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Using the Nintendo Wii Balance Board™ + Wii Fit™ software to decrease the risk of falls in the geriatric population

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Introduction: During my first geriatric rotation, I have gained valuable insight into the lives of these very interesting people; still waters truly do run deep, and these slow-moving, often sedentary individuals have quite the unassuming depth. For example, I have learned that creative interventions are necessary to compensate for age-related deficits, that geriatric pharmacology reaches far beyond Beer's Criteria, and that a group of 90-year old Japanese women will laugh when I suggest they come to the gym for exercise. Nearly every one of my long-term care residents is considered a high fall risk, but I cannot make them participate in balance exercises or strength training, especially if Bingo is being played a floor above my gym.

Clinical Scenario: The patient who led me to pursue this question is a 92-year-old female with a diagnosis of mild Alzheimer's-related dementia and generalized weakness. She ambulates with a front-wheeled walker (FWW) independently under nursing supervision and is considered a high fall risk based on her Tinetti Balance Assessment score of 18/28. This patient has refused physical therapy intervention on numerous occasions, explaining that she still walks and does not want to exercise. Medical treatment to date includes pharmacological management of her dementia and medical management of comorbidities as they arise. Physical impairments contributing to her fall risk include decreased strength, decreased static balance, and decreased gait-related dynamic balance. Several studies have found that older adults consistently preferred, and were more motivated to participate in, game-based rehabilitation over conventional exercise-based rehabilitation.[1,2,3,4,5] In one study, a patient even remarked that "I worked harder than I would have in normal therapy [done] in the bars."[6] We have an underutilized Nintendo Wii™ gaming system at Kula Hospital, and I feel that this patient would benefit from mutually agreeable balance retraining intervention.

Clinical Question: Is the Nintendo Wii Balance Board™ + Wii Fit™ software an appropriate tool to retrain balance deficits in geriatric patients classified as a moderate or high fall risk?

Clinical Question PICO:

Population: Geriatric patients classified as a moderate or high fall risk
Intervention: Wii Balance Board™ + Wii Fit™ software
Comparison: Conventional balance retraining intervention
Outcome Measures: Berg Balance Scale (BBS), Timed Up & Go (TUG), gait speed, Tinetti Balance Assessment Tool

Overall Clinical Bottom Line: Based on two studies by Pigford and Andrews and Williams *et al*., integrating the Nintendo Wii Balance Board™ + Wii Fit™ software into a conventional balance retraining program may improve balance, in the short-term, in older adults at a moderate or high risk for falls. In a single case study, Pigford and Andrews demonstrated that balance retraining with the Nintendo Wii™ in addition to conventional balance exercises resulted in clinically significant

improvements on the Berg Balance Scale (BBS) and the Timed Up & Go (TUG), and some improvement in gait speed in an 87-year-old resident of a long-term care facility. This study had fair to good internal validity and the subject of this study was similar to patients in long-term care facilities who share his level of fall risk, but extrapolation of the results is questionable because this was a case study. In 15 community-dwelling adults over the age of 70 years, Williams *et al*. demonstrated a statistically significant improvement in mean BBS score at four weeks ($p = 0.02$), but this improvement was not sustained through the week 12 assessment; no score change on the Tinetti Balance Assessment Tool was demonstrated at either four or 12 weeks. This study had poor internal validity and compromised the generalization of these results to the greater long-term care population. Both studies mentioned the Wii™ as a low-cost alternative to other force-plate systems, but the outcomes of these articles do not justify purchasing the system if one is not already available. Future studies should include standardized protocols for the Wii™ balance interventions, including a set frequency and duration for each Wii Fit™ game, and a progression of the level of difficulty within and between games. Ideally, future studies should randomize intervention and control groups from a single subject pool, with between-group analyses to determine any baseline differences in their level of fall risk, number of medications, and any other criterion which may contribute to falls. A randomized controlled study design would provide a higher level of evidence for inclusion of the Wii™ into a balance retraining regimen, and, hopefully, would validate the Wii™ as a fun, potentially very useful tool without any unique adverse effects compared to traditional balance retraining interventions.

Search Terms: Wii, balance

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Rationale for chosen articles

My search for articles pertaining to therapeutic balance retraining and the Nintendo Wii™ began via the Medline - Ovid and PubMed databases. The literature on this subject is very sparse, presumably because use of the Nintendo Wii™ as a therapeutic intervention is relatively new. I found several articles pertaining to use of the Nintendo Wii Balance Board™ with proprietary, researcher-developed software, but I did not think these articles were appropriate because the software is not commercially available; I was in search of something more clinically applicable. I expanded my search to Google Scholar and found a relevant online community of physical and occupational therapists.[7,8] These therapists provided me with links to articles and, in one case, the email address for a Queen's University Belfast scholar who had recently submitted an article on this subject for publication. I considered the similarities of these article PICOs to my clinical PICO in order to determine which articles to critically appraise. Scores ranking the quality of studies via the Physiotherapy Evidence

Database (PEDro) scale were not a factor in my decision because two of the articles were case studies and could not be rated using this system; all three articles are compared in Table 1.

