

## Nintendo Wii Game in Balance Stroke Rehabilitation: A Narrative Review

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### Review Article

#### Abstract

**Introduction:** Stroke is known as the second cause of disability in adults, which finally leads to disabilities such as movement impairments, cognitive disorders, and speech disorders. Balance disturbance and neuromuscular incoordination are the most common adverse effects of stroke. Using virtual reality systems are considering as a standard treatment method in neurologic disorders especially in stroke. Nintendo Wii games let patients do different tasks in miscellaneous environment.

**Materials and Methods:** Medline, PEDro, and Cochrane library databases were searched until 2018. Articles that used Nintendo Wii in treatment of balance disturbance in any phase of stroke were selected.

**Results:** Among 21 studies, 8 were selected. In these studies, balance test was used as main outcome measure. Improvement of static balance was shown in 2 studies. In 3 of them, balance improved significantly in intervention group rather than control group. Moreover, in 3 other studies, improvement process was reported in patients with stroke, but the results were not significant.

**Conclusion:** The result of all included studies showed positive effect of Nintendo Wii game on balance in patients with stroke.

**Keywords:** Stroke; Posture balance; Nintendo Wii

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#### Introduction

The sudden death of brain cells that occurs due to blockage or rupture of arteries and leads to a decrease in oxygen is referred to as a stroke (1). Although stroke rates are declining in developed countries, the prevalence of this disease is increasing in older communities (2). Stroke is known to be the second leading cause of disability in adults (3), which ultimately leads to disabilities such as motor, cognitive, and language disorders. Balance disturbance and neuromuscular incoordination are among the most common complications of stroke (4,5), which reduces individual's participation in society and limits their daily activities (6).

Today, the use of virtual reality (VR) games as a standard treatment has been considered along with traditional therapies in neurological diseases,

especially stroke (7). The importance of these games is due to the creation of a different environment with the aim of training and learning movements, which attracts the patient's attention and they enthusiastically performs the desired task with motivation (8,9). Nintendo Wii is a motion game system in which purposeful training is performed in a different way in a repetitive manner and interactive environment (9). The system can be used with a remote controller (Wii Remote) or a force plate (Wii Balance Board) that involves visual and auditory feedback (10,11). Nintendo Wii was introduced in 2006 in Japan as a new type of VR, and today, due to its cost-effectiveness, it is known as the most common treatment among VR modalities (12,13). The validation of this device has been examined in various studies in stroke survivors with balance

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problems and upper limb motor disorders (14). Additionally, a systematic review showed that using Nintendo Wii improves balance in adults and patients with Parkinson's disease (15). Variety of studies conducted on the effect of this game on improving the balance in patients with stroke since its introduction into the treatment field, reviewing the existing studies to summarize the therapeutic effects and conditions of the effect of this game seemed valuable. Therefore, the present study is carried out to examine the findings of the studies performed on the impact of Nintendo Wii on the balance in stroke patients.

### Materials and Methods

The MEDLINE, PEDro, and Cochrane Library databases were searched, and articles using the Nintendo Wii system to treat stroke patients and were published by the end of 2018 were selected for review. The keywords used included "Stroke, Balance, and Nintendo Wii." After reviewing the abstract of the articles published, the irrelevant articles were removed from the study.

### Results

21 articles extracted from the databases. Among 21 articles, 7 articles were on upper limb and 14 on lower limb function of stroke survivors. Finally, 9 articles which main outcome was on balance assessment test were selected. The selection criteria included experimental and review articles that used Nintendo Wii to treat balance disorders in patients with stroke in different phases. The studies which examined the impact of the Nintendo Wii on the upper limbs, but whose results did not address the impact on balance, were excluded. The information of the selected articles was extracted and classified by one of the researchers, with the details reported in table 1.

