

Original Article

The effects of virtual reality game exercise on balance and gait of the elderly

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Abstract. [Purpose] The aim of this study was to examine the effects of ball exercise as a general exercise on the balance abilities of elderly individuals by comparing ball exercise with virtual reality exercise. [Subjects and Methods] Thirty elderly individuals residing in communities were randomly divided into a virtual reality game group and a ball exercise group and conducted exercise for 30 min 3 times a week for 8 weeks. [Results] Step length increased significantly, and the average sway speed and Timed Up and Go time significantly decreased in both groups. A comparison of sway length after the intervention between the two groups revealed that the virtual reality game exercise resulted in a reduction than the ball exercise. [Conclusion] The results of this study indicated that the virtual reality game exercise may improve balance and gait of elderly individuals in communities.

Key words: Elderly, Balance, Virtual reality exercise

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INTRODUCTION

Regular exercises performed by the elderly can improve walking, balance, muscle strength, and mobility capabilities by increasing their functional abilities, thereby eliminating the risk of falling and providing stabilization¹⁾.

Previous studies have reported that the following approaches are more effective in improving balance ability than general and passive interventions: focused and repetitive training²⁾, reality-related training³⁾, motivational intervention with active participation⁴⁾, constraint-induced movement exercise⁵⁾, visual exercise feedback⁶⁾, auditory exercise feedback⁷⁾, goal-oriented training⁸⁾, and task-oriented training⁹⁾. However, it is difficult to utilize such approaches in indoor environments and to guarantee the safety of elderly individuals. In addition, there are difficulties in observing and enforcing exercise at home, which is why it is difficult to identify the effects of constant balance exercises¹⁰⁾.

In recent years, intervention methods based on virtual reality have been introduced¹¹⁾. Virtual reality refers to interactive simulations in which computer hardware and software are used that enable users to have virtual experiences that are similar to reality¹²⁾. In virtual reality, a user moves and controls objects and performs predetermined tasks by reacting as if they are performing the actions in reality¹³⁾. This

method can increase motivational effects while the users perform tasks with interest and fun^{14, 15)}.

As described above, virtual reality has been studied to overcome limitations in existing interventions, and preventive medicine exercises can be applied with it to prevent falling in the elderly. However, the existing studies are limited because they only studied the balance ability of the elderly after the application of virtual reality exercise programs, and most of them only focused on comparing the application of virtual reality programs and exercises that combined a virtual reality exercise program and a visual and auditory sensory feedback exercises. Thus, it is necessary to compare virtual reality exercise with balance exercises that involve other tasks and are set in other environments. To achieve this goal, this study aimed to test the effects of ball exercise as a general exercise on the balance abilities of elderly individuals by comparing ball exercise with virtual reality exercise.

SUBJECTS AND METHODS

The subjects of this study were 30 elderly individuals living in Daegu Metropolitan City, a local community. The subject selection criteria were as follows: over 65 years old, no fall experience within the most recent year, and no disease that could affect performance during the experiment. Additionally, elderly individuals with visual and auditory sense damage or vestibular system problems who could not understand the experimental tasks were excluded. All the subjects understood the purpose of this study and provided written informed consent prior to participation in the study in accordance with the ethical standards of the Declaration of Helsinki (Table 1).

The subjects were divided equally into a virtual reality

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Table 1. General characteristics of the subjects

	VR	BE
Gender (M/F)	9/3	10/2
Age (years)	66.5±8.1	65.2±7.9
Height (cm)	163.3±7.2	164.2±5.4
Weight (kg)	62.3±8.1	65.0±4.2

Mean±SD. VR: virtual reality game exercise; BE: ball exercise

game group and a ball exercise group. They performed their exercises for 30 min 3 times a week for 8 weeks. Three subjects in each group voluntarily withdrew in the middle of the experiment due to personal matters. The virtual reality game exercises were chosen from the Wii Fit balance exercise game/program: Soccer Heading, Snowboard Slalom, and Table Tilt. The subjects spent 10 min on each game for a total of 30 min.

In the Soccer Heading game, the participant “heads” soccer balls as they fly towards them by shifting his/her body weight to the left and right. In the Snowboard Slalom game, the participant must pass certain flags one at a time while riding a virtual snowboard by moving his/her body up and down in the side-standing position. In the Table Tilt game, the participant moves his/her body in the forward, backward, right, and left directions freely to get a ball to fall into a hole in the floor.