Article #1
Pigford T, Andrews A. Feasibility and benefit of using the Nintendo Wii Fit™ for balance rehabilitation in an elderly patient experiencing recurrent falls. *Journal of Student Physical Therapy Research*. 2010;2(1):12-20.

PEDro score: This was a single-subject case study and cannot be rated on the PEDro scale.
Population: Eighty-seven year-old male resident of a long-term care facility classified as a high fall risk who ambulated with a FWW
Intervention: Five hours of physical therapy intervention, including the Nintendo Wii Fit™, per week for two weeks.
Comparison: No comparison group; pre-test and post-test assessment (single-subject case report)
Outcome Measures: Berg Balance Scale (BBS), Timed Up & Go (TUG), gait speed

Article #2
Williams M, *et al.* EXercising with Computers in Later Life (EXCELL) - pilot and feasibility study of the acceptability of the Nintendo Wii Fit™ in community-dwelling fallers. *BMC Res Notes*. 2010;Sep 13(3):238-45.

PEDro score: 2/10; I rated this article independently using the PEDro criteria.
P: Community-dwelling individuals over the age of 70 years who had fallen the previous year
I: Nintendo Wii Fit™ sessions two times per week for twelve weeks in addition to standard care
C: Standard care: twelve-week exercise/education program supervised by a physical therapist
O: Berg Balance Scale, Tinetti Balance Assessment Tool

Article #3
Clark R, Kraemer T. Clinical use of Nintendo Wii Bowling™ simulation to decrease fall risk in an elderly resident of a nursing home: a case report. *J Geriatr Phys Ther*. 2009;32(4):174-80.

PEDro score: This was a single-subject case study and it cannot be rated on the PEDro scale.
P: Eighty-nine year-old female resident of a nursing home diagnosed with unspecified balance disorder and classified as a High Fall Risk; ambulates without assistive device, history of non-injurious falls
I: Nintendo Wii Bowling™ sessions three times per week for two weeks
C: No comparison; pre- and post-test assessment (single-subject case study)
O: Berg Balance Scale, Timed Up & Go (TUG), Activities-specific Balance Confidence scale (ABC), Dynamic Gait Index (DGI)

Table 1. Comparison of PEDro Scores

	Pigford and Andrews	Williams *et al.*	Clark and Kraemer
Random allocation	cannot be rated; single-subject case study	No	cannot be rated; single-subject case study
Concealed allocation		No	
Baseline comparability	-	No	-
Blind Subjects	-	No	-
Blind Therapists	-	No	-
Blind Assessors	-	No	-
Adequate Follow-up	-	Yes	-
Intention-to-Treat	-	No	-
Between Group	-	No	-
Point Estimates & Variability	-	Yes	-
Total Score	n/a	2/10	n/a

I chose to critically appraise the articles by Pigford and Andrews and Williams *et al.,* due to their use of the Wii Fit™ software as an intervention. This was the most clinically relevant aspect of the studies in my opinion, because, unlike proprietary software, the Nintendo Wii Balance Board™ + Wii Fit™ hardware/software package is commercially available and easily implemented in the clinic. I excluded the article that used Wii Bowling™ as an intervention because some patients in this population have difficulty with the rotational component of bowling, and difficulty with upper extremity/lower extremity motor control. The populations and outcome measures were appropriate in all cases.

Article: Pigford T, Andrews A. Feasibility and benefit of using the Nintendo Wii Fit for balance rehabilitation in an elderly patient experiencing recurrent falls. *Journal of Student Physical Therapy Research*. 2010;2(1):12-20.

Clinical Bottom Line: Based on the results of this single-subject case study, inclusion of 3.5 hours of balance training using the Nintendo Wii Balance Board™ + Wii Fit™ game into a conventional balance retraining program (of 5 hours total) over two weeks resulted in clinically relevant improvements in Berg Balance Scale (BBS) score and Timed Up & Go (TUG) time, and some improvement in gait speed, in an 87-year-old male resident of a long-term care facility. After two weeks of training, the subject's score on the BBS improved 12 points (13/56 to 25/56); this improvement exceeded the MDC of five points[4] and upgraded this resident's fall status from "high risk" to "moderate risk". His 15-second improvement on the TUG (62 to 47 seconds) met the reported MDC of 15 seconds.[4] The subject's gait speed quickened from 0.24 m/s to 0.39 m/s (improvement of 0.15 m/s); this improvement did not meet the MDC of 0.25 m/s.[4] This study had fair to good internal validity, with the two major threats being the concurrent use of the Wii Fit™ and conventional balance retraining interventions and the lack of an established progression for the Wii Fit™ intervention (which was set by the subject). This subject was very similar to other residents of long-term care facilities who share ambulation status and a similar level of fall risk. Because this was a case study, it can only be cautiously extrapolated to a larger population. The low cost of the Wii™ compared to force platform with center of pressure mapping and visual feedback for balance retraining (under $200 versus over $10,000).[11,12,13] suggests the Nintendo Wii™ hardware/software system is an attractive training tools for clinics seeking to improve balance in their patients or residents. Further research into the Wii Balance Board™ and requisite games is needed to establish which games, how often, and for how long, best address balance deficits in this patient population. A controlled, randomized study is necessary to establish which improvements in balance, if any, are due to this gaming intervention and which follow from conventional balance retraining exercises. Current literature on this subject is sparse, owing to the recent advent of this technology, but we should expect a flood of relevant research to be available in the near future.

