Effects of Virtual Reality Exercise Program on Balance, Emotion and Quality of Life in Patients with Cognitive Decline

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Purpose: In this study, we investigated the effectiveness of a 12-week virtual reality exercise program using the Nintendo Wii console (Wii) in improving balance, emotion, and quality of life among patients with cognitive decline.
Methods: The study included 30 patients with cognitive decline (12 female, 18 male) who were randomly assigned to an experimental (n = 15) and control groups (n = 15). All subjects performed a traditional cognitive rehabilitation program and the experimental group performed additional three 40-minute virtual reality based video game (Wii) sessions per week for 12 weeks. The berg balance scale (BBS) was used to assess balance abilities. The short form geriatric depression scale-Korean (GDS-K) and the Korean version of quality of life-Alzheimer's disease (KQOL-AD) scale were both used to assess life quality in patients. Statistical significance was tested within and between groups before and after treatment, using Wilcoxon signed rank and Mann-Whitney u-tests.
Results: After 36 training sessions, there were significant beneficial effects of the virtual reality game exercise on balance (BBS), GDS-K, and KQOL-AD in the experimental group when compared to the control group. No significant difference was observed within the control group.
Conclusion: These findings demonstrate that a virtual reality-training program could improve the outcomes in terms of balance, depression, and quality of life in patients with cognitive decline. Long-term follow-ups and further studies of more efficient virtual reality training programs are needed.

Keywords: Balance, Cognitive impairment, Dementia, Virtual reality exposure therapy

INTRODUCTION

Dementia is a degenerative disease of the nervous system, which is prevalent in the elderly population. It involves deterioration in cognitive function and ability to perform everyday activities. As the early diagnosis and treatment of dementia is delayed, its economic costs and burden on families and society are gradually increasing and becoming a social problem.[1] Older people with dementia have an increased risk of falls and lower levels of everyday activities being performed due to cognitive decline and decreased muscle mass. This is a result of reduced physical activity, which further deteriorates their quality of life.[2] Therapeutic interventions to improve cognitive function and to increase activities of daily living (ADL) in patients with dementia are divided into pharmacological and non-

pharmacological treatments. For pharmacological treatment, acetylcholinesterase inhibitors and N-methyl-D-aspartate receptor antagonists are the most widely used in clinical practice.[3] However, because pharmacological treatment alone cannot prevent the progression of cognitive decline and ADL deterioration in patients with dementia, various non-pharmacological treatments including cognitive therapy or physical exercise are used as additional treatments.[4]

Recent reports have stated that regular exercise was effective in delaying cognitive impairment in people with dementia.[5] In a three-year follow-up study of healthy older people, a combination of cognitive activity and physical activity was found to be effective in reducing the risk for mild cognitive impairment.[6] However, physical activity was found to be more important than cognitive activity in order to further reduce the risk for cognitive decline.[6] When older

people with dementia performed regular physical exercise, there was an improvement in the mini-mental state examination (MMSE) score.[7] Physical exercise prevented the deterioration of ADL.[8] The mechanism of the benefit of physical exercise on patients with dementia is thought to be that it can facilitate neuroplasticity, promote injury recovery mechanisms at a molecular level and facilitate self-healing of the brain through its neuroprotective effect.[9]

However, unless individuals perform exercise in the long run, such beneficial effects of exercise may wear off, leading to impaired brain function and worsened disease.[10] Therefore, patients with dementia should continue exercise under the supervision of professional physical therapists in order to stop the progression of cognitive impairment for a long time. In order to achieve this, it is required to keep patients interested in the exercise therapy allowing them to maintain adherence. However, it is difficult to execute exercise treatment continuously in patients with dementia because of space, time, and cost issues in Korea. Patients get easily bored and tired of passive and simply repetitive forms of exercise treatment. In general, 20-50% of older people who start an exercise program will stop within six months.[11] Patients with dementia are expected to be more likely to discontinue exercise program due to lowered levels of patience and self-regulation abilities. Therefore, exercise programs utilizing media, including games, attempt to keep patients interested in exercise programs and to improve therapeutic effects. With recent advances in scientific technologies and computer programs, exercise and rehabilitation interventions using virtual reality are being introduced in the medical field.[12] Virtual reality refers to a computer-generated environment that allows users to have experiences similar to those in the real world. It is an interactive simulation characterized by technology that provides reality through various feedbacks.[13] While performing predetermined tasks such as playing a game in virtual reality, users manipulate objects as if they were real and can control their movements by giving and receiving various feedbacks via numerous senses such as sight and hearing.[14]

