Effects of Virtual Reality Training using Xbox Kinect on Motor Function in Stroke Survivors: A Preliminary Study

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Background: Although the Kinect gaming system (Microsoft Corp, Redmond, WA) has been shown to be of therapeutic benefit in rehabilitation, the applicability of Kinect-based virtual reality (VR) training to improve motor function following a stroke has not been investigated. This study aimed to investigate the effects of VR training, using the Xbox Kinect-based game system, on the motor recovery of patients with chronic hemiplegic stroke. *Methods:* This was a randomized controlled trial. Twenty patients with hemiplegic stroke were randomly assigned to either the intervention group or the control group. Participants in the intervention group (n = 10) received 30 minutes of conventional physical therapy plus 30 minutes of VR training using Xbox Kinect-based games, and those in the control group (n = 10) received 30 minutes of conventional physical therapy only. All interventions consisted of daily sessions for a 6-week period. All measurements using Fugl–Meyer Assessment (FMA-LE), the Berg Balance Scale (BBS), the Timed Up and Go test (TUG), and the 10-meter Walk Test (10mWT) were performed at baseline and at the end of the 6 weeks. *Results:* The scores on the FMA-LE, BBS, TUG, and 10mWT improved significantly from baseline to post intervention in both the intervention and the control groups after training. The pre-to-post difference scores on BBS, TUG, and 10mWT for the intervention group were significantly more improved than those for the control group ($P < .05$). *Conclusions:* Evidence from the present study supports the use of additional VR training with the Xbox Kinect gaming system as an effective therapeutic approach for improving motor function during stroke rehabilitation.
Key Words: Stroke—Motor activity—Virtual reality—Video game.

Introduction

The therapeutic approach to the rehabilitation of patients with hemiplegic stroke requires repetitive training in combination with continuous modification of the training program to maintain patient engagement. Recreational programs often provide emotional support and practical environments for intervention as a major therapeutic effect.[1] In patients with hemiplegic stroke, continuous virtual feedback facilitates corticospinal activation to a greater extent than the continuous visual feedback provided by the performance of activities in front of a real mirror.[2] Virtual reality (VR)-based feedback has also been shown to increase activation of the primary sensorimotor cortex, the supplementary motor area, and the cerebellum during hand-clenching tasks.[3]

VR-based systems that use sensor technology to monitor whole-body movements can elicit patients to perform

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high-intensity and high-energy movements. Kinect-based systems (Microsoft Corp, Redmond, WA) reduce the demand on staff time for intervention and increase patients' motivation toward rehabilitation.[4] Kinect-based VR training that includes auditory and visual stimulation, feedback information about "winning" or "losing," and repetitions of the same motion can provide a variable rehabilitation tool that reduces barriers to individuals performing rehabilitation exercises.[3]

Commercial active gaming systems, such as those that fall within the category of exergaming,[5] those used by the Kinerehab system,[4] and those for the Wii console (Nintendo, Kyoto, Japan), can be effectively used in rehabilitation programs to assist in patients' recovery of motor function.[5,6] The most recently released Xbox Kinect system has an RGB camera and a dual infrared depth sensor for the automatic detection of limb and body position and motion. The system uses these elements to capture data to create a 3-dimensional human body model in real time, called an avatar, which allows for players to use their own body as the controls to play a game.[7] The reliable visual feedback from the on-screen player's avatar may provide accurate feedback on movement. The built-in commercial games of the Kinect-based system can be used for real-time rehabilitation training. An important advantage of the Kinect software development kit (SDK) or the OpenNI SDK for noncommercial use is the availability of open-source tools that allow for the adaptation or creation of new games.[7] The OpenNI SDK enables developers to create or modify the software.

These Kinect-based games have been adapted and used to treat patients with neurological problems. The Kinect-based choice reaction time task is 1 prototype game that has been developed for step training in elderly patients in clinical practice.[8] Kinect-based games have been effectively used in children with degenerative ataxia to improve whole-body coordination, dynamic balance capacities, and step length over an 8-week training program.[9] Significant improvement has also been seen in the upper limb function of patients with chronic stroke after VR training using the Kinect-based game "Fruit" during a 3-week training program.[3]

Although the Kinect gaming system has been shown to be of therapeutic benefit in rehabilitation, the applicability of Kinect-based VR training to improve motor function in patients following the occurrence of a stroke has not been evaluated. Therefore, the present study aimed to evaluate the effects of additional VR training with Xbox Kinect on the motor recovery of the lower extremity in patients with a chronic hemiplegic stroke.

Materials and Methods

Design and Setting

A randomized clinical trial was conducted in a rehabilitation hospital in Seoul, South Korea.

Participants

The study participants were inpatients at the rehabilitation center with a clinical diagnosis of hemiplegic stroke. To recruit participants, the purpose and procedures of the study were described in an advertisement placed throughout the hospital. Twenty-five volunteers were recruited and screened by a research assistant on the basis of the following inclusion and exclusion criteria. The inclusion criteria were a period of more than 6 months between stroke and randomization, hemiplegic stroke as diagnosed by a neurologist, a total score of 21 or greater on the Mini–Mental State Examination (MMSE), no problems with auditory or visual functioning, an ability to walk more than 10 m with or without assistive devices, not taking any medication that could influence balance, stable vital signs, and a capacity to provide informed consent. The exclusion criteria were severe conditions that require medical care, such as uncontrolled blood pressure or angina; musculoskeletal impairments of the lower extremity; psychological conditions; or the refusal to use a video game. One volunteer refused to use a video game and was excluded.

Ethical Consideration

All participants who fulfilled the inclusion criteria participated in the study after the purpose and procedures of the study were fully explained to them. All procedures were approved by the Sahmyook University Institutional Review Board, and all patients signed an informed consent before participating in the study.

Randomization

The participants were allocated to the intervention group and the control group using random number tables. The allocation of the groups was initially concealed. A research assistant, with no involvement in any of the assessment or intervention components of the trial, opened envelopes consecutively based on the patient enrollment sequence and forwarded the random number to the researcher in charge of enrollment to arrange intervention and outcome measurements for each participant.

Interventions

The intervention group participated in a 30-minute VR training session using Xbox Kinect, followed by a 30-minute session of conventional physical therapy. The control group participated in a 30-minute conventional physical therapy session only. All interventions were performed daily for 6 weeks.

VR Training using Xbox Kinect

For the VR training, the Xbox Kinect system, which consists of a Kinect sensor and console, was used. The Kinect