

# Wii Fit Gaming System—How to Select among Balance Exercise and Measurement Tools

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**Abstract:** VR (virtual reality) and video game technology has been proven to be beneficial in rehabilitation. The majority of studies have focused on the use of Nintendo Wii in the rehabilitation of neurological disorders most commonly stroke. It is not the only commercially available gaming system however it is the most popular virtual gaming used at home, research and clinical practice. VR training has been proven to be beneficial in lower extremity functions, balance and gait recovery. Previous studies focused on evaluating the efficacy and effectiveness of the Nintendo Wii and VR and the dosage and intensity of the “Wii therapy” remained unclear. The objective of the recent trial was to evaluate the knowledge about balance games and clinical measurement using Nintendo Wii, alongside helping clinicians plan therapy with Nintendo Wii.

**Key words:** Balance, rehabilitation, Nintendo Wii, video game, VR.

## Abbreviations

Virtual Reality	VR
Fugl-Meyer balance subtest	BS
Romberg	R
Sharpened Romberg	SR
One-legged stance test	OLS
6-minute walking test	6MWT
Timed Up and Go test	TUG
Functional Ambulation Categories	FAC
Wii Balance Board	WBB
Center of Pressure	COP
Enriched Environment	EE

## 1. Introduction

The number of balance-related research papers tripled in the past decades. VR (virtual reality) training has been proven to be beneficial in lower extremity functions, balance and gait recovery. Wii Fit gaming system is well accepted and widely used for balance assessment and therapy in rehabilitation.

Nintendo Wii is a video game with various activities designed by Nintendo. It was released in 2007, in Europe on 25 April 2008. The Nintendo Wii is based around an intuitive motion sensor system that provides real-time information on performance, using visual, auditory and sensory feedback. It provides multimodal physical exercise including muscle strength, balance, gait and cardiovascular capacity [2, 3]. The system is relatively inexpensive, easy to assess and highly engaging. It became clear that the virtual environment has beneficial impact on gait, balance and walking speed among stroke patients [2, 5, 9-12]. Previous studies indicated that it may be more effective in improving dynamic balance control and preventing falls in sub-acute and chronic stroke patients compared to conventional therapy [4, 14]. However it may not always be superior to routine therapy methods regarding balance and walking speed [9-12] and can provide the same amount of improvement [16]. It gives possibility to alternate conventional physical therapy [16]. Different devices with different characteristics were used in VR therapy. Duration of

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the VR therapy differed in a range from 20 min to 1 h. Furthermore the number of therapy sessions varied between 9 and 20 [15]. Several studies included VR training in addition to conventional therapies without increasing the number of therapy sessions in the control group. Due to the heterogeneity of tools used for VR training and the variety of sample characteristics and outcome measurements of studies, the dosage, duration and intensity of VR training still remain unclear.

The main objective of this study is to help clinicians plan VR training especially using Wii Fit gaming system. The other aim of this study is to discuss different clinical assessment tools in correlation to balance for stroke patients.

## 2. Methods

The study was approved from the Human Research Ethics Committee of the University of Debrecen (the process number is HRB/052/00514-2/2013).

### 2.1 Measurements

Different tests and tools were used to assess balance and walking ability. FMBS (Fugl-Meyer balance subtest), R (Romberg), SR (sharpened Romberg), and OLS (one-legged stance test) were used to measure balance. 6MWT (6-minute walking test), TUG (timed up and go test) were used to assess functional mobility. Walking ability was valued by FAC (Functional Ambulation Categories). Moreover, we used WBB (Wii Balance Board) to measure weight bearing asymmetry. The data were summarized and published in a prospective randomized trial [16]. In this article game-related scores were given each patient in each game by their performance. Wilcoxon signed rank test was used to analyze differences between game-related scores at baseline and end of the therapy sessions. Data analysis was done by the SPSS (Statistical Package in Social Science) version 18. The null-hypothesis was rejected when the probability value was less than or equal to 0.05.

### 2.2 Participants

Eleven (4 men and 7 women) hemiparetic stroke patients' game related scores were analyzed. Their ages were from 37 to 78 (mean 58.11) years. Hemiparetic post-stroke (7 right-sided, 4 left-sided) patients with impaired walking ability were included in case of: (1) positive Romberg test, (2) minimum muscle strength on BMC scale 3 in the gluteal muscles and femoral quadriceps muscle, (3) spasticity between mild to moderate (MAS1+ or 2) in the impaired lower extremity. All of them agreed to take part in the study.

