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Research Article

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Effects of Gaze Stabilization Exercise and Cognitive Training on Balance and Gait in Subacute Stroke Patients: Randomized Controlled Trial

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| Abstract |

PURPOSE: The purpose of this study was to evaluate the effects of simultaneous application of gaze stabilization exercise and cognitive training on the balance and gait ability in subacute stroke patients.

METHODS: Thirty-five patients diagnosed with stroke within 3-6 months were randomly assigned, and the experimental group (n = 18) to which both gaze stabilization exercise and cognitive training were applied and the control group (n = 17) to which only gaze stabilization exercise was applied were targeted. It was performed for 30 minutes at a time, three times a week, for a total of 4 weeks. Berg Balance Scale, Timed Up and Go test, 10Meter Walking Test, and Walking symmetry were evaluated.

RESULTS: In the comparison of changes between Berg Balance Scale, Time Up and Go test, 10 Meter Walking Test, and Gait symmetry, both experimental and control groups showed significant differences before and after the intervention, and in the evaluation of Gait symmetry, significant differences between groups.

CONCLUSION: As a result of this study, when gaze stabilization exercise and cognitive training were allied simultaneously, it was possible to improve the balance and gait ability of subacute stroke patients, and had a more significant effect on gait ability. In considered that training that simultaneously applies gaze stabilization exercise and cognitive training can be presented as a balance and gait rehabilitation for stroke patients on the future.

Key Words: Balance, Cognitive training, Eye movement, Gait, Stroke

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Ⅰ. Introduction

Stroke is a disease that ranks second to third among the causes of death in Korea [1]. Hemiplegia, one of the stroke symptoms, reduces balance ability due to asymmetric posture, and is easily exposed to fall down due to difficulty in postural control [2]. This has a negative effect on the performance of activities of daily living in stroke patients [3], and there may be a limitation in activity and participation [4,5]

Stroke patient balance is one of the abilities that must be improved to reach rehabilitation goals. In stroke patients, there is a problem with balance due to the negative combination of sensory information and motor nerves accepted for posture control [6,7]. and injuries of sensory and motor functions decrease weight shift, asymmetric posture alignment, and movement control becomes difficult [8,9,10]. They also have difficulty changing directions when walking, and they easily lose balance when turning their heads or turning their bodies [11]. This balance disorder interrupts the activities of daily living and function recovery of stroke patients, causing an increase in fall down risk [12].

After stroke, 30% experience visual problems, up to 70% experience visual problems with occipital lobe damage, and the most common symptoms are decreased visual field and difficulty in visual perception [13]. Stroke patients are reported to be caused by abnormal large and inconsistent head and gaze movements compared to normal people, which are caused by sensory defects, including ecological factors and changes in vestibular eye reflexes [14]. In a previous study, when 64 elderly people were subjected to gaze stabilization exercise for 10 weeks, gaze stabilization exercise had a positive effect on the static and dynamic balance of the elderly compared to functional exercise [15], In another previous study, when eye movement and gaze stabilization exercise were performed on 41 young people for 3 weeks, it was found that active head rotation and dynamic vision improvement had a positive effect on posture stabilization [16]. In the case of stroke, there are some types that have reported that vision can be improved by natural recovery, but eye muscle damage caused by stroke is rarely cured without treatment [13]. Improving the balance and gait ability of stroke patients is an important rehabilitation goal. In order to achieve this, it is believed that the risk of fall down is low, and intervention using gaze stabilization exercise that can be easily accessed in everyday life and can be used as a home exercise program is considered necessary.

Cognitive disorder is exposed to the risk of dementia, shows a decrease in mobility [17], and has a high fall down rate due to a decrease in balance [18]. According to previous studies, it can be seen that there is a relationship between cognitive and balance, and accordingly, it is believed that interventions for cognitive recovery to improve balance and gait ability of stroke patients should be carried out together [19].

There are previous studies that show that gaze stabilization exercise affects balance ability, and various individual studies have been reported that cognition is also one of the factors affecting balance. Nevertheless, research on applying gaze stabilization exercise and cognitive training as dual tasks to subacute stroke patients is insufficient. Therefore, this study aims to investigate the effect of eye stabilization exercise and cognitive training on balance and gait ability of subacute stroke patients as a double task, and to provide an effective intervention method for the treatment of stroke patients in clinical practice.