The ball game exercise was based on the program principles proposed by Janda¹⁶. It consisted of 20 min of bouncing, pelvic tilting in the right and left directions, pelvic tilting in the forward and backward directions, and the pelvic circle while sitting on an exercise ball and 10 min of tilting the body to the right and left sides while putting the legs on the ball in the supine position, bending the knees, and putting the soles of the feet on the ball to form a bridge position, for a total of 30 min of exercise.

In this study, the 30 sec sway length and average sway speed with the open eyes and gazing at the front on the top of an analysis system with biofeedback (AP1153, BioRescue, RM Ingénierie, Rodez, France) were measured to determine the subjects’ static balance abilities before and after the intervention, and a Timed Up and Go (TUG) test was performed to determine the subjects’ dynamic balance abilities. All measurements were expressed as means and standard deviations.

PASW Statistics for Windows (version 18.0) was used to analyze the data in this study. To determine if there were any differences before and after the intervention, a paired t-test was used, while an independent t-test was used to determine any differences between the groups. The statistical significance level was set at $\alpha = 0.05$.

RESULTS

After the intervention, both groups showed a decreased their sway length ($p < 0.05$), average sway speed ($p < 0.05$), and TUG time ($p < 0.05$). After the intervention, comparison of sway length between the two groups showed that the virtual reality game exercise resulted in a greater reduction

Table 2. Comparison of pre- and post-intervention measurement values

Variable	Group	Pre	Post
Sway length (mm)	VR	54.8±5.9	41.6±4.1 ^a
	BE	55.2±4.1	47.1±9.2 ^a
Average sway speed (mm ²)	VR	0.7±0.1	0.6±0.1 ^a
	BE	0.7±0.1	0.6±0.4 ^a
TUG (sec)	VR	21.8±8.6	17.6±7.4 ^{ab}
	BE	21.6±7.5	19.3±5.8 ^{ab}

^aSignificant difference between the pre- and post-intervention values. ^bSignificant difference in post-intervention values between VR and BE

than the ball exercise ($p < 0.05$) (Table 2).

DISCUSSION

A change in balance is one of the largest factors for falls in the elderly^{11, 17}, and lack of balance and fall occurrence have a high correlation¹⁵. Shumway-Cook and Woollacott¹⁸ defined balance as the ability to maintain the center of mass on the base of support. Dynamic balance exercise in particular can reduce the fall risk factor significantly^{19, 20}.

In this study, both the virtual reality game group and the ball exercise group showed a significantly reduced sway length and average sway speed after the 8-week intervention. In particular, the virtual reality game group showed a greater decrease in sway length than the ball exercise group, which reveals that dynamic balance exercise can also affect static balance abilities.

In this regard, the effect of introducing virtual reality-based interventions is positive¹¹, because they can provide immediate visual and auditory feedback concerning the exercise results, thereby increasing the exercise learning effect. This suggests the possibility of using virtual reality-based games/programs for a broad range of exercise applications^{14, 15}.

In this study, the virtual reality game group also showed an increase in TUG time, revealing improved balance abilities. A study by Walker et al.²¹, in which traditional physical therapy and balance training using visual feedback training and verbal and tactile signals, proved the effects of visual perception feedback training by improving the TUG time. A study by Geiger et al.¹⁹, in which biofeedback/force plate training and existing balance improvement exercise were compared, also showed improvements in balance ability, since the TUG time was reduced after the intervention. A study by Cikajlo et al.²², in which remote rehabilitation using virtual reality tasks was studied, also reported improvement in the TUG time after the intervention.

In the present study, which compared functional balance factors before and after the experiment, the virtual reality game group showed significant differences between before and after the experiment, whereas no significant difference was found in the ball exercise group. The above comparison results between the two groups showed that the elderly individuals did not move within a predetermined movement boundary but rather moved into larger areas to perform

social activities. This study has some limitations, since the study subjects were limited to patients who satisfied the selection criteria set in this study and were within the designated geographical area.

For future research, such limitations can be overcome by studying more older individuals, and it is necessary to study the effects of long-term exercise over 3 months and changes in the environment. Furthermore, we hope that more virtual reality exercise programs will be available for the elderly in the future.

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