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The Effects of Virtual Reality Interactive Games on the Balance Ability of Elderly Women with Knee Osteoarthritis

Sam-yeol Wi, PT, MS, Jong-ho Kang, PT, CPO, PhD[1]

Department of Physical Therapy, Nam San Hospital
[1]Department of Physical Therapy, Catholic University of Pusan

가상현실 상호작용 게임이 무릎 골관절염 여성 노인의 균형능력에 미치는 영향

위삼열 · 강종호[1]

남산병원 물리치료실, [1]부산가톨릭대학교 물리치료학과

<Abstract>

연구목적 : 본 연구는 Xbox 360 Kinetic Sensor를 사용한 가상현실 상호작용 게임이 무릎 골관절염을 앓는 여성 노인의 균형능력에 미치는 영향을 알아보는 것이다.

연구방법 : 65세 이상의 지역사회에 거주하는 여성 노인으로 무릎 골관절염으로 진단받은 40명을 대상자로 선정하였다. 대상자는 20명씩 무작위로 실험군과 대조군에 배치되었다. 실험군은 Xbox 360 Kinetic Sensor를 사용한 가상현실 상호작용 게임을 매 30분, 주 3회, 4주간 처치하였다. 대조군은 가상현실 상호작용 게임을 적용하지 않았다. 결과 측정은 눈을 뜬 상태와 눈을 감은 상태에서 신체 중심의 이동거리로 측정하였다.

연구결과 : 실험군의 신체중심 이동거리는 눈을 뜬 상태와 눈을 감은 상태 모두 중재 전보다 유의하게 증가하였다. 또한 중재후 실험군의 신체중심 이동거리는 눈을 뜬 상태와 눈을 감은 상태 모두 대조군보다 유의하게 높게 증가하였다.

결론 : Xbox 360 Kinetic Sensor를 이용한 가상현실 상호작용 게임은 무릎 골관절염을 앓는 여성 노인의 균형능력을 증진시키는데 효과적이었다.

Key Words : 가상현실 상호작용 게임, 무릎 골관절염, 균형

Ⅰ. Introduction

One of the causes for the functional disabilities of elderly people is osteoarthritis. Knee osteoarthritis damages proprioception that is produced from the tissues around joints. Proprioceptive defects that

교신저자 : 강종호, E-mail: swithun@cup.ac.kr
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occur from the mechanoreceptors around knee joints cause motor control disabilities (Guccione et al., 1994). These also result in an increase in joint instability and cause alterations in postural and balance controls (Lyytinen et al., 2010). In other words, weakened postural control and balance abilities due to osteoarthritis may be a major problem in old age activity limitations. In fact, this problem is causing greater trouble in older women than in older men (Cho et al., 2011).

Various therapeutic resources to minimize the problems of osteoarthritis patients have been proposed. Traditional exercise programs such as the range of motion (ROM) or stretching exercises, strengthening exercise, and endurance exercise are known to be helpful in the pain or functions in osteoarthritis patients (Kim and Kim, 2006). Meanwhile, some studies have researched functional training effects rather than such traditional training techniques. Functional training may consist of active daily living movements. For example, it includes going up and down the stairs, walking, and standing from a chair. In other words, the movements that are closer to everyday life may relieve the symptoms and improve the performance of functional activities in osteoarthritis patients(Jee et al., 2006; Roddy et al., 2005).

Such therapeutic resources have good clinical evidences of resolving the problems of osteoarthritis (Topp et al., 1993; Lord and Castell, 1994; Crilly et al., 1989). Lowered postural control and balance abilities are the first change that comes from osteoarthritis and have been placed as an important indicator in monitoring the functions of osteoarthritis patients(Silva et al, 2012). However, the studies related to balance or postural controls are still insufficient, and the accurate optimal mode, duration, and intensity of therapeutic interventions for improved postural control and balance abilities have not yet been identified. Despite their limitations, virtual reality interactive games are known to be effective in postural control and balance ability. Particularly, recent studies have reported the potential to apply the game training using virtual reality interactive game consoles, which currently show a smooth commercial distribution, to rehabilitation training (Gil-Gomez et al., 2011).

