# The contribution of Nintendo *Wii Fit* series in the field of health: a systematic review and meta-analysis

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**Background.** *Wii Fit* was originally designed as a health and fitness interactive training experience for the general public. There are, however, many examples of *Wii Fit* being utilized in clinical settings. The present review aims to identify the contribution of *Wii Fit* in the field of health promotion and rehabilitation by: 1) identifying the health-related domains for which the *Wii Fit* series has been tested, 2) clarifying the effect of *Wii Fit* in those identified health-related domains, and 3) quantifying this effect. **Method.** A systematic literature review was undertaken. The MEDLINE database and *Games for Health Journal* published content were explored using the search term "wii-fit". Occurrences resulting from manual searches on Google and material suggested by experts in the field were also considered. Included articles were required to have measurements from *Wii Fit* activities for at least one relevant health indicator. The effect of *Wii Fit* interventions was assessed using meta-analyses for the following outcomes: activity-specific balance confidence score, Berg balance score, and time-up-and-go test. **Findings.** One-hundred-fifteen articles highlight that the *Wii Fit* has been tested in numerous healthy and pathologic populations. Out of these, only a few intervention studies have focused on the prevention of chronic diseases. A large proportion of the studies focus on balance training (N=55). This systematic review highlights several potential benefits of *Wii Fit* interventions and these positive observations are supported by meta-analyses data (N=25). For example, the Berg balance score and the time-up-and-go test respond to a similar extend to *Wii Fit* interventions compared with traditional training. **Conclusions.** *Wii Fit* has the potential to be used as a rehabilitation tool in different clinical situations. However, the current literature includes relatively few randomized controlled trials in each population. Further research is required.

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## Abstract

**Background.** *Wii Fit* was originally designed as a health and fitness interactive training experience for the general public. There are, however, many examples of *Wii Fit* being utilized in clinical settings. The present review aims to identify the contribution of *Wii Fit* in the field of health promotion and rehabilitation by: 1) identifying the health-related domains for which the *Wii Fit* series has been tested, 2) clarifying the effect of *Wii Fit* in those identified health-related domains, and 3) quantifying this effect. **Method.** A systematic literature review was undertaken. The MEDLINE database and *Games for Health Journal* published content were explored using the search term “wii-fit”. Occurrences resulting from manual searches on Google and material suggested by experts in the field were also considered. Included articles were required to have measurements from *Wii Fit* activities for at least one relevant health indicator. The effect of *Wii Fit* interventions was assessed using meta-analyses for the following outcomes: activity-specific balance confidence score, Berg balance score, and time-up-and-go test. **Findings.** One-hundred-fifteen articles highlight that the *Wii Fit* has been tested in numerous healthy and pathologic populations. Out of these, only a few intervention studies have focused on the prevention of chronic diseases. A large proportion of the studies focus on balance training (N=55). This systematic review highlights several potential benefits of *Wii Fit* interventions and these positive observations are supported by meta-analyses data (N=25). For example, the Berg balance score and the time-up-and-go test respond to a similar extend to *Wii Fit* interventions compared with traditional training. **Conclusions.** *Wii Fit* has the potential to be used as a rehabilitation tool in different clinical situations. However, the current literature includes relatively few randomized controlled trials in each population. Further research is required.

## Introduction

The past decade saw the emergence of home-based active video games (AVG), with the *Wii* (Nintendo Co. Ltd, Japan) being released in 2006, followed by the PlayStation *Move* (Sony Corp, Japan) and the *Kinect* (Microsoft, Washington, USA) in 2010. These systems take advantage of accelerometry and/or video camera-mediated motion detection technologies to track the player's movements and convert them into gaming commands. The *Wii* offers an original game modality with the *Wii Balance board* accessory, which can be used as a weighing scale or as a gamepad sensitive to body sway [1].

Among those home-based AVG, the well-known *Wii Fit* series (Nintendo, Japan) is run on the *Wii* consoles and consists of a combination of both serious and entertaining activities requiring body movement to fulfill gaming commands. The software displays various kinds of health metrics (body mass index, number of kilocalories burned over a given period) encouraging the players to improve their physical fitness. Whilst the *Wii Fit* was primarily designed to be used in homes by healthy individuals for health and fitness purposes, an overview of the literature indicates that physical therapists and physicians from different medical fields include the use of *Wii Fit* in their clinical practice. For instance, the *National Stroke Audit: Rehabilitation Services Report* recently indicated that 76% of Australian hospitals have a *Wii* console available to aid with the rehabilitation of stroke patients (the *National Stroke Foundation*, 2012 in [2]).

Many reviews have focused on AVG and their effects on health and describe mitigated outcomes [3, 4]. However, the distinction between *Wii Fit* and other AVG is not always clear, resulting in the inability to ascertain an objective picture of the contribution from the *Wii Fit*. The goals for this systematic review are as follows:

- Goal 1: Identifying the health-related domains (i.e. populations and clinical situations) in which the *Wii Fit* series has already been tested/used. A scientific data base search with reasoned exclusion criteria was undertaken.
- Goal 2: Understanding the effect of *Wii Fit* in identified populations (cf. Goal 1). A qualitative systematic review of studies including *Wii Fit* interventions was performed, with particular attention given to health and physical activity outcomes.
- Goal 3: When possible, quantification of the effect *Wii Fit* has on selected health-related domains was achieved by conducting meta-analyses.

## Method

*Literature search*

The selection process is summarized in a PRISMA flow diagram presented in Figure 1. Several strategies were adopted: 1) The MEDLINE database was used to conduct a systematic search using the following keywords: “wii fit”, “wii-fit” and “wiifit” (occurrences: N=122). 2) The same keywords were used to search for additional articles in the Mary Ann Liebert, Inc. *Games and Health Journal* (N=121). 3) Additional peer-reviewed articles were identified during manual searches *via* Google Search (Google Inc., California, USA) (N=1). 4) Articles suggested by authors active in the field of AVG (N=10) or identified in the reference section of eligible papers (N=46). 5) Only papers in English, French or Japanese were eligible for the present review. The search and data extraction were performed by two independent researchers (Murakami H and Tripette J). The discrepancies were solved by a third contributor (Miyachi M).

