



Original Article

Effects of a virtual reality video game exercise program on upper extremity function and daily living activities in stroke patients

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Abstract. [Purpose] This study examined the effects of training using virtual reality games on stroke patients' functional recovery. [Participants and Methods] Twenty-four hemiplegia patients whose disease duration was longer than six months participated in this study. The participants were divided at random into a control group (n=12), which received traditional rehabilitation therapy, and an experimental group (n=12), which received both traditional rehabilitation therapy and training using virtual reality games. The program lasted for a total of 12 weeks. To examine the participants' functional recovery, their upper limb function was measured using the Fugl-Meyer Assessment and Manual Function Test before and after they completed the training and their daily living activities were measured using the Stroke Impact Scale before and after they completed the training. [Results] The experimental group participants' daily living activities improved after training. In addition, the experimental group scored significantly higher on all the tests than the control group, but upper extremity function between the groups was not significantly different. [Conclusion] Stroke patients who completed the additional training using virtual reality games showed significantly greater improvement in their daily living activities than those who only received traditional rehabilitation therapy.

Key words: Stroke, Virtual reality game, Functional recovery

(This article was submitted Jul. 10, 2018, and was accepted Sep. 12, 2018)

INTRODUCTION

Generally, neurological disorders that can occur in stroke patients show various symptoms, such as motor, sensory, cognitive, language, and emotional disorders, and many stroke patients live with permanent disorders without recovering their normal movements or functions because of the loss of their motor skills¹⁾. Among stroke patients, 69% experience functional motor disturbance in their upper extremity, and 56% complain of discomforts five years or even longer after the onset of their disease²⁾. Reduced motor skills in stroke patients due to hemiplegia is a major factor that reduces the levels of activities of daily living (ADLs) and social activities³⁾. This issue is not only the patients' own problem, but it also heavily affects the quality of life of their families while causing psychological distress⁴⁾. The problem is that despite significant advances in the prevention and treatment of stroke, the incidence of stroke has continued to increase⁵⁾. This trend has gradually increased the number of survivors who do not completely recover from a stroke, and this situation subsequently leads to more unpredictable situations⁶⁾. Stroke patients may repeatedly practice and be trained in daily living tasks to effectively improve their motor skills. Wolf et al.⁷⁾ reported the positive effects of repetitive exercises, task-oriented training, and active exercises including functional movements. However, the lasting effects of rehabilitation exercises could not be easily assessed because patients had difficulty performing certain tasks in their actual environments, the safety of patients could not be fully ensured, and observing whether patients properly performed at home the tasks that they had performed in hospital was difficult⁸⁾.

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However, with the advancement in computers beginning in the late 1990s, virtual reality (VR), which provides stable and realistic environments by compensating for the weaknesses of conventional methods, began to be used in the rehabilitation of stroke patients⁹. In VR, users have their own images expressed on the screen through the video capture system and resolve problems by interacting with tasks appearing on the screen¹⁰. This method has the effect of increasing users' self-motivation to perform tasks by creating interest and enjoyment¹¹. Most previous studies that applied VR in stroke patients used it as an intervention tool to improve the patients' upper extremity function and reported that VR was effective in restoring their upper extremity function¹². Walker et al.¹³ noted that VR was effective in improving balance ability and walking speed in stroke patients. Seo¹⁴ found that VR was effective in visual and cognitive functions, upper extremity function, and muscle strength. Saposnik et al.¹⁵ reported that VR training was effective in upper extremity function and in the ability to perform ADL. However, most previous studies applied VR programs or video games in a single participant or group, and only a few studies identified the effects of VR on upper extremity function, balance ability, visual and cognitive functions, and the ability to perform ADL in stroke patients¹⁶⁻¹⁸.

Therefore, this study aimed to examine the effects of VR programs as an intervention for rehabilitation after a stroke on upper extremity function and the ability to perform ADL in stroke patients.

PARTICIPANTS AND METHODS

This study design was a single blinded, randomized controlled trial. In total, 24 individuals agreed to participate and separated in two groups using (n=12 for each group) Randomization Allocation Software in on block (p<0.05 was accepted). Randomization was conducted by a person not involved in the study.