Hung et al. conducted a study on 30 patients over the age of 18 who were suffering from a stroke for more than six months and had a Berg Balance Scale (BBS) of less than 56, followed instructions, could watch television, and were able to walk without assistive device. The patients were divided into test and control groups using the random number table. It should be noted that all subjects, because they were in the chronic phase of the disease, always performed strengthening, stretching, and walking exercises, and continued the exercises during the study. Moreover, exercises as 30 minutes of console training or traditional therapy (weight-shift training) were added to their treatment protocol according to the test or control group. The treatment protocol was performed twice a week for 12

weeks under the supervision of an occupational therapist. The measurement outcomes were measured before the start of the treatment, at the end of the treatment program, and also, three months after the end of the treatment. Static balance and weight-shift on the affected side were measured using the Tetrax Balance System and the Stability Index system, respectively. Furthermore, the Functional Reach Test (FRT) and Timed Up and Go (TUG) tests were evaluated to assess the dynamic balance. Eventually, the study findings suggested that training with the Wii Nintendo game console could improve static balance more than weight-shift training in patients with chronic stroke. The results of the subsequent trials after three months also showed that both groups walked faster and the fear of falling was reduced in all patients, however the two groups did not differ significantly from each other (16).

In a study, Morone et al. examined 50 patients aged 18-85 years old who were suffering a stroke for three months and whose gait deficiency was in a moderate level. Patient with ROM limitation more than 80%. due to the lower limb spasticity were excluded from the study. For 12 sessions, the patients in the experimental group practiced games that focused on their balance three times a week for 20 minutes each session. In addition to the standard treatment, the patients in the control group performed 20 minutes of balance training three times a week. These exercises were based on the patients' abilities, including trunk stabilization exercises, weight-shift on the affected side, and proprioception exercises using balance boards. The main measurement outcome in the Study by Morone et al. was BBS, and 10-meter walk (10-MWT) and Functional Ambulation Category (FAC) tests were performed on patients as well. At the end of treatment, the value have been measured in all tests were significantly higher in the experimental group compared to the control group (17).

Bower et al. examined 108 patients over 18 years old who had experienced stroke for less than three months and were able to stand for at least 30 seconds without assistance (18). The patients were divided into two groups of balance and upper limb based on the Stroke Rehabilitation Assessment of Movement (STREAM) criterion (23). In addition to their standard multidisciplinary treatment, both groups also played with the Nintendo Wii console.

45 minutes of treatment was performed three times a week for a minimum of two weeks and a maximum of four weeks (depending on the patient's hospitalization). Standard treatment included physiotherapy and occupational therapy, and game console therapy was different for the two groups.

**Table 1.** Summary of studies reviewed in the present study

Reference	Number of samples (in each group)	Number of treatment sessions	Follow-up period	Intervention group program	Control group program	Outcomes measured	Measurement tools	Study type	Results
Hung et al. (16)	30	12 sessions (3 sessions per week)	3 months	Previous therapies + Wii	Previous therapies + weight-shift training	Static balance, dynamic balance, fear of falling, enjoyment of physical activity	Posturography, TUG, Forward reach test (FRT), FES-I, PACES	Randomized clinical trial	Static balance in patients with chronic stroke improved in the experimental group compared to the weight-shift training group [HB <sub>0</sub> P = 0.03, HB <sub>1</sub> P = 0.04, PO <sub>0</sub> P = 0.02].
Morone et al. (17)	50	12 sessions (3 sessions per week)	None	Standard treatment + Wii	Standard treatment + Balance exercises	Functional balance, inability, ability to walk, gait speed	BBS, BI, FAC, 10-MWT	Randomized clinical trial	Use of this game with routine treatment was significantly more effective than routine treatment alone (P < 0.001 in BI, BBS, and FAC tests)
Bower et al. (18)	30	2 to 4 weeks (3 sessions per week)	None	Physiotherapy and occupational therapy + Wii balance games	Physiotherapy and occupational therapy + upper limb games with Wii	Balance, mobility, UE results	Step Test, FRT	Randomized clinical trial	Nintendo Wii significantly improved the balance of patients with stroke (P = 0.022).
Yatar and Yildirim (19)	30	12 sessions (3 sessions per week)	None	Bobath + Wii	Bobath + Balance exercises	Static balance, dynamic balance, confidence, daily activities	Wii, BBS, TUG, FRT, GDI	Randomized clinical trial	Dynamic balance (BBS, TUG, DGI, and FRT tests) and FAI quality of life (P ≤ 0.05) had a higher improvement in patients treated with game consoles compared to the control group.
Bang et al. (20)	40	24 sessions (3 sessions per week)	None	Wii	Treadmill	Balance, gait	Pedo Scan, Smart Step	Randomized clinical trial	Static balance and gait pattern improved in the game group. The amount of P was not reported.
Trinh et al. (21)	20	14 consecutive 1-hour sessions	None	Wii	Wii	Lower limb function, balance	BBS, 6-MWT, Stair-Climbing Speed	Quasi-experimental	Increase in dorsal flexor ankle muscle activity following upper limb console exercises
Golla et al. (22)	14	6 weeks with follow-up and 6 weeks without follow-up	Weeks 6 and 12	Wii	Traditional exercises	Balance	BBS, DGI	Preliminary	A growing trend was observed in improving balance in patients.