Article PICO

Population: Eighty-seven year-old male resident of a long-term care facility classified as a high fall risk who ambulated with a FWW

Intervention: Five hours of physical therapy intervention, including the Nintendo Wii Fit™, each week for two weeks

Comparison: No comparison group; pre-test and post-test assessment (single-subject case report)

Outcome Measures: Berg Balance Scale (BBS), Timed Up & Go (TUG), gait speed

Blinding: Neither the subject nor therapists who directed the interventions were blinded due to the nature of the intervention. The single assessor who administered the balance assessment tools was not blinded either; this lack of blinding was not a threat to validity because the outcome measures were objective scores and times, and not subjective assessments which might be susceptible to observer bias.

Controls: This was a single-subject case report and there was no control.

Randomization: There was no randomization. This subject was referred to physical therapy following four falls within the previous two months.

Study: This was a single-subject case design. An 87-year old resident of a long-term care facility experienced four unexplained falls within two months and was referred to physical therapy for evaluation and treatment. This resident was an independent ambulator with a FWW. His past medical history included insulin-independent diabetes mellitus, high blood pressure, recurrent pneumonia, and a hip fracture eight months prior. Four assessments were administered to determine this resident's level of fall risk: Berg Balance Scale (BBS), Timed Up & Go (TUG), Activities-specific Balance Confidence scale (ABC), and gait speed. The intervention consisted of five hours of exercise (3.5 hours of which were focused on balance activities on the Wii Fit™ platform) over a period of two weeks. Treatment sessions were 60 minutes long, five times per week for two weeks, and consisted of ten minutes of warm-up on a recumbent bike, 15 - 25 minutes of Wii Fit™ gaming, then 25 - 35 minutes of conventional balance retraining interventions. Three Wii Fit™ games were chosen for their specific focus on balance: Deep Breathing™ required the resident to maintain his center of pressure (COP) within a small circle, Ski Slalom™ required lateral weight shifts to guide a skier through a slalom course, and Table Tilt™ required both anterior/posterior and lateral weight shifts to guide a ball into holes on a table top. Conventional balance retraining consisted of gait training, repeated sit-to-stands, alternating toe taps, standing cone pick-ups, and therapeutic exercise. The patient was allowed to determine the progression of each Wii Fit™ game, but not the progression of the conventional balance exercises. All assessment tools were re-administered after the two-week intervention.

Outcome Measures: Three of the four outcome measures are relevant to my clinical question: the Berg Balance Scale (BBS), the Timed Up & Go (TUG), and gait speed. The authors addressed the reliability, sensitivity, and predictive value of these assessment tools: the BBS was reported to have an interrater reliability Intraclass Correlation Coefficient (ICC) of 0.98 and a test-retest reliability ICC of 0.98; the TUG was reported to be 87% sensitive for identifying fall risk in older adults; gait speed (calculated via the Ten-Meter Walk Test) was predictive of recurrent falls when less than 0.55 m/s.[4]

Each of these tools has been thoroughly researched in the literature. I did not choose to look at the ABC because several of the activities noted were not relevant to my clinical question population (*e.g.* "…walk in a crowded mall" and "…step onto or off an escalator while holding onto parcels,"[9]). In addition, the ABC requires the patient to "imagine" himself or herself performing the activity. [4] The authors reported the Minimal Detectable Change (MDC) associated with these assessment tools. An improvement of 5/56 is necessary for a clinically relevant MDC on the BBS, a 15-second improvement for an MDC on the TUG, and the MDC for gait speed on the Ten-Meter Walk Test is 0.25 m/s.[4] These MDCs are specific to older adults and are appropriate for my clinical question population.

Study Losses: There were no study losses.

