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Original Article

The Effect of Horse-Riding Simulator Exercise on Balance Control Ability and Gait in the Elderly with Dementia

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SUMMARY

Background: The aim of the present study was to investigate the effect of horse-riding simulator (HRS) exercise on balance control ability and gait in the elderly with dementia.
Material and Methods: This study was conducted on people aged 65 years or older living in D city (Korea) enrolled in the day care center with a diagnosis of dementia as documented by the Korean Ministry of Health and Welfare. The control group performed the same exercise therapy previously performed at the center for 30 minutes (per session), and the experimental group performed the conventional intervention (15 minutes per session) and HRS exercise (15 minutes per session). In both groups, intervention was performed 3 times a week for 8 weeks.
Functional reach test (FRT), timed up-and-go (TUG), 10 Meter Walk Test (10MWT), and Short Form Berg Balance Scale (SFBBS) tests were used measured to evaluate balance control ability and gait ability before and after intervention to confirm its effect.
Results: Pre-intervention no intergroup differences were found between FRT, TUG, 10MWT, or SFBBS results. ($p > 0.05$). However, post-intervention comparison, the experimental group had significantly better FRT, TUG, 10MWT, and SFBBS results ($p < 0.05$).
Conclusion: We found HRS exercise and exercise therapy improved balance control ability and gait speed, and that HRS exercise produced better results than convention exercise.

1. Introduction

Aging is accompanied by overall weakening of the body. Cognitive function also decreases gradually, and the probability of dementia development increases, and as dementia progresses, cognitive decline function affects movement control.[1]

When the ability to control movement is reduced, movement activities are also reduced due to the risk of accidents such as falls during daily life.[2] This reduced activity in turn weakens physical functions and is associated with reductions in cognitive and physical functions.[2,3] In order to prevent this vicious cycle, active rather than passive responses are essential and various methods must be applied.

Regular exercise is the commonly used form of exercise for preventing physical weakness and managing health in the elderly. Physical activities of appropriate intensity have many advantages because they can improve blood circulation and maintain physical strength and function.

Maintaining physical function through exercise is closely related to independence in life, and thus, has a positive effect on quality of life,[4] and regular exercise can have positive effects on the elderly with dementia. Many studies have shown that regular exercise improves physical functions such as muscle strength, balance control ability, and walking ability in elderly people with dementia, and some have shown that even cognitive function can be improved in the elderly with dementia.[1,5–7]

Among the exercises developed for health management in the elderly, horse-riding simulator (HRS) exercise offers a suitable means of improving gait and balance control ability. When the elderly perform HRS exercise, they receive the same stimulus as if they would during, that is, this exercise provides an indirect experience of gait,[8,9] and many previous studies have reported that such stimulation improves gait and balance control ability in the elderly.[10,11] However, many previous studies on the effects of horse-riding simulator exercise were conducted on general elderly people, and few have studied its effects on elderly people with dementia.

We hypothesized that horse-riding exercise would have a positive effect on the elderly with dementia and undertook this study is to investigate the effect of HRS exercise on balance control ability and gait in the elderly with dementia. Therefore, the purpose of this study is to investigate the effect of HRS exercise on balance control ability and gait in the elderly with dementia.

2. Methods

2.1. Subjects

This study was conducted on people aged 65 years or older living in D city (Korea) enrolled in the day care center with a diagno-

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sis of dementia as documented by the Korean Ministry of Health and Welfare.

To promote the recruitment of subjects, after explaining the research contents to day care centers (registration of more than 30 people), it was conducted in the centers that agreed to visit. Researchers visited the consented centers and recruited subjects through explanation.

The number of subjects required for the study was calculated using G power (Heinrich-Heine-Universität Düsseldorf, Germany) for the t-test, assuming a significance level (α) of 0.05, a power of 0.95, and an effect size of 1.1, as performed previously.[11] As a result, we found that at least 30 subjects were required. To account for a dropout rate of 20%, 36 subjects were initially selected for the study. However, two refused to provide informed consent, and 4 people dropped during the study intervention, and thus, the study was conducted on 30 subjects (male: 7, female: 23) (Table 1).