Ⅱ. Methods

Based on the selection criteria, this study was conducted with 40 stroke patients who were hospitalized at a rehabilitation hospital in Daegu. The purpose and method of the preliminary study were explained to all subjects, and those who wanted to participate voluntarily were asked to participate in this study after completing the agreement, and the subjects were approved by the Research Ethics Committee of Daegu University (IRB: 1040621-202307-HR-059).

The criteria for inclusion of the study subjects are, first, those within three to six months of being diagnosed with a stroke, Second, those who can walk independently for more than 10 meters regardless of whether or not they use a cane [20], and, Third, those with a score of 21 or higher in the Korea Mini-Mental State Examination (K-MMSE) [21]. Severe internal medicine diseases, infections, peripheral vestibular organ disorders, orthopedic diseases or people with visual and hearing impairments, and those who took drugs affecting balance 24 hours before this study were excluded.

After accurately explaining the contents of the experiment and signing the consent form, general characteristics such as gender, age, weight, height, Korea mini-mental state examination score, onset time, stroke type, and damage were measured. Subjects were each given 20cards and each was randomly selected. Subjects with a "1" card were assigned to the experimental group (n = 20), and subjects with a "2" card were assigned to the control group (n = 20). During the study period, five of the subjects were discharged from the hospital, and a total of 35 subjects were tested in the experimental group (n = 18) and the control group (n = 17).

1. Interventions

In the experimental group, gaze stabilization exercise and cognitive training were performed as dual tasks, and in the control group, only gaze stabilization exercise was performed. Gaze stabilization exercise was performed with reference to research by Morimoto et al and Pimenta et al [22,23]. The subject relaxed the eye muscles through eye movements before and after gaze stabilization exercise, and warmed up by moving the eyes up, down, left, and right. Gaze stabilization exercise performed a total of six

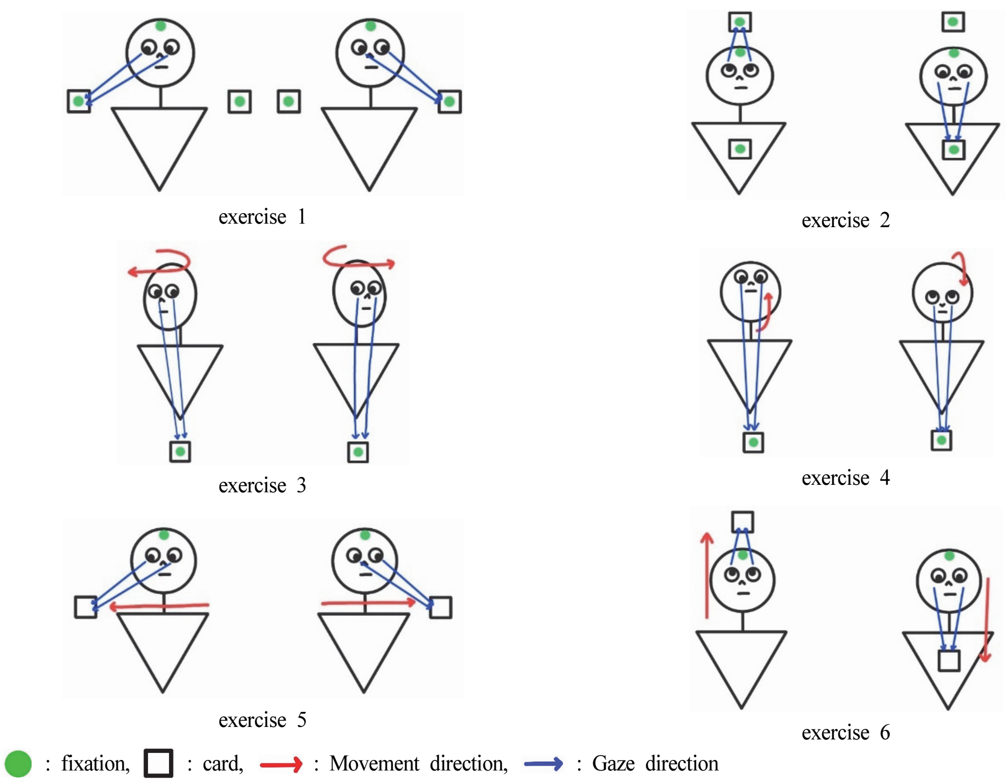

Fig. 1. Gaze stabilization exercise.

exercises by performing three exercises in the horizontal and vertical directions. Exercise 1 and 2 saccadic eye movement executions were carried out in a way that the cards fixed to both sides were viewed left and right/up and down with the head fixed. Exercise 3 and 4 adaptation times were performed by turning the head left and right/up/down and looking at a fixed card in front of the face. Exercise 5 and 6 smooth pursuit exercise was performed by tracking one card moving left and right/up/down with the head fixed (Fig. 1).

