table 1 summarizes the general characteristics of the subjects who participated in this study.

A physical therapist with clinical experience of more than one year conducted the muscle strengthening exercise, range of motion exercise, and stretching exercise, for all subjects. The control group received PNF gait pattern training by the therapist, wherein they walked back and forth over 10 m. This exercise was conducted for 30 min three times per week for four weeks. The experimental group conducted flexion of the knee joint of the paretic side and flexion, adduction, and external rotation of the hip joint of the paretic side. The therapist held the ankle and anterior medial part of the knee of the experimental group and directed, "Raise your ankle and flex the lower limb up the diagonal line". The experimental group moved their paretic lower limb joint to the end of the range of motion at the same time, and to provide the appropriate resistance, the therapist with the right hand placed on the knee joint applied force to the lateral part of the knee and applied resistance to the adduction and external rotation of the hip joint with the other hand[11, 12]. When the subjects exhibited rapid fatigue, respiratory problems, or dizziness during training, the training was stopped immediately and for safety, careful observation and assistance followed[13].

The experimental group received training on a specially devised ramp whose angle of inclination, length, and width were 10°, 10 m, and 0.8 m, respectively, for 30 min per day. Gait training involving traveling back and forth over 10 m was conducted three times per week for four weeks. The subjects received PNF lower extremity gait pattern training with the help of a physical therapist in front of the ramp gait-training device. The training method was the same as that for the control group. When the subjects exhibited rapid fatigue, respiratory problems, or dizziness during training, the training was stopped immediately and for safety, careful observation and assistance were followed[13].

The BBS test is used to evaluate the balance of elderly people and neurological disease patients. It is a functional test that simply evaluates three aspects within a short time, such as postural maintenance, postural adjustment by voluntary movement, and reaction to external perturbation[14]. It has high intra-rater reliability, inter-rater reliability, and internal validity[15]. The BBS test consists of 14 items and each item is scored from zero to four points, giving a maximum possible total score of 56 points. When a subject performs the evaluation items independently or within a fixed time, four points are given[14].

The TUG test is a method of evaluating functional motions, including dynamic balance and gait ability. A subject stands, walks 3 m back and forth, and sits down in the original spot. It can test functional movement in a simple and swift manner. The TUG test measures the time taken to stand from a sitting posture, walk 3 m and return, and sit down in the chair. In this study, it was performed three times and the average value was calculated and recorded. When the time taken is 30 s or longer, the subject has an unstable movement ability, is dependent, and cannot walk outdoors independently. Because the measurement method is simple, it can be easily performed by hemiplegic patients with lower limb disability, and it has a high reliability[16]. FRT is used to evaluate the stability limit and is also a measurement of dynamic balance ability. The measurement method involves subjects standing at a 10 cm distance from a wall on a flat floor, spreading their feet shoulder-width apart in a comfortable standing posture, extending the elbows, flexing the shoulders to 90 degrees, moving the body forward to a maximal extent using the ankle joints only, stretching the body in parallel to a maximal extent, and the distance the end of the middle finger tip has moved is measured[17].

Table 1. General characteristics of the subjects

	CG	EG
Gender (M/F)	5/5	6/4
Age (yrs)	60.5 ± 2.1	62.1 ± 6.2
Height (cm)	161.5 ± 4.9	162.1 ± 3.6
Weight (kg)	60.9 ± 4.1	62.2 ± 6.4
Paretic side (R/L)	5/5	6/4
Onset duration (mon)	12.2 ± 5.2	14.1 ± 7.0

Values are means ± SD; EG: experimental group; CG: control group

Statistical analysis was performed using SPSS 17.0 for Windows. To test of the significance of differences in the results before and after the experiment, the paired t-test was conducted. The independent t-test was performed to test the significance of differences between the groups, before and after the experiment. A statistical significance level of $\alpha = 0.05$ was used.

RESULTS

After the intervension, the experimental group BBS and FRT values had significantly increased ($p<0.05$) and the TUG value had significantly decreased ($p<0.05$). In contrast, the control group's BBS, FRT, and TUG values showed no significance ($p>0.05$). In the comparison of the results of the two groups after the training, a significant difference in the BBS values was found ($p<0.05$) (Table 2).

DISCUSSION

This study examined the effects of ramp gait training with the PNF technique for four weeks on hemiplegic patients' balance ability. Stroke patients have difficulty with gait due to unstable standing balance, the weakening of muscle tone, and abnormal muscular contraction timing[18]. In addition, the shift of much weight onto the non-paretic side lower limb restricts their physical activity because of asymmetric support, stroke patients and decreases weight movement ability[19]. Furthermore, decreases in dynamic balance ability reduce ability to respond appropriately to environmental changes and diverse tasks, and dynamic balance ability is

Table 2. Comparison of the balance ability of the experimental and control subjects

	CG (n=10)		EG (n=10)	
	pretest	posttest	pretest	posttest
BBS (score)	23.1 ± 3.1	23.3 ± 2.3	22.8 ± 2.1	28.1 ± 2.9*[a]
TUG (sec)	51.2 ± 7.3	50.9 ± 7.1	53.4 ± 6.2	48.6 ± 4.6*
FRT (cm)	5.3 ± 2.1	5.4 ± 1.1	6.1 ± 1.3	7.1 ± 2.7*

Mean±SE, * Significant difference from pre-test, $p<0.05$; a significant difference in gains between the two groups, $p<0.05$; EG: experimental group; CG: control group; BBS: Berg Balance Scale; TUG: Timed Up and Go test; FRT: Functional Reach Test

closely related to gait ability[20]. Our results show that after the intervention, the experimental group's BBS and FRT values had significantly increased, and its TUG value had significantly decreased; however, the control group's BBS, FRT, and TUG value significant differences. In addition, there was no significant difference between the two groups after the intervention. This is because the proprioceptive senses of the ankle joints are stimulated more during gait on a ramp than during gait on the ground, or because when flexion of the ankle joints takes place on a ramp, the body's forward and vertical movements occur and balance ability is required to counterbalance the force generated by the lower limbs and align the body.

In one experiment, chronic hemiplegic patients were divided into a proprioceptive sense training group and a visual feedback training group, and the proprioceptive sense group's BBS score increased[21]. Bohannon and Lusardi[22] reported BBS scores increased with age in a proprioceptive training group. In a study by Hwang[23], BBS and TUG values of hemiplegic patients, for whom proprioceptive stimulation was performed, were significantly greater than those of a visual feedback group. Geiger et al.[21] divided the subjects into a proprioceptive training group and a control group, and reported the TUG time of the proprioceptive training group decreased from 23.08 s to 14.62 s. Lee et al.[24] conducted PNF lower limb pattern training for four weeks using elderly people divided into an elastic band group and a control group, and reported the PNF group's FRT values were statistically significantly different; a result which is consistent with the present study results.

In the present study, the balance ability of hemiplegic patients who received ramp gait training with the PNF technique significantly improved. This study provides important material for clinicians. It confirms balance recovery through the PNF technique in rehabilitation training owing to the manual treatment effect based on Dietz's principles[25]. If composite gait training including diverse double tasks is conducted rather than mere lower extremity pattern training with PNF, it should lead to better functional improvement in the gait ability of stroke patients.

ACKNOWLEDGEMENT

This Research was supported by the Korean Nazarene University Research Grants 2015.

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