The virtual reality-enhanced exercise consisting of exercise with computer-simulated environments and interactive videogame features allows patients to enjoy performing tasks, encourages competition, and creates motivation and interest in their treatment.[15] Participation in a virtual reality-enhanced exercise was reported to lead to higher exercise frequency and intensity and enhanced health outcomes when compared with traditional exercise.[16]

However, despite these advantages, conventional virtual reality systems could not be widely available for patients in clinical settings due to several limitations including high costs and a large size.[17] Therefore, it is necessary to develop virtual reality exercise programs that are easy to follow in hospitals and at home. As an alternative, the use of computer-based individual training programmes is becoming increasingly popular due to the low cost, independence and ease of use in the home. One such system that is increasing in popularity for use in exercise training is the Nintendo Wii (Wii; Nintendo Inc., Kyoto, Japan) personal game, which became commercially available. Wii is a video gaming console with a simple method, as its virtual reality system is implemented via a television monitor. It combine physical exercise with computer-simulated environments and interactive videogame features. Because the Wii console is inexpensive and small in size, it is easy to install or move it in hospitals or at home. This gaming console is designed to be controlled using a wireless controller, allowing user to interact with his/her own avatar, which is displayed on the screen through a movement sensing system. The controller is provided with an acceleration sensor that responds to acceleration changes recognizing direction and velocity changes.[18] Wii-balance board is being used when playing a Wii Fit game. It is a force plate collecting movement information in the center of pressure of the standing user, enabling reflection of movements in a virtual environment on the monitor and thus constantly resending visual feedback to the user. Through this process, the user can adjust his/her postural responses. Studies have shown that the Wii balance board can be helpful in postural control training.[19] Because Wii is a typical example of virtual reality applications and is simple, inexpensive, and easily accessible, Wii is expected to create interest among patients encouraging them to put more efforts in exercise via games and thus augmenting effects of the treatment.

Domestic studies on the use of Wii have reported its effects on the upper extremity function, visual perception and sense of balance in chronic stroke patients,[20] spinal cord injury patients,[21] Parkinson's disease patients,[22] and multiple sclerosis patients.[23] However, there have been only a few controlled research studies about the effects of Wii on patients with cognitive decline. The present study aimed to analyze effects of virtual reality exercise program on balance function, emotions, and quality of life (QOL) in patients with cognitive decline.

METHODS

1. Subjects

Thirty patients with cognitive decline were enrolled in the present study. They visited Dementia Care Center at this hospital between March and August 2015 and were diagnosed with cognitive impairment according to the Petersen diagnostic criteria,[24] or mild dementia based on the Korean version of clinical dementia rating (CDR)[25] (CDR = 0.5 or CDR = 1) agreeing with Alzheimer disease diagnostic criteria.[26]

All subjects were diagnosed by performing a detailed medical history checkup, neurological examination, blood tests, cognitive assessment, computerized tomography (CT) and magnetic resonance imaging (MRI) of the brain. Among them, there were 26 patients, who comprised 26% of all the subjects treated with acetylcholinesterase enzyme inhibitor or memantine, whose dosages were supposed to remain unchanged before and after treatment. Patients were excluded if blood test results indicated thyroid dysfunction or vitamin B12 and folic acid deficiencies that could have an effect on cognitive function. Patients with metabolic diseases such as chronic renal failure, uncontrolled diabetes or liver failure, history of alcohol intake of more than 3 cups daily, and history of stroke were also excluded. Other exclusion criteria included: difficult-to-communicate dementia, inability to participate in the program due to paralysis or impaired balance, lungs and heart diseases enabling physical exercise, and vision problems.

