The Effect of Virtual Reality Games on Muscle Activity and Balance in Elderly Women

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Purpose The aim of this study was to investigate the effects of virtual reality games (VRG) on muscle activity and balance in elderly women. ***Methods*** Subjects were elderly women aged 65 or older (n =20). The subjects were assigned to VRG group, and 10 were assigned to a general exercise group, The intervention was performed for 40 min per session, twice a week, for eight weeks. ***Results*** As shown by the result of the Berg balance Scale (BBS) and Functional Reach Test (FRT), there were no significant differences in the balance abilities of the GE group, wheras there was a significant difference in those of the VRG group. There was also significant between group difference in balance abilities. In the comparison of the muscle activity of the tibialis anterio (TA) and gastrocenemius medialis (GCM), there was no significant difference in the GE group and whereas there was significant difference in the VRG group. Furthermore, there was significant between group difference in muscle activity. ***Conclusion*** VRG was effective in improving muscle activity and balance in elderly women aged 65 and older.

Key words Elderly Women, Balance, SEMG, Virtual reality, Games

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Ⅰ. Introduction

With aging, people experience physiological changes, inculding sarcopenia (i. e., decreased skeletal muscle mass). By reducing muscle strength, sarcopenia can affect balance and postural control and result in disability[1)], which affects activities of daily living (ADL) and leads to a lower quality of life (QoL).[2)] It can also increase the risk of mortality in the elderly. Balance is required to maintain posture in an external space and to perform various tasks, which are accomplished by complex processes involving the neuromusculoskeletal system. AS, the elderly can not respond rapidly to body perturbations, improveing their balance is very important prevent falls.[3)] Such falls can incur high medial costs and adversely physical and psychological functions, further lowering the QoL of eldery. The elderly may experience alls in various environments during ADL. Although physical muscle strengthening exercises have been suggested for fall prevention, balance training using multiple tasks may be more appropriate.[4)]

VRG have recently been used in exercise interventions using various applications and developments in computer programs, they have been used instead of traditional treatment and as a supplementary treatment in clinical settings.[5)] VRG have been widely used in physical therapy and/or occupational therapy, and multidisciplinary fall-prevention programs and specific exercises have been applied to improve balance and reduce falls. Performing a number of physical activities could improve the QoL and prevent falls during ADL. However, though VRG may be effective for treating individual older people, they are too expensive to use regularly in clinical settings.[6)]

Only a few studies have provided evidence of the positive effects of virtual reality based game exercises on the balance and muscle activity of older adults.

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The aim of this study was to evaluates the effects of VRG training on the balance and muscle activity of older adults.

II. Materials and Methods

1. Participants

This study was conducted with elderly women aged of 65 years and older in S welfare center, Sungnam-si, South Korea. The inculsion criteria were no falls in the previous year, no central or peripheral disease, no orthopedic problems that would affect the ability to complete the exercise programs, and a score of 24 or more in the MMSE score. This study included a control group assigned to general exercise (GE, n=10) and an experimental group assigned to virtual reality game (VRG, n=10). All the subjects provided written informed consent prior to participating in the study. The general characteristics of the participants are shown in Table 1.

2. Intervention

The GE involving the subjects moving their weight from side to side and forth to back, standing on one leg, squats, and walking on the spot while standing on balance pad. VRG was conducted with a Gymplate (TECHNO CONCEPT, France), and both groups performed the intervention programs for eight weeks, twice a week, 40 min per session. The Gymplate has four directional pressure sensors, which input information about the force placed on the foot plate into a computer program via, a USB port, in addition to information on the distribution of balance in the top, bottom, left and right. The programs use in the VRG are shown in figures 1 and 2. In the VRG, there were six grades and the subjects performed the task gradually

3. Outcome measures

(1) Surface electromyography (SEMG)

SEMG (MyoSystem 1400A, Noraxon, USA) was used to measure the muscle activity of the tibialis anterior and gastrocnemius medialis. Details on the muscle attachment are outlined in Table 2. Each participants' skin was cleaned with alcohol and electrodes were attached with tape and elastic strips. An Electrode (Electrode2237, 3M, USA) was placed on the dominant leg. The maximal voluntary contraction (MVC) of each

Table 1. General characteristics of the subjects

	GE[a] (n=10)	VRG[b] (n=10)	t	p
Age(year)	75.00±5.62	76.00±6.42	0.17	0.86
Weight(kg)	55.14±7.05	54.57±9.07	0.25	0.72
Height(cm)	156.57±4.57	155.14±4.67	0.06	0,57

zean ± SD, *p< 0.05, [a]GE: general exercise, [b]VRG: virtual reality game

Figure 1 Keep the center of pressure in the path connecting the both sides and find the target.

