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Effects of White Noises on Gait Ability of Hemiplegic Patients during Circuit Balance Training

This study examines the effects of different environments on the application of hemiplegia patients circuit balance training. Group 1 performed circuit balance training without any auditory intervention Group 2 performed training in noiseless environments and Group 3 performed training in white noise environments. First, among lower extremity muscular strength evaluation items, maximum activity time(MAT) was not significantly different(p>.05). Maximum muscle strength(MMS) increased significantly in Group 3(p<.01), there was no significant difference in MMS among the groups. Average muscle strength(AMS) indexes also significantly increased in Group 3(p<.01), there was no significant difference in AMS among the groups. Second, among balancing ability evaluation items, Berg's balance scale(BBS) scores significantly increased in all groups(p<.05), BBS scores were significantly difference among the groups. Based on the results, Group 1, 2 and Group 1, 3 showed significant increases (p<.05). Functional reach test(FRT) values significantly increased in Group 2, 3(p<.05), and there was no significant difference in FRT values among the groups. Timed up and go(TUG) test values significantly decreased in Group 2, 3(p<.05), and there was no significant difference in TUG test values among the groups. Third, among walking speed evaluation items, the time required to walk 10m significantly decreased in all groups(p<.05), and there was no significant difference in the values among the groups. Average walking speeds showed significant increases in Group 1, 3(p<.05), and there was no significant difference in the values among the groups. Based on the results of this study, noise environments should be improved by either considering auditory interventions and noiseless environments, or by ensuring that white noise environments facilitate the enhancement of balancing ability.

Key words: *White Noise; Circuit Balance Training; Gait Ability*

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INTRODUCTION

Stroke patients are at high risk of injuries from a fall or secondary damages due to balance disorder resulting from cognitive function decrease, orientation disturbance, reduction in motor ability, and decrease in proprioceptive and position senses(1).

Balance involves integration of visual, auditory, and vestibular stimuli and those delivered by proprioceptive and sensory receptors in the central nervous system, and functional factors such as visual spatial recognition, muscle tone that responds to environmental changes swiftly and precisely, muscle strength, endurance, and joint mobility engage in balance; Disorder in one of these factors may result in loss of balance performance ability(2, 3).

Reactions to auditory stimuli are different from those to visual or olfactory stimuli. Repetitive auditory stimuli are delivered to the reticular formation of brainstem without the cognitive process directed by the cerebral cortex, thereby resulting in body movements through nerve cells of the spinal cord motor system(4, 5).

The brain areas involving concentration include the prefrontal lobe, posterior cortical, and thalamic areas(6). Hemiplegic patients needed to exert concentration in order to maintain their postures(7) and subacute stroke patient's postural stability was in proportion to their visual and auditory concentration(8). In high intensity noises, their intensity itself was a very important variable in task performance but in low intensity noises, their predictability more greatly influenced task performance than their intensity; auditory stimuli like white noises with repetitive frequency wave forms in a general noise environment of between 60dB and 80dB increased concentration and adaptability, thereby resulting in improved task performance(9). Therefore, auditory stimuli that help to improve concentration may significantly influence balance adjustment or motor learning in patients with hemiplegia resulting from stroke and environmental constraints to motions should be considered in a motor learning process(10).

Meanwhile, a circuit walking program be applied to stroke patients in order to improve balance, mobility, muscle strength, and function activities(11). Circuit training was conducive to increasing muscle strength as one of exercises recommended for stroke patients (12). Training patients on tasks appropriate for them in a lump is an effective and clinically easy way to apply task-oriented training(13, 14, 15). Diverse elements are included in a treatment environment: the size of treatment space, intensity of illumination, and moving line(10). Noise is also one of important elements. However, there is no environmental regulation for rehabilitation treatment and facilities of treatment rooms are equipped without any clear standard. In particular, there has been some research on interior design or environmental composition of play therapy rooms for children(16), but relevant studies on adults or the elderly are lacking.

Accordingly, this study aimed to examine effects of circuit balance training on lower limb muscle strength, balance adjustment capabilities, and gait velocity of hemiplegic patients in a general noise environment, artificial no-noise environment, and white noise environment which has been proven to enhance concentration and efficient muscle movements, and to provide basic materials for future environmental regulations on treatment rooms.

