CLINICAL REPORT

Feasibility and Benefit of Using the Nintendo Wii Fit for Balance Rehabilitation in an Elderly Patient Experiencing Recurrent Falls

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ABSTRACT

Introduction: The purpose of this case report was to examine whether a balance training program utilizing the Nintendo Wii Fit platform could improve dynamic balance control in an elderly patient with balance impairments. Also, the investigators sought to determine whether the motivational aspect of the video games would stimulate the patient's desire to participate in the balance rehabilitation program. ***Case Description:*** An elderly patient with a recent history of falls underwent two weeks of balance training utilizing the Wii Fit platform along with other traditional therapeutic interventions. Pre-intervention and post-intervention outcome measures were recorded. For this report, the selected outcome measures were: Berg Balance Scale, Activities-specific Balance Confidence Scale, Timed Up and Go, and gait speed. ***Outcomes:*** Post-intervention, the patient demonstrated improvements in all of the selected balance outcome measures. During the intervention, the patient demonstrated a high level of cooperation resulting in increased time spent performing balance activities. ***Conclusions:*** This case report gives insight on how the Wii Fit was combined with more traditional physical therapy interventions to enhance an elderly patient's participation in the interventions and improve balance performance.

Introduction

As the population of the United States continues to age, physical therapists will be faced with an influx of clients with diminished motor control skills. Most of this growth is related to the fact that the baby-boom generation, which constitutes one-third of the U.S. population, is beginning to enter its seventh decade of life.[1] As the human body ages, a number of physiological changes occur that directly affect balance. Some of these changes include: loss in visual and auditory function, decrease in lean body mass, neuromuscular changes such as increased reaction time, and decreased strength of muscles, tendons, and ligaments.[2,3] These factors combine to play a role in the increased incidence of falls sustained by persons 65 and older. More than one-third of adults 65 and older fall each year in the United States.[4] Many people who fall, even those who are not injured, develop a fear of falling.[5] This fear may cause them to limit their activities, leading to reduced mobility and physical fitness, and increasing their actual risk of falling.[5] Physical therapists have been on the forefront of training these individuals and are faced with the challenge of providing interventions that are effective in addressing the impairments in balance that lead to an increased fall risk.

There is growing evidence that rehabilitation programs that include balance training demonstrate the ability to reduce the number of falls among participants as well as improve reaction time in the older population.[6-8] Physical therapists utilize a number of interventions for balance rehabilitation, some of which include step training, Tai Chi movements, and a variety of static and dynamic stance activities. Visual biofeedback / force plate systems are also used in the rehabilitation of clients with impaired balance. However, because of the high cost of such equipment, many physical therapists do not have these systems available to them. Many of these force plate systems incorporate the body's center of pressure (COP) as a biofeedback signal that gives instant visual feedback to the patient along with auditory feedback from the therapist. Recently, Nintendo released the Wii Fit platform* that includes a built-in COP sensor that is incorporated into yoga, strength training, aerobics, and balance games. This is the first publicly-available gaming system that uses such a force platform to provide feedback to participants. Providing real time feedback, this gaming platform may provide patients with a fun, engaging way to perform balance activities. With the relatively inexpensive Nintendo Wii gaming system and the Wii Fit platform, physical therapists in all settings could have access to the COP biofeedback technology previously reserved for more expensive equipment.

Previous researchers found benefits from using a gaming system with elderly individuals undergoing rehabilitation following stroke.[9,10] Flynn et al. utilized the Sony PlayStation 2 Eyetoy† as an intervention with a patient who had residual deficits from a chronic stroke.[9] After using the Eyetoy for 20 sessions, the patient experienced improvements in sensorimotor abilities as well as functional abilities. Rand et al. found from their use of the Eyetoy that this technology was a feasible intervention for patients with acute and chronic stroke. There are, however, no other published reports of the improvements experienced by elderly patients who utilize the COP biofeedback provided by the Wii Fit gaming system.

The purpose of this clinical report was to determine if use of the Wii Fit platform in conjunction with other therapeutic interventions would improve dynamic balance control in an elderly patient with balance impairment. This report also sought to examine the Wii Fit's feasibility in terms of set-up time as well as a geriatric patient's ability to perform the desired movements and activity level required to use the programs included in the Wii Fit.

Case Description

The patient was an 87-year-old male resident of a long term care facility who was independently ambulatory in the facility using a rolling walker. He was referred to physical therapy after experiencing four falls while walking within the previous two months. Informed consent was obtained from the patient. There was no identified etiology for these falls. The BBS, TUG, ABC scale, and gait speed were all conducted in order to determine his increased risk for falls. His past medical history was significant for high blood pressure, insulin dependent diabetes mellitus, a hip fracture eight months prior to the examination, and recurrent pneumonia. He denied any history of seizures.