Song et al.[27] described that the number of samples required for two-sided independent t-test was at least 13 subjects per each group obtained from the results of previous studies on exercise therapy in older patients with degenerative diseases, considering the effect size of 0.7, significance level of 0.05, and the power of test of 80%. Initially, there were 15 participants in the experimental group and 17 in the control group of the present study. However, two patients dropped out from the control group (the dropout rate: 11.7%). Consequently, the total number of subjects was 30 including 15 individuals in the experimental group and 15 in the control group.

Present study was approved by the institutional review board (IRB) at the university hospital. Purposes and methods of the present study were fully explained to patients and anonymity of participants was guaranteed prior to their participation. Finally, a written consent to voluntarily participate in this study was signed. In addition, we explained to patients that they can withdraw from the study with their own or legal representative's intention at any time. After receiving a written consent, data were collected twice before and after the intervention. Cognitive function of patients was assessed before the experiment using the mini-mental state examination-K (MMSE-K).[28] The MMSE-K consisted of seven domains: orientation to time (5 items), orientation to place (5 items), registration (3 items), recall (3 items), attention and calculation (5 items), language and visuospatial (9 items). 1 point was given if an individual correctly responded to an item, and if the answer was incorrect, 0 points were given. The maximum score was 30 points. Any score greater than or equal to 24 points indicates a normal cognition. Below this, scores can indicate severe (≤ 9 points), moderate (10-18 points), or mild (19-23 points) cognitive impairment.

Subjects were randomly assigned to experimental (n = 15) or control groups (n = 15). The control group, who had similar conditions in terms of age, duration of the disease, the severity of symptoms, and exercise habits to the experimental group, participated in a traditional cognitive rehabilitation program which was carried out at the center for 12 weeks. This cognitive training programmer involved a total of thirty-six sessions for 12 weeks. Each session included 20 minutes of computer-based cognitive training (visual searching, forward backward digit recall and calculation). Each session was supplemented with paper and pencil home assignments. All the participants continued with their usual routine medical care.

The experimental group participated in both a virtual reality exercise program for 40 minutes per session three times a week and a cognitive rehabilitation program. Twelve weeks later, a follow-up study was conducted. There were no changes in the number of participants. Subjects in the control group were made unaware of the type of treatment they were receiving. All subjects were assessed by physical therapists who had more than 5 year experience in hospitals and neurologists. Professionals evaluating patients were unaware of assessment purposes.

2. Experimental methods
1) Virtual reality exercise program

Wii-Fit and Wii sports software produced by Nintendo (Nintendo Inc., Kyoto, Japan) was used for virtual reality exercise program. Wii balance board, as part of the Wii-Fit program, contains a sys-

Table 1. The list and descriptions of Fit games

Game	Description
Soccer heading	Participant shifts weight to the right or left in order to head series of soccer balls that are kicked at him/her while trying to avoid distractions (i.e. soccer cleats, panda heads). Game ends when time runs out.
Table tilt	Participant shifts his/her weight to the right or left, forward and/or backward in order to tilt a table surface to direct series of rolling balls into holes in the table. Difficulty level increases when each series of balls are successfully navigated into holes. Game ends when time runs out.
Penguin slide	Participant shifts his/her weight to the right or left in order to tilt an iceberg and slide a penguin back and forth to catch fish. A faster weight shift makes the iceberg toss the penguin up to catch the fish resulting in more points. Game ends when time runs out.
Ski slalom	Participant shifts his/her weight to the right and left in order to navigate through series of gates on a slalom ski course. Game ends when the end of the course is reached.
Tightrope tension	Participant walks in place while attempting to cross a tightrope. Participant must bend and extend his/her knees to jump over obstacles. Game ends when participant falls off the tightrope, reaches other side, or when time runs out.
Snowboard slalom	Participant stands on the balance board sideways and shifts him/her weight forwards and backwards in order to navigate through series of gates on a slalom snowboard course. Shifting weight to the right increases speed. Game ends when the end of the course is reached.