METHODS

Subjects

The subjects were 25 patients who were hospitalized at E long term care hospital located in Jinju-si and voluntarily consented to participate in this study. They were assigned to one of three groups; they were made to be homogeneous as much as possible in consideration of the subjects disease durations. The group 1 was trained without auditory intervention during circuit balance training. The group 2 was trained under a non-noise environment. The group 3 was trained under a white noise environment. The criteria for selection as a subject were: chronic patients who were diagnosed with hemiplegia caused by stroke and whose onset period ranged from six months to 24 months; those who did not have cognitive impairment, with their Korean mini-mental state examination(K-MMSE) scores at 24 points or higher; and those who had no auditory impairment within the recent two years; and those who did not use any aid or were able to walk 10m with an aid.

Procedure

Sufficient explanation on the circuit balance training was made to physical therapists with at least three years of working experiences and how to conduct it was shown to them. The same physical therapists applied training to the subjects for 7 weeks. The researcher referred to the circuit balance training program proposed by Carr and Shepherd(17) and the subjects were made to conduct six different tasks. For five minutes prior to the initiation of this training, the subjects conducted warm-up exercise for themselves. They took a rest for 1 minute between tasks in order to minimize their fatigue. They performed training 5 times per week for a total of 7 weeks. When necessary, the intensity of tasks was heightened in consideration of the subjects conditions. The 6 exercises were: 1) sitting down on and standing up from a mat of diverse height; 2) standing on a balance board; 3) walking on a treadmill; 4) walking following patterns on the ground; 5) going up and down the stairs of 7cm height each; 6) throwing a sand bag on a treatment ball. Each group's changes in the results prior to and after the program were compared and analyzed.

Measurement

A double-blind clinical test was performed regarding all functional evaluations. Two physical therapists who received training in advance conducted measurements and calculated mean values.

Measuring L/E muscle power

Walking Man II(CyberMedic Inc., Korea) was used to measure lower limb muscle strength. The rectus femoris among the quadriceps which it was easy to apply electromyography was selected as a measurement area. For maximum isotonic contraction, the subject sat on a backless mat of knee height and bended the trunk sidebending with the knee joint at 90 degrees and stretched and maintained the knee of the affected side. A surface electrode was used as a recording electrode. In order to minimize skin resistance, the attachment area was washed with alcohol. The connection cable jacks were connected to the cable in the order of red, black, and gray ones. 3 items maximum activity time(MAT), maximum muscle strength(MMS), and average muscle strength(AMS) were statistically analyzed.

Measuring balance control ability

The Berg balance scale(BBS), functional reach test(FRT), and timed up and go test(TUG) were performed to evaluate the subjects dynamic balance, standing postural balance, and gait balance, respectively.

Measuring gait speed

For gait speed, 10m-timed walk test was performed; the time taken to walk 10m and average velocity were estimated.

Data Analysis

The collected data were encoded and SPSS 18.0 was used for statistical analysis. A non-parametric test was carried out to analyze post-training changes in the evaluated items. A Wilcoxon signed ranks test was conducted to examine each groups post-training changes in muscle strength of the lower extremity of the affected side, balance adjustment capabilities, and gait velocity. The Kruskal Wallis test was used to compare post-training changes in the evaluated items between the groups. The Bonferroni post hoc test was applied to significantly different results among the groups. The results of this study were presented α=.05 was considered statistically significant.

RESULTS

General Characteristics of Subjects

The subjects average age was 67.29±12.51 years old in the group 1, 67.33±7.94 years old in the group 2, and 64.67±10.71 in the group 3. Their onset duration was 19.14±5.43 months in the group 1, 22.00±2.40 months in the group 2, and 21.78±2.64 months in the group 3(Table 1).

Table 1. General characteristics of subjects (Mean±SD)

	Group		
	Group 1	Group 2	Group 3
Age(yrs)	67.29±12.51	67.33±7.94	64.67±10.71
Onset duration (months)	19.14±5.43	22.00±2.40	21.78±2.64
K-MMSE(score)	27.71±1.89	28.44±1.88	28.11±1.45

Changes in L/E Muscle Power

Changes in lower extremity muscle strength of the affected side after the training were examined and the result was that MAT increased in the groups 1 and 2 but decreased in the group 3, which was not statistically significant(Fig. 1).