Initial Examination

Prior to initiating balance training interventions, the patient underwent a series

of balance tests and measures to gather initial baseline data. All of the measures were administered by the same examiner (TP). The following four outcome measures were selected for this report: the Berg Balance Scale (BBS),[11] the Timed "Up & Go" Test (TUG),[12] the Activities-specific Balance Confidence Scale (ABC),[13] and gait speed velocity over 10 meters.[14] The BBS scores the patient on a scale from 0 to 56, with the higher score suggesting better balance. The BBS consists of a 14-item test that uses a five-point ordinal scale to quantify the patient's performance in various tasks such as standing up, standing with eyes open or closed, and standing with feet together. Research has demonstrated a strong relationship between fall risk among older adults and the BBS.[15] The BBS has also been reported in the literature to have an interrater reliability Intraclass Correlation Coefficient (ICC) of .98 and a test-retest reliability correlation coefficient (ICC) of .98.[11]

The TUG measures the time required to stand up from a standard (43 centimeters) chair, ambulate three meters, turn, walk back, and sit back in the chair.[12] The patient then is asked to perform the same task again while turning in the opposite direction and the time is recorded. The times for the two trials are then averaged. The TUG has been shown by researchers to have a sensitivity of 87% for identifying older adults who are susceptible to falls.[16]

Gait speed was measured using the 10-meter walk test, which requires the patient to walk 10 meters at his self-selected gait speed. The course is marked with three lines of tape; one of which is three meters before the 10-meter start line, a start line, and a finish line. The examiner does not start the stopwatch until the patient reaches the second line. This helps to eliminate measuring the time that it takes the patient to initiate gait, and allows for a more accurate measure of gait speed. During the trial no verbal encouragement was administered. One study found that elderly persons with a gait speed <0.55 meters per second (m/sec) are at risk for recurrent falls.[17] Researchers have proposed an argument for the concurrent validity of gait speed based on correlations between measurements of gait speed and measurements obtained for weight-shifting tasks on the NeuroCom Balance Master‡ (r=-0.49 to -0.72).[18]

The patient was also asked to complete the ABC scale which is used as a self-reported confidence rating scale when performing 16 different daily activities (0= no confidence, and 100= full confidence). If the patient does not currently perform the activity, the patient is then asked to imagine how confident he would be if he had to perform the activity. The use of ambulatory assistive devices to perform the activity is allowed when rating self-confidence. The ABC scale cut-off score of predicting falls in the elderly is below 67, with a sensitivity of 84.4%.[19]

Diagnosis and Prognosis

The patient's BBS (13/56) revealed impairments with dynamic balance activities that required him to shift his center of gravity in any direction in order to attempt to complete the task. A score of 0-20 places the patient at a high risk for falls.[20] He required 62 seconds to perform the TUG with a rolling walker, and was found to have a gait speed of 0.24 meters per second, also with a rolling walker. He had a low level of confidence in his balance performance as evidenced by scoring 32/100 on the ABC scale.

Intervention

The patient participated in 60 minute intervention sessions five times a week for two weeks. Each intervention session was structured such that the patient was allowed to warm up for 10 minutes on a recumbent bike, followed by balance training sessions on the Nintendo Wii Fit. Each session using the Wii Fit lasted between 15 and 25 minutes. Following the balance training sessions, a variety of other therapeutic interventions were performed. A summary of daily interventions can be found in Appendix 1.

Balance activities on the Wii Fit were chosen according to the patient's ability to perform the activity properly, willingness to perform the activity, and amount of displacement of center of gravity required. Figure 1 demonstrates the initial set up of the screen and Wii Fit platform. The monitor was positioned slightly below eye level and a walker was used to regain balance as needed. The patient was allowed to use the walker for external support for the first two days of treatment in an attempt to better learn the movements required and prevent frustration initially. Thereafter, the walker was used by the patient only when he felt he needed the upper extremity support to prevent an impending fall.

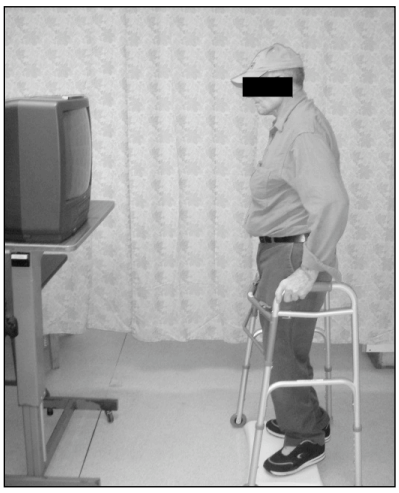

Figure 1. Initial Set Up of Wii Fit Platform with Walker Serving as External Support.