When performing exercise 1, 2, 5 and 6 the visual field was measured by performing a confrontation visual field test. When testing one side, the other eye was covered with the palm of the hand. The subject looks at a central fixation point, and the therapist moves the finger from the far side to the center and suggests numbers with the finger. Ask the patient to say when they first see the target. Interventions were performed by measuring both side. The above exercise was maintained for 5 seconds per movement, and after 10 times each of the left and right, 2 sets of 6 movements were performed 20 times through rest for 30 seconds. If the patient felt dizziness or discomfort during gaze stabilization exercise, the intervention was immediately stopped and the subject took sufficient rest in a comfortable position. At this time, a therapist was nearby to check the subject's condition. When performed as above, it takes 26 minutes, and interventions were performed for a total of 30 minutes including warm-up and cool-down 4 minutes. Since cognitive training was applied at the same time as eye stabilization exercise, we chose a training method that is not difficult to answer. It was conducted by referring to the questionnaire of the Korea version of Mini-Mental State Examination [24], and during the gaze stabilization exercise, it was conducted by asking and answering questions with orientation, attention and calculation, and language function. In orientation, time was asked to answer questions such as year, month, day, date, and season, and the place was asked to answer questions such as town and place, and in attention and calculation were conducted with single-digit addition, single-digit subtraction, and consecutive questions of subtracting 7 from 100. In language, it was conducted by name, age speaking and word speaking, word speaking related to the word on the card, speaking word backwards, word chain, speaking word related to color, and three words speaking according to the classification.

2. Outcome Measures

1) Berg Balance Scale (BBS)

The berg balance scale was used to evaluate the static and dynamic balance of the subjects and the risk of fall down. Sitting, standing, and posture changes, each of the 14 questions consists of 0 to 4 points, and a total of 56 points. This measurement tool has high reliability and validity with an intrarater reliability r = .99 and an interrater reliability r = .98 [25].

2) Timed Up and Go Test (TUG)

The timed up and go test was used to evaluate the subjects functional mobility and balance. Subjects were required to stand up from a chair with armrests, walk 3m, turn around, return to the chair, and sit down. The time it took to complete this task was measured with a stopwatch. Subjects were asked to walk as fast as possible, and the average value was used after three trials. The Interrater reliability of this measurement tool is r = .99 and the Interrater reliability is r = .98 [26].

3) 10Meter Walking Test (10MWT)

The 10meter walking test was used to evaluate the subjects gait ability. The therapist measures the time with a stopwatch while the subject walks to a 10M mark on a flat surface. To increase accuracy, each 2M at the beginning and end was viewed as an accelerator and a decelerator, and the time of 6M was measured excluding the accelerator and decelerator. Subjects were asked to walk as fast as possible, and the average value after three trials was used. The reliability of this measurement tool is ICC = .89-1.00 [27].

4) Gait Symmetry

Zebris pressure platform treadmill (zebris FDM-T, Germany) was used to measure the subjects Gait symmetry. Mat with 10,240 pressure sensors attached under the treadmill belt. The pressure transmitted to the sole of the foot when the subject walks on the treadmill is recorded at a rate of 120Hz. The input pressure sensor signal displays the measurement values of spatio-temporal with center of pressure (COP) in 2D and 3D graphs [28]. In Zebris FDM-T, the butterfly diagram analyzes the movement of COP during the step cycle and forms a typical butterfly-shaped diagram excluding the double stance section. In the diagram, Gait symmetry was measured through horizontal symmetry values that represent the horizontal distance from the two feet of COP to the center point where they intersect. The subjects held the treadmill handle barefoot and walked for 1 minute at the speed at which the subject felt comfortable. The reliability of this measurement tool is ICC = .86 [28].

3. Data Analysis

The collected data was analyzed using the SPSS (statistical package for the social sciences) version 20.00 for window software (SPSS Inc. Chicago) program. The general characteristics of the subjects were chi-square test for categorical variables and independent t-test for continuous variables. A normality test was performed to determine the normal distribution. The Independent t-test was performed using difference values to examine differences between groups, the Paired t-test was performed to examine differences within groups. The level of statistical significance was set at $p < .05$.