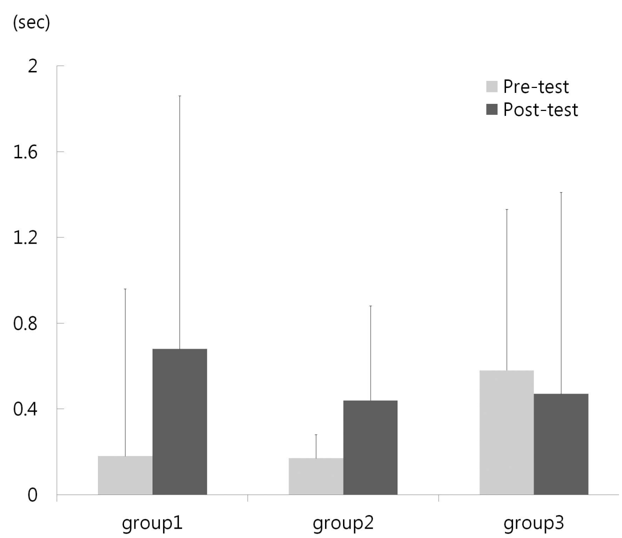

Fig. 1. Changes in MAT

MMS showed no statistically significant changes in group 1 and 2 but group 3 showed their MMS values significantly increase from 66.00±77.60㎶ to 93.78±92.80㎶($p<.01$)(Fig. 2).

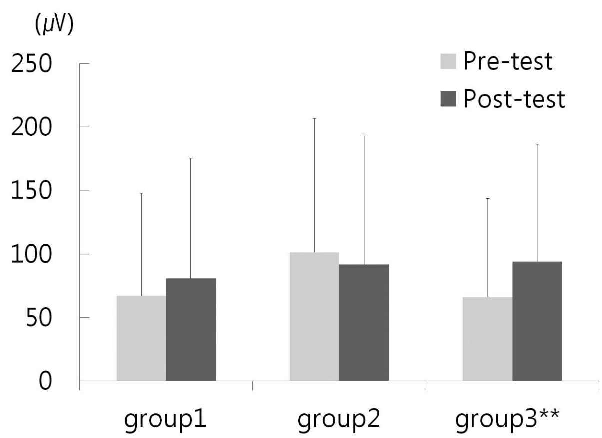

Fig. 2. Changes in MMS

**: p<.01

AMS did not significantly differ between prior to and after the training in group 1 and 2 but it significantly increased after the training from 50.67±6.84% to 57.22±8.09% in group 3($p<.01$)(Fig. 3).

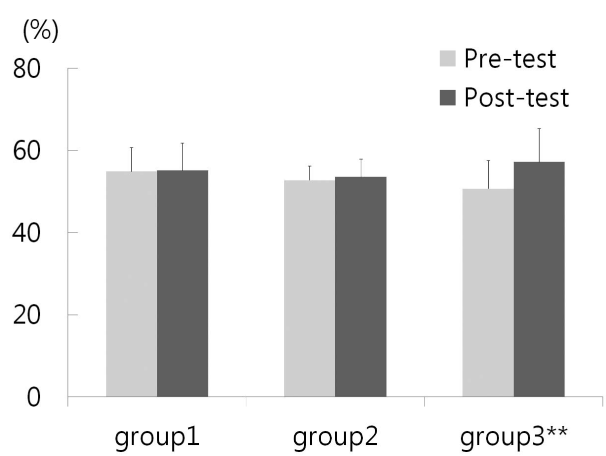

Fig. 3. Changes in AMS

**: p<.01

Changes in Balance Control Ability

Changes in balance adjustment capabilities after the training were examined and the result was that BBS scores significantly increased from 31.00±8.35 points to 33.00±8.04 points in group 1($p<.05$), from 34.78±10.27 points to 41.56±5.83 points in group 2($p<.01$), and from 31.33±7.42 points to 45.11±4.51 points in group 3($p<.01$)(Fig. 4).

After the 7 weeks training, balance adjustment capabilities of the 3 groups were compared and analyzed, with significant increases in BBS and in group 1 and 3 and group 2 and 3 in the post hoc test result.