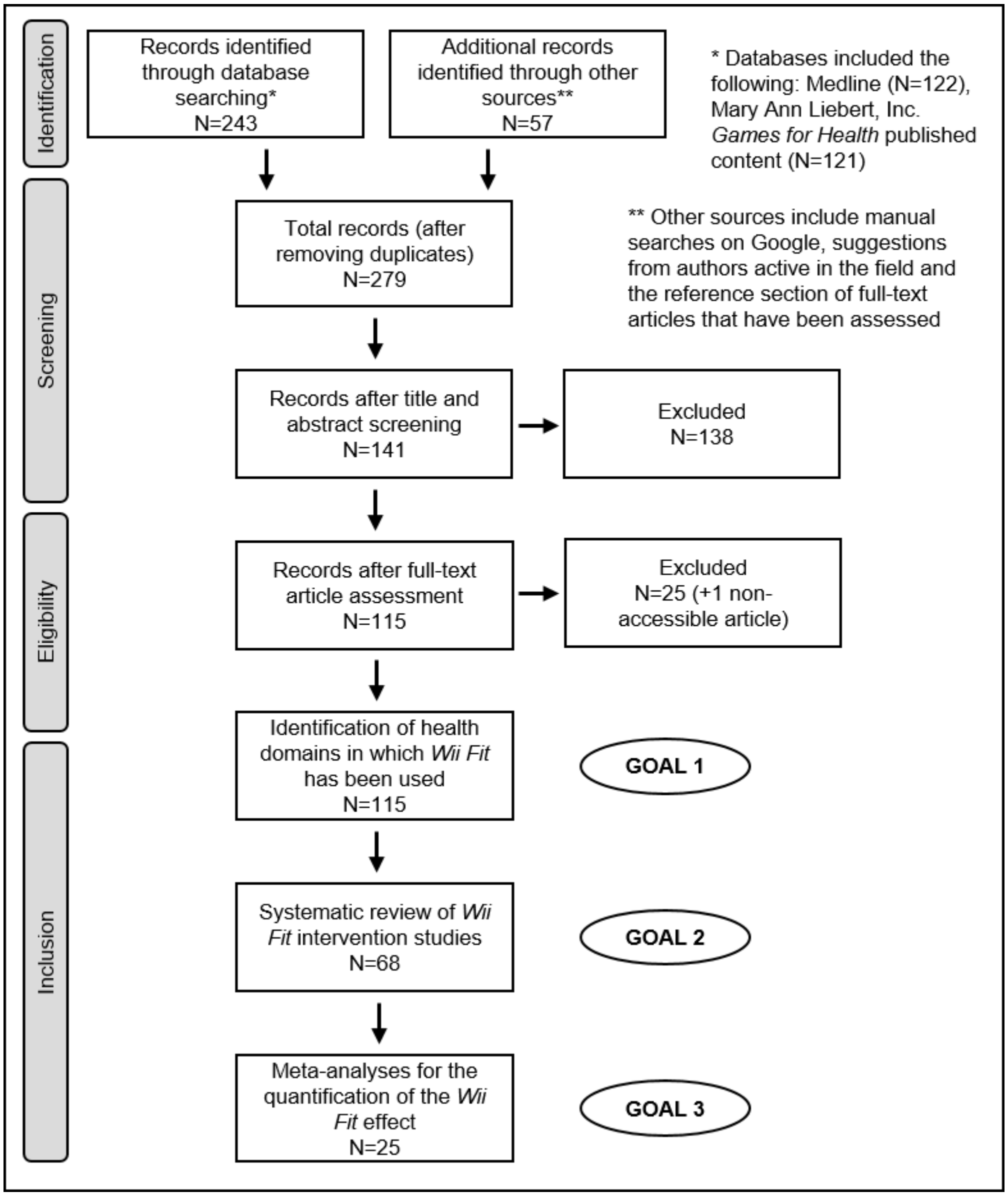


**Figure 1. Flow diagram for the selection of studies included in the systematic review and the meta-analyses.** Details about exclusion criteria and the selection process can be found in the Table 1 and Methods section.

The literature search was completed in June 2015. A total of 200 articles were identified. In order to meet the primary inclusion criteria, studies were required to: A) have a primary focus on any software of the *Wii Fit* series, and B) focus on a recognized health issue. 279 articles were screened after the identification and removal of 21 duplicates (Figure 1).

*Goal 1: Identification of health domains*

The exclusion criteria applied to identify medical domains in which the *Wii Fit* has already been tested/used are described in the Table 1. The identification process was performed by screening titles and abstracts and the full text was read when the abstract provided insufficient details (Figure 1 & Table 1).

**Table 1. Summary of exclusion criteria**

| **Literature review stage** | **Exclusion criteria** |
|---|---|
| *Screening* | 1) The study was not about any *Wii Fit* software.<br>2) The study does not focus on any health issue.<br>3) The article does not describe an original study.<br>4) The article is one of the following: letter, commentaries, symposium reports, interviews, conference abstracts, study protocols, reviews.<br>5) The article has not been peer-reviewed. |
| *Goal 1* | 1) *Wii Fit* was not the main component of the intervention.<br>2) *Wii Fit* was used only to induce a stimulus without being the main object of the study.<br>3) The study focused on the *Wii Fit* avatar system rather than on its gaming content.<br>4) The article reports the development of software for the *Wii Balance Board.*<br>5) The study focuses on the *Wii Balance Board* capabilities not on the *Wii Fit* gaming content. |
| *Goal 2* | 1) The article does not describe an intervention study.<br>2) The study does not include an objective assessment for at least one health or physical activity indicator, assessed quantitatively.<br>3) The protocol includes less than 5 subjects and/or does not report average or median values. |
| *Goal 3* | 1) The study does not include numerical data for the activities-specific balance confidence test (ABC), Berg balance score (BBS), and/or the time-up-and-go test (TUG).[a]<br>2) The data reported for ABC, BBS and TUG are not mean ±SD, or does not allow the calculation of a mean values and the imputation of SD.[b]<br>3) The magnitude of changes in ABC, BBS or TUG, were expected to be important due to patients' initial condition and regardless of the chosen rehabilitation program (e.g. post-surgery orthopedic patients).[c]<br>4) The population sample average age was less than 5-years old.[d] |

[a] Examples of excluded studies for this selection criteria are [5, 6]. [b] Examples of excluded studies for this selection criteria are [7-10]. [c] An example of an excluded study for this selection criteria is [11]. [d] An example of an excluded study for this selection criteria is [12]. SD: standard deviation.

*Goal 2: Systematic review, data extraction and synthesis*

A qualitative systematic review was performed to understand the effect of *Wii Fit* in the previously identified health domains. The study follows the 2009 PRISMA guidelines for the conductance of systematic reviews and meta-analyses [13] (see, "S1 Checklist. PRISMA checklist"). The exclusion criteria applied at this stage are described in the Table 1.

The content of each eligible article was extracted according to the following protocol: 1) Study identification (first author's name, year, and country), 2) methodological details (study design, sample size, population characteristics, etc.), 3) activities used, 4) description of each identified primary or secondary health / physical activity outcome, and 5) key findings (i.e. pre-/post-intervention as well as differences between *Wii Fit* and control groups) (see tables 3 & 4).

*Goal 3: Meta-analyses*

The effect of *Wii Fit* was quantified for some selected health-related domains. The most recurrent outcomes noted were the activities-specific balance confidence test (ABC), Berg balance score (BBS), and/or the time-up-and-go test (TUG). These three tests are frequently used to assess patients' balance abilities [14-16]. First, pre-/post-intervention meta-analyses were performed for each of these three outcomes. Second, *Wii Fit* vs. traditional therapy meta-analyses were completed, which only included results from randomized control (RCT) or two-arm trials. The exclusion criteria applied at this stage are described in the Table 1. Only studies that used the 3-meter version of the TUG test were included. Groups submitted to a combination of *Wii Fit* activities and more traditional therapy exercises were excluded from the pre-/post-intervention meta-analysis (e.g., [17-19]).

