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Effect of Virtual Reality Exercise Using the Nintendo Wii Fit on Muscle Activities of the Trunk and Lower Extremities of Normal Adults

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Abstract. [Purpose] The present study aimed to determine the effect of virtual reality exercise using the Nintendo Wii Fit on the muscle activities of the trunk and lower extremities of normal adults. [Subjects] The subjects of the study were 24 normal adults who were divided into a virtual reality exercise group (VREG, n=12) and a stable surface exercise group (SEG, n=12). [Methods] The exercises of the VREG using the Nintendo Wii Fit and the SEG using a stable surface were conducted three times a week for six weeks. Electromyography was used to measure the muscle activities of the tibialis anterior (TA), medial gastrocnemius (MG), erector spinae (ES), and rectus abdominal (RA) muscles. [Results] VREG showed significant within group differences in TA and MG muscle activities, while the SEG showed a significant difference in the muscle activity of the MG. [Conclusion] Virtual reality exercise using the Nintendo Wii Fit was an effective intervention for the muscle activities of the TA and MG of normal adults.
Key words: Virtual reality exercise, Stable surface exercise, Muscle activity

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INTRODUCTION

In order to increase the gait efficiency of normal gait in daily living, an exercise that can improve the action of weakened muscles or strengthen distal muscles can be employed[1)]. Furthermore, it is important to conduct efficient and systematic gait training for improvement of balance and gait. To this end, a variety of training methods have been employed, such as using functional electrical stimulus, task-oriented exercises, and virtual reality exercise.

Virtual reality exercise can provide sensory feedback (auditory, visual, and proprioception sensations) in a virtual reality environment offering an exercise training program that meets individual needs and creates a training environment that can adjust the difficulty of the exercise according to individuals' adaptation levels[2)]. A virtual reality program using Nintendo Wii Fit equipment can be conveniently and inexpensively enjoyed at home. Virtual reality can also stimulate excitement and fun motivating users to use the program. Furthermore, its reliability has been proven, and many studies related to virtual reality have been conducted[3)]. In previous research, various studies of the effects on balance of a virtual reality program with expensive equipment have been conducted. However, few studies have been performed to determine the muscle activities of the trunk and lower extremities using the Nintendo Wii Fit virtual reality program. Therefore, the present study aimed to determine the effect of virtual reality exercises using the Nintendo Wii Fit on the muscle activities of the trunk and lower extremities.

SUBJECTS AND METHODS

The subjects of the present study were 24 adults (15 males, 9 females) who were divided into a virtual reality exercise group (VREG; age 21.9±1.4 years, height 169.8±8.1 cm, weight 66.3±13.2 kg) and a stable surface exercise group (SEG; age 24.3±3.9 years, height 168.3±9.2 cm, weight 67.4±114.3 kg). All the subjects were given an explanation of the purpose and exercise methods of the present study prior to the experiment. Subjects voluntarily signed forms giving their consent to participation in accordance with the ethical principles of the Declaration of Helsinki. The subjects enrolled were adults who had not experienced orthopedic or neurological injury in the past six months.

The VREG performed a virtual reality exercise program using the Nintendo Wii Fit (Nintendo Company Ltd., Japan). The virtual reality system starts the game when the balance plate recognizes motion. When subjects move or maintain their weight on the balance plate, the system applies this to the virtual reality displayed on the screen. Furthermore, an avatar (Mii) is shown on the screen who follows the subject's movement, providing not only visual and auditory feedback, but also sensory feedback through vibrational responses to the user's various movements. In the

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present study, three programs (tennis, baseball, and bowling) were chosen from a total of five. The training time of a single session was 40 minutes, and training sessions were conducted three times a week for six weeks. Each program was conducted for 10 minutes, and five minutes of rest was given between the programs.

The SEG performed their training on a stable support surface. They conducted their exercise on flat ground in an upright posture. First, they crossed both hands in front of the chest and touched both shoulders. With both eyes open, they lifted and held their heels up for six seconds, followed by lifting and holding up the toes for six seconds. Next, they bent their shoulders to about 45 degrees as their arms were straightened, followed by turning the trunk to the right and left while lifting the toes and heels in sequence. Finally, they crossed both hands in front of the chest and touched both shoulders while standing balanced on one foot, then the other foot, alternately. The training was conducted for both groups three times a week for six weeks, with each session lasting 40 minutes. The subjects conducted the above three steps repeatedly in each session, and five minutes of rest was given between the steps. In order to measure the change in muscle activity, surface electromyography (MP150, BIOPAC System Inc., Santa Barbara, CA, USA) was used. Surface electrodes were attached to the skin over the tibialis anterior (TA), medial gastrocnemius (MG), erector spinae (ES), and rectus abdominal (RA) muscles. The electromyograms (EMG) were sent to the MP150 system and converted into digital signals that were processed using a personal computer using AcqKnowledge software (version 4.01). The average value of the EMG of a muscle is presented as percentage of the maximum voluntary isometric contraction (%MVIC).