tem that allows an avatar (Mii) to appear on the screen and to follow movements of a participant standing on the balance board that has pressure sensors. In turn, Wii Balance board provides not only a variety of visual and auditory feedback on the movements but also vibrational responses to various movements through Wii remote controller. Sensors on the Wii balance board were not altered and were used as released by Nintendo.[19]

Participants in the program performed an individual exercise of 40 minutes three times a week. Participants exercised for a total of 120 minutes a week and followed a 12-week program (a total of 36 exercise sessions). In each session, exercising took 30 minutes on the balance board using Wii Fit balance game and 10 minutes with Wii sports game (golf or bowling). Balance games used in the present study are described in Table 1.

Participants were instructed to hold the remote controller in hands and to perform movements as if in actual sports while playing Wii sports games. After providing a sufficient explanation about virtual reality games and showing demonstrations to all participants, the interventions were initiated. For subjects who had difficulties in learning how to play a game, repeated demonstrations and explanations were provided to encourage their participation in the intervention. When the intervention was in progress, one physical therapist stayed nearby to implement a continuous safety management in preparation for falls. When any subject felt fatigued or dizzy, the individual was instructed to get enough rest and to resume to the game. All subjects received a diary to record their progress and scores. They were instructed to record if they performed at each exercise session, the length of exercise time, the presence or absence of side effects, aggravation of symptoms, and difficulties. All these data were being reported to therapists. In addition, satisfaction rate

after the game was analyzed.

2) Measurements
(1) Balance ability

Balance function performance in patients was measured using the berg's balance scales (BBS). The BBS consists of 14 functional tasks, and the scores for each task are divided into 5 grades ranging from the lowest score of 0 to the highest score of 4 with a maximum total score of 56. Individuals having a score lower than 45 were at a high risk of falls. The inter-rater reliability and intra-rater reliability of BBS was r = 0.97 and r = 0.98 respectively.[29]

(2) Depression

Depression was assessed using the short form geriatric depression scale-Korean (GDS-K),[30] which is the geriatric depression scale developed by Yesavage et al.[31] and locally adapted for South Korea. The GDS-K can be measured based on responses of an individual with 'yes' or 'no' answers to each question. GDS-K reflects thinking, emotional, cognitive, physical, and social aspects allowing easy recognition of depression. A score of 14-18 on the GDS-K indicates suspected and mild depression, a score of 19-21 indicates moderate depression, and a score higher than 22 indicates severe depression.

(3) Quality of life

The QOL in patients was assessed using the Korean version of quality of life-Alzheimer's disease (KQOL-AD) scale.[32] It is the quality of life-Alzheimer's disease scale originally developed by Logsdon et al.[33] and adapted for local use in South Korea. KQOL-AD is an assessment technique designed for older adults with dementia to assess their own QOL. Advantages of KQOL-AD include simple

questions, detailed instructions, and availability of QOL assessment of older adults with dementia by their caregivers. The KQOL-AD consists of a total of 13 parts including physical health, energy, mood, living situation, memory, family, marriage, friends, self as a whole, ability to do chores around the house, ability to do things for fun, money, and life as a whole. Score for each part ranges from 1 (bad) to 4 (very good), and the total score ranges from 13 to 52. A lower score indicates a lower QOL. The KQOL-AD is a reliable assessment technique with excellent internal consistency split half reliability and test-retest reliability.

Table 2. General characteristics of subjects

Variables	Experimental group (n = 15)	Control group (n = 15)	p
Gender (male:female)	10:05	8:07	0.87
Age (year)	63.8 ± 10.2	65.5 ± 8.1	0.73
Weight (kg)	65.7 ± 8.9	71.7 ± 7.5	0.52
Height (cm)	163.7 ± 7.3	164.4 ± 6.8	0.65
MMSE	22.7 ± 1.5	22.6 ± 1.4	0.81
Disease duration (month)	19.8 ± 5.6	18.7 ± 4.3	0.61

Values are presented as mean ± standard deviation.
Significance level at p < 0.05 for difference between the groups.
MMSE: mini-mental state examination.