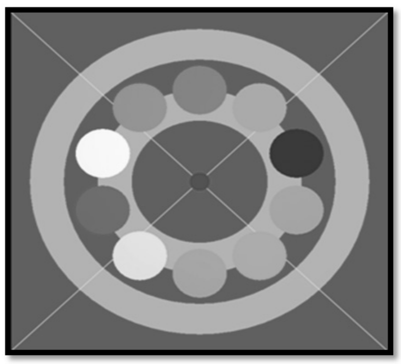

Figure 2. Move in to the center into the target when it is blinking

Table 2. electomyography attachment position

Muscle	attachment position
tibialis anterio	The percentage distance from the tuberosity of tibia to the inter-malleoli line, starting frome the tuberosity of tibia
gastrocenemius medialis	The percentage distance from the medial side of the popliteus cavity to the medial side of the Achilles tendon insertion starting frome the Achilles tendon

Table 3. Comparison of the balance of the ability groups

		GE[c](n=10)	VRG[d](n=10)	t	p
FRT[a] (cm)	Pre	10.40±2.54[e]	10.40±3.27	−.22	.85
	Post	10.40±3.13	14.10±4.25	−1.48	.13
	Change	.90±3.82	3.70±1.94	−3.08	.00
	t	−.36	−2.84		
	p	.71	.00		
BBS[b] (score)	Pre	48.80±2.69	49.30±3.09	−.42	.67
	Post	49.80±2.52	52.40±2.31	−1.95	.05
	Change	1.00±1.49	3.10±1.28	−2.79	.00
	t	−1.76	−2.82		
	p	.07	.00		

[a]FRT: Functional Rech Test, [b]BBS:Berg Balance Scale. [c]GE:general exercise,
[d]VRG; virtual reality game, [e]Mean ± SD,

muscle, while applying manual resistance was measured in according with the method of Danieis and Worthingham. Muscle activity while standing on one leg was measured three times for 5 sec each time, of which the activity data obtained during the middle 3 sec were recorded (i. e., the 1 sec before and after were excluded). The EMG activity was expressed by root mean squares, which were normalized by the MVC and reporte in percentages.

(2) Berg Balance Scale(BBS)

Balance ability was tested using the Berg Balance Scale (BBS), which includes 14 functional balance items, with scores ranging from 0 to 56 points; better balance is indicated by a higher score. within- and between-reliability is 0.98 and 0.97 respectively.[7)]

(3) Functional Rech Test (FRT)

FRT is to measure dynamic balance ability, during which the subject is positioned on standing, putting heel on the floor, to reach his arm forward maximally. the distance is measured using a tapeline

4. Statistical Analysis

A statistical analysis of the data was conducted with SPSS version 18. The demographic data between groups was calculated using T-test. the change of variables before and after intervention were compared with Wilcoxon's sign ranks test, and Mann-Whitney U test was used to compared the changes between groups. A p-value < 0.05 was considered to indicate significance.

III. Results

1. Comparison of the balance ability of the groups

As shown by the FRT, there was no, significant difference after the intervention in the GE group (p>.05), but the VRG group showed a significant change (p<.05). with regard to the BBS, there was a significant improvement in the VRG group but not in the

GE group. There was significant between group difference in both BBS and FRT. Table 3

2. Comparison of the muscle activity of the groups

There was no significant difference in the TA muscle activity after training in the GE group, but there was a meaningful change in that of the VRG group. With regard to the GCM muscle, there was a significant change in the VRG group but not in the GE group. There was a between group difference only in the activity of the GCM. Table 4

IV. Discussion

The aim of this study was to explore the effect of VRG and GE on the muscle activity and balance of elderly women. The muscle activity and balance of the VRG group showed a significant change after the training, but there was no significant difference in the GE group. There was a between group difference in both the muscle activity and balance.