The criteria used for subject selection were as follows; 1) An age of $\geq$ 65 years, 2) The absence of a serious visual or somatosensory damage that might affect the study, 3) The ability to walk more than 10 m unaided, 4) The absence of pain that might affect walking, 5) A sufficient level of consciousness to participate in the study, and 6) A diagnosis of dementia by the National Health Insurance Service and registration at a day care center.

In accordance with the Declaration of Helsinki, all subjects were briefed on the purpose and procedures involved in the study and voluntarily agreed to take part in the study before study commencement. The study was approved by the Institutional Review Board of SunMoon University (SM-202103-011-2).

2.2 Study protocol

The 30 study subjects were randomly assigned to an experimental group or a control group. The control group performed the same exercise therapy previously performed at the center for 30 minutes (per session), and the experimental group performed the conventional intervention (15 minutes per session) and HRS exercise (15 minutes per session; JOBA, Panasonic Inc., Japan). Conventional exercise therapy consists of mat exercise, sit to stand, and gait training. The HRS exercise starts from a sitting position on a fixed machine, and induces movements similar to walking in the pelvis through three-dimensional movements (front and back, left and right, up and down). In both groups, intervention was performed 3 times a week for 8 weeks.

In this study, functional reach test (FRT), timed up-and-go (TUG), 10 Meter Walk Test (10MWT), and Short Form Berg Balance Scale (SFBBS) tests were used measured to evaluate balance control ability and gait ability before and after intervention to confirm its effect. Researchers were trained beforehand how to perform these tests. Since subjects were elderly, sufficient rest time was provided after evaluations based on considerations of individual physical strengths. These tests were performed only 1 test per day (between 9am and 4pm), and each test was performed separately on a different day. After a test had been completed, the schedule was discussed with subjects to determine the date for the next evaluation. In order to exclude bias due to the learning effect, the order of applying these tests was randomly assigned to each subject. Each test was performed three times, and results were expressed as means $\pm$ standard deviations.

2.3. Functional reach test (FRT)

FRT is used to evaluate balance control ability by measuring the range of forward movement of arms while maintaining the posture described below. FRT results have been shown to be negatively correlated with the risk of falling in the elderly.

Subject spread legs at shoulder width with closed fists and held up his arm in parallel with the ground at 90° shoulder flexion without moving feet off the ground, reach forward as far as possible.

Starting and finishing point using the head of the 3rd metacarpal bone are measured.

FRT has been used to measure static balance control ability in the elderly, and has a reported test-retest reliability (ICC) of 0.92 and inter-rater reliability of r = 0.98, and thus, is considered a highly reliable tool.[12]

2.4. Timed up-and-go (TUG)

TUG is a simple, quick test that provides a measure of basic mobility, balance control, and gait ability. Subjects were asked to sit on a chair and lean back and then, when instructed, to get up, walk 3 m, return to the chair, and sit down.[13]

The TUG is commonly used to evaluate balance control ability and mobility in the elderly and is a highly reliable tool with a test-retest reliability of ICC = 0.98.[14]

2.5. 10 Meter Walk Test (10MWT)

This test provides a measure of walking ability. Subjects are asked to walk at a comfortable speed 10 m without any assistance. Times taken are used as measures of walking ability. When measuring times, the first and final 2 m were excluded. Thus, results are stated as times taken to cover the middle 6 m. The 10MWT test has also been shown to have high test-retest reliability (ICC = 0.93 – 0.91).[15]

2.6. Short Form Berg Balance Scale (SFBBS)

The SFBBS reduces the 14 items of the Berg balance scale to 7 core items and provides an assessment of 14 movements performed in daily life and objective measures of static and dynamic balance abilities.[16] Measurement times are short, and SFBBS can be applied easily and quickly and provides consistent results (test-retest reliability ICC = 0.95),[17] which makes it a highly efficient evaluation tool. The 7 core items can be divided into sitting, standing, and changing postures. Each item is scored using a 3-point scale (0 to 4 points), and thus, the maximum possible score is 28 points. Higher scores mean better balance abilities.