Summary of Internal Validity: The authors chose reliable, valid outcome measures and discussed appropriate MDCs, but this study had only fair to good internal validity based on flaws in its design which resulted in two significant threats and one lesser threat. The possible interaction of different treatments was the first significant threat to internal validity. The physical therapy sessions consisted of conventional balance retraining exercises and Wii Fit™ gaming, and there was no way to discern the source of balance improvement noted at the end of the two-week study because both types of interventions were conducted concurrently. Two additional limitations were acknowledged by the authors; the first, which was not relevant to my clinical question and is a lesser threat to validity, was that no objective measure of patient motivation was taken regarding the Wii Fit™ intervention.[4] The second, which was both a significant threat and relevant to my clinical question, was that the resident was allowed to determine the progression (*i.e.*, the number of sets played of each Wii Fit™ game.)[4] The authors postulated that a structured, therapist-directed Wii Fit™ gaming progression may have resulted in greater improvement on the outcome measures; I agree with this assumption.

Evidence: The outcome measures most relevant to my clinical question were pre-test and post-test values on the Berg Balance Scale, Timed Up & Go, and gait speed. The authors noted that all clinical measures of balance showed improvement, but not all of the improvements were clinically significant. Table 2 exhibits the pre-test and post-test scores, and the resident's improvement on each assessment.

Table 2. Pre-test and Post-test Scores

	Pre-test Score	Post-test Score	Resident's Improvement
Berg Balance Scale (BBS)	13/56	25/56	12 points
Timed Up & Go (TUG)	62 seconds	47 seconds	15 seconds
Gait Speed	0.24 m/s	0.39 m/s	0.15 m/s

Over the course of the two-week intervention, the subject improved from being considered a high fall risk on the BBS (≤ 20 indicates High Risk of Falls) to being considered a moderate fall risk (21 - 40 indicates Moderate Risk of Falls).[14] Performance on the Timed Up & Go and gait speed improved, but neither assessment stratifies fall risk. This subject was still considered to be at risk for falls based on his TUG time of 47 seconds and 0.24 m/s gait speed; a TUG time greater than 13.5 seconds indicates that an ambulator is at risk for falls, and gait speed slower than 0.55 m/s indicates that an ambulator is at risk for recurrent falls.[4] This resident's fall risk status did not change based on either the TUG or gait speed, but improvements in these two assessments were encouraging because they trend toward a decreased risk of falls.

The authors presented the Minimal Detectable Change (MDC) for each assessment based on the literature to establish clinical significance of the subject's improvement. Table 3 compares this resident's improvement with the MDC for each assessment, and notes significance.

Table 3. Comparison of Resident's Improvement and Minimal Detectable Change

	Resident's Improvement	Minimal Detectable Change (MDC)	Significant Improvement
Berg Balance Scale (BBS)	12 points	5 points	yes
Timed Up and Go (TUG)	15 seconds	15 seconds	yes
Gait Speed	0.15 m/s	0.25 m/s	no

The resident demonstrated clinically significant improvements on two of the three assessments in which I was interested. The BBS has a MDC of five points for older individuals,[4] and the resident's improvement of 12 points far exceeded this threshold; this improvement corresponded with the clinically significant improvement in the level of fall risk (from high to moderate fall risk). The TUG has an MDC of 15 seconds for older individuals who require assistance with activities of daily living,[4] which is the same magnitude as the resident's improvement. Since the subject only just met the MDC, the significance of this improvement should be interpreted with caution. Although the subject met the criterion for a detectible change, his improved time of 47 seconds to complete the TUG test is still much longer than the 13.5 seconds to complete the TUG, which is the documented threshold indicating that there is a risk of falls.[4] The subject's 0.15 m/s improvement in gait speed did not meet the MDC of

0.25 m/s. His quickened gait speed of 0.39 m/s still is slower than the 0.55 m/s, which indicates a risk for recurrent falls.[4]

The three outcome measures I chose to consider illustrate a progressive battery of balance assessments. The BBS focuses on static and dynamic balance without a gait component; the TUG considers sitting balance, initial standing balance, and dynamic balance during ambulation; gait speed considers only dynamic balance during ambulation. The subject's improvements (Table 3) may reflect the fact that the interventions in this study focused on standing balance, with emphasis on reducing postural sway and improving control during anterior/posterior and lateral weight shifts. Dynamic balance retraining during ambulation was not incorporated into the study interventions, but there appeared to be carryover from standing balance retraining to dynamic balance during ambulation. Not surprisingly, this resident improved significantly only in the dimensions practiced during treatment. The authors made an additional observation during this study: weight shifts demonstrated by the resident during Wii Fit™ gaming (goal-directed weight shifts) exhibited greater displacement and velocity than shifts demonstrated during the conventional balance interventions.[4] This was noted anecdotally, however, and the differences were not quantified.

Applicability of Study Results:

Similarity to my Patient Population: The subject was very similar to the population in my clinical PICO. Many residents of long-term care facilities are considered high fall risks despite being able to ambulate independently with an assistive device, and these patients would benefit from balance retraining interventions to reduce their risk of falls. This subject's comorbidities are relatively common in the long-term care facility population as well, with the exception of DM1.