3. Data analysis

Data was analyzed using SPSS ver. 12.0 for Windows (SPSS Inc., Chicago, IL, USA). Descriptive statistics was performed to determine general characteristics of subjects. Homogeneity test between experimental and control groups was performed using the two-sided χ^2-test at a significance level of 0.05. Normality was determined using the Shapiro-Wilk test. Differences within group before and after intervention were analyzed using Wilcoxon signed rank test, a non-parametric test because normality was unmet. Differences between the groups when comparing effects of intervention were analyzed using Mann-Whitney u-test. The p-value was set at 0.05.

RESULTS

1. General characteristics of participants

A total of 30 subjects participated in the present study. The demographic characteristics of subjects are shown in Table 2. The mean age was 63.8 ± 10.2 years in the experimental group and 65.5 ± 8.1 years in the control group. No significant difference in gender, age, height, weight, duration of disease or cognitive function was found

Table 3. The comparison of variances within each group

Variable	Experimental group				Control group			
	Pre-test	Post-test	z	p	Pre-test	Post-test	z	p
BBS	40.47 ± 4.64	45.83 ± 5.73	-2.53	0.012*	39.13 ± 5.38	39.90 ± 6.17	-0.11	0.917
Short form-GDS-K	9.15 ± 4.46	4.50 ± 3.42	-2.52	0.012*	10.11 ± 3.98	10.01 ± 5.43	-0.01	0.925
KQOL-AD								
Patient report	22.13 ± 6.23	26.70 ± 5.03	-3.21	0.002*	22.31 ± 5.18	22.84 ± 5.34	-0.11	0.923
Caregiver report	24.63 ± 5.42	28.68 ± 5.75	-2.5	0.012*	24.53 ± 5.15	25.51 ± 5.23	-1.69	0.781

Values are presented as mean ± standard deviation
*p < 0.05.
BBS: berg balance scale, Short form-GDS-K: short form geriatric depression scale-Korean, KQOL-AD: Korean version of quality of life-Alzheimer's disease scale.

Table 4. The comparison of variances between each group

Variable		Experimental group	Control group	Z	p
BBS	Pre-test	40.47 ± 4.64	39.13 ± 5.38	-0.11	0.912
	Post-test	45.83 ± 5.73	39.90 ± 6.17	-2.51	0.012*
Short form-GDS-K	Pre-test	9.15 ± 4.46	10.11 ± 3.98	-0.53	0.623
	Post-test	4.50 ± 3.42	10.01 ± 5.43	-2.52	0.012*
KQOL-AD					
Patient report	Pre-test	22.13 ± 6.23	22.31 ± 5.18	-0.10	0.951
	Post-test	26.70 ± 5.03	22.84 ± 5.34	-2.52	0.012*
Caregiver report	Pre-test	24.63 ± 5.42	24.53 ± 5.15	-0.10	0.932
	Post-test	28.68 ± 5.75	25.51 ± 5.23	-2.24	0.03*

Values are presented as mean ± standard deviation.
*p < 0.05.
BBS: berg balance scale, Short form-GDS-K: short form geriatric depression scale-Korean, KQOL-AD: Korean version of quality of life-Alzheimer's disease scale.

between two groups (p > 0.05).

2. Changes before and after experiment between and within groups

The results of the comparison are shown in Table 3, 4. The BBS score in the experimental group significantly improved starting with 40.47 points before intervention and finishing with 45.83 points after intervention (p < 0.05). The BBS score in the control group was 39.13 points before intervention and 39.90 points after intervention which was not statistically significant (p > 0.05). In addition, the experimental group showed a statistically significant improvement in BBS score when compared with the control group (p < 0.05).