The Xbox 360 Kinetic Sensor enables people to enjoy motion recognition virtual reality interactive games. Unlike existing exercise programs that consist of simple types of motions, the training through interactive virtual reality interactive games can perform more functional and diverse movements. Besides, such training can easily provide a motivation to perform, which is the most important factor in applying it to elderly people, and draw active participation. Latest studies have been reporting that the exercise programs based on virtual reality interactive games can improve balance in community-dwelling older fallers and patients with nervous system disorders(Williams et al., 2010). However, no evidence has yet been found for the acceptability of virtual reality interactive games as a balance enhancer in osteoarthritis patients. Therefore, this study intends to examine the feasibility of applying interactive virtual reality interactive games that use the Xbox 360 Kinetic Sensor in order to improve balance in elderly women with osteoarthritis.

Ⅱ. Methods

1. Subjects and experimental design

The subjects of this study were 40 elderly women aged 65 or older who could walk on their own, were diagnosed with degenerative osteoarthritis by a doctor, and were provided with a full explanation about this study and voluntarily agreed to participate in its experiment. Meanwhile, the

candidates who experienced nervous system diseases, mental disorders, rheumatoid diseases, knee joint operations, arthritis except degenerative osteoarthritis, and were unable to communicate properly were excluded in the screening process.

Out of 40 total subjects, each 20 subjects were randomly placed into a experiment group and a control group. Firstly, a basic physical therapy that consists of hot packs and electrical stimulations was applied to the 40 elderly female participants in their knee joints. As for the experiment group, an actual experiment was performed 30 minutes after the completion of the basic physical therapy. The experiment group performed virtual reality interactive games three times a week and for 30 minutes each time for a four-week period.

2. Experiment method

The hardware used to apply virtual reality interactive games was the Xbox 360 Kinetic Sensor (Microsoft Co. USA) and the software used was Your Shape (UBISOFT, Entertainment, USA). The virtual reality interactive games selected for this study were Virtual Smash and Light Race that drew the most interest from the subjects. In Virtual Smash, payers are supposed to break bricks in the virtual reality using their hands and feet while avoiding bricks using their trunk. The subjects performed this game for 15 minutes each time. Meanwhile, Light Race is a game where players do steps by moving their foot or both feet back and forth and left and right according to blue or green signs displayed on the game screen. The subjects also performed this game for 15 minutes each time. After each subject finished her game, she was informed of the game results and allowed to share the outcome with other participants.

3. Measurement

The balance abilities of the subjects were evaluated by measuring their postural sway using Biorescue (RM, INGENIERI, France)(Yuk. 2012). Postural sway typically can be measured with center of pressure using a force platform. The center of pressure is equal to the a downward forces of feet. Because, postural muscle forces is acting on the force platform(Winer, 1990). Each subject stood with each foot 30°apart according to the guiding lines marked on a Biorescue platform. While maintaining the standing posture for 30 seconds in each open and closed eye conditions, the postural sway of each subject was measured. When measured in the open eye condition, the subjects were instructed to stare at a certain point at their eye level two meters ahead.

4. Analysis

The collected data were analyzed using SPSS 17.0 for Windows and all the data were indicated by means and standard errors. In order to compare the results between the pre-application and post-application of virtual reality interactive games, paired t-tests were conducted. To identify whether any changes occurred between the experiment group and the control group after virtual reality interactive games were applied, ANCOVA, which processed pre-intervention values into covariances, was performed. The statistical significant slevel was set at 0.05.

Ⅲ. Results

The results of the postural sway before and after the application of virtual reality interactive games are as follows. In both open and closed eye conditions, the postural sway in the control group deceased, however, the results were statistically not significant. Meanwhile, in both open and closed eye

Table 1. Balance abilities before and after the intervention

unit: cm

	Pre-test	Post-test	*p*
CG(EO)	6.16±1.55	5.53±.81	.084
EG(EO)	6.02±1.56	5.03±.63	.009
CG(EC)	6.01±1.38	5.72±.58	.411
EG(EC)	6.03±1.17	5.27±.57	.001

CG: Control group, EG: Experiment group, EO: Eye open, EC: Eye close
Values are mean±SD

conditions, the postural sway in the experiment group declined at a statistically significant level (Table 1)($p<.05$).

In order to identify if there are any differences in the postural sway between the experiment group and control group after a four-week period of applying virtual reality interactive games, ANCOVA was carried out processing pre-intervention values into covariances. According to this, in both open and closed eye conditions, the postural sway in the experiment group were revealed to be lower than those in the control group at a statistically significant level (Table 2).