### 2.3 Nintendo Wii/WiiFit Games

Wii Fit game play features different exercises using WBB on which the user stands during the exercise. There has been concern about its suitability for rehabilitation purpose because it was designed for "fit and healthy" individuals. However, wide range of the games, variety of difficulty levels and nature of feedbacks are the characteristics that enabled it to use in physical rehabilitation [2, 3].

In this study balance games had been used as therapeutic exercises. We provided 10 sessions for each participant daily in a 2-week period. Duration of one therapy session was 30 min.

#### 2.3.1 Characteristic of the Balance Exercise

Balance games focus on the dynamic aspects of the balance control. Patients virtually represented in the game by their avatars (called "Mii"). The goal of balance games is to move this patient's representation on a television screen via shifting the center of pressure (COP). Balance games last between 30 s and 3 min and patients receive a game-specific score after playing what expresses their overall performance.

#### 2.3.2 PenguinSlide/Heading

COP control is required along a single axis (e.g. medial-lateral), direct visual feedback through mirroring the movement and auditory feedback after a success is provided. It also gives verbal information about weight shifting (Heading) emphasizing it. The

games are considered to improve balance, coordination and the ability of muscles, sustain or generate forces over a period of time.

### 2.3.3 Balance Bubble

Greater COP control is needed through simultaneous displacement along both medial-lateral and anterior-posterior axis. It gives visual and auditory information about successful movement. The games are considered to improve balance. Greater control of body movement is needed to succeed.

### 2.3.4 WBB

WBB is a game controller. Four pressure sensors were situated at each corner of the board, which allow users to control their avatar on the screen by shifting their weight in the side to side (COPx) and front to back (COPy) directions. Also it detects slight movements, determine foot position and weight distribution and asymmetry (percentages). The information is transmitted to the Wii console via wireless (i.e. Bluetooth) technology [2].

## 3. Results

Stroke patients participated in 30min balance therapy with Wii Fit gaming system per day every

weekday in a two-week period. Participants have been asked to take part in 10 training sessions. It has resulted 300 min (5h) balance therapy besides the conventional physical therapy for each patient. The mathematical analysis revealed statistically significant changes in PenguinSlide game scores between the 1st and 5th sessions ( $42.57273 \pm 9.719024$ ;  $51.90636 \pm 12.33499$ ,  $p=0.0044$ ), as well as between the 1st and 10th therapy sessions ( $42.57273 \pm 9.719024$ ;  $51.44111 \pm 9.484739$ ,  $p=0.0090$ ). Statistically significant improvement was found in Heading ( $22.18 \pm 32.47306$ ;  $15.51556 \pm 4.813741$ ,  $p=0.0438$ ) and BalanceBubble game scores ( $30.429 \pm 13.57623$ ;  $40.70111 \pm 19.24166$ ,  $p=0.0120$ ) between the 5th and 10th sessions. Statistically significant improvement was found in Heading ( $18.72455 \pm 26.66091$ ;  $15.51556 \pm 4.813741$ ,  $p=0.0504$ ) and Balance Bubble ( $23.996 \pm 8.433092$ ;  $40.70111 \pm 19.24166$ ,  $p=0.0209$ ) between the 1st and 10th sessions, too (Fig. 1).

In this study we applied different measurements of balance (R, SR, OLS, FMBS) and assessed the mobility with 6MWT and TUG, also categorized walking ability with FAC. Training with Nintendo