Ⅲ. Results

There was no significant difference between groups on the general characteristics of the subjects who participated in this study ($p > .05$) (Table 1). As a result of Berg Balance Scale and Time Up and Go tests to measure balance ability, there was a significant difference between the two groups in the comparison before and after the intervention ($p > .05$), but there was no significant difference between the groups ($p > .05$) (Table 2, Table 3) . As a result of 10Meter Walking Test to measure gait ability, there was a significant

Table 1. General characteristics of the subjects (n = 35)

Characteristic	EG (n = 18)	CG (n = 17)	p/x²
Age (year)	59.28 ± 12.02[a]	60.00 ± 15.20	.877
Weight (kg)	72.78 ± 16.26	62.76 ± 14.34	.063
Height (cm)	168.67 ± 8.58	164.35 ± 10.12	.182
K-MMSE (score)	26.83 ± 3.46	26.23 ± 3.32	.607
Onset time (month)	4.11 ± .83	4.06 ± .89	.859
Gender (male/female)	15/3	9/8	3.747
Stroke type (Infarction/Hemorrhagae)	10/8	10/7	.038
Affected side (left/right)	5/13	9/8	2.307

[a] Mean ± SD, EG: gaze stabilization and cognitive exercise, CG: gaze stabilization exercise, *p < .05

difference between the two groups in the comparison before and after the intervention (p > .05), but there was no significant difference between the groups (p > .05) (Table 4). In the Gait symmetry comparison, there were significant differences between the two groups before and after the intervention (p < .05), and there were also significant differences in the comparison between the groups (p < .05) (Table 5).

Table 2. Changes of BBS score between two groups (M ± SD) (unit: score)

	Pre	Post	Difference value	t	Change rate(%)	p
EG	46.77 ± 8.66[a]	48.77 ± 6.56	2.00 ± 3.28	-2.57	4.10	.020*
CG	44.05 ± 10.07	45.88 ± 9.06	1.82 ± 3.32	-2.26	3.98	.038*
t	.858	1.087	.158			
p	.397	.285	.876			

[a] Mean ± SD, EG: gaze stabilization and cognitive exercise, CG: gaze stabilization exercise, BBS: Berg Balance Scale, *p < .05

Table 3. Changes of TUG score between two groups (M ± SD) (unit: sec)

	Pre	Post	Difference value	t	Change rate(%)	p
EG	21.87 ± 12.70[a]	18.09 ± 11.49	-3.77 ± 2.94	5.44	20.89	.000*
CG	20.75 ± 14.97	17.51 ± 12.33	-3.24 ± 6.05	2.21	18.50	.042*
t	.237	.143	-.335			
p	.814	.887	.740			

[a] Mean ± SD, EG: gaze stabilization and cognitive exercise, CG: gaze stabilization exercise, TUG: Timed Up and Go test, *p < .05

Table 4. Changes of 10MWT score between two groups (M ± SD) (unit: sec)

	Pre	Post	Difference value	t	Change rate(%)	p
EG	14.91 ± 9.89[a]	10.73 ± 7.95	-4.18 ± 4.10	4.32	38.95	.000*
CG	14.73 ± 9.81	12.44 ± 8.63	-2.28 ± 1.80	5.24	18.40	.000*
t	.053	-.611	-1.747			
p	.958	.545	.090			

[a] Mean ± SD, EG: gaze stabilization and cognitive exercise, CG: gaze stabilization exercise, 10MWT: 10Meter Walking, *p < .05

Table 5. Changes of Gait symmetry score between two groups (M ± SD)

	Pre	Post	Difference value	t	Change rate(%)	p
EG	22.11 ± 16.96[a]	13.80 ± 12.39	-8.31 ± 6.44	5.47	60.21	.000*
CG	16.02 ± 13.90	12.26 ± 10.64	-3.75 ± 6.43	2.40	30.66	.028*
t	1.158	.392	-2.093			
p	.255	.697	.044*			

[a] Mean ± SD, EG: gaze stabilization and cognitive exercise, CG: gaze stabilization exercise, *p < .05

Ⅳ. Discussion

The purpose of this study was to investigate the effect of applying gaze stabilization exercise and cognitive training as a dual task for improving balance and gait ability of subacute stroke patients. A total of 35 patients with subacute stroke within 3-6 months were simultaneously subjected to gaze stabilization exercise and cognitive training in 18 experimental groups, and only gaze stabilization exercise was performed in 17 control groups. It was conducted three times a week for four weeks, and we tried to find out the changes in balance and gait ability through comparison between groups. BBS and TUG were used to evaluate balance ability, and 10MWT and Walking symmetry were used to evaluate gait ability.