2.7. Statistical analysis

SPSS for Windows (version 23.0; IBM Corp, Chicago IL, USA) was used for the analysis. Descriptive statistics were used to analyze the general characteristics of subjects. The Shapiro-Wilk test was used to confirm normality of the collected data, and the normality was

Table 1
General characteristics of subjects.

	Control	HRS
Age (year)	79.20 ± 6.17	81.87 ± 6.93
Height (cm)	152.87 ± 9.89	155.07 ± 10.15
Weight (kg)	55.95 ± 5.42	55.27 ± 13.21
CIST (score)	15.27 ± 8.01	13.94 ± 7.17
Sex (M/F)	3/12	4/11

Mean ± SD, CIST: Cognitive Impairment Screening Test.

satisfied. A paired t-test was used to determine the significances of differences between measurements taken before and after intervention, and the independent t-test was used to determine the significances of differences between the experimental and control groups. Cohen's d[18] was used to calculate the effect size of intervention, and statistical significance was defined as α values ≤ 0.05.

3. Results

3.1. Comparisons before and after intervention

FRT and SFBBS were significantly higher post-intervention in the control and experimental groups ($p < 0.05$), and TUG times were significantly shorter post-intervention in both groups ($p < 0.05$). However, 10MWT times were not significantly shorter post-intervention in the control group ($p > 0.05$) but were significantly shorter in the HRS group ($p < 0.05$) (Table 2).

3.2. Comparison between groups

Pre-intervention no intergroup differences were found between FRT, TUG, 10MWT, or SFBBS results. ($p > 0.05$). However, post-intervention comparison, the experimental group had significantly better FRT, TUG, 10MWT, and SFBBS results ($p < 0.05$) (Table 2).

4. Discussion

The subjects of this study were elderly people ($\geq$ 65 years old) with dementia who were registered with the Korean National Health Insurance Service and at a day care center. Dementia was diagnosed in each case by a doctor.

The intervention was conducted for 8 weeks. Only general exercise treatment was performed in the control group, whereas general exercise treatment and HRS exercise were conducted in the experimental group.

FRT, SFBBS, TUG, and 10MWT were used to confirm improvements in balance control and walking ability. FRT, SFBBS, and TUG were significantly improved in both the control group and HRS group post-intervention, but 10MWT times only increased significantly in the HRS group.

Many previous results have reported similar results, that is, regular exercise has a positive effect on physical function in the elderly with dementia, and these results support the results of the present study, which shows balance control and gait ability were improved by exercise.[19,20]

In a study by Christofoletti et al., when the elderly with dementia performed exercise for 6 months, there were significant improvements in the Berg balance scale and TUG.[21] In our study, SFBBS, a short version of the BBS, was used, and it showed the same improvements after exercise therapy. In addition, in this previous study, TUG improved from 13.7 ± 1.2 seconds before exercise to 12.9 ± 1.0 seconds after conventional exercise,[21] which concurs with our results for the control group.

Toots A et al. and Rolland et al. reported that it had the effect of slowing down the velocity decrease in BBS and ADL after regular exercise in elderly people with dementia.[22,23] Buettner reported that walking, strength exercise, and balance functional training enhanced strength and walking distance in the elderly with dementia.[24] Stevens and Killeen reported regular exercise increased the strength of elderly people with dementia,[25] and Santana-Sosa et al. found muscle strength, flexibility, gait, and balance ability improved after exercise in the elderly with dementia.[26] In the current study, gait speed as determined by 10MWT improved significantly in the experimental group, which was in line with the results of previous studies. Thus, the results of previous studies and those of the present study are remarkably similar and show that regular exercise has a positive effect on physical ability and physical function in the general elderly population and in the elderly with dementia.