Benefits vs. Costs: Laboratory-grade force platforms with COP mapping and visual feedback are the current "gold standard" for assessing and retraining balance because they measure COP, the magnitude and velocity of weight shifts within one's cone of stability, responses to perturbations, and other challenges to static and dynamic postural control that are difficult for the therapist to quantify subjectively.[1,6,10] Unfortunately, laboratory-grade force platforms are prohibitively expensive for most clinics with base models costing well over $10,000.[11,12] The Nintendo Wii™ gaming system with the Wii Balance Board™ and Wii Fit™ game, on the other hand, costs less than $200, is portable, and the games have been designed for all ages and levels of ability.[13] More importantly from a clinical standpoint, the Wii Balance Board™ possesses "concurrent validity" with the laboratory-grade force platform and provides comparable data to a force plate when assessing COP during standing balance trials; both the Wii Balance Board™ and the laboratory-grade force plate " . . . exhibited good to

excellent COP path length test-retest reliability within-device (ICC = 0.66-0.94) and between-device (ICC = 0.77-0.89)."[10]

I would consider the use of this Nintendo Wii™ hardware/software package in the clinical setting based upon the improvement in the level of fall risk for this resident, the benefits of force platforms as therapeutic tools for retraining balance, the validity and relatively low cost of this equipment, and, although it was not considered relevant to my clinical question, patient preference of game-based over conventional exercise-based balance rehabilitation. No disadvantages or adverse effects were noted in this study.

Feasibility of Treatment: This study illustrates that it is very feasible to integrate the Wii Balance Board™ + Wii Fit™ software into a conventional balance retraining regimen. The authors included their protocol in Appendix 1[4], which is reproducible in any clinical setting without the need for additional equipment (except, of course, for the Nintendo Wii™). The number of sessions per week (five) is appropriate, and the number of weeks (two) is well within the typical number allowed by insurance companies. There are likely to be questions regarding the appropriateness of using video games with this patient population; these questions arise from a cultural prejudice which suggests that "old dogs can't learn new tricks." In my experience, older patients are fully capable of learning new games, and research involving the Wii Balance Board™ corroborates my experience.[1,2,3,4,5,6] There was no home exercise program given to the subject, though he continued to ambulate independently throughout the study.

Summary of External Validity: The fair to good internal validity of this single-subject case report does not compromise the ability to generalize these results to others in long-term care facilities who share this subject's ambulation status and level of fall risk. It is tempting to extrapolate this single subject's improvement in balance to a larger patient population, but, while everyone in this setting could probably benefit from balance exercises, the results of this study do not support that speculative leap.

Article: Williams M, Soiza R, Jenkinson A, Stewart A. EXercising with Computers in Later Life (EXCELL) - pilot and feasibility study of the acceptability of the Nintendo Wii Fit in community-dwelling fallers. *BMC Res Notes*. 2010;Sep 13(3):238-45.

Clinical Bottom Line: Based on the results of this study of 15 community-dwelling adults over the age of 70 years, two hours of Nintendo Wii Fit™ balance retraining per week for 12 weeks resulted in a statistically significant improvement in Berg Balance Scale (BBS) score at four weeks, but this was not sustained at 12 weeks. The mean score on the BBS improved from 43.7/56 to 48.1/56 at week four, with 33% of the subjects meeting or exceeding the minimal detectable change (MDC) for this outcome measure suggested by Donoghue *et al.*[16] No statistically significant change in score was demonstrated on the Tinetti Balance Assessment Tool at either four or 12 weeks following the Wii Fit™ balance retraining intervention. This study had poor validity as a consequence of four significant and two minor threats to its internal validity. Significant threats included group differences at baseline and design flaws regarding the procedural intervention, and minor threats were a lack of blinding and the omission of an intention to treat analysis. Subjects in the intervention group were not representative of older adults at an increased risk for falls, *i.e.* residents of long-term care facilities who are at a moderate or high risk of falls, and the results of this study cannot be extrapolated this population because of differences in setting and level of fall risk. A costs vs. benefits analysis does not support incorporating the Wii Fit™ into a balance retraining regimen despite its low cost, because the intervention group improved significantly in only one outcome measure and the improvement was not maintained throughout the study. A controlled, randomized study with a well-designed intervention protocol is needed to determine the possible benefits of the Nintendo Wii Balance Board™ + Wii Fit™ as a balance retraining tool.