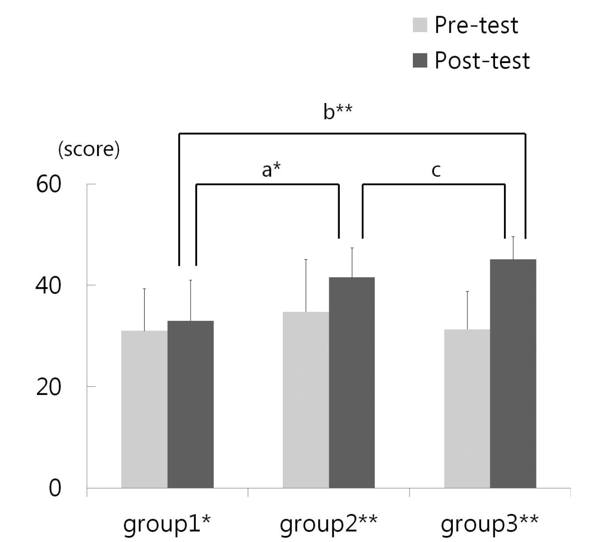

Fig. 4. Changes in BBS

*: p<.05, **: p<.01

a: between–groups (group1 & group2)
b: between–groups (group1 & group3)
c: between–groups (group2 & group3)

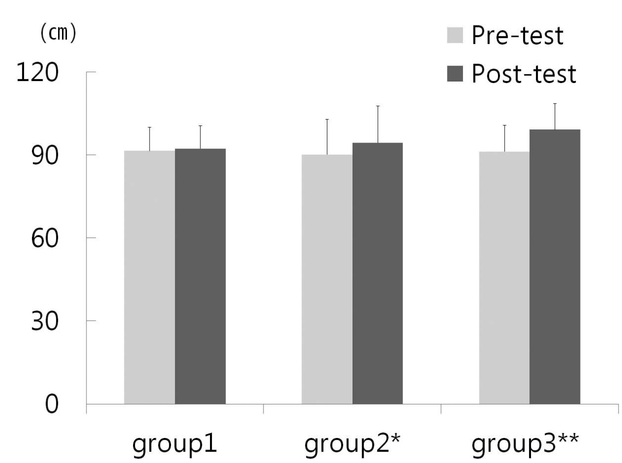

Fig. 5. Changes in FRT

*: p<.05, **: p<.01

FRT of group 1 increased after the training but the change was not statistically significant. On the other hand, after training FRT significantly increased from 90.16±12.67cm to 94.44±13.28cm in group 2(p<.05) and from 91.25±9.52cm to 99.17±9.45cm in group 3(p<.01)(Fig. 5).

The TUG of group 1 slightly decreased after the training and the change was not statistically significant. The TUG of group 2 was 43.00±25.75 seconds prior to the training statistically significantly decreased to 39.87±26.28 seconds(p<.05). Likewise, the TUG of group 3 also statistically significantly decreased from 49.00±18.44 seconds to 30.85±12.74 seconds after the training(p<.01)(Fig. 6).

