J. Phys. Ther. Sci.
27: 3699–3701, 2015

Original Article

Effect of coordination movement using the PNF pattern underwater on the balance and gait of stroke patients

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Abstract. [Purpose] To investigate the effect of coordination movement using the Proprioceptive Neuromuscular Facilitation pattern underwater on the balance and gait of stroke patients. [Subjects and Methods] Twenty stroke patients were randomly assigned to an experimental group that performed coordination movement using the Proprioceptive Neuromuscular Facilitation pattern underwater and a control group (n =10 each). Both the groups underwent neurodevelopmental treatment, and the experimental group performed coordination movement using the Proprioceptive neuromuscular facilitation pattern underwater. Balance was measured using the Berg Balance Scale and Functional Reach Test, and gait was measured using the 10-Meter Walk Test and Timed Up and Go Test. To compare in-group data before and after the intervention, paired t-test was used. Independent t-test was used to compare differences in the results of the Berg Balance Scale, Functional Reach Test, 10-Meter Walk Test, and Timed Up and Go Test before and after the intervention between the groups. [Results] Comparison within the groups showed significant differences in the results of the Berg Balance Scale, Functional Reach Test, 10-Meter Walk Test, and Timed Up and Go Test before and after the experimental intervention. On comparison between the groups, there were greater improvements in the scores of the Berg Balance Scale, Functional Reach Test, 10-Meter Walk Test, and Timed Up and Go Test in the experimental group. [Conclusion] The findings demonstrate that coordination movement using the Proprioceptive Neuromuscular Facilitation pattern under water has a significant effect on the balance and gait of stroke patients.

Key words: Coordination movement using the PNF pattern, Balance, Gait

(This article was submitted Jul. 29, 2015, and was accepted Sep. 2, 2015)

INTRODUCTION

Stroke results in impaired blood flow that hinders blood supply to the brain tissue, and this can cause brain damage[1)]. Although stroke patients survive with appropriate emergency measures and early treatment, they may have defects in cognition, perception, language, sensibility, and exercise ability[2)]. Additionally, they may have difficulty in independently performing daily activities owing to physical and mental damage[3)]. Stroke patients exhibit hemiplegia paralysis on either the left or the right side of the body caused by weakening of muscles, and abnormal muscle contractions and movement patterns[3, 4)]. Weakening of muscles and asymmetric posture due to hemiplegia increase posture disturbances and degrade balancing ability, leading to walking difficulties in stroke patients[3, 5)].

Functional approaches, neurodevelopment treatments controlling motion, Proprioceptive Neuromuscular Facilitation (PNF) using a diagonal movement pattern, and dual-task training are being used for improving the balance and gait of stroke patients[5, 6)]. Recent studies reported that aquatic exercises have a positive effect on the neurological functions of stroke patients[7)]. The resistance from water while performing underwater exercises promotes balancing ability by enhancing the muscles of the lower limb and stimulating deep muscle proprioceptors[8, 9)]. Additionally, buoyancy effectively supports body weight and mitigates any shock on the joints[10)].

Coordination movement using the PNF pattern is devised by patterning the upper and lower limbs for exercise[11, 12)]. Movements of the human body occurring in three dimensions through gait and induced motion of the body are analyzed[11)]. Coordination movement using the PNF pattern integrates the patterns of each segment and standardizes them into a coordinated system[12)]. This effectively promotes appropriate posture maintenance, as bilateral exercises in-

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Table 1. General characteristics of subjects

	EG (n=10)	CG (n=10)
Gender (male / female)	5/5	5/5
Age (years)	65.9±6.2[a]	64.1±3.6
Weight (kg)	66.8±5.02	66.4±7.5
Height (cm)	165.9±7.6	165.3±5.3
Paretic side (right / left)	5/5	5/5
Onset (months)	11.3±1.1	12.3±1.3

[a]Mean±SD. EG: Experimental Group, CG: Control Group

Table 2. Comparison of the results of the BBS, FRT, 10MWT, and TUGT between the experimental and control groups

	Group	Pre	Post	D-Value
BBS	EG	42.5±1.1	45.1±1.3*	2.6±1.1[#]
(score)	CG	40.7±1.5	41.6±1.2	0.9±1.2
FRT	EG	18.3±1.1	20.4±0.8*	2.1±1.2[#]
(cm)	CG	18.8±0.9	19.4±1.0	0.6±0.9
10MWT	EG	14.6±1.1	12.6±1.7*	−2.0±1.4[#]
(sec)	CG	14.9±1.1	14.3±0.9	−0.6±1.3
TUGT	EG	18.4±1.2	16.1±1.6*	−2.3±1.6[#]
(sec)	CG	18.5±1.0	18.2±1.0	−0.3±1.0

[a]Mean±SD.
*$p<0.05$: paired t-test, [#] $p<0.05$: independent t-test
D-value: Difference value, EG: Experimental Group, CG: Control Group, BBS: Berg Balance Scale, FRT: Functional Reach test, 10MWT: 10-Meter Walk Test, TUGT: Timed Up and Go Test

volve both sides of the body[13]. Coordination movement using the PNF pattern has been shown to have a positive effect on the balance and gait of stroke patients, and many studies on coordination movement using the PNF pattern have been reported[11–13]. However, studies on the effect of coordination movement using the PNF pattern under water on balance and gait in stroke patients are limited[14–16].

The purpose of this study was to investigate the effect of coordination movement using the PNF pattern under water on balance and gait in stroke patients.