We used the paired sample t-test to determine the significance of the changes in muscle activities within the groups. We used SPSS 12.0 for Windows for statistical processing, and a significance level of α= 0.05.

RESULTS

The results show after the intervention, there were significant differences in TA and MG activities in VREG ($p<0.05$), and that the SEG showed a significant difference in MG activity ($p<0.05$) (Table 1).

Table 1. Comparison of the muscle activities of each group between pre- and post-intervention (unit: %)

	Group	Pre-intervention	Post-intervention
TA	VREG*	389.6±286.1	849.6±298.3
	UEG	509.4±198.4	613.3±243.4
MG	VREG*	1,119.1±82.7	1,390.6±223.0
	UEG*	1,151.2±488.9	1,559.6±442.3
ES	VREG	114.7±43.1	130.6±62.3
	UEG	226.4±135.7	231.8±250.2
RA	VREG	108.2±63.7	375.2±590.9
	UEG	121.4±29.3	165.9±202.9

TA: tibialis anterior muscle, MG: medial gastrocnemius muscle, ES: erector spine muscle, RA: rectus abdominis muscle. *: $p<0.05$, **: $p<0.01$ (paired t-test)

DISCUSSION

The present study aimed to determine the effect of virtual reality exercise using the Nintendo Wii Fit on the muscle activities of the trunk and lower extremities of normal adults.

Saposnik et al.[4] studied 22 patients with stroke and reported that a group that performed virtual reality training programs showed greater improvement in upper extremity functions than a group performing recreational exercise. Yavuzer et al.[5] studied 20 patients with stroke and reported that a group that did virtual reality exercise for four weeks showed a significant increase in upper extremity functions, such as dressing, in terms of functional independence measures compared to a control group. Merians et al.[6] also studied patients with stroke and reported that virtual reality programs using robots, motion detection, sensor-attached gloves, and computers were effective at recovering upper extremity functions. They suggested that traditional exercise treatment with virtual reality is more beneficial, because exercise intervention using virtual reality can provide appropriately modified visual feedback, thereby activating brain tissue. Quaney et al.[7] studied 10 patients with stroke and reported that the performance of a virtual reality exercise program that can provide visual feedback elicited a significant improvement in the grasping ability of the hands.

Dunning et al.[8] studied patients with stroke who were more than nine months old and conducted exercise using virtual reality systems for eight weeks. They reported that the patients showed improvements in gait velocity, ankle movement, and plantar flexion while pushing their ankles, resulting in an increase in ankle muscle strength and gait velocity. Walker et al.[9] studied patients with chronic stroke and reported that weight-supported treadmill training provided in a virtual environment increased the Berg Balance Scale result from 43.8 to 48, showing that treadmill training using virtual reality was more effective at improving balance than general treadmill training. Mirelman et al.[10] conducted a program to improve lower extremity functions using a robot virtual reality system for four weeks and reported that the experimental group using the robot system showed greater improvements in gait velocity, gait distance, and cadence. In addition, Yang et al.[11] conducted virtual reality–based training lasting four weeks for stroke patients, and concluded that the augmented reality–based treadmill training improved gait velocity. In the present study, muscle activities of the trunk and lower extremities were measured before and after the virtual reality training intervention, and the results show that in the VREG, the muscle activities of the TA and MG significantly increased. This result indicates that virtual reality training contributed to improvement of ankle joint stability, since those muscles are mainly used in ankle strategy. It also shows that balance training using virtual reality changed the center of pressure movements in anteroposterior and mediolateral directions, since the TA and MG are the muscles primarily used for balance. In the VREG, no significant difference was found in the muscle activity of the ES or the RA. This was because the virtual reality program requires dynamic movements of the lower extremity, whereas it requires comparatively less movement involving the muscles of the trunk.

The limitations of the present study are as follows: first, this study did not include a large number of subjects; second, it is difficult to generalize the study results because the subjects were only chosen from adults living in Chungbuk Province in Korea. In future research, a study of the effects of virtual reality exercise using the Nintendo Wii Fit on the functional recovery of athletes who have an ankle injury is required.

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