After the purpose of the study was explained to the patients, the experiment was conducted on those who agreed to participate. This study was approved by hospital, and all the participants provided their written informed consent (Mokpo Rehabilitation Hospital).

The selection criteria were as follows:

- 1) Those who had passed at least six months after the onset of a stroke.
- 2) Those who scored 21 points or above in the Berg Balance Scale.
- 3) Those who scored Stage 4 or above in the Brunnstrom motor recovery stages of arm and hand.
- 4) Those who understood the therapist's instructions with 24 points or above in the Mini-Mental State Examination.

This study aimed to investigate the effects of VR exercise programs using video games on upper extremity function and daily living in stroke patients. To this end, pre- and post-experimental designs were employed involving a control group that underwent traditional rehabilitation (12 weeks, 5 times per week, and 30 min per time, same exercise program) and an experimental group that underwent VR exercise programs using video games in addition to the traditional rehabilitation (12 weeks, 3 times per week, and 40 min per time, same VR exercise program).

The Wii Sports and Wii Fit software produced by Nintendo of Japan were used to comparatively measure the effects of the VR exercise programs using video games. Prior to this work, a preliminary study was conducted on five subjects who met the experimental conditions. Their levels of participation in and satisfaction with a range of exercise programs were estimated, and then a final exercise program was selected based on the results of the analysis of their activities performed by the researcher. Four programs, namely, tennis, baseball, and golf in Wii Sports and balance training in Wii Fit, were finally selected as the study's exercise programs through the preliminary experiment.

The upper extremity function was measured using the Fugl-Meyer Assessment (FMA) and Manual Function Test (MFT). The effects of the programs on daily living were measured using the Stroke Impact Scale (SIS). The mean value of two repeated measurements was adopted for data analysis. All assessments were made before treatment and on the last day of treatment by the same evaluator/occupational therapist, who was blinded to the treatment groups.

This study was intervened by one occupational therapist to improve objectivity. The therapist has 5 years of clinical experience. And I completed nerve mobilization education in Korea.

For the analysis, the paired samples t-test was used to identify the differences within each group before and after the experiment, and the independent samples t-test was used to compare the changes in the scores between the two groups before and after the experiment. The statistical significance level was set to $\alpha=0.05$.

RESULTS

The subjects of the study were 24 patients (15 men and 9 women) diagnosed with hemiplegia due to a stroke at M Hospital in Jeollanam-do, and they were randomly assigned to either the experimental group or the control group (n=12 for each group).

The general characteristics of the subjects were as follows: The average ages of the control and experimental groups were 57.23 ± 14.63 and 50.91 ± 9.57 , respectively. The average heights of the control and experimental groups were 164.16 ± 7.51 cm and 168.5 ± 7.20 cm, respectively. The average weights of the control and experimental groups were 58.83 ± 7.48 kg and 67.41 ± 14.70 kg, respectively. For each variable, no statistically significant difference was found between the groups (p=0.22 for age, p=0.08 for height, and p=0.16 for weight).

The analysis of changes in the upper extremity function before and after the training showed the following results. The assessment of the upper extremity function using the FMA indicated that the control group scored 53.50 ± 12.59 points before the training and 55.42 ± 11.61 points 12 weeks after the training, and the experimental group scored 44.67 ± 12.52 points before the training and 49.00 ± 10.00 points 12 weeks after the training. In terms of the difference in each group before and after the training, the control group exhibited no statistically significant difference, whereas the experimental group showed a statistically significant difference ($p < 0.05$). Moreover, no statistically significant difference was observed between the two groups before and after the training. The assessment of the upper extremity function using the MFT revealed that the control group scored 22.92 ± 5.05 points before the training and 23.75 ± 4.96 points 12 weeks after the training, and that the experimental group scored 20.17 ± 3.19 points before the training and 21.58 ± 3.20 points 12 weeks after the training. In terms of the difference in each group, both the control group ($p < 0.05$) and the experimental group ($p < 0.01$) showed a statistically significant difference. The analysis of differences in the MFT between the two groups exhibited no statistically significant difference.