ADL: Activities of daily living; BBS: Berg Balance Scale; TUG: Timed Up and Go; DGI: Dynamic Gait Index; FRT: Functional Reach Test; 6-MWT: 6-Minute walking test; FAC: Functional Ambulation Category; 10-MWT: 10-Meter Walk Test; FES-I: Falls Efficacy Scale International; PACES: Physical Activity Enjoyment Scale; BI: Barthel Index

For the balance group, games in standing position, were selected and mostly included jumping and weight-shift activities. For the upper limb group, games in static position were selected including hand movements such as boxing and bowling. The TUG and Falls Efficacy Scale International (FES-I) tests and the game console balance board data were applied to assess dynamic balance. The data analysis revealed that using the games that were performed in the standing position and included dynamic activities such as jumping and stepping, in addition to standard treatment, can improve outcomes related to balance in patients with stroke (18).

In a study, Yatar and Yildirim investigated the balance of 33 patients with stroke more than six months. The patients were divided into two groups. The Bobath approach was performed individually for both groups taking into account the patient's condition and needs. The patients in the weight bearing therapy (WBT) group practiced 30 minutes with the game console for 12 sessions (3 times a week) in addition to the 30-minute Bobath treatment. In addition to 30 minutes of treatment, patients in the Progressive Balance Training (PBT) group performed progressive balance training for 12 30-minute sessions.

Static balance was measured using the game balance board data and the dynamic balance was measured using BBS, TUG, Dynamic Gait Index (DGI), and FRT tests. Finally, the results showed that both treatments were effective in improving balance and activities that required self-confidence, as well as in improving the daily activities of patients with stroke (19).

Bang et al. randomly divided 40 patients with the mean age of 60 years (between 30-31 months after stroke) who had no limitation in communicating, watching, hearing, standing, and walking into two groups. The first group practiced with the game console and the second group practiced walking on a treadmill. All patients were treated three times a week for 8 weeks as 40-minute sessions. They used Pedometer to assess the patients' balance. This device includes a plate with many sensors that measure the amount of weight-shift and pressure value while standing. The patient is asked to get up from the chair and stay still for 30 seconds. Additionally, the Smart Step device was used to evaluate gait. This device also measures the amount of pressure applied by the sensors embedded in the patients' dominant foot shoe. Based on the results, both groups indicated significant differences in balance improvement at the end of treatment. Evaluation of gait indices also showed a

significant difference between patients who practiced with the game console compared to the treadmill group (20).

In a semi-experimental study, Trinh et al. studied the upper limbs of 20 patients aged 23 to 75 with stroke over 14 days of treatment with the Nintendo Wii game console. Between 3 and 123 months had passed since the incidence of stroke in these patients. In this study, wireless NCV electrodes instead of nerve and were used to record the activity of patients' dorsal flexor muscles during upper limb activity. This data was recorded on the second and eighth day of training. The treatment (60 minutes) was performed as a 14-day protocol focusing on the use of games that involved the upper limbs of patients. Lower limb activity was measured using the BBS, 6-Minute walking test (6-MWT), and stair climbing speed. The findings suggested that the upper limb activity could be effective in improving lower limb function. Changes in the improvement of lower limb muscle activity during the game may justify the improvement in the results of the balance and walking tests of these patients (21).