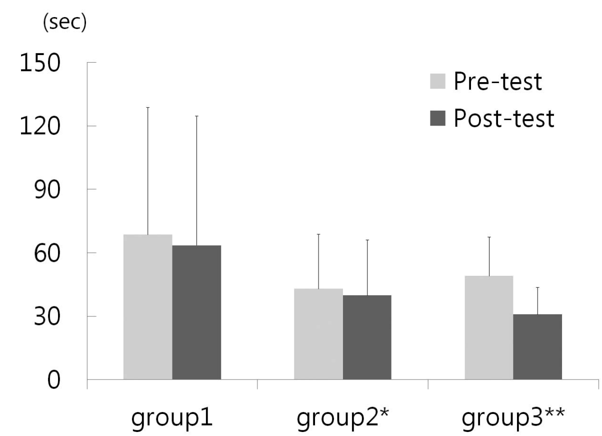

Fig. 6. Changes in TUG

*: p<.05, **: p<.01

Changes in Gait Speed

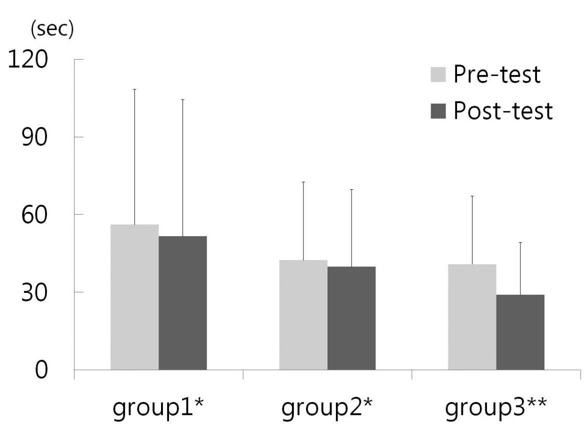

Fig. 7. Changes in 10MTW lead time

*: p<.05, **: p<.01

Changes in gait velocity in the 10MTW test through circuit balance training were examined. Gait velocity statistically significantly decreased from 56.14±52.19 seconds to 51.65±52.80 seconds(p<.05) in group 1, from 42.45± 30.15 seconds to 39.83± 29.81 seconds(p<.05) in group 2, and from 40.88±26.21 seconds to 29.15±20.06 seconds in group 3(p<.05) after the training(Fig. 7).

Average velocity significantly increased from .35 ±.27 m/s to .44±.33 m/s(p<.05) in group 1 and .35 ±.21 m/s to .52±.34 m/s(p<.05) in group 2. Although group 3 average velocity also increased after the training but the change was not statistically significant(Fig. 8).

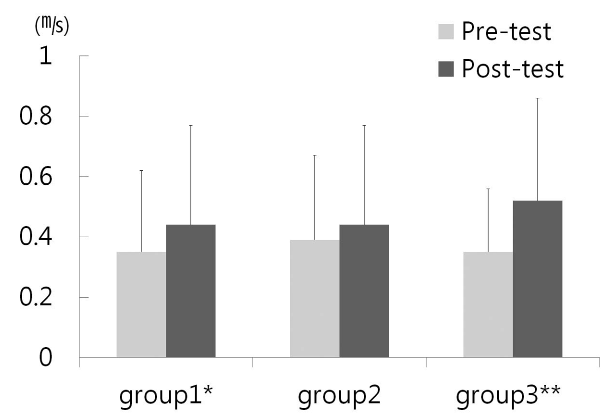

Fig. 8. Changes in 10MTW average velocity

*: p<.05, **: p<.01

DISCUSSION

Task-oriented circuit exercise improved acute stroke patients gait ability(18) and subacute stroke patients gait endurance, sense of balance, and motor function(19). Such exercise also enhanced sitting and standing ability and gait velocity of stroke patients whose duration of the disease was one year or longer(20). Programs to increase muscle strength of the lower extremities, gait balance, gait velocity, and gait distance were very effective to stroke patients, and weakened muscle of the lower extremities may greatly affect their body support, balance, and movement(15). Joo applied task-oriented circuit training to stroke patients for 40 minutes each time, twice per week, for a total of six weeks(21). In this study, the training was applied for 35 minutes each time, five times per week, for a total of seven weeks.

MMS of the rectus femoris of the affected side significantly increased from 66.00±77.60㎶ to 93.78±92.80㎶ in group 3($p<.01$) and AMS significantly increased from 50.67±6.84% to 57.22±8.09% in group 3 as well($p<.01$). Kim applied proprioceptive neuromuscular facilitation(PNF) exercise and circuit exercise programs to chronic stroke patients and compared and analyzed their balance, gait, motor function and EMG results of the quadriceps femoris; the circuit exercise group saw their muscle activities increase from 3.06±5.11% to 4.42±9.66%, which was not statistically significant($p>.05$)(22). All groups saw their BBS significantly increase from 31.00±8.35 points to 33.00±8.04 points in group 1($p<.05$), from 34.78±10.27 points to 41.56±5.83 points in group 2($p<.01$), and from 31.33±7.42 points to 45.11±4.51 points in group 3($p<.01$). 7 weeks after the training, BBS showed significant differences among the 3 groups, with significant increases in group 1 and 2 and in group 1 and 3 in the post hoc test. This result means that non-noise and white noise environments are more effective than an environment without auditory intervention in improving balance adjustment capabilities. Leroux et al. observed that task-oriented training applied to chronic stroke patients significantly increased their BBS from 48.3±5.9 points to 51.1±5.1 points ($p<.05$)(23). Lee and Kim also reported that task-oriented circuit training for balance improvement significantly increased patients BBS from 43.20±10.50 points to 49.70±4.40 points(24), which was consistent with the present study result($p<.05$).