The pre-/post- intervention effect was calculated for the three selected outcomes. The reported pre-intervention values were subtracted from the post-intervention values, and then used in meta-analysis as difference in means. For the *Wii Fit* vs. traditional therapy meta-analyses, the difference between the pre-/post- *Wii Fit* intervention changes and the pre-/post- traditional intervention changes were used as inputs in the meta-analysis. The variance imputation methods described by Follmann et al. were used to estimate the standard deviations of effect size when the authors did not report them [20]. Heterogeneity between the studies was assessed using the homogeneity test. A fixed-effect model was used when the $I^2$ statistic, which is the index of heterogeneity, was under 75%. Sub-analyses were conducted in patients and healthy subjects. For ABC, because only two studies includes a comparison between *Wii Fit* and traditional therapy [19, 21], only the pre-/post- intervention meta-analysis was performed. The risk of bias in each individual study included in the *Wii Fit* vs. traditional therapy meta-analyses has been also assessed. Criteria are reported in Figure 2. Meta-regressions were also performed to assess the impact of intervention duration and volume (i.e. session duration*number of session) on ABC, BBS and TUG. $p<0.05$ indicates statistical significance. Meta-analysis was performed using STATA 12.1 (StataCorp, Texas, USA).

## Results

The literature search provided a total of 279 references of interest (Figure 1). Following the title and abstract screening process 138 studies were discarded, as they did not meet the selection criteria. One article was not accessible so was also discarded at this stage. An additional 25 references were removed after reading the full-text. Finally, 115 studies were included in the qualitative analysis, covering a 6.5-year period from winter 2009 [22] to June 2015.

### *Goal 1: Health domains and populations of interest*

The 115 selected studies focus on *Wii Fit* as a novel tool to improve physical function, fitness or health status. The content of the 115 articles was used to determine the different health domains in which *Wii Fit* may have potential benefits. Data are summarized in Table 2.

**Table 2. *Wii Fit* studies, health domains and populations of interest**

| Health domains | Studies (name of authors, years, reference number) |
|---|---|
| ***Juvenile population*** | |
| Healthy children / adolescents [a] | Graves et al. 2010 [23][f]; Levac et al. 2010 [2] ; Owens et al. 2011 [24][f] ; White et al. 2011 [25] ; O'donovan et al. 2014 [26][f] |
| Overweight children / adolescents | O'donovan et al. 2014 [32][f] ; Owens et al. 2011 [30][f] |
| Children with developmental delay | Salem et al. 2012 [12] ; Fergusson et al. 2013 [27] ; Hammond et al. 2014 [28]; Mombarg et al. 2013 [29]; Jelsma et al. 2014 [30] |
| Children with migraine | Esposito et al. 2013 [31] |
| Children with Raynaud disease | Qualls et al. 2013 [32] |
| Children with cystic fibrosis | O'donovan et al. 2013 [33]; del Corral et al. 2014 [34] |
| Children with cerebral palsy | Ramstrand & Lygnegard 2012 [35] ; Jelsma et al. 2013 [36] ; Tarakci et al. 2013 [37] ; Ballaz et al. 2014 [38] |
| Adolescents with autism spectrum disorders | Getchell et al. 2012 [39] |
| ***Young adults & middle-age adults*** | |
| Healthy adults [a,b] | Gras et al. 2009 [22] ; Graves et al. 2010 [23][f]; Miyachi et al. 2010 [40]; Deutsch et al. 2011 [41]; Owens et al. 2011 [24][f]; Gioftsidou et al. 2013 [42]; Melong & Keats 2013 [43]; Douris et al. 2012 [44]; Garn et al. 2012 [45][f]; Lyons et al. 2012 [46][f]; Michalski et al. 2012 [47]; O'donovan & Hussey 2012 [48]; Griffin et al. 2013 [49]; Khan et al. 2013 [50]; Tietavaienen et al. 2013 [51]; Lee et al. 2014 [52]; Monteiro-Junior et al. 2014 [53]; Park et al. 2014 [54]; Tripette et al. 2014 [55]; Xian et al. 2014 [56]; Cone et al. 2015 [57] ; Naumann et al. 2015 [58] |
| Healthy women | Cummings & Duncan 2010 [59]; Nitz et al. 2010 [60]; Jacobs et al. 2011 [61][f]; Worley et al. 2011 [62]; Steenstrup et al. 2014 [63][g]; Tripette et al. 2014 [64] |
| Overweight adults | Guderian et al. 2010 [65]; Jacobs et al. 2011 [61][f]; Owens et al. 2011 [24][f]; Garn et al. 2012 [45][f]; Mullins et al. 2012 [66]; Lyons et al. 2012 [46][f] |
| Depressed soldiers | Reger et al. 2012 [67] |
| Adults with drug dependency | Cutter et al. 2014 [68] |
| Women with systemic lupus erythematosus | Yuen et al. 2011 [69]; Yuen et al. 2013 [70] |
| Adults with vestibular disorders | Meldrum et al. 2012 [71][h]; Meldrum et al. 2015 [21] |
| Patients in orthopedic rehabilitation | Fung et al. 2011 [11]; Baltaci et al. 2012 [72]; Wikstrom et al. 2012 [73]; Sims et al. 2013 [74]; Punt et al. 2015 [75] |
| Amputees | Miller et al. 2012 [76] |
| COPD patients | Albores et al. 2013 [77] |
| Diabetic patients | Kempf & Martin 2013 [78] |
| Hemodialysis patients | Cho & Sohng 2014 [79] |
| Lower back pain patients | Kim et al. 2014 [80] |
| Adults with multiple sclerosis | Brichetto et al. 2012 [81]; Nilsagard et al. 2013 [82]; Plow & Finlayson 2013 [83]; Prosperini et al. 2013 [84]; Forsberg et al. 2015 [85]; Robinson et al. 2015 [86] |
| Cancer patients [c] | Hoffman et al. 2013 [87]; Hoffman et al. 2014 [88] |
| Stroke patients [c] | Barcala et al. 2013 [17]; Bower et al. 2014 [89]; Hung et al. 2014 [90]; Morone et al. 2014 [5]; Subramamiam et al. 2014 [91]; Omiyale et al. 2015 [92] ; Yatar & Yildirim 2015 [19] |
| Spinal cord injury patients | Wall et al. 2015 [6] |
| ***Senior populations*** | |

| | |
|---|---|
| Healthy seniors | Williams et al. 2011 [93]; Yamada et al. 2011 [94][f]; Bateni et al. 2012 [95] ; Duclos et al. 2012 [96] ; Franco et al. 2012 [97] ; Orsega-smith et al. 2012 [98] ; Rendon et al. 2012 [9][f]; Toulotte et al. 2012 [99][f]; Bieryla & Dold 2013 [7] ; Chao et al. 2013 [100] ; Janssen et al. 2013 [8]; Chao et al. 2014 [101]; Cho et al. 2014 [102]; Taylor et al. 2014 [103]; Chao et a. 2015 [104]; Nicholson et al. 2015 [105]; Roopchand-Martin et al. 2015 [106] |
| Senior with balance impairment [d] | Pigford & Andrews 2010 [107]; Williams et al. 2010 [108]; Agmon et al. 2011 [109]; Bainbridge et al. 2011 [10]; Yamada et al. 2011 [94][f]; Chan et al. 2012 [110]; Daniel et al. 2012 [18]; Jorgensen et al. 2012 [111]; Rendon et al. 2012 [9][f]; Toulotte et al. 2012 [99][f]; Janssen et al. 2013 [8]; |
| Seniors with cognitive impairments [e] | Padala et al. 2011 [112]; Esculier et al. 2012 [113]; dos Santos et al. 2012 [114]; Padala et al. 2012 [115]; Pompeu et al. 2012 [116]; Mhatre et al. 2013 [117]; Esculier et al. 2014 [118]; Goncalves et al. 2014 [119]; Liao et al. 2014 [120] |
| Seniors with peripheral neuropathy | Hakim et al. 2015 [121] |
| Other senior population | Laver et al. 2011 [122] |