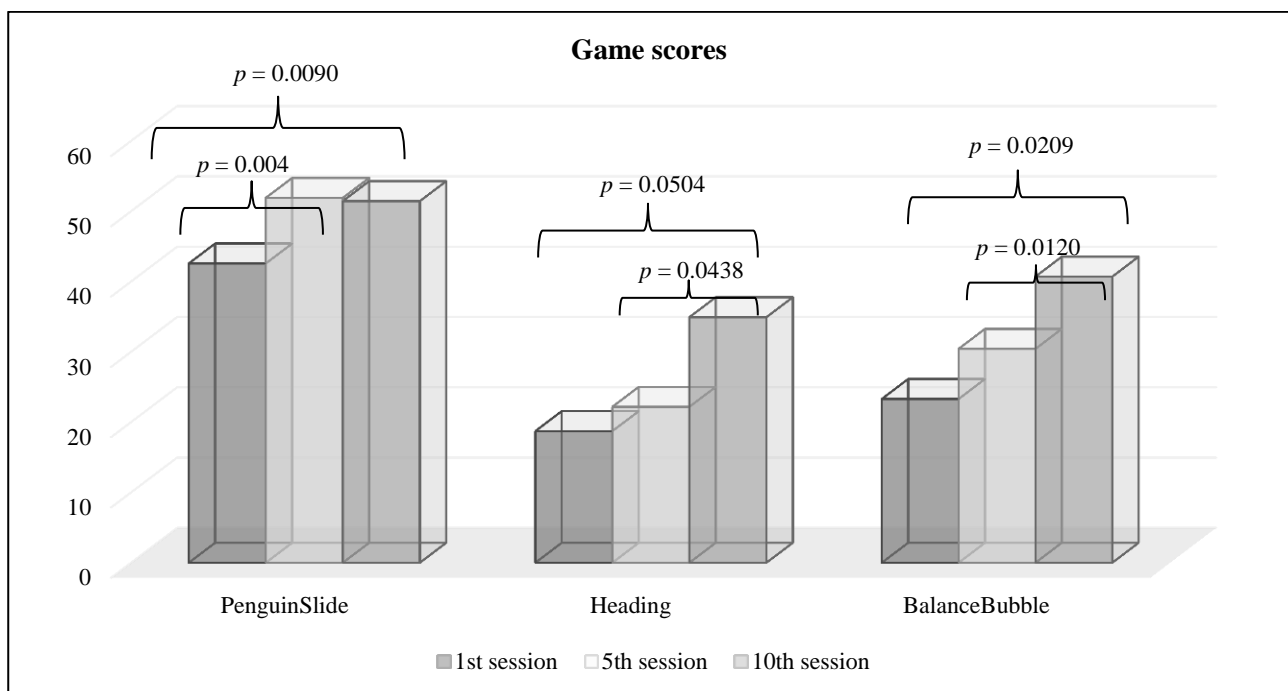


Fig. 1 Improvement of game scores in each game throughout the therapy sessions.

Wii™ resulted in statistically significant positive improvement both in the balance and mobility functions: FMBS  $p = 0.0046$ , FAC  $p = 0.0267$ , OLST2  $p = 0.0068$  and OLS1  $p = 0.0067$  (affected side), 6MWT  $p = 0.0123$  [16].

#### 4. Discussion

Our main aim was to help clinicians in decision of measurement and treatment planning. Previous studies focused on evaluating the efficacy and effectiveness of the Nintendo Wii. However the superiority above the conventional therapy is not sufficient [9-12]. Moderate evidence supports that VR training is effective as adjunction to standard methods [9-12, 16]. Different treatment methods regarding dosage, intensity and type of the games were used in trials. The variety of measurement used may also affect the conclusion of reviews and meta-analysis regarding the effectiveness and efficacy of Nintendo Wii. An important factor influencing the effectiveness of the intervention is the amount of time devoted to the training. Dosage and duration differs widely in VR studies [1, 7, 10, 11]. According to the Royal Dutch Society of Physical Therapy the duration of therapy session should be 30 min for 5 days per a week for several weeks [15]. According to another recommendation the therapy session should be 45 min [2]. In our study the dosage and duration was very similar to their recommendation. Stroke patients were asked to take part in 10 therapy sessions (5 within a week) with 30 min per occasion. VR training is a specific model of task-oriented motor learning in EE (enriched environment). The high repetition of task-oriented exercises was described as being important for locomotor recovery. The key features of all VR applications are the sense of presence in and control over the simulated environments. The ability to maintain upright posture is essential to maintain balance. Although the majority of stroke patients recover gait function after rehabilitation, balance and gait deficits persist through the chronic stage. Reduced

static and dynamic balance are major risk factors of falls and limit the ability to perform activities of daily living [4]. Number of scores awarded day by day increased and at the end of the training the scores were significantly higher compared to the first occasion in all games. Repetition ( $n = 10$ ) proved itself to be effective in growing walking distance and speed (6MWT). Furthermore it helped to improve the ability of independent walking (FAC). Furthermore balance improved significantly (FMBS) as well as the ability to maintain balance on one leg, both sides (OLS). Patients' performance improved with using Wii Fit games positively affecting the balance ability and gait control [16]. Simpler games like Penguin Slide that are more easily executed in terms of balance may already be 5 times sufficient to exert a therapeutic effect. But games with more difficult equilibrium requirements like Heading, Balance Bubble, need 10 times more practice to achieve the same therapeutic effect. Our findings supports that practicing more difficult gaming helps to improve balance, motor control and mobility. Our recommendation is to start with a simple game followed by 2 or more effortful exercises. Simple games help patients to engage in therapy, provide more sense of achievement and help to practice the movement pattern and prepare for more difficult exercise. However more difficult exercise is needed to improve balance, motor control and mobility. High repetition is needed to achieve clinical improvement among stroke patients. In this trial we applied similar dosage and intensity recommended by the Royal Dutch Society of Physical Therapy [15]. Based on the statistical and clinical improvement shown by stroke patients we concluded that "Nintendo Wii therapy" is needed at least 5 times a week minimum 2 week period.