Ⅳ. Discussion

In this study, virtual reality interactive games using the Xbox 360 Kinetic Sensor were applied to older women with osteoarthritis for four weeks. During this experiment, no subjects exhibited a problem of balance loss. Moreover, no subjects complained of their pain or functional abnormality. Overall, virtual reality interactive games are considered to be an intervention that can be safely applied to osteoarthritis patients. However, some studies using Nintendo Wii Fit reported that they applied the game in a modified format due to safety concerns (Laver et al., 2011). In this regard, as safety differences can take place according to tool and game types, safety measures at the levels of supervision or close guarding are likely to be necessary.

By regular participations in physical activities and exercise training that include the movements of joints and trunk, osteoarthritis patients can improve their balance abilities. The virtual reality interactive games implemented in the present work were Light Race and Virtual Smash. Light Race consists of its player standing on a virtual platform displayed on the game screen and doing steps on the platform by stretching his/her left or right lower limbs back and forth and left and right according to blue or green signs. Virtual Smash, on the other hand, requires its player to break bricks displayed on the screen by stretching arms and legs using upper and lower limbs, and avoiding bricks by moving his/her trunk back and forth and left and right.

In this study, the virtual reality interactive games applied over a four-week period were revealed to increase the postural sway in community-dwelling

Table 2. Balance abilities in the control group and the experiment group after the intervention

unit: cm

	CG	EG	*p*
EO	5.53±.81	5.03±.63	.040
EC	5.72±.58	5.27±.55	.015

Values are mean±SD

elderly women with osteoarthritis at a statistically significant level, and the experiment group exhibited a higher increase than the control group at a statistically significant level. Such results indicate that the intervention of Light Race and Virtual Smash games generated appropriate levels of joint and trunk movements. In other words, virtual reality interactive games presented the potential to be applied as an intervention for the improvement of balance in elderly women with osteoarthritis. In contrast, general physical therapy that was applied to the control group did not affect the center of pressure.

Although the number of cases was limited at seven people, virtual reality game experiment using Nintendo Wii Fit improved the berg balance scale in 84-year-old older adults (Agmon et al., 2011). Additionally, previous case study that applied Nintendo Wii Bowling to 89-year-old community residents reported an improvement in the berg balance scale (Clark and Kraemer, 2009). Meanwhile, these studies reported improvements in walking and daily life abilities, in addition to balance ability.

The present work derived similar results by applying virtual reality interactive games using the Xbox 360 Kinetic Sensor. Additionally, this study conducted an experiment by placing each 20 subjects to a experiment group and a control group, and observed any improvement in the postural sway between the pre- and post-intervention phases in the experiment group. Thereafter, a comparison between the experiment group and control group after a four-week experience was made by translating the pre-intervention balance abilities in the experiment group and control group into covariances. As a result, the postural sway in the experiment group was revealed to become higher than that in the control group at a statistically significant level. While this study did not obtain functional results, in light of an improved balance ability demonstrated in this study through a proper control and processing of experiment methods, a functional improvement similar to the results of previous studies were also likely to have taken place in this study.

In the open eye condition, visual and vestibular sensations and proprioception come to participate in the experiment. In the closed eye condition, visual sensation is blocked, and thus, only vestibular sensation and proprioception come to participate in the experiment. Although visual information is important in maintaining postural orientation within the limits of stability, it is not an essential element in postural control because one can perform a sufficient postural control while his/her eyes are closed. What enables this is proprioception (Willems et al, 2002). Therefore, the intervention methods to improve balance should be able to enhance proprioception sufficiently. In this study, improvements in balance ability were also observed in the closed eye condition. In other words, virtual reality interactive games are considered to have influenced the proprioception in older women with osteoarthritis.

The virtual reality interactive games used in this study provided visual and auditory feedback by immediately responding to physical activities and movements through their screens and speakers. Such visual and auditory feedback is considered to have had an effect on improving balance abilities. The advantages of visual and auditory feedback are already well known by previous studies (Zijlstra et al., 2010). Additionally, the older female subjects in this study showed active participation in their experiment. The subjects appeared to become highly interested in new types of virtual reality interactive games that they had not experienced previously. Along with this, each subject was informed of her game results and allowed to share the results with other subjects. Such aspects were likely to encourage the active participation of elderly women with osteoarthritis. Existing studies have already reported

that motivation and active participation deliver superior functional results (Maclean et al., 2000).

Ⅴ. Conclusion

The virtual reality interactive games using the Xbox 360 Kinetic Sensor have the potential as an effective intervention in improving balance in elderly women with osteoarthritis. Meanwhile, further research on various types of games will be necessary in the future.

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