When we compared the control and experimental groups, we found FRT, TUG, 10MWT, and SFBBS improvements after exercise were greater in after HRS exercise. In previous studies on the effects of HRS exercise in the elderly, exercise was found to have a positive effect on physical ability, and several previous studies have reported that the effects of horse-riding simulator exercise are better than those of general exercise.[27] Kim and Lee (2015) reported balance control ability and trunk muscle activity increased more in the elderly that performed 8 weeks of HRS exercise,[10] and Lee S et al. (2014) reported balance ability was improved in the elderly by HRS exercise.[27] Kim et al. showed that HRS exercise improved FRT, TUG, and 10MWT in the elderly, and their results were similar to those of the present study.[11]

Studies have also reported that HRS exercise improves cognitive ability among the elderly with dementia. In a study by Dabelko-Schoeny et al. (2014), equine-assisted intervention helped improve stress and cognitive function in the elderly with dementia,[28] and de Araujo et al. (2019) found HRS exercise improved TUG times and balance control and cognitive abilities in the elderly with dementia.[29] Thus, the results of previous studies and the present study show that HRS exercise in the elderly improves physical functions (e.g., strength) and balance control and gait abilities and that in the elderly with dementia, in addition to balance control ability, and walking ability and cognitive function were improved by this form of exercise.

In the current study, Cohen's d was used to determine effect size. This measure indicates an intervention is ineffective if < 0.2, medium if > 0.5, large if > 0.8, and very large if > 1.2.[18,30] We found Cohen's d of FRT was very large in the control group (d = 1.68) and

Table 2
Comparison of measurement values at pre-test and post-test.

Variable	Group	Pre	Post	t	p	Cohens' d
FRT (cm)	CON	20.43 ± 2.66	24.36 ± 2.39	-6.49	0.000*	1.68
	HRS	20.90 ± 3.72	26.43 ± 2.87†	-8.64	0.000*	2.23
TUG (seconds)	CON	13.91 ± 2.13	12.25 ± 1.64	3.74	0.002*	0.97
	HRS	12.89 ± 2.32	9.83 ± 2.28†	5.46	0.000*	1.41
10MWT (m/s)	CON	1.17 ± 0.28	1.17 ± 0.22	-0.08	0.941	0.02
	HRS	1.18 ± 0.24	1.35 ± 0.22†	-3.02	0.009*	0.78
SFBBS (score)	CON	18.20 ± 2.62	20.30 ± 1.98	-5.85	0.000*	1.51
	HRS	19.47 ± 4.50	22.60 ± 3.70†	-3.87	0.002*	0.99

* $p < 0.05$ (Mean ± SD).
CON: control group, HRS: horse-riding simulator exercise group.
† Statistically difference between CON and HRS in post.

the HRS exercise group (d = 2.23). TUG was large in the control group (d = 0.97) and very large in the HRS exercise group (d = 2.23). SFBBS was very large in the control group (d = 1.51) and large in the HRS exercise group (d = 0.99), and 10MWT was medium only in the HRS exercise group (d = 0.78).

Overall, in the elderly with dementia, HRS exercise had a larger effect size on balance control than general exercise therapy, which we attribute to different continuities of movement. General exercise therapy is mainly performed on a mat or bed, and it is common to performed movements separately, whereas HRS exercise involves movements trunk and pelvis that are similar to those performed while walking, and since these movements are performed continuously.[8,9]

The limitation of this study is that cognitive ability was not evaluated, and thus, it was not possible to investigate the effects of exercise on cognitive ability in the cohort. In addition, due to the small number of subjects recruited, caution should be exercised regarding the generalization of our findings.

In conclusion, we found HRS exercise and exercise therapy improved balance control ability (as determined using FRT, TUG, and SFBBS results), and that HRS exercise produced better results than convention exercise. Furthermore, only HRS exercise was found to have a positive effect on gait speed. Thus, the results of this study emphasize the need for physical exercise in addition to cognitive treatment for the elderly with dementia. We hope that the results of this study serve as a basis for the use of HRS exercise in the elderly with dementia to strengthen physical functions. In addition, we suggest future research should be conducted on the effects of HRS exercise on the cognitive abilities of elderly subjects.

Conflict of interest

There are no conflicts of interest regarding this research.

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