[a] Not including overweight populations; [b] Not including studies that focus on healthy adult women only; [c] includes both middle-age adults and seniors; [d] includes subjects referred for rehabilitation, presenting a history of accidental fall, having fear of falling or described as frail / pre-frail; [e] includes both Parkinson's and Alzheimer's patients; [f] some papers focused on various populations may appear in several rows; [g] the study included healthy subjects but targeted women with urinary incontinence; [h] patients with « other neurological disorders » are included as well.

*Goal 2: Systematic review of Wii-Fit interventions*

From the previous record of 115 selected *Wii Fit* articles, 68 were intervention studies and meet the selection criteria for inclusion in the systematic qualitative review. Overall, these studies involved 2183 participants from both sexes (females: 1161, males: 844, not specified: 178), with a wide age range (49 ±6 months - 86 ±6 years [12, 100]), and various medical conditions. Primary and secondary outcomes, intervention content, as well as observation period vary from study to study. The intervention durations vary from 2 to 20 weeks [89, 99], frequencies from 1 to 7 sessions per week (respectively, [99, 110] and [64, 78]), and session time from 10 to 60 minutes (respectively [8, 97] and [72, 81, 99]).
Six papers report adverse effects: In young adults, light to moderate adverse effects (muscle soreness, pain, sprain, etc.) have been observed [55]. Among seniors, hip strain, neck strain, lower back pain as well as one fall have been reported [105, 108, 109]. In multiple sclerosis patients, knee pain and lower back pain were also reported [84]. Bower et al. (2014) observed a relatively high rate of falls in stroke patients (four events over a group of thirty patients, [89]).

Table 3 describes the characteristics and main results from studies with a primary focus on the effect of *Wii Fit* intervention on physical activity level, physical fitness or patients' health status. Among 13 studies, 10 observed positive effects [8, 18, 64, 68, 79, 77-80, 87, 88, 110] and three presented more contrasted results [24, 60, 77]. Interestingly, 4 intervention studies have been conducted in patients with chronic diseases. They all report a significant improvement in health status and well-being (chronic obstructive pulmonary disease, type two diabetes mellitus, chronic kidney disease, and lower back pain) [77-80]. Two reports describe *Wii Fit* interventions as both feasible and effective methods for improving the overall physical fitness, mobility and independence of senior subjects [8, 18, 110].

174 **Table 3. *Wii Fit* interventions for health status and well-being improvement [a]**

| Authors Year Country | Population characteristics | Study design | *Wii Fit* activities (or other video games) | Outcomes and measures | Key findings **& Data used for the meta-analyses** |
|---|---|---|---|---|---|
| ***Healthy population*** | | | | | |
| Nitz et al. 2010 Australia [60] | Women (N=10)<br>*Age range:* 30-60 yrs<br>*Mean age:* 47 ±10 yrs | Intervention<br>*1 group*<br>*Duration:* 10 wks (30 min, 2 sessions /wk)<br>*Location:* Home (supposedly) | Not specified, possibly all the *Wii Fit's* activities | Physical fitness (6-min walk test, lower limb strength), body composition, balance and functional mobility (TUG, $TUG_{cog}$, step test, CTSIB, basic balance master test), well-being (home-made scale), adherence (attendance) | Improvement for some balance tests and lower limb strength. The overall attendance was 70%.<br>*Adverse events:* No<br><br>**<u>TUG (sec):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 4.93 ±0.76**<br>**Post-intervention: 5.00 ±0.73** |
| Owens et al. 2011 USA [24] | Eight Families (parents and children, *F/M*, *N*=13/8)<br>*Age range:* 8-44 yrs | Intervention<br>*1 group* (statistical analysis: children *vs.* adults)<br>*Duration:* 13 wks (no further specifications: naturalistic approach)<br>*Location:* Home | Not specified (subjects used the four categories of activities: *yoga, strength, aerobics, balance*) | PA (accelerometry), body composition, balance (SOT), physical fitness ($VO_2$max, upper limb strength, flexibility), adherence (playing time) | No significant change has been noted in most of the physical fitness outcomes. Peak $VO_2$ increased in children only. Adherence declined over time. In realistic conditions *Wii Fit* may not provide sufficient stimulus for fitness improvement.<br>*Adverse events:* No |
| Tripette et al. 2014 Japan [64] | Postpartum women (N=34)<br>*Mean age:* 32 ±5 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* passive control<br>*Duration*: 5 wks (30 min, daily)<br>*Location:* Home | All activities included in the *Wii Fit Plus* software | Body composition, physical fitness (flexibility and strength), energy intakes (questionnaire), adherence (playing time) | Women playing *Wii Fit* lost more weight than their passive control counterpart. They expended an average 4700 ±2900 kcal playing *Wii Fit* and decrease their energy intakes.<br>*Adverse events:* lower back pain (N=1), ankle twist (N=1) and wrist tendinitis (N=1) |
| ***Chronic diseases*** | | | | | |
| Albores et al. 2013 USA | COPD patients (*F/M, N*=14/6)<br>*Mean age:* 68 ±10 yrs | Intervention<br>*1 group*<br>*Duration:* 12 wks (30 min, daily) | *Aerobics:* Basic Run, Free Step; *training plus:* Bird's Eye Bull's-Eye, Obstacle | *Primary:* physical fitness (ESWT and other tests)<br>*Secondary:* health | A home-based *Wii Fit* training improved physical fitness and overall health status but not dyspnea in COPD patients.<br>*Adverse events:* No |