The functional reach test reflected endurance, muscle strength, flexibility, and postural adjustment mechanisms(25). Task-oriented training to improve forward reach position was useful in treating stroke patients(26). In this study, group 1 FRT was not statistically significantly different between prior to and after the training($p>.05$), which was consistent with prior study results. On the contrary, FRT significantly increased from 90.16±12.67cm to 94.44±13.28cm($p<.05$) in group 2 and from 91.25±9.52cm to 99.17±9.45cm in group 3($p<.01$), with better results than in an environment without auditory intervention. Lee and Kim observed that patients FRT increased from 27.70±9.08cm to 47.00±5.70cm in task-oriented circuit training for balance improvement but such increase was not statistically significant(24). However, the present study obtained more significant result than those of previous studies on auditory intervention. TUG significantly decreased from 43.00±25.75 seconds to 39.87±26.28 seconds in group 2($p<.05$) and from 49.00±18.44 seconds to 30.85±12.74 seconds in group 3($p<.01$). Dean et al. performed a TUG test to compare dynamic balance ability through circuit exercise and observed that their circuit exercise group balance ability improved from 27.4±23.2 seconds to 19.5±14.1 seconds(13). Song et al. noted that the result of TUG test conducted in order to examine dynamic balance ability in circuit exercise and traditional exercise groups was that the former's TUG more greatly increased to an average of 5.00±4.33 seconds relative to the latter at an average increase of 2.12±1.74 seconds(27).

Bogle and Newton reported that enhancement in lower limb muscle strength was associated with improvement in gait velocity(28). According to the present study result, the time taken to walk 10m significantly decreased in all groups from 56.14±52.19 seconds to 51.65±52.80 seconds($p<.05$) in group 1, from 42.45±30.15 seconds to 39.83±29.81 seconds($p<.05$) in group 2, and from 40.88±26.21 seconds to 29.15±20.06 seconds($p<.01$) in group 3. Dean et al. reported that the time taken to walk 10 m decreased from 18.2 seconds to 14.1 seconds in their circuit exercise group, which was a larger change than that of group 3 of the present study from 11.3 seconds to 11.2 seconds(13). Song et al. also noted that their circuit exercise group saw a greater reduction in the time taken to walk 10m by an average of 4.87±2.22 seconds than their traditional exercise group by an average of 1.69±1.40 seconds(27). Leroux et al. reported that task-oriented training with a gradual load increase significantly decreased the time taken to walk 10m from 25.2±14.4seconds to 20.8±10.5 seconds, which was consistent with the present study result(22).

Song et al. examined effects of visual and auditory capabilities on balance performance in different age groups; In Korean adults balance performance, their average time in balance decreased from 25.97 seconds with their eyes open to 23.14 seconds with their eyes open and their ears covered and from 10.45 seconds with their eyes closed to 10.18 seconds with their eyes closed and their ears covered(29). In their experiments, the subjects used earplugs and headphones, which did not greatly influence their balance maintenance.

However, their result is responses to instant auditory stimuli and different from the result of the present study in which the subjects were exposed to sustained auditory stimuli. Auditory capabilities make it possible to hear instructions, warnings, or sounds of approaching objects and are conducive to maintaining physical balance(2). In the present experiment as well, non-noise or white noise environments sustained for 7 weeks were more significantly effective than an environment without auditory intervention in improving BBS results.

CONCLUSION

This study, exposure to a white noise environment significantly increased treatment efficiency, as measured by MMS and AMS of the lower extremity of the affected side. Balance adjustment capabilities and the time taken to walk 10m significantly differed between prior to and after the training in all measurement items. After the 7 weeks training, in particular, BBS significantly increased in non-noise and white noise environments than in an ordinary environment, showing obvious differences. Non-noise or white noise environments are regarded effective in improving gait function during circuit balance training. In future exercise treatment for hemiplegic patients, improvement of treatment environment in consideration of auditory intervention will be necessary.

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