The degree of depression in the experimental group was significantly reduced after intervention (p < 0.05) whereas there was no significant change in the control group (p > 0.05). There were statistically significant GDS-K score differences before and after intervention between the groups (p < 0.05). KQOL-AD scale was used to determine changes in QOL by using virtual reality program. Patient-reported score in the experimental group improved significantly from 22.13 ± 6.23 points before intervention to 26.70 ± 5.03 after intervention. Caregiver-reported score improved significantly from 24.63 ± 5.42 points before intervention to 28.68 ± 5.75 points after intervention (p < 0.05). Whereas patient-reported score in the control group changed from 22.31 ± 5.18 points before intervention to 22.84 ± 5.34 points after intervention and caregiver-reported score changed from 24.53 ± 5.15 points before intervention to 25.51 ± 5.23 points after intervention with no significant difference. There was a statistically significant score difference before and after intervention between the groups.

3. Satisfaction after Wii game

In terms of surveyed patient and caregiver satisfaction after using Wii game, 91% of the patients responded positively when asked if using Wii game was helpful improving daily activities of living, and 55.21% of the patients indicated a strong positive response. In addition, 84.6% of caregivers responded positively when asked if it was helpful in patient care and 47.3% of the caregivers indicated a strong positive response. 77.0% of participants responded positively when asked if they would like to continue using the Wii game in the future (Figure 1).
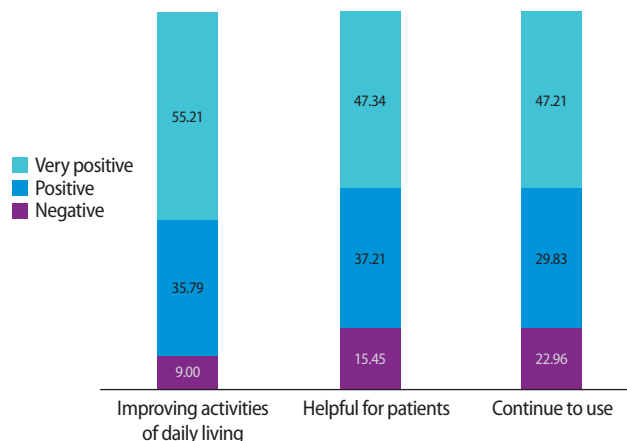

Figure 1. The level of satisfaction about Wii game for dementia patients (Number = %).

DISCUSSION

In the present study, we aimed to investigate the effects of a virtual reality exercise program in improving balance and QOL in patients with dementia. Although there have been many reports indicating that physical exercise therapy was effective as an intervention for patients with dementia, only few studies have attempted to determine whether virtual reality-based exercise programs applied with newly developed electronic game devices, are also useful.

In terms of improving balance to enhance postural instability in patients with dementia, there was a statistically significant difference between experimental group using virtual reality exercise program and the control group. In the experimental group, there was a balance difference of -5.36 ± 3.62 before and after intervention showing an increase in balance. There was also a statistically significant difference between the groups. Past studies report that, for the virtual reality intervention group consisting of chronic stroke patients, BBS score significantly increased from 44.42 points before to 51.18 points after intervention. And there was also a significant difference between experimental and control groups.[20] Kim et al.[34] reported that following virtual reality-based continuous slow exercise administered to older adults with a high risk of falls, their balance significantly improved in the experimental group compared with the control group. Lee et al.[35] reported that virtual reality exercise program administered to elderly women aged 65 years or older significantly increased balance abilities when compared with the treadmill walking exercise group. In addition, a study of Parkinson's disease

patients performing an 8-week virtual reality exercise program found statistically significant differences in the BBS, the functional reach test, the one-leg stance test, the timed up and go test, and the sit-to-stand test compared with the control group undergoing hyperthermia alone.[22] Virtual reality exercise program using Wii game also significantly improved balance in multiple sclerosis patients but not in a control group.[23] In a study reported by Esculier et al.[36] 10 subjects with Parkinson's disease and 8 healthy subjects participated in a home-based balance program using Wii Fit for 40 minutes per session three times a week for 6 weeks. Each session consisted of the Wii Fit Plus exercise such as ski jump using the balance board for 30 minutes followed by the Wii sports game such as golf or bowling for 10 minutes. Subjects showed increased muscular strength of lower extremities resulting in improved balance. The above-mentioned findings demonstrating positive effects of virtual reality program on balance in patients with neurologic diseases were consistent with findings of the present study.