Three activities were selected as the main balance interventions: Ski Slalom, Table Tilt, and Deep Breathing. Ski Slalom consists of the patient shifting his weight right and left in an attempt to maneuver a skier through flag slaloms on a downhill course. Table Tilt is a puzzle where the patient has to shift his balance in all directions in order to roll balls into holes. Lastly, the Deep Breathing yoga activity requires the patient to maintain his COP within a small circle while inhaling and exhaling.

Outcomes

The outcomes of all clinical measures are summarized in Table 1. At the end of the two week training period the patient's balance had improved in all clinical measures. The BBS score increased by 12 points (from 13 to 25). A score of 25/56 places this individual at a medium fall risk (21-40).[20]

The TUG was also completed faster post-intervention. The patient was able to improve his TUG score by 15 sec (approximately 24%) with a time of 47 sec, which is still well above the 13.5 second cut-off for predicting those at risk for falls. The level of confidence when asked about performing daily activities was increased as well. The ABC Scale score increased from 32% to 38%. Gait speed also improved (approximately 62%) after two weeks of training from 0.24 m/s to 0.39 m/s, which continued to put the patient at risk for recurrent falls with a gait speed < 0.55 m/sec.[17]

Six weeks after the patient had been discharged from physical therapy services including working with the Wii Fit, he was still independently ambulatory over indoor surfaces using a rolling walker. Furthermore, he had not sustained any more

falls since his discharge from physical therapy.

Clinical Outcome Measure	Initial Examination	Post-Intervention
Berg Balance Scale	13/56	25/56
Timed Up and Go	62 sec	47 sec
Gait Speed	0.24 m/s	0.39 m/s
ABC Scale	32/100	38/100

Table 1. Clinical Findings at Initial Examination and at the End of Two Weeks of Intervention.

Discussion

Therapists often must decide whether or not a specific intervention provides the patient with an improved functional outcome. There are countless tests and measures that aim to provide information as it relates to an improved outcome. Another problem faced by therapists is deciding exactly what the results of the tests mean and whether those changes are clinically significant or not. For this reason, the minimal detectable change (MDC) needs to be provided by researchers for specific populations and tests.[21] The MDC for the functional tests selected in this clinical report were: BBS=5/56 for elderly individuals,[22] ABC Scale=18,[23] fast gait speed=0.25 m/s, determined from community-dwelling elders,[23] and TUG=15 sec determined from elderly individuals with assistance required for activities of daily living.[24] Table 2 provides a comparison of the MDC for the selected tests and the patient's improvement after two weeks of training with the Wii Fit platform. While the patient demonstrated improvements in all outcome measures administered, only the two balance measures had a MDC (BBS=12/56, TUG=15 sec.). Improvement in balance scores was expected given that the Wii Fit interventions focused on quiet and dynamic standing balance activities. The patient improved his gait speed by 0.15 m/s and the ABC Scale score by eight percent; however these changes did not fall within the MDC for these tests.

Utilizing the Wii Fit as a means of balance exercise exhibited numerous advantages when compared to traditional clinical balance exercise techniques, both of which were utilized with this patient. First, the movements required to perform the selected activities require the patient to perform goal-directed shifts in his COP to achieve the desired task. The goal-directed shifts appeared to be performed with greater displacement and velocity when visually compared to shifts in COP with other forms of balance interventions that did not incorporate visual biofeedback. Second, the Wii Fit provided an interactive environment for the patient. The selected games were goal-based and challenging. After each game, an objective score was calculated by

Clinical Outcome Measure	Patient's Improvement	MDC
Berg Balance Scale	12/56	5/56
Timed Up and Go	15 sec	15 sec
Gait Speed	0.15 m/s	0.25 m/s
ABC Scale	6/100	18/100

Table 2. Comparison of Patient's Improvement in Clinical Outcome Measures to Minimal Detectable Change (MDC) for Each Test.

the Wii Fit system based on the patient's performance. These scores served as motivation to improve balance performance with the next attempt. Another benefit of using the Wii Fit over other forms of balance biofeedback systems is cost. Center of pressure feedback systems marketed to rehabilitation professionals, while albeit offering options in the domain of balance examination that are currently unavailable with the Wii Fit, can cost up to $100,000 while the Wii Fit currently costs less than $100. Ease of use and portability are other advantages of using the Wii Fit for rehabilitation purposes. Simply plugging the Wii Fit system into any television monitor allows access to an abundance of balance oriented interventions. The Wii Fit only takes about three minutes to set up and can be easily stored out of the way preserving ever needed clinic space. Thus the device can be used in a wide variety of health care settings and because the entire system is compact and weighs approximately five kilograms, it can be transported easily and set up in community settings and in patients' homes. Although not used with this patient, surfaces of various heights and densities may be incorporated on top of the Wii Fit platform to further increase the level of difficulty of each activity.