SUBJECTS AND METHODS

The study included 20 individuals diagnosed with stroke by using computed tomography and magnetic resonance imaging more than 6 months previously. The stroke patients were informed of the study objectives and agreed to participate. They were randomly assigned to an experimental group that performed coordination movement using the PNF pattern under water (n = 10; five male and five female patients) and a control group (n = 10; five male and five female patients). The study included stroke patients who had 24 points on the Mini Mental State Examination (MMSE), could independently walk 10 meters, and did not have any visual impairment, visual field defect, and orthopedic disease in the upper and lower limbs. This study complied with the ethical standards of the Declaration of Helsinki, and written informed consent was received from each participant. The ethical committee of Daegu University approved this study. The general characteristics of the participants are presented in Table 1. The mean age, height, weight, and onset time were 65.9±6.2 y, 165.9±7.6 cm, 66.8±5.0 kg, and 11.3±1.1 months in the experimental group and 64.1±3.6 y, 165.3±5.3 cm, 66.4±7.5 kg, and 12.3±1.3 months in the control group, respectively.

Both the groups received neurodevelopment treatment (mat exercise, resistance exercise, postural control exercise, and functional activity exercise) for 30 minutes a day five times a week for 6 weeks. The experimental group additionally performed coordination movement using the PNF pattern underwater at a temperature of 32–34 °C and depth of 100 cm. The coordination movement using the PNF pattern involved the sprinter and skate patterns. In the sprinter pattern, the right upper limb and the left lower limb are in flexion, adduction, and external rotation, and simultaneously, the left upper limb and the right lower limb are in extension, abduction, and internal rotation. In the skate pattern, the right upper limb is in extension, adduction, and internal rotation and the left lower limb is in extension, adduction, and external rotation, and simultaneously, the left upper limb and right lower limb are in flexion, abduction, and internal rotation. The sprinter and skate patterns were required to be maintained for 10 s each from a standing posture in left and right alternation. One set included 10 movements, and a total of five sets were performed. Prior to the experimental intervention, the participants were acquainted with the sprinter and skate patterns through training.

Balance was measured using the Berg Balance Scale (BBS) and Functional Reach Test (FRT). The BBS is divided into three sections (sitting, standing, and changing posture) and includes 14 items. The total score is 56 points and a higher score indicates good balancing ability. The FRT measures the distance between the start and end positions while standing comfortably, raising an arm 90° from the torso, and reaching out without losing balance.

Gait was measured using the 10-Meter Walk Test (10MWT) and Timed Up and Go Test (TUGT). The 10MWT assesses walking speed. The participants walked 14 m, and the time taken to walk 10 m was measured, excluding the first 2 m and last 2 m. The TUGT assesses functional motility. The time taken to sit on an armchair, stand up at the starting signal, walk 3m, and return to the sitting position is measured.

The collected data were analyzed using SPSS 12.0 (SPSS, Chicago, IL, USA). Descriptive statistics were processed using the general characteristics of the participants. The paired t-test was used to compare in-group data before and after the intervention. Moreover, the independent t-test was used to compare the changes in the results of the BBS, FRT, 10MWT, and TUGT before and after the intervention between the groups. The significance level was set at $\alpha=0.05$.

RESULTS

The changes in the results of the BBS, FRT, 10MWT, and TUGT are presented in Table 2. There were significant differences in these results before and after the experimental

intervention. On comparison between the groups, there were greater improvements in the results of the BBS, FRT, 10MWT, and TUGT in the experimental group.

DISCUSSION

This study investigated the effect of coordination movement using the PNF pattern under water on the balance and gait of stroke patients. There were significant differences in the results of the BBS and FRT (used for balance) before and after the experimental intervention. On comparison between the groups, there were greater improvements in the results of the BBS and FRT in the experimental group. Lee et al.[14] and Jeong et al.[15] showed an improvement in balancing ability after applying coordination movement using the PNF pattern in stroke patients. Chol et al.[17] reported that coordination movement using a tapping and PNF combination pattern enhanced the balance of stroke patients. Previous studies differ from the present study in the treatment environment, but the results correspond. Coordination movement using the PNF pattern improves function and enhances balancing ability by stimulating a proprioceptive sense of the muscles and tendons[7, 8]. During coordination movement using the PNF pattern underwater, the water provides resistance and helps to strengthen the muscles[7–9]. In a challenging condition with buoyancy and turbulent currents, muscle fibers are activated to maintain posture and balance, and this is expected to improve balance[7–9].

Gait is the fundamental motion in body movement that requires coordination of the upper and lower limbs and involves continuous and repetitive movements of each segment[18]. Coordination is crucial for functional gait[18]. Stroke patients exhibit an inefficient gait condition with high energy consumption, and they have difficulty in walking independently[19]. In the present study, the results of the10MWT and TUGT (used for gait) significantly differed before and after the intervention in the experimental group. On comparison between groups, the results of the 10MWT and TUGT showed greater improvements in the experimental group. Lee et al.[14] and Jeong et al.[16] showed an improvement in gait ability after applying coordination movement using the PNF pattern in stroke patients. Previous studies differ from the present study in the treatment environment, but the results correspond. Coordination movement using the PNF pattern has been designed by analyzing patterns of interrelated movements of each body segment[11, 12]. It improves posture and balance by efficiently working on the muscles on the paralyzed side and thus improves walking ability[11–13]. An underwater environment promotes joint movement as it decreases gravitational influence[20]. Additionally, it supports 75% of the body weight with buoyancy, and this partial weight support positively influences gait function[20, 21]. The findings of this study indicate that coordination movement using the PNF pattern may be an appropriate therapy method for stroke patients who have problems with gait because of declined weight support and balancing ability.

This study has some limitations. The findings may not be generalizable as the participants were selected using specific criteria. Additionally, no follow up was conducted; therefore, the duration of the effect after the experimental intervention is unknown. Further studies are needed to address these issues

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