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Original Article

Effect of aquatic dual-task training on balance and gait in stroke patients

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Abstract. [Purpose] The purpose of this study was to determine the effect of aquatic dual-task training on balance and gait in stroke patients. [Subjects and Methods] Twenty stroke patients were divided into the experimental (n=10) and control (n=10) groups. Both groups underwent neurodevelopmental treatment. The experimental group additionally underwent aquatic dual-task training for 30 minutes a day, 5 days a week, for 6 weeks. Balance was measured using the Berg balance scale, Five Times Sit-to Stand Test, and Functional Reach Test. Gait was measured using the 10-Meter Walk Test, Timed Up and Go Test, and Functional Gait Assessment. [Results] For intragroup comparison, the experimental group showed a significant change after the experiment in all balance and gait assessment tests. For intergroup comparison, the experimental group showed relatively more significant change after the experiment in all balance and gait assessment tests. [Conclusion] Our results showed that aquatic dual-task training has a positive effect on balance and gait in stroke patients.

Key words: Aquatic dual-task training, Balance, Gait

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INTRODUCTION

Stroke is a disease caused by a lack of blood supply to the brain following ischemia or hemorrhage[1)]. The reduced motility following stroke results in a body imbalance that appears as asymmetric posture, proprioception disorder, and abnormal muscle tone that lead to the degeneration of balancing ability[2)]. Such balance instability causes stroke patients to have a short duration of weight support on the paralyzed side and stride differences between sides, deteriorating physical ability, and slowing gait speed, all of which interrupt daily activities[2, 3)].

To solve such problems concerning balance, walking, and daily activities related to stroke, various treatment methods, such as neurodevelopmental treatment (NDT), proprioceptive neuromuscular facilitation, the Brunnstrom approaches, and motor relearning programs, have been developed[4)]. A superior treatment is yet to be discovered, and other effective treatment approaches are being developed[4, 5)].

Circumstances in which one is required to perform multiple tasks simultaneously frequently occur during daily activities[6)]. Thus, dual-task training focuses on conducting an assignment while performing another task or carrying out more than two tasks constantly[7)]. Yang et al.[6)] argued that gait ability in stroke patients is enhanced after the application of dual-task training. In studies by Hyndman[8)] and An et al.[9)], balance and gait abilities in stroke patients were effectively improved after the use of dual-task training.

Aquatic exercise involves low workload on the lower limbs and has been shown to improve muscle strength, muscle en-

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durance, balance, gait, and cardiovascular endurance[10]. Compared with exercises performed on the ground, aquatic exercise can help patients exercise more consistently and positively affect their emotional state[11].

Although numerous studies on dual-task training have been reported, those investigating its effect on balance and gait in stroke patients are relatively few. Therefore, the purpose of this study was to determine the effect of aquatic dual-task training on balance and gait in stroke patients.

SUBJECTS AND METHODS

This study selected 20 patients with at least a 6-month history of a stroke diagnosis according to findings on computed tomography and magnetic resonance imaging. The patients were randomly arranged to a control (n=10; five males, five females) or experimental (n=10; five males, five females) group. All participants scored >24 points on the Mini-Mental State Examination, were capable of independently walking >10 m, had no visual field effect or handicap, and had no orthopedic disease of the lower limbs. The participants were sufficiently explained the purpose and methods of the experiment and provided consent. This study was approved by the Daegu University Institutional Review Board and conducted in accordance with the ethical standards of the Declaration of Helsinki. The participants' general features are listed in Table 1. Mean age, height, weight, and disease onset in the experimental group were 69.1 ± 3.2 years, 169.3 ± 7.0 cm, 70.8 ± 5.9 kg, and 10.5 ± 1.1 months, respectively. Mean age, height, weight, and disease onset in the control group were 68.0 ± 3.1 years, 168.2 ± 4.9 cm, 69.68 ± 5.6 kg, and 11.3 ± 1.1 months, respectively.

Both groups performed NDT for 30 minutes a day, 5 days a week, for 6 weeks. The experimental group additionally conducted aquatic dual-task training in water with a temperature of 32–34 °C and a depth of 100 cm for 30 minutes a day, 5 days a week, for 6 weeks. Aquatic dual-task training consisted of a stability exercise (standing with eyes closed), stability exercise while conducting an assignment by using the hands (playing catch with the therapist), movement exercise (walking 10 m at a comfortable speed), and movement exercise while conducting an assignment by using the hands (walking 10 m at a comfortable speed while holding a 200-mL cup of water without spilling).

Balance was measured using the Berg Balance Scale (BBS), Five Times Sit to Stand Test (FTSST), and Functional Reach Test (FRT). The BBS consists of sitting, standing, and posture change, with a total of 14 items. The total possible score is 56 points, with a higher score indicating better balance. The FTSST involves sitting on a 43-cm-high chair without leaning the back and repeatedly standing up five times rapidly, with the unaffected arm holding the paralyzed arm. The FRT measures the starting and end points of both arms while holding them up at 90° and standing comfortably, without losing balance.