After the first two days of training on the Wii Fit, the patient was able to perform the activities without external support. Since the Wii Fit is designed for persons of all ages, the games and commands were simple yet effective with respect to challenging this patient's balance. The patient did not have any difficulty understanding the technology or figuring out the object of each game after being instructed once. When given the option to perform other traditional balance activities or use the Wii Fit, the patient eagerly chose the Wii Fit. The Wii Fit seemed to motivate the patient to increase his practice volume and attention span during training. He even had a family member come and observe him "skiing" during therapy. This patient's positive experience with this gaming technology is supported by the work of other researchers who found that a virtual reality experience was motivating to elderly individuals who had experienced a stroke.[25]

While any balance intervention program must be designed to fit each specific patient's needs and impairments, this clinical report demonstrates that the Wii Fit was an effective option providing COP biofeedback to this patient in standing. One limitation of this case report, however, is that we lacked an ability to accurately determine the patient's level of motivation for performing the balance activities on the Wii Fit. An objective measure of motivation may have helped determine the degree of motivation we subjectively noted with the patient. Another limitation of this study is that we allowed this patient to determine the number of sets for each Wii Fit activity. A more structured progression of utilization of the Wii Fit system (e.g. two sets of Ski Slalom on Day 1, three sets on Day 2, four sets on Day 3, etc.) may have yielded even better results for the patient. More research is needed to not only determine the feasibility of using the Wii Fit with the elderly population with balance impairments, but in other populations commonly seen by physical therapists as well.

Conclusions

This clinical report supports the contention that an 87-year-old patient with a history of recent falls can actively participate in and improve his balance performance with a rehabilitation program that includes training

on the Wii Fit. The patient's improved balance from this training program performed five times a week for only two weeks contributed to a cessation of his falls in the subsequent weeks.

Footnotes

* Nintendo of America, Inc., P. O. Box 97032, Redmond, WA 98073-9732 USA
† Sony Computer Entertainment America, 919 East Hillsdale Boulevard, 2nd Floor, Foster City, CA 94404 USA
‡ NeuroCom International, Inc., 9570 SE Lawnfield Road, Clackamas, OR 97015 USA

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Appendix 1

Day	Activity Performed	Total Amount of time on Wii Fit (minutes)
1	Examination	
2	Deep Breathing x 2, Tilt board x 3, Ski slalom x 3 (both with UE Support). Standing cone pick-ups 1x20, Gait training navigating multiple objects with turns, 3 x 5 sit to stand, standing alternating toe taps on stool 1x20, Bike x 10 min level 1.	20
3	Tilt board x 3, Ski Slalom x 5 (both with UE Support). Standing LE exercises in parallel bars : hip flexion, hip extension, heel raise, hip abduction, all 2x15.	25
4	Deep Breathing x 3, Tilt Board x 4, Ski Slalom x 4 (all without UE support). Supine Strait Leg Raise, hip ABD, Hip flexion all 2x10. Sitting Knee extension 3# 2x10, Standing Heel Raise, Sit to Stands 2x5 (quickly), Alternating Stool Taps 2x10.	25
5	Tilt Board x 3, Ski Slalom x 3. Standing hip ABD, Hip Flexion, Hip Ext all 2x10 with 2#. Heel Raise 2x15, Alternating Step Taps 2x10, Sit to Stands 2 x 5 (quickly).	20
6	Tilt Board x 2, Ski Slalom x 4, Standing exercises as on Day 5 with 3#. Sit to Stands 3 x 5 (quickly).	20
7	Tilt board x 3, Ski Slalom x 2, Standing cone pick up from stool 2x20, Sit to Stands 3 x 5 (quickly), Stool tabs 1x20, Gait training on varied surfaces with turns and navigation of objects.	20
8	Tilt board x 4, Ski Slalom x 3, Standing rebounder toss 3x10 on foam surface, Sit to Stands 3 x 5 (quickly), Multiple bouts gait training focus on increased speed.	25
9	Tilt Board x 3, Ski Slalom x 2, Standing Exercises as on day 5 with 3#, Sit to Stands 4 x 5 (quickly), Multiple bouts gait training focus on fast gait speed.	20
10	Ski Slalom x3, Step ups 2x10 each, Sit to Stands 4 x 5 (quickly). Standing Exercises as on day 5 with 3#	15
11	Tilt board x 3, Ski Slalom x 3, Standing rebounder toss 3x10 on foam surface, Sit to Stands 3 x 5 (quickly), Multiple bouts gait training focus on increased speed.	20