The analysis of changes in the ability to perform ADL before and after the training showed the following results. The control group scored 223.42 ± 19.66 points before the training and 227.75 ± 19.99 points 12 weeks after the training, and the experimental group obtained 216.33 ± 34.81 points before the training and 216.33 ± 34.81 points 12 weeks after the training. In terms of the difference within each group before and after the training, the control group showed no statistically significant difference, whereas the experimental group exhibited a statistically significant difference ($p < 0.001$). The analysis of differences in the SIS between the two groups showed a statistical significant difference ($p < 0.05$).

DISCUSSION

This study was conducted to identify the effects of VR exercise programs using video games on upper extremity function and the ability to perform ADL in stroke patients. The comparative analysis of upper extremity function between the two groups using the FMA and MFT showed no statistically significant differences between the groups. However, the study by Park Jeong-Mi and Kim Jung-Seon¹⁹⁾ involving 16 stroke patients reported statistically significant differences ($p < 0.05$) before and after the treatment in all tests conducted, including the Box and Block Test, FMA, Jebson-Taylor Hand Function Test, and Upper Extremity Function Test. This result differs from that of the present study. In addition, the studies by Saposnik et al.¹⁵⁾, Decker et al.²⁰⁾, and Brosnan et al.²¹⁾, which were all conducted using VR games similar to the present study, confirmed statistically significant differences in the upper extremity function before and after the treatment. This difference between the previous studies and the present study may have resulted from their differences in research design. First, the subject selection criteria are all different. Whereas the present study selected stroke patients with Stage 4 or above in the Brunnstrom motor recovery stages of arm and hand to evaluate their upper extremity function, Park JM¹⁹⁾ selected stroke patients who showed no improvement in upper extremity function and no orthopedic diseases, and Saposnik et al.¹⁵⁾ involved stroke patients with Stage 4 or above in the Chedoke-Master Stroke Assessment Scale (arm). Second, Decker et al.²⁰⁾ and Brosnan et al.²¹⁾ applied their respective training programs in a single participant or group. For this reason, comparing their findings with those of the present study, which compared two groups, may be inappropriate. However, as with Decker et al.²⁰⁾ and Brosnan et al.²¹⁾, the present study also showed that the experimental group had statistically significant greater improvements in the upper extremity function than the control group when the differences in each group after the intervention were compared. Given that this outcome coincides with that of the previous studies, treatments using VR may have positive effects on upper extremity function in stroke patients.

An analysis was performed using the SIS to examine the differences in the ability to perform ADL between the two groups and showed a statistically significant difference ($p < 0.05$) between the groups. Saposnik et al.¹⁵⁾ and Brosnan et al.²¹⁾, who examined the effects of training using VR in stroke patients using the SIS, reported statistically significant differences that corresponded with the findings of the present study. In particular, Brosnan et al.²¹⁾ revealed that improvements in the domain of daily living were pronounced ($F=54.365$) and that training using VR was effective in reducing stroke patients' limitations in ADL due to anxiety, a sense of deprivation, and dependence, and their avoidance of using the affected side due to hemiplegia. The SIS, which was employed in this study, assigns scores for the quality of life, health status, and degree of recovery from a stroke according to the subjective opinions of participants. Therefore, the SIS values of the study suggest that the experimental group playing VR games was more interested in and was self-motivated in the given tasks than the control group, thus leading to improvements in their ability to perform them and their quality of life. Accordingly, this study also confirmed using the SIS that the treatment of stroke patients using VR increased their performance, satisfaction, motivation, and interest. Therefore, VR exercise programs using video games positively influenced stroke patients' ability to perform ADL.

The above results suggests that VR exercise programs using video games positively affect the recovery of upper extremity function and the ability to perform ADL in stroke patients. Nevertheless, this study had some limitations. First, at least six months had to pass after the onset of a stroke for the participants, and thus accurate data could not be obtained regarding any specific training performed within the six months after onset. Second, the small number of participants made generalizing the results of this study difficult for all stroke patients. Therefore, future studies should be conducted to apply VR exercise programs using video games in larger numbers of strokes patients from the initial stages of their treatment to collect more information and suggest proper protocols using these programs to improve upper extremity function, balance ability, visual

and cognitive functions, and ability to perform ADL in stroke patients.

Funding

This work was supported in part by the Howon University Research Fund.

Conflict of interest

The author declares no conflicts of interest.

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