Since virtual reality exercise program can provide sensory-enriched environment, combining visual, auditory, and proprioceptive feedback, patients can watch their own balance and movement states and receive visual and auditory feedback while performing an exercise. This allows patients to strengthen stimulation of the vestibular system and proprioceptors. In other words, it enables patients to exert more attention and focus on mobility required to play the game and leverage muscular motor system, oculomotor, cerebellum, and limbic circuits to improve physical balance. In view of the fact that improving balance of patients is important for preventing falls and enhancing their QOL, the findings of the present study showing an improvement in BBS of the experimental group imply that game-based exercise program may improve balance and overcome restrictions on activities of daily living, and thus enhance the QOL.

The results of the present study showed a statistically significant difference of degree of depression before and after intervention in the experimental group, indicating that the intervention program had benefit effects on depressed patients. Shin et al.[37] reported that game-based virtual reality reduced depression and improved the QOL in chronic stroke patients. A study by Hertz et al.[38] indicated that 20 patients with Parkinson's disease who performed various Wii sports games such as boxing or tennis without the balance board three times a week during 8 weeks, showed improvements in activities of daily living, motor function, and depression when compared to baseline. However, it was mentioned that when subjects were reevaluated after not playing the game for one month, the outcome measures returned to the baseline level, and thus it is important to adhere to virtual reality exercise program like in other exercise programs. Interestingly, 60% of subjects wanted to buy the game in order to play the Wii even after the completion of that study. Looking at satisfaction with the video game found in the present study, more than 80% of the respondents said that the intervention was helpful in patient care and more than 70% responded that they would continue to use the video game. This shows that overall satisfaction with the video game was very high.

The reasons why QOL improved in the experimental group using the Wii are considered to be social and emotional benefits that game-based virtual reality programs can offer. These are listed as follows. First, the concentration of game users increased. In the case of virtual reality-based exercise program, patients may look at it like a game but not like a therapeutic situation. Responding to audiovisual stimuli that they receive through the screen makes them more interested in the program allowing to increase their exercise adherence and concentration.[15] Next, patients who are immersed in the game-based exercise may be encouraged by their competitive spirit and motivation to get more scores during the game. By this, the reward circuitry may be activated and dopamine secretion may be increased as a placebo result thereby improving depression. Consequently, patients can be actively involved in their treatment.[39] Finally, stress and anxiety can be relieved by playing such a game. In particular, the Wii can be easily installed at home and its operation is relatively easy. Wii can be used to play enjoyable games together with a family and is thus helpful in relieving anxiety.

However, there are a few limitations of the present study. First, the number of subjects in the experimental group was not large enough to apply results to the entire elderly population with cognitive decline. Second, the study period was relatively short, so that pre-existing cognitive rehabilitation therapy could influence the results. Third, patients with non-severe symptoms were selected and patients with severe symptoms were excluded. Fourth, although the numbers of the patients who had considered Wii game helpful were very high, there were relatively less numbers of participants who would like to continue using the Wii game. This may be due to problems of advanced age of the participants. Finally, since studies

examining the Wii as a physical intervention for patients with dementia have been recently reported and previous related studies are scarce, it is difficult to conduct a proper comparison.

Results of the present study showed that: 1) BBS scores and balance were improved in patients with dementia who performed Wii game-based virtual reality rehabilitation exercise program when compared to pre-intervention values. 2) There were improvements in the GDS, an indicator of depression, and the KQOL-AD score, an indicator of QOL. Wii game-based exercise program has advantages including small size, low cost, and it being easy to move and install at home and in hospitals. In addition, the fact that an increased interest in virtual reality may drive motivation of patients indicates the need for further studies applying Wii game-based programs to physical therapies in patients with dementia. In conclusion, virtual reality treatment using video games can be a cost-effective and safe intervention that can improve balance, increase activities of daily living, alleviate depression, and enhance the QOL in dementia patients.

ACKNOWLEDGEMENTS

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