Golla et al. conducted a preliminary study on patients with a stroke over the age of 60 who 12 weeks had been passed since their discharge from the hospital. The patient inclusion criteria included obtaining an FAC score of more than 4 and the ability to walk at a speed of at least 4 meters per minute. The patients in the experimental group (n = 6) trained under the supervision of a physiotherapist for the first 6 weeks and without support with Nintendo Wii at home during the second 6 weeks, and patients in the control group (n = 8) performed traditional balance exercises. All patients had to practice 3 times a week for 30 minutes each time. The results of BBS and DGI tests showed a growing trend in improving patient balance. Moreover, despite the limitations, this study showed that these games can be very effective for patients with stroke who are able to move but cannot perform well (22).

## Discussion

The present study was accomplished with the aim to investigate the effect of VR games on rehabilitating the balance of patients with stroke. The results of all the studies included in the review were indicative of a positive effect of Nintendo Wii on improving the balance of patients with stroke.

In the articles have been reviewed, the rate of spasticity changes was not measured. Increased muscle tone due to mechanical changes in the muscle-tendon complex results in an abnormal pattern of movement, followed by a loss of balance in patients

with stroke (24,25). It seems that the use of VR games can change the spasticity level in the patients. Some games increase muscle tone and others reduce it, leading to changes in muscle function and ultimate function of patients. Gatica-Rojas et al. concluded that using Nintendo Wii significantly reduces spasticity in plantar flexor muscles in children with cerebral palsy (CP) (26). It can be concluded that VR games can improve muscle function by changing the muscle tone and, ultimately, lead to the better balance in subjects with a stroke.

VR games can improve the static balance in individuals with stroke by stimulating the vestibular system and somatosensory stimulation. Observing the avatar in the illustrator, the individuals see their weight-shift and improve their proprioceptive behavior (27,28). The findings of the study by Barcala et al. indicated that Nintendo Wii games can improve weight-shift on the affected leg in patients with stroke (29). More weight-shift on the affected side improves gait pattern, enhances balance, and reduces the risk of patients falling.

A follow-up of patients three months after treatment in the study by Hung et al. revealed that the improvement in the weight-shift on the affected side did not remain stable in the Nintendo Wii test group, and this could be due to the fast rhythm of the games of this console; Because weight-shift changes are performed slowly in patients with stroke (16). On the other hand, in this study, participants needed to use assistive devices to stand, which is a big limitation for playing games (16); Because some games involve the whole body, besides, the use of hands to maintain balance is a natural strategy, but the hands of these people are involved in keeping the assistive devices, and this fact may disrupt the correct performance required, especially weight-shift, while upper limb exercises can improve the balance and walking distance of patients with stroke (21). The record of the tibialis anterior muscle also showed that depending on the type of game performed, the pattern of involvement of this muscle is completely different, but the activity of this muscle in golf game is the most and in tennis game, the activity of the muscles in both legs are more similar, which improves walking in these patients (21).

Despite all the limitations in the studies reviewed,

the common denominator of all studies is the ability of the Nintendo Wii game to provide an attractive environment, a different therapy, and simple but engaging exercises that can make patients more interested in continuing their treatment.

### Limitations

Lack of access to all available databases was one of the limitations of the current study.

### Recommendations

Based on the available studies, it is suggested that in future studies, in addition to considering the correct design of a clinical trial study, more samples be used and intervention factors such as spasticity, patient age, type of games, and place of games be considered as well.

### Conclusion

The present study considers Nintendo Wii to be an effective treatment for improving the balance of patients with stroke in addition to traditional treatments. The studies investigated in this review were accompanied by numerous limitations and some were not of sufficient quality, but their results suggested the use of VR game consoles.

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### Authors' Contribution

Javid Mostamand: specialized manuscript evaluation in terms of scientific concepts, confirmation of the final manuscript to be sent to the journal office; Ehsan Ghasemi: specialized manuscript evaluation in terms of scientific concepts, confirmation of the final manuscript to be sent to the journal office; Narges Yousefi: Study design and ideation, data collection, analysis and interpretation of the data.

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### Conflict of Interest

The authors declare no conflicts of interest.

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