Article PICO:

Population: Community-dwelling individuals with no dementia over the age of 70 years who had fallen the previous year

Intervention: Twenty-four Nintendo Wii Fit™ sessions (two times per week for 12 weeks)

Comparison: Twelve-week exercise/education program supervised by a physical therapist

Outcome Measures: Berg Balance Scale, Tinetti Balance Assessment Tool, Falls Efficacy Scale (FES-1), Attitude to Falls-Related Interventions Scale (AFRIS), an interview to determine acceptability of the Wii Fit™ intervention, and Wii Fit™ Age calculated by the Wii Fit™ software

Blinding: The nature of the intervention precluded blinding of the subjects, and the lack of blinding of the English National Health Service (NHS) therapists who conducted the 12-week exercise/education program was not a threat because they had access to only the control group and did not perform any assessments. The therapists who administered the Wii Fit™ intervention and performed all of the assessments were also not blinded; this was not a threat to validity because the objective nature of the outcome measures insulated the results from observer bias. The subjective interview was conducted and transcribed by an unblinded researcher and a thematic analysis of these interviews was performed by two independent raters; the fact that the researcher conducting the interview was not blinded was a threat to validity and I did not consider this outcome measure in my appraisal of this article.

Controls: The control group was recruited from individuals referred to a falls prevention group at the local NHS hospital. This group participated in standard care consisting of a 12-week exercise/education program supervised by therapists at this hospital. The authors did not stipulate the length of each exercise/education session, the number of sessions per week, or what activities constituted the program. The intervention group attended 24 Nintendo Wii Fit™ sessions twice per week for 12 weeks, and the authors included the Wii Fit™ activities in an appendix. There were four statistically and/or clinically significant differences at baseline between the control and intervention groups that may have compromised the comparison of outcome measures. The control group had a lower mean weight ($p = 0.03$) and higher number of comorbidities ($p = 0.01$). The mean lower weight and higher number of comorbidities reflect the authors' acknowledgment that the control group represented a "frailer population" than the intervention group.[5] The control group also had a lower mean baseline score on the BBS than the intervention group (37.0 +/- 9.6 versus 45.4 +/- 9.2). The difference reflects different mean categories of fall risk: the control group was at a moderate risk for falls (21 - 40), while the intervention group was at a low risk for falls (41 - 56).[14] The difference in categorized fall risk is clinically significant, regardless of the statistical significance of score difference between these two groups ($p = 0.08$). Last, the control group recorded a lower mean score on the Abbreviated Mental Test (AMT). This difference, though statistically significant ($p = 0.04$), may not have carried over to influence the subjects' balance because mean scores by both groups were above the cutoff of 6/10 that indicates cognitive impairment.[15] Based on the statistically significant differences in weight and number of comorbidities, the difference in baseline fall risk via the BBS, and the possible influence of the statistically significant difference in AMT scores, this was not an appropriate comparison group.

Randomization: The subjects were not randomized into groups. Members of the control group were recruited from a falls group run by NHS physiotherapists at the local hospital; these subjects were assessed, but not treated, by the authors. The intervention group was recruited through an issued press

release. The authors did not state through which medium the release was issued, nor to which population. The authors noted that the release resulted in "widespread press coverage."[5]

Study: This study was controlled but not randomized. There were six subjects in the control group and 15 subjects in the treatment group, and, to be included in the study, subjects needed to be community-dwelling adults age 70 years and older and have fallen at least once in the previous year. Subjects were excluded if they were wheelchair-bound, were living in a care home or long-term care facility, or if they were enrolled in an exercise or rehabilitation program at the time of recruitment. Subjects were also excluded if they scored less than 7/10 on the AMT; this criterion was used to exclude subjects with dementia or cognitive impairment. The authors administered the BBS and the balance portions of the Tinetti Balance Assessment Tool to all subjects three times: prior to intervention, at four weeks, and at 12 weeks following conclusion of the intervention. The control group participated in the 12-week fall prevention class and had no interaction with the authors except for the reassessments; the authors failed to note the duration of each class, frequency per week, or precisely what treatments the control group participated in. The intervention group met two times per week for 12 weeks, and each Wii Fit™ sessions consisted of balance and aerobic gaming. The balance games included Table Tilt™, Ski Slalom™, Ski Jump™, Heading™, and a Yoga game which emphasized controlled breathing while maintaining a static standing posture with minimal postural sway. The subjects were allowed to change Wii Fit™ games and to end the sessions at any time, so there was no established length or sequence of gameplay.

Outcome Measures: Outcome measures relevant to my clinical question are the Berg Balance Scale and the balance portion of the Tinetti Balance Assessment Tool. Each outcome measure was assessed at baseline, four weeks, and 12 weeks. The authors did not perform their own tests of reliability for these tools, but they cited that both measures have good inter- and intrarater reliability,[5] and each outcome measure has been thoroughly validated in the literature as an appropriate tool for balance assessment and the categorization of fall risk. Donoghue *et al.* established MDCs for the Berg Balance Scale based on a sample of 118 older adults similar to subjects in this study; a functional change was found at four points for subjects with an initial score of 45 - 56, five points with an initial score of 35 - 44, seven points with an initial score of 25 - 34, and five points when the subjects' initial score was below 24/56.[16] No MDC was noted by the authors for the Tinetti Balance Assessment Tool, and I was not able to find an MDC in the literature.