| | | | | | |
|---|---|---|---|---|---|
| [77] | | *Location:* Home | Course | status (CRQ-SR, dyspnea assessment) | |
| Kempf & Martin 2013 Germany [78] | T2DM patients (*F/M, N*=119/101)<br>*Age range:* 50-75 yrs<br>*Mean age:* 61 ±8 yrs | Intervention (RCT)<br>*2 groups: Wii Fit*-traditional care *vs.* traditional care-*Wii Fit*<br>*Duration:* 12 wks (30 min/day)<br>*Location:* Home | Not specified (supposedly, all the activities included in *Wii Fit Plus*) | *Primary:* glycemic variations (HbA1c) and various blood markers<br>*Secondary:* body composition, blood pressure, PA (questionnaire), adherence (retention), health status (SF-12, PAID) and well-being & quality of life (WHO-5, CESD) | Subjects adhered to the *Wii Fit* intervention (retention rate: 80%). Playing *Wii Fit* on a daily basis significantly decreased HbA1c in T2DM patients (-0.3 ±1.1). Fasting glucose, weight, BMI, PA, as well as other well-being outcomes were also improved.<br>*Adverse events:* No |
| Cho & Sohng 2014 Korea [79] | Hemodialysis patients (*F/M, N= 18/28*)<br>*Mean age:* 59 ±8 yrs | Intervention (RCT)<br>*2 groups:* Wii Fit vs. passive control<br>*Duration:* 8 wks (30 min, 3 sessions/wk)<br>*Location:* Hospital | *Yoga:* Chair, Half Moon, Standing Knee (supposedly); *strength:* Torso Twist, Triceps Extension (supposedly); *balance:* Balance Bubble, Tightrope Walk; *aerobics*: Basic Steps (supposedly), Hula Hoop; *training plus*: Big Top Juggling, Bird's-Eye Bulls-Eye, Rhythm Kung Fu, Rhythm Parade (+5 other activities that are not explicitly named) | Physical Fitness (back strength, handgrip, leg strength, sit-and-reach, single leg stance test), body composition (bioimpedancemetry), fatigue (analogue scale) | Significant improvements were noted for physical fitness, body composition and fatigue in the *Wii Fit* group but not the control group, suggesting that this software could be used for health promotion program in hemodialysis patients.<br>*Adverse events:* No |
| Kim et al. 2014 Korea [80] | Middle-aged women with lower back pain (*N=30*)<br>*Mean age:* 47 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* traditional therapy<br>*Duration:* 4 wks (30 min, 3 sessions/wk)<br>*Location:* not specified | *Yoga:* Chair, Deep Breathing, Half Moon, Palm Tree, Sun Salutation (supposedly), Tree, Warrior | Pain (visual analogue scale, pressure algometry), disability (ODI, RDQ, FABQ) | Both interventions induced lower pain and self-perceived disability. *Wii Fit* induced significant higher improvement for all outcomes except for deep tissue mechanical pain sensitivity (pressure algometry).<br>*Adverse event*: No |

| | | | | | |
|---|---|---|---|---|---|
| ***Drug dependency problems*** | | | | | |
| Cutter et al.<br>2014<br>USA<br>[68] | Opioid- / cocaine-dependent subjects (*F/M, N=17/12*)<br>*Mean age:* 43 ±9 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* sedentary video games<br>*Duration:* 8 wks (20-25 min, 5 sessions/wk)<br>*Location:* Drug rehabilitation center | For each session, subjects were invited to choose, two *aerobics* activities, 1 *yoga* activity, 1 *balance* activity and 1 *strength* activity. | Acceptability (attendance, 4-item questionnaire), physical activity (in-session energy expenditure, IPAQ-L), substance use (diary, urine toxicology screening), well-being (PSS, BLSS, LOT) | Both interventions showed high level of acceptability, decreased substance use and increased well-being. *Wii Fit* participants reported high level of MVPA at the end of the intervention period.<br>*Adverse events:* No |
| ***Cancer patients (fatigue management)*** | | | | | |
| Hoffman et al. [b]<br>2013<br>USA<br>[87] | Post-surgical non-small lung cancer patients (*F/M, N*=5/2)<br>*Age range:* 53-73 yrs<br>*Mean age:* 65 ±7 yrs | Intervention (phase 1, cf. phase 2 below)<br>*1 group*<br>*Duration:* 6 wks (5-30 min "walking with the Wii (see elsewhere) + 3-4 *Wii Fit* balance activities, 5 sessions/wk)<br>*Location:* Home | *Aerobics:* "walking with the Wii" (might described an *aerobics* – Free Run - activity played by walking instead of running); *balance:* Ski Slalom, Soccer Heading; *Training Plus*: Driving Range; and "other activities" | Acceptability (questionnaire), fatigue (BFI), Fatigue management (PSEFSM), balance and functional mobility (ABC, self-efficacy for walking duration instrument, step-count) and adherence (playing time) | Patients adhered to the *Wii Fit* intervention, which was rated as acceptable. Perceived efficacy for balance and functional mobility increased, perceived fatigue decreased, and perceived self-efficacy for fatigue self-management increased (No statistics however). Light intensity home-based exertion delivered via a game console is effective for fatigue self-management in cancer patients.<br>*Adverse events:* No |
| Hoffman et al.<br>2014 [b]<br>USA<br>[88] | Same as for phase 1 (cf. above) | Intervention (phase 2, cf. phase 1 above)<br>*1 group*<br>*Duration:* 10 wks (30 min "walking with the Wii (see elsewhere) + 3-4 *Wii Fit* balance activities, 5 sessions/wk)<br>*Location:* Home | Same as for phase 1 (cf. above) | Same as for phase 1 (cf. above) | Positive outcomes noted at the end of phase 1 (cf. the above) are maintained or reinforced at the end of the phase 2. Light intensity home-based exertion delivered via a game console is effective for fatigue self-management in cancer patients (even for those undergoing an adjuvant therapy) for a period as long as 16 weeks at least.<br>*Adverse events:* No<br><br>**<u>ABC (no unit):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 72.8 ±20.5**<br>**Post-intervention: 83.7 ±24.8** |
| ***Systemic lupus erythematosus*** | | | | | |

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| Yuen et al.<br>2011<br>USA<br>[69] | African American women with systemic lupus erythematosus (*N*=15)<br>*Age range:* 25-67 yrs<br>*Mean age:* 47 ±14 yrs | Intervention<br>*1 group*<br>*Duration:* 10 wks (30min, 2 sessions/wk)<br>*Location:* Home | *Yoga*, *strength* and *aerobics* activities | *Primary:* fatigue (FSS)<br>*Secondary:* anxiety level, pain intensity, body composition, step-count, physical fitness, adherence | Fatigue, anxiety and pain were reduced. Body composition and physical fitness improved. Good adherence.<br>*Adverse events:* No |
| | *Seniors* | | | | |
| Chan et al.<br>2012<br>China<br>[110] | Elderly referred for rehabilitation (*F/M, N*=22/8, 13 of them having acquired neurological disorders)<br>*Mean age:* 80 ±7 yrs | Intervention<br>*1 group* (+ comparison with a historic pool of 60 patients)<br>*Duration:* 5-9 wks (10 min, 1-2 sessions/wk, total of 8 *Wii Fit* sessions)<br>*Location:* Geriatric center | *Aerobics:* 2P Run | *Primary:* feasibility (Borg scale, HR), adherence (playing time), acceptability (questionnaire)<br>*Secondary:* functional ability (FIM) | Participants completed an average of 72 ±7 min of *Wii Fit* during their 5-9-wk rehabilitation period (instructions: about 80 min). No difference was noted in exertion rate between the *Wii Fit* activity and a traditional arm ergometer exercise. *Wii Fit* participants exhibited a higher improvement in functional abilities compared to historic controls and wanted to continue the game at home.<br>*Adverse events:* No |
| Daniel<br>USA<br>2012<br>[18] | Pre-frail elderly (*F/M, N*=14/9, )<br>*Mean age :* 77 ±5 yrs | Intervention (RCT)<br>*3 groups :* passive control *vs.* seated exercise training *vs. Wii Fit* + weight vest<br>*Duration:* 15 wks (45 min, 3 sessions/wks)<br>*Location:* Laboratory | Not specified (supposedly, all activities included in *Wii Fit* and *Wii Sports*) | Physical fitness (SFT, CHAMPS) body composition, balance & functional mobility (ABC, LLFDI, 8-feet TUG), adherence (attendance) | Authors described an improvement in physical fitness and balance confidence in the *Wii Fit* group, but no statistical significance is indicated. Same attendance rate (86%) in both seated exercising and *Wii Fit* groups.<br>*Adverse events:* No |

[a] When balance outcomes are included concomitantly with other outcomes, and are not described as a primary outcome alone, the study is only included in Table 3. [b] Hoffman et al. (2013 & 2014) report results from two different phases of the same project [87, 88].