Gait was measured using the 10-Meter Walk Test (10MWT), Timed Up and Go Test (TUGT), and Functional Gait Assessment (FGA). The 10MWT involves walking 14 m and measuring the time taken for the 10 m in the middle, excluding the first and last 2 m. The TUGT measures the time spent from sitting on a chair with the arms at rest, walking 3 m when a signal is given, walking 3 m back to the chair, and sitting. The FGA assesses posture stability while walking and consists of 10 items. The total possible score is 30 points, with a higher score indicating better gait ability.

The gathered data were analyzed using SPSS version 18.0 (SPSS, Chicago, IL, USA). The patients' general features were analyzed with descriptive statistics. To compare differences within groups before and after the experiment, the paired t-test was conducted. To compare differences between groups before and after the experiment, the independent t-test was conducted. Statistical significance was set as α=0.05.

RESULTS

Differences in the BBS, FTSST, FRT, 10MWT, TUGT, and FGA before and after the experiment are listed in Table 2. On intragroup comparison, the experimental group showed a significant change after the experiment in all balance and gait assessment tests. On intergroup comparison, the experimental group showed a relatively more significant change after the experiment in all balance and gait assessment tests.

DISCUSSION

The purpose of this study was to determine the effect of aquatic dual-task training on balance and gait in stroke patients. The experimental group showed a significant change in balance according to the BBS, FTSST, and FRT after the experiment ($p<0.05$). Compared with the control group, the experimental group showed a relatively more significant change in those balance assessment tests ($p<0.05$). Yang et al.[6] proved that dual-task training positively affects the static balance index of stroke patients. Kim et al.[12] argued that isolating patients from unstable ground and view improves balance ability. An et al.[9] also reported that various dual-task training has a positive effect on balance in stroke patients. Although there were differences in therapeutic environment, advanced studies and this study do have similarities. Aquatic dual-task training reportedly has a positive effect on balance in stroke patients[13]. Aquatic dual-task training uses water resistance to improve muscle strength, thus improving balance ability[13, 14]. The buoyancy of water also supports body weight, increasing posture stability and enhancing balance[10]. Based on these results, aquatic dual-task training is helpful for enhancing balance in stroke patients.

Walking requires massive energy consumption in stroke patients due to their difficulty with independent gait[15]. In this

Table 1. Subjects' general characteristics

	EG (n=10)	CG (n=10)
Gender (male/female)	5/5	5/5
Age (years)	69.1 ± 3.2[a]	68.0 ± 3.1
Weight (kg)	70.8 ± 5.9	69.6 ± 5.6
Height (cm)	169.3 ± 7.0	168.2 ± 4.9
Paretic side (right/left)	5/5	5/5
Onset (months)	10.5 ± 1.1	11.3 ± 1.1

[a]Mean ± SD. EG: experimental group, CG: control group

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

	Group	Pre	Post	D-Value
BBS (score)	EG	41.8 ± 1.6	44.4 ± 1.4*	2.6 ± 1.5#
	CG	39.4 ± 2.2	40.2 ± 1.9	0.8 ± 1.1
FTSST (sec)	EG	18.7 ± 0.9	15.2 ± 1.7*	−3.5 ± 2.1#
	CG	17.9 ± 1.9	17.4 ± 1.6	−0.5 ± 1.0
FRT (cm)	EG	19.5 ± 1.7	22.0 ± 1.3*	2.5 ± 1.5#
	CG	19.7 ± 1.2	20.1 ± 0.9	0.4 ± 0.9
10MWT (sec)	EG	15.9 ± 1.4	12.9 ± 1.9*	−3.0 ± 1.4#
	CG	15.6 ± 1.5	15.1 ± 1.1	−0.5 ± 0.8
TUGT (sec)	EG	22.9 ± 1.3	20.1 ± 1.9*	−2.8 ± 1.3#
	CG	20.4 ± 1.0	20.1 ± 1.1	−0.3 ± 0.9
FGA (score)	EG	18.6 ± 1.1	21.9 ± 1.3*	3.3 ± 1.8#
	CG	19.1 ± 1.5	19.8 ± 1.6	0.7 ± 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; FTSST: Five-Time Sit to Stand Test; FRT: Functional Reach test; 10MWT: 10-Meter Walk Test; TUGT: Timed Up and Go Test; FGA: Functional Gait Assessment

study, the experimental group showed a significant change in gait according to the 10MWT, TUGT, and FGA ($p<0.05$). Compared with the control group, the experimental group showed relatively more significant changes in those gait assessment tests ($p<0.05$). Yang et al.[6] reported that dual-task training is effective for improving gait speed, stride, and time. Studies by An et al.[9] and Kim et al.[16] showed that dual-task training improved gait ability in the experimental group. Although there were differences in the experimental environment, the advanced studies and this study have similar results. Aquatic exercise uses the resistance and buoyancy of water to increase muscle strength and sensory feedback, leading to improved gait ability[14, 17]. The exercise also reinforces the lower limb muscles by involving various muscle activities, leading to significant improvement in gait ability[17, 18]. Therefore, aquatic dual-task training has a positive effect on balance and gait by activating sensory input in stroke patients.

A limitation of this study is that the duration effect cannot be determined due to the short experimental period and lack of follow-up. In addition, control over dual tasks and movement during the participants' daily activities was in sufficient. Finally, the patient sample is not large enough to determine whether the findings can be generalized to other populations. Further research is required to resolve such limitations.

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