Study Losses: Two of six subjects (33.3%) in the control group dropped out of the study. Both of the subjects who withdrew were admitted to the hospital for unspecified reasons: one prior to the week four assessment, and the second between the week four and week 12 assessments. Two of 15 subjects (13.3%) in the intervention group dropped out of the study. The first subject withdrew secondary to

knee pain prior to the week four assessment and the authors did not note if the knee pain was a result of the Wii Fit™ intervention; the second subject withdrew between the week four and week 12 assessments following the death of a spouse. The discrepancy between drop-out rates between the groups is likely due to the differences in group sizes, and small samples overall, at baseline. The data collected from all subjects were included in the results, and no intention-to- treat (ITT) analysis was performed. The Physiotherapy Evidence Database (PEDro) recommends an ITT be performed when the drop-out rate exceeds 15-20%;[17] this criterion impacts the control group but not the intervention group.

Summary of Internal Validity: Overall, this study had poor internal validity. This was not a randomized, controlled trial and not appropriate for grading by PEDro standards, but the PEDro guidelines are a good indicator of study validity. There were several significant threats to the validity which would have resulted in a score of 2/10, if appropriate. The first significant threat was the drawing of subjects from dissimilar pools of participants; this recruitment resulted in significantly different control and intervention groups at baseline in variables that likely affect the outcome measures. The design of the procedural intervention also suffered numerous flaws that amounted to a significant threat. Subjects in the intervention group were allowed to stop or change games, and to end the session, at any point. This lack of protocol could have affected the results. For example, it is not known if some subjects chose to play only balance games (at the expense of aerobic games), or no balance games at all. The lack of detailed protocol also resulted in a lack of defined intervention progression because no effort was made to increase challenges to balance as the study proceeded. Minor threats included a lack of blinding of subjects and assessors, and the omission of an ITT analysis that should have been performed on the control group due to high study losses.

Evidence: The outcome measures most relevant to my clinical question were scores assessed on the Berg Balance Scale (BBS) and on the balance portion of the Tinetti Balance Assessment Tool, taken at baseline, four weeks, and 12 weeks. Both the four-week and 12-week timepoints were chosen to assess short-term and long-term improvements in balance. Tables 4 and 5 display the results of these assessments for the control and intervention groups, respectively. Only within-group analyses were performed because a between-group analysis would not be valid due to the significant differences at baseline between groups.

Table 4. Control Group Assessment Scores

	Baseline	Week 4	p-value (Baseline vs. Week 4)	Week 12	p-value (Baseline vs. Week 12)
Berg Balance Scale (BBS) [mean/56 (SD)]	36.3/56 (9.9)	40.0/56 (3.0)	0.49	39.0/56 (10.2)	0.94
Tinetti Balance Assessment Tool (balance portion) [mean/16 (SD)]	11.7/16 (4.2)	11.0/16 (3.6)	0.64	11.2/16 (5.5)	0.77

There were no statistically significant improvements on either assessment tool, at either the forth or twelfth week, in the control group. The smaller standard deviations during the forth week on both the BBS and the Tinetti imply that the control group tested more consistently at this point, but the authors did not attribute this to any study factor.

Table 5. Intervention Group Assessment Scores

	Baseline	Week 4	p-value (Baseline vs. Week 4)	Week 12	p-value (Baseline vs. Week 12)
Berg Balance Scale (BBS) [mean/56 (SD)]	43.7/56 (9.5)	48.1/56 (7.2)	0.02	44.8/56 (11.8)	0.77
Tinetti Balance Assessment Tool (balance portion) [mean/16 (SD)]	13.2/16 (2.9)	13.4/16 (2.9)	0.67	13.9/16 (2.9)	0.40

The intervention group demonstrated statistically significant improvement on only the BBS at four weeks ($p = 0.02$).[5] In addition, the authors noted that 33% of the subjects who completed the week four assessment had a change in BBS score of at least 8/56;[5] this change exceeded the MDCs established by Donoghue *et al*.[16] This statistically and clinically significant change was not reflected in an improved categorization of fall risk, however, because the intervention group at baseline was already at a low risk for falls (41 - 56).[14] The subjects' mean BBS score at 12 weeks returned to within 1.1 points of baseline, which indicated that the gains demonstrated at the week four assessment were not sustained. There was no statistically significant improvement on the Tinetti Balance Assessment

Tool at either four or 12 weeks; in fact, the procedural intervention appeared to have virtually no effect whatsoever on Tinetti scores.