%: percentage; ABC: activities-specific balance confidence scale; BFI: brief fatigue inventory; BLSS: brief life satisfaction scale; BMI: body mass index; CESD: center for epidemiologic studies depression scale; CHAMPS: community healthy activities model program for seniors; COPD: chronic obstructive pulmonary disease; CRQ-SR: chronic respiratory questionnaire; CTSIB: clinical test of sensory interaction and balance ; EE: energy expenditure; ESWT: endurance shuttle walk test; FABQ: fear avoidance beliefs questionnaire; FIM: functional independence measure; FFS: Fatigue Severity Scale; HR: hear rate (beats/min); IMI: Intrinsic Motivation Inventory; LLFDI: late life function and disability index; IPAQ-L: physical activity questionnaire-long version; LOT: life orientation test; METs: metabolic equivalent; MVPA: moderate-to-vigorous physical activity; PSEFSM: perceived self-efficacy for fatigue self-management;  RPP: rate pressure product; PAID: problem areas in diabetes scale; sec: second; SEES: subjective exercise experience scale; SFT: senior fitness test; PA: physical activity; PACES: physical activity and exercise questionnaire; ODI: Oswestry low-back pain disability index; PSS: perceived stress scale; RDQ: Roland Morris disability questionnaire; SF-12:

short form-12 health survey; SOT: sensory organization test; TD2M: type 2 diabetes mellitus; TUG: time up and go; VPA: vigorous physical activity; $VO_2$: oxygen consumption; $VO_2$max: maximal oxygen consumption; WHO-5: five-item WHO well-being index.

For the same test, unit may vary from one paper to another.

For each population, Table 4 summarizes study characteristics and the main results for protocols with a primary focus on the effect of *Wii Fit* intervention on balance activities and related physical functions. Overall, the qualitative review of these studies supports a positive effect of *Wii Fit* interventions on balance outcomes. Among the 55 studies, 50 observed a positive effect of *Wii Fit* on at least one parameter [5-7, 9-12, 17, 19, 21, 27-31, 36, 37, 42, 43, 52, 57, 72, 74, 75, 81, 82, 84, 86, 90, 92, 93, 95, 98-102, 105, 106, 108, 109, 111, 113-120]. There are numerous examples were balance–related parameters improved to a similar or even higher extent when using *Wii Fit* compared to traditional therapies [5, 11, 17-19, 21, 42, 43, 52, 72, 74, 75, 81, 96, 90, 95, 99, 105, 111, 116, 120]. Only 5 papers described contrasted results or expressed some reservations about the ability of the software to induce benefits in balance skills [8, 35, 58, 89, 97], with three of these studies being conducted in healthy populations [8, 58, 97].

200 **Table 4. *Wii Fit* interventions for functional balance training**

| Authors<br>Year<br>Country | Population characteristics | Study design | *Wii Fit* activities (or other video games) | Outcomes and measures | Key findings<br>**& Data used for the meta-analyses** |
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| ***Healthy young adults or middle-aged adults*** | | | | | |
| Gioftsidou et al.<br>2013<br>Greece<br>[42] | Healthy young adults<br>(*F/M, N*=18/22)<br>*Age range*: 20-22 yrs<br>*Mean age:* 20 ±1 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* BOSU ball-based therapy<br>*Duration*: 8 wks (14 min, 2 sessions/wk)<br>*Location:* Laboratory (supposedly) | *Balance:* Balance Bubble, Penguin Slide, Snowboard Slalom, Ski Slalom, Soccer Heading, Table Tilt; *Training plus*: Balance Bubble Plus, Skateboard Arena, Table Tilt Plus | Balance (single leg stance tests[a] and various indexes using *Biodex* system) | Balance improvement for both BOSU ball and *Wii Fit* intervention. Only one test (the balance board anterior-posterior single-limb stance test) showed greater improvement for the BOSU ball training.<br>*Adverse events:* No |
| Melong & Keats<br>2013<br>Canada<br>[43] | Healthy young adults<br>(*F/M, N*=12/8)<br>*Mean age:* 20 ±1 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* BOSU ball-based therapy<br>*Duration:* 4 wks (20 min, 3 sessions/wk)<br>*Location:* Laboratory | *Balance:* Ski Jump, Ski Slalom, Soccer Heading, Table Tilt (+ a other activities played with the Wii balance board) | *Primary:* adherence (attendance and playing time)<br>*Secondary:* enjoyment (PACES), balance (stabilometry) | Balance improvement were noted in both groups. While the *Wii Fit* group showed higher levels of enjoyment, this did not lead to a significant higher attendance or playing time. This study may have been underpowered.<br>*Adverse events:* No |
| Lee et al.<br>2014<br>Korea<br>[52] | Healthy young adults<br>(*N*=24)<br>*Mean age:* 20 ±1 yrs | Intervention (RCT)<br>*2 groups: Wii Fit* vs. indoor horseback riding exercise<br>*Duration:* 6 wks (25 min, 3 sessions/wk)<br>Location: not specified (« indoor » ) | *Balance:* Balance Bubble, Ski Slalom, Table Tilt | Balance (dynamic tests using *Biodex* system: anteroposterior, mediolateral, and overall stability) | Both the *Wii Fit* and indoor horseback riding programs induce significant improvement in all three dynamic balance tests.<br>*Adverse events:* No |
| Cone et al.<br>2015<br>USA<br>[57] | Healthy young adults<br>(*F/M, N*=16/24)<br>*Age range:* 18-35 yrs<br>*Mean age*: 23 ±3 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* passive control<br>*Duration:* 6 wks (30-45 min, 2-4 sessions/wk)<br>*Location:* Laboratory (supposedly) | *Balance:* Balance Bubble, Penguin Slide, Snowboard Slalom, Ski Slalom, Soccer Heading, Table Tilt, Tightrope Walk | Balance (SOT, LOF) | Significant higher improvements in both LOS and SOT scores were noted for the *Wii Fit* group. Because those tests respectively focus on dynamic stability and sensory weighting, the results suggest that individual with vestibular system alterations or dynamic balance control impairments may benefit from a *Wii Fit* training. |