Both the experimental group and the control group performed BBS and TUG to find out the balance ability, and showed a significant effect before and after the intervention ($p < .05$). Pimenta et al reported that when eye movement was applied to adult hemiplegia patients, it showed positive improvement in balance ability [29], Correia et al supports this study by reporting that gaze stabilization during walking affects balance changes by controlling the movement of the head, trunk, and pelvis during walking [30]. Roh & Lee reported that eye stabilization exercise affects cognition and balance, and balance and cognition are related [31]. Choi et al supports this study as he reports that dual work of training and cognitive function that can improve balance and cognitive function improves balance because cognitive and motor functions in stroke patients have a complex disability [32].

In the 10MWT conducted to determine gait ability, both the experimental group and the control group showed significant effects ($p < .05$). In the Gait symmetry, both groups showed significant effects ($p < .05$), and there was also a significant difference in comparison between groups ($p < .05$). Zhao et al conducted gaze stabilization exercises on 40 stroke patients, and the experimental group that performed gaze stabilization exercise showed a significant effect compared to the control group that only performed general physical therapy ($p = .025$) [33], These results are consistent with the results of this study, which reported that proprioception on the affected side was stimulated, resulting in increased pressure center (COP) movement, which improved body weight and ability to stand on one leg, resulting in significant improvement in balance and gait ability. Jung & Won support this study because we report that dual tasks that applying both cognitive training and movement exercises in chronic stroke patients showed more significant improvements in balance and gait ability [34].

In this study, when comparing before and after the Gait symmetry intervention measured to determine gait ability, there was a significant effect within the group ($p < .05$), and there was also a significant effect in the comparison between the groups ($p < .05$). When comparing before and after BBS, TUG, and 10MWT, the group that applied both gaze stabilization exercise and cognitive training showed a greater rate of change than the result of the gaze stabilization exercise group, but the intervention period was as short as 4 weeks, so there was no significance between the groups. Taking the above results together, it can be said that the simultaneous application of gaze stabilization exercise and cognitive training has a positive effect on the balance and gait ability of subacute stroke patients, and it was found to have a more significant effect when both gaze stabilization exercise and cognitive training were applied in Gait symmetry. Ji et al reported that dual task training was more effective in improving balance and gait ability when applied to subacute stroke patients than simple task training [35], Through these preliminary studies and the results of this study, it is hoped that the simultaneous application of gaze stabilization exercise and cognitive training can be used as more effective treatments for rehabilitation of stroke patients.

In this study, comparison of changes between Berg

Balance Scale, Time Up and Go test, 10 Meter Walking Test, and Gait symmetry, both experimental and control groups showed significant differences before and after the intervention, and in the evaluation of Gait symmetry, significant differences between groups. As a limitation of this study, first, gaze stabilization exercise was performed three times a week for four weeks to evaluate the effectiveness, so the effectiveness of the long-term treatment could not be determined and the continuity of the effect could not be confirmed because follow-up tests were not performed. Second, there is a limitation that it is difficult to generalize to all stroke patients by implementing it only to those who meet the selection criteria of this study among subacute stroke patients. Third, these treatments were unable to control the subjects' daily lives during the experiment, and they may have affected their balance because they underwent conventional inpatient treatment, neurodevelopmental treatment (NDT). Finally, cognitive training used in this study used low-difficulty test items that can be easily answered. This study was conducted on subjects with a score of 21 or higher in Korea Mini-Mental State Examination (K-MMSE), and did not reach the level of difficulty enough to stimulate the subject's cognitive function. In future studies, it is believed that various and continuous studies are needed to improve the quality of life through rapid and effective rehabilitation treatment of stroke patients by supplementing these limitations.

Ⅴ. Conclusion

The purpose of this study was to compare the balance and gait ability of subacute stroke patients in the group that applied both gaze stabilization exercise and cognitive training and the group that only performed gaze stabilization exercise. Through this study, it was proved that applying both gaze stabilization exercise and cognitive training can lead to a positive effect of balance and gait ability in subacute stroke patients. In the future, it is believed that balance and gait rehabilitation treatment and home exercise programs for stroke patients can present a dual task intervention of gaze stabilization exercise and cognitive training.

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