A previous study, that compared the balance ability of elderly women aged of 65 years, or older after VRG training for eight weeks reported a decrease in body sway with eyes open and closed and an increase in the FRT distance.[8)] The authors of that study suggested that this VRG might be useful for improving dynamic and static balance. Another study showed that training involving a VRG impoved the dynamic and static balance of older people (aged 65-90 years) by enhancing their postural control in various tasks, and that this reduced their risk of the fall.[9)] Moreover, in individuals 65 years and older, the limit of stability and center of pressure increase after training using a VRG, thereby reducing both the fear of falling and the fall rate.[10)]

In the present study, as shown by the BBS and FRT, the VRG training significantly improved the performance of elderly women aged 65 years and older, a fiding consistent with that of the aforementioned literature. Falls among older people result in increased medical costs and they have adverse effects on independent ADL. Most exercise programs for the elderly are designed to prevent falls. The VRG utilized in the present study can be used by individuals. The program has several advantages. First, it can be applied individually to prevent falls among the elderly. Secod, the VRG can overcome the problem of boredom, which hampers general physical therapy programs. Therefore, the VRG may be a supplementary intervention to increase balance and prevent fall risks the elderly.

Older people may be more reliant on visual stimuli, which compensat for a lack of proprioceptive senses, A previous study demonstrated that the visual stimuli

Table 4. Comparison of muscle activity between groups

(Unit:%MVIC)

		GE[a](n=10)	VRG[b](n=10)	t	p
tibialis anterio	Pre	28.20±5.78[c]	39.30±20.98	−1.21	.22
	Post	28.70±5.67	46.10±18.59	−2.12	.03
	Change	1.00±.81	6.80±3.58	−2.80	.00
	t	−1.38	−2.80		
	p	.16	.00		
gastrocene-mius medialis	Pre	40.20±19.82	47.20±19.46	−1.02	.30
	Post	41.30±19.13	54.80±20.12	−1.59	.11
	Change	1.10±1.96	7.60±8.88	−2.81	.00
	t	−1.55	−2.81		
	p	.12	.00		

[a]GE:general exercise, [b]VRG; virtual reality game, [c]Mean ± SD

in a VRG, combined with performing tasks on various supporting surfaces, improved the balance of elderly individual.[11] Moreover, in a study of older with Parkinson's disease, taking part in a VRG improved the patients responses to visual stimul in various environments.[12] VRG featuring eye and head tracking technology were shown to increase participants's interest in performing related exercises, as the system provideds an interactive environment and instant feedback. Positive results were also reported when video games were incorporated into virtual environments, as these provideds purposeful and challenging exercise.[13] Research also revealed that performing a VRG while standing has positive affects on postural control and muscle strength.[14] The results of the present study, which required the subjects to respond to visual stimuli and perform a task while standing, showed an improvement in balance after training. These fiding were consistent with those in the literature. However, we did not assess visual stimuli. A future study is needed in this area.

To displace the COG and maintain balance control, an ankle strategy is critical. In a previous study of subjects aged 65 to 80 years, who participated in a VRG, the muscle activities of the TA and GCM increased, enabling the subjects to control their COG. The same study reported that the ankle strengthening helped to prevent falls.[15] In the presentis study the muscle activities of the TA and GCM increased in the VRG group. This finding was in accordance with that of the previous literature. It is likely that an increase in the muscle activities of the TA and GCM may not only improve the balance ability of elderly individuals in a standing position but also enable them to respond rapidly to body perturbation, thereby preventing falls.

There were several limitations in this study, The same size was small and external validity may be limited, as it included only elderly women from a single welfare center. We also did not measure the fall histories of the participants. However, several outcome measures that have been clinically demonstrated to predict falls were used to odjectively assess the balance status of the participants.

V. Conclusion

The VRG intervention (40 mins per a session, twice a week, for eight weeks) significantly improved the performance of the participants on the BBS and FRT. Moreover, there were significant between group differences in the muscle activities of the TA and GCM. Studies are needed to determine the long term benefit of the intervention and to develop an intervention that could be applid in a clinical setting.

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