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| | | | | | *Adverse events:* No |
| Naumann et al.<br>2015<br>Germany<br>[58] | Healthy young adults<br>(*F/M, N*=29/8)<br>*Age range:* 20-34 yrs<br>*Mean age*: 23 ±3 yrs | Intervention (RCT)<br>*3 groups: Wii Fit vs.* MFT Challenge Disc® *vs.* passive control<br>*Duration:* 4 wks (30 min, 3 sessions/wk) + follow-up after 4 weeks<br>*Location:* Laboratory (supposedly) | *Balance:* Balance Bubble, Ski Slalom, Snowboard Slalom, Table Tilt | Balance (game scores, single- or two-leg stance COP excursion) | The performance on trained games increase in both intervention groups. But no changes were noted for the COP excursion tests. Similarly, the *Wii Fit* group did not show any increase in MFT Challenge Disc® scores, and *vice-versa*. This result suggests that the training effect of *Wii Fit* is highly specific and may not be transferred to real life balance-related tasks.<br>*Adverse events*: No |
| ***Healthy seniors*** | | | | | |
| Williams et al.<br>2011<br>USA<br>[93] | Elderly (*F/M, N*=18/4)<br>*Age range:* 74-84 yrs<br>*Mean age:* 84 ±5 yrs | Intervention<br>*1 group*<br>*Duration:* 4 wks (20 min, 1 session/wk)<br>*Location:* Geriatric center-based | *Balance* and *aerobic*s activities | Balance (BBS) | *Wii Fit* induced improvement in balance skills. The post-intervention BBS scores (49 ±5) were significantly higher than pre-intervention scores (39 ±6).<br>*Adverse events:* No<br><br>**<u>BBS (no unit):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 39.41 ±6.28**<br>**Post-intervention: 48.55 ±4.58** |
| Bateni<br>2012<br>USA<br>[95] | Elderly (*F/M, N*=9/8)<br>*Age range:* 53-91 yrs<br>*Mean age:* 73 ±14 yrs | Intervention (RCT)<br>*3 groups: Wii Fit vs. Wii Fit* + traditional physical therapy *vs.* traditional physical therapy alone<br>*Duration:* 4 wks (15 min – estimation, 3 sessions/wk)<br>*Location:* Rehabilitation center | *Balance:* Balance Bubble, Ski Jump, Ski Slalom; *training plus:* Table Tilt plus | Balance (BBS and *Wii Fit* Balance Bubble score) | Improvement in both BBS and Balance Bubble score in all of the 3 groups. However, subjects who underwent traditional therapy exercises performed better at the BBS compared to subject who only play *Wii Fit* alone.<br>*Adverse events:* No |
| Franco et al.<br>2012<br>USA<br>[97] | Elderly (*F/M, N*=25/7)<br>*Mean age:* 78 ±6 yrs | Intervention (RCT)<br>*3 groups: Wii Fit* + strength training *vs.* traditional balance training *vs.* passive | *Balance:* Ski Jump, Ski Slalom, Soccer Heading, Table Tilt, Tightrope Walk | Balance and gait (BBS, Tinetti test), functional health and well-being (SF-36), enjoyment (home- | *Wii Fit* did not induce any balance and gait improvement. Same outcomes were observed in the traditional training group. Subjects playing *Wii Fit* reported high level of enjoyment. |

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| | | control<br>*Duration:* 3 wks (10-15 min, 2 sessions/wk)<br>*Location:* Community dwelling | | made questionnaire) and adherence (playing time) | *Adverse events:* No<br><br>**BBS (no unit):**<br>***Wii Fit group***<br>**Pre-/post-intervention delta: 3.55 ±5.03**<br>***Traditional therapy group***<br>**Pre-/post-intervention delta: 3.45 ±2.50** |
| Orsega-Smith et al.<br>2012<br>USA<br>[98] | Elderly (F/M, N=30/4)<br>*Age range:* 55-86 yrs<br>*Mean age:* 72 ±8 yrs | Intervention (No-RCT)<br>3 groups: playing *Wii Fit* for 4 wks vs. playing *Wii Fit* for 8 wks vs. passive controls<br>*Duration:* 4 or 8 wks (30 min, 2 sessions/wk)<br>*Location:* Community dwelling | *Yoga:* Deep Breathing, Half Moon, Palm Tree; *aerobics:* Hula Hoop; *balance:* Balance Bubble, Penguin Slide, Snowboard Slalom, Ski Jumping, Ski Slalom, Table Tilt | Balance (BBS), mobility (8-feet TUG), leg strength (STST), balance confidence (ABC, FES), autonomy (ADL) | Balance, and ability to complete activities of daily living were improved in the two *Wii Fit* groups. Leg strength increased in the 4-wk intervention group only, while balance confidence increased in the 8-wk intervention group only. No change was noted in the control group<br>*Adverse events:* No<br><br>**ABC (no unit):**<br>***Wii Fit group (A: 4-week)***<br>**Pre-/post- intervention delta: 3.20 ±13.88**<br>***Wii Fit group (B: 8-week)***<br>**Pre-/post- intervention delta: 6.07 ±7.04**<br>**BBS (no unit):**<br>***Wii Fit group (A: 4-week)***<br>**Pre-/post- intervention delta: 1.44 ±2.34**<br>***Wii Fit group (B: 8-week)***<br>**Pre-/post- intervention delta: 1.22 ±1.09** |
| Rendon et al.<br>2012<br>USA<br>[9] | Elderly (*F/M, N*=26/14; 6 using an assistive devise)<br>*Age range:* 60-95 yrs<br>*Mean age:* 85 ±5 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* passive control<br>*Duration:* 6 wks (35-45 min, 3 sessions/wk)<br>*Location:* Community | *Strength:* Lunge, Single Leg Extension, Single Leg Twist | *Primary:* balance (ABC, 8ft up and go test)<br>*Secondary:* depression (GDS) | *Wii Fit* improved dynamic balance and balance confidence. No effect on depression score.<br>*Adverse events:* No |