##### *4.1 Evaluation of Nintendo Wii as Measurement Tool in Clinical Trials*

Measurements in general have to fulfill three criteria like (1) relatively simple to administer, (2) no

need of expensive equipment, and (3) commonly used in clinical settings [2]. A variety of outcome measures were employed in different trials regarding the effectiveness of Nintendo Wii. A number of the studies included impairment measures of body structure and function (Modified Ashworth Scale and Fugl-Meyer Assessment). Several studies included measures of activities (Berg Balance Test, 10 m Timed Walk) and measures of participation (Stroke Impact Scale). Few studies employed more complex measures looking at all three levels [2]. The Berg Balance Scale and Timed Up and Go test belong to the most common used ones to assess the effectiveness of VR prior to and after intervention. In our studies we included measurement of body structure (OLS, R, SR), body function (FMBS) and mobility (6MWT, TUG, FAC). In levels of body structure, function and activity we were able to detect statistically significant changes with some measurement tools (FMBS, OLS, FAC, 6MWT). Stroke patients have shown impaired reactive balance response and difficulty initiating protective stepping which can cause increased need for external assistance and more risk of falling [8]. The need of assistance and the independent walking ability are essential to measure. The maintenance of postural control through the movement is important, too. It was found that balance control is a strong predictor of functional recovery [8]. The measurement of balance specifically designed for stroke patients can help to gather information about their capacity of functional recovery as well as the effectiveness of the VR training. Measurement of both anticipatory and reactive balance control is sufficient in a decision to increase functional mobility in a clinical practice. In a scientific level we suggest measuring body structure, function and mobility regarding the effectiveness of Nintendo Wii. In a clinical practice we emphasize to assess functional mobility and the need of assistance regarding fall prevention.

Nintendo Wii is being used for treatment and as an assessment device. Overall studies were more focused

on using it as a therapeutic device (feasibility, acceptability, technical details, effectiveness) than an assessment tool. Some studies concluded that Wii Fit software based measures of balance are not effective [2]. Weight bearing asymmetry is relevant part of the balance impairment. Greater body weight usually shifted on the less impaired limb [3]. A number of the studies showed that healthy participants can directly correct their asymmetry in weight bearing if visual feedback is provided [9, 14]. Visual feedback provided by VR may enable stroke patients to adjust their incorrect center of body weight. Wii Fit software based measurement provides information about the percentage of the weight bearing asymmetry between the affected and non-affected lower limb [5-7, 9]. However it is not as effective as other clinical measurement tools in assessing the effectiveness of the therapy [3, 5-7, 9, 13] we suggest taking into consideration the measurement of body weight bearing by WBB. It can provide useful information in the clinical practice (percentage of weight shifting divided between the affected and non-affected side) and it can help the patient to visualize and correct the weight bearing asymmetry.

## 5. Conclusion

We concluded starting with simpler games like Penguin Slide can help to engage and motivate patients to the rehabilitation because little repetition is enough to experience success. More difficult games like Balance Bubble, Heading, need more time to practice and probably help improve balance, motor control and mobility [16]. We agree in terms of dosage and duration at least 2 week period 5 times a week therapy is needed to achieve effectiveness in balance and mobility. A cross controlled trial is needed to further investigate the exact dosage and intensity. Weight bearing assessment is a relatively novel method to measure balance ability. Weight bearing asymmetry affects stroke patients' activity of daily living. We suggest using WBB to assess weight

bearing considering it is easy to use, and can provide visual feedback about weight shifting. We strongly advise to use functional mobility assessment because from the patients' point of view the performance is more easily transferred to activity of daily living. It helps to engage the therapy and understand the need of it. Moreover we suggest measuring balance function specifically designed for stroke patients regarding the prediction of their recovery.

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