Applicability of Study Results:

Similarity to my Patient Population: There were significant differences between the control and intervention groups at baseline, and I considered only the intervention group in this appraisal because they received the Wii Fit™ balance retraining intervention. Unfortunately, subjects in the intervention group were not appropriately similar to my envisioned patient population. The patients of my clinical PICO were older adults classified as either a moderate or high fall risk; the older subjects in the intervention group had a mean BBS score of 45.4/56,[5] which was indicative of a low risk for falls (41 - 56).[14] The standard deviation of +/- 9.2 did suggest, however, that some of the subjects fell into the moderate fall risk category (21 - 40);[14] conversely this standard deviation implied that some subjects had virtually no fall risk with a BBS score approaching 55/56. My clinical question was inspired by a patient in a long-term care facility who had several comorbidities and compromised cognition. The subjects in the intervention group had relatively few comorbidities (2.6 +/- 1.3) and no cognitive impairment (all subjects scored 10/10 on the AMT).[5]

Benefits vs. Costs: Analysis of data from this study indicates that there is some potential clinical advantage to using the Wii Fit™ gaming system for balance retraining, but the benefits do not outweigh the cost of the system and the expenditure of time that could be better spent on more effective interventions. The Wii Fit™ system is attractive because it costs less than $200,[13] but these results were not very encouraging. The intervention group improved significantly in mean BBS score after four weeks of treatment, but the mean score decreased at 12 weeks and returned to a point not statistically significantly higher than baseline. This drop in BBS score over the latter two-thirds of the study may be due to a lack of procedural intervention progression, as there was no protocol in place to escalate challenges to subjects' balance. The intervention group's mean score on the BBS did not reach the established MDCs at any point during the study. There was no statistically significant improvement in scores on the balance portion of the Tinetti Balance Assessment Tool at either four or 12 weeks. There were two adverse events reported during the intervention. One subject fell backwards while stepping off the Wii Balance Board™, and another subject complained of lightheadedness following an intervention session. I feel that these events should be considered when working with the Wii Fit™ system, but neither a loss of balance nor lightheadedness are reactions isolated to this specific tool.

Feasibility of Treatment: The authors made it very easy to reproduce this study in the clinic by including their exercise program in Appendix 1,[5] and no additional equipment would be needed aside from the Wii Fit™ system. The duration and frequency of intervention sessions were appropriate at 60

minutes each, twice weekly, for 12 weeks, and the intensity of treatment seemed appropriate for this study population. Another important benefit of this gaming intervention is the willingness of subjects to participate; the authors noted that 80% of the subjects attended at least 75% of the sessions. Another aspect of feasibility is that, although no home program was instituted during this study, the Wii Fit™ system is affordable and commercially available, and patients could continue this intervention in their own homes.

Summary of External Validity: The subjects in the intervention group were not similar to patients I would expect to see in long-term care facilities, but they are similar to other community-dwelling older adults who might be at a low to moderate risk for falls. The results might have been extrapolated to the latter population if not for several substantial threats to internal validity. The lack of blinding, the heavy study losses (13.3% of the intervention group and 33.3% of the control group, for an average loss of 19%), and the flawed procedural intervention design compromise the study to such an extent that the results are suspect at best, and, at worst, invalid.

Synthesis/Discussion:

My purpose for reviewing the articles by Pigford and Andrews and Williams *et al*. was to determine if use of the Nintendo Wii Balance Board™ + Wii Fit™ software, when used in conjunction with conventional balance retraining exercises, would result in a significant improvement in fall risk for older adults at a moderate or high risk of falls. It appears that integration of the Nintendo Wii™ into a balance retraining regimen may provide some short-term balance improvements, but with several caveats. The study by Pigford and Andrews demonstrated clinically significant improvements over the MDCs on the BBS and TUG, with some improvement in gait speed, but this was a case study and therefore is considered low-level evidence. Also, this study lacked an established protocol for the Wii™ balance intervention. This subject was allowed to determine the duration, sets, and frequency of each Wii Fit™ game, and it is unclear whether or not there was any progression of the level of difficulty throughout the study. Favorably, the subject was similar to other older adult residents of long-term care facilities, and, based on its fair to good internal validity, it is appropriate to extrapolate the results of the study to this population though with serious caution due to the sample size of one. The study by Williams *et al*. reported a clinically significant improvement over the MDC in BBS score at four weeks in the group receiving the Wii™ balance intervention, but this improvement was not demonstrated at 12 weeks; also, no improvement was demonstrated at either four or 12 weeks on the Tinetti Balance Assessment Tool. Unfortunately, this study had several threats to its internal validity, including a lack of a Wii™ balance intervention protocol and significant differences between groups at baseline, which precluded the extrapolation of results to the population of older adult residents of long-term care facilities who are at a moderate or high risk of falls. Despite the lack of standardized and consistent Wii™ balance interventions, and the poor internal validity of the article by Williams *et al*., there is enough evidence to support the cautious integration of the Nintendo Wii Balance Board™ + Wii Fit™ software into a conventional balance retraining program. It is necessary that future studies include larger sample sizes, randomized subjects, and appropriate control groups; future intervention designs need also incorporate a protocol that includes set frequencies and durations for each Wii Fit™ game, and a progression of the level of difficulty within and between games.

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