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| Toulotte et al.<br>2012<br>France<br>[99] | Elderly (some had an history of falling;<br>*F/M, N*=22/14)<br>*Age range:* >60 yrs<br>*Mean age:* 75 ±10 yrs | Intervention (RCT)<br>*4 groups:* passive control *vs. Wii-Fit*, adapted physical activities *vs. Wii Fit* + adapted physical activities<br>*Duration:* 20 wks (60 min, 1 session/wk)<br>*Location:* Fitness room | *Yoga* activities and some *balance* activities (Soccer Heading, Ski Jump, Ski Slalom, Tightrope Walk, and another activity identified as "game balls") | Balance (static tests only: a single leg stance test[a] and the *Wii Fit* balance test; static and dynamic test: Tinetti test) | *Wii Fit* significantly improved static balance but not dynamic balance. The conventional adapted PA training improved both. Combining both interventions did not induce additional benefits.<br>*Adverse events:* No |
| Bieryla & Dold<br>2013<br>USA<br>[7] | Elderly (*F/M, N*=10/2)<br>*Age range:* 70-92 yrs<br>*Mean age:* 82 ±6 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* passive control<br>*Duration:* 3 wks (30 min, 3 sessions/wk) + follow-up at 4-wk<br>*Location:* Community dwelling (supposedly: "supervised") | *Yoga:* Chair, Half Moon, Warrior; *aerobics:* Torso Twists; *balance:* Ski Jump Soccer, Heading | Balance (BBS, TUG, FAB, functional reach test) and adherence (retention rate) | In the *Wii Fit* group, the retention rate was 4/6 at the 4-wk follow-up. The *Wii Fit* training induced improvement in the BBS only.<br>*Adverse events:* No |
| Chao et al.<br>2013<br>USA<br>[100] | Assisted living residents *(F/M, N*=5/2, 3 of them having acquired neurological disorders)<br>*Age range:* 80-94 yrs<br>*Mean age:* 86 ±5 yrs | Intervention<br>*1 group*<br>*Duration:* 8 wks (30 min, 2 sessions/wk)<br>*Location:* Assisted living dwelling | *Yoga*: Chair, Deep Breathing; *strength*: Lunge; *aerobics*: Basic Run; *balance*: Penguin Slide, Table Tilt | Balance & mobility (BBS, TUG, 6-min walk test, FES), perceived efficacy (SSE, OEE), acceptability (questionnaire), safety | The *Wii Fit* intervention was acceptable and safe, and induced significant improvements in BBS. Trends only (p= 0.06) were noted for improvement in other balance and mobility indexes.<br>*Adverse events:* No<br><br>**BBS (no unit):**<br>***Wii Fit group***<br>**Pre-intervention: 40.9 ±8.5**<br>**Post-intervention: 45.1 ±8.3**<br>**TUG (sec):**<br>***Wii Fit group***<br>**Pre-intervention: 19.4 ±5.5**<br>**Post-intervention: 15.8 ±5.1** |
| Janssen et al.<br>2013<br>The | Home nursing residents (*F/M, N*=20/9, some had an | Intervention (No-RCT)<br>3 groups: *Wii Fit* | Table Tilt Plus (*Training Plus*) and 2 other games of | *Primary:* balance (BBS)<br>*Secondary:* physical | No significant balance improvement in both *Wii Fit* intervention groups. However, subjects increased their |

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| Netherland<br>[8] | history of falling)<br>*Average age:* 65-90 yrs<br>*Mean age*: 82 ±9 yrs | (without history of playing) *vs. Wii Fit* (with an history of playing) *vs.* passive control<br>*Duration:* 12 weeks (10-15 min, 2 sessions/wk)<br>*Location:* Assisted living dwelling | participants' choice | activity (LASAPAQ) | volume of physical activity by about 60 min/day.<br>*Adverse events:* No |
| Chao et al.<br>2014<br>USA<br>[101] | Assisted living resident<br>(*F/M, N=24/8*)<br>*Mean age:* 85 ±6 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* "education" semi-passive control<br>*Duration:* 4 wks (30 min, 2 sessions/wk)<br>*Location:* Assisted living dwelling | *Yoga:* Chair, Deep Breathing; *strength:* Lunge; *balance*: Penguin Slide, Table Tilt; aerobics: Basic Run | Balance and physical function (BBS, TUG, 6-min walk test, FES, SEE), depression (GDS), quality of life (SF-8) | Significant improvements in balance related-function and depression parameters were found in the *Wii Fit* group only. *Wii Fit* might be considered as a potential activity for older adults in assisted living dwellings.<br>*Adverse events:* No<br><br>**<u>BBS (no unit):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 40.53 ±6.59**<br>**Post-intervention: 43.93 ±6.34**<br>**<u>TUG (sec):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 18.52 ±5.60**<br>**Post-intervention: 15.27 ±4.68** |
| Cho et al.<br>2014<br>Korea<br>[102] | Elderly (*N=32*)<br>*Mean age:* 78 ±1 yrs | Intervention (RCT)<br>*2 groups*: *Wii Fit vs.* passive control<br>*Duration:* 8 wks (30 min, 3 sessions/wk)<br>*Location:* not specified | *Balance:* Balance Bubble, Ski Slalom, Table Tilt | Balance (Romberg test) | Significant improvements were noted in the *Wii Fit* group only.<br>*Adverse events:* No |
| Nicholson et al.<br>2015<br>Australia<br>[105] | Elderly (*F/M, N=14/27*)<br>*Age range:* 65-84 yrs<br>*Mean age:* 75 ±5 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* usual exercise<br>*Duration:* 6 wks (30 min, 3 sessions /wk)<br>*Location:* Community | *Balance:* Penguin Slide, Ski Jump, Ski Slalom, Soccer Heading, Table Tilt, Tightrope Walk; *training plus*: | Balance and mobility (TUG, functional reach tests, single leg stance test[a], STST, Icon-typed FES, walking speed), | The *Wii Fit* group showed more important improvements compared to the control group for the followings: TUG, lateral reach, left-leg single leg stance test and gait speed. Interestingly, enjoyment increased during the |

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| | | dwelling | Snowball Fight, Perfect 10 | enjoyment (PACES), adherence (playing frequency) | intervention and the adherence was very high (average attendance: 17.5 out of 18 recommended sessions)<br>*Adverse events:* exacerbations of lower back pain (N=2)<br><br>**<u>TUG (sec):</u>**<br>***Wii Fit group***<br>**Pre-/post- intervention delta: -0.61 ±0.79**<br>***Traditional therapy group***<br>**Pre-/post- intervention delta: -0.14 ±0.88** |
| Roopchand-Martin et al.<br>2015<br>Jamaica<br>[106] | Elderly (*F/M, N=26/7*)<br>*Mean age:* 70 ±7 yrs | Intervention<br>*1 group*<br>*Duration:* 6 wks (30 min, 2 sessions/wk)<br>*Location:* Community dwelling | *Yoga:* Tree; *balance:* Balance Bubble, Penguin Slide, Snowboard Slalom, Soccer Heading, Table Tilt; *training plus:* Obstacle Course, Skateboard | Balance and function (BBS, MCTSIB, MDRT, SEBT) | Significant balance and functional improvements were noted at the end of the *Wii Fit* intervention (i.e. for BBS, MDRT, SEBT, but not for MCTSIB)<br>*Adverse events*: No<br><br>**<u>BBS (no unit):</u>**<br>***Wii Fit group***<br>**Pre-/post- intervention delta: 1.54 ±2.60** |
| ***Seniors presenting balance impairments*** | | | | | |
| Williams et al.<br>2010<br>UK<br>[108] | Elderly with an history of falling (*N*=21)<br>Mean age: 77 ±5 yrs | Intervention (RCT)<br>2 groups: *Wii Fit vs.* standard care<br>*Duration:* 12 wks (2 sessions/wk)<br>*Location:* Rehabilitation center | *Yoga:* Deep Breathing; *aerobics:* Basic Step, Hula Hoop, Running activities; *Balance:* Ski Jump, Ski Slalom, Soccer Heading, Table Tilt, | Functional balance (BBS, Tinetti test), static balance (*Wii Fit age* test) Balance confidence (FES), acceptability (retention, playing frequency, interviews) | The intervention met a high rate of acceptability. Balance improved in the *Wii Fit* group only.<br>*Adverse events:* fall (N=1, no injury)<br><br>**<u>BBS (no unit):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 43.7 ±9.5**<br>**Post-intervention: 44.8 ±11.8**<br>***Traditional therapy group***<br>**Pre-intervention: 36.3 ±9.9**<br>**Post-intervention: 39.0 ±10.2** |
| Agmon et al.<br>2011<br>USA<br>[109] | Elderly with balance impairment (*F/M, N*=4/3)<br>*Age range:* 78-92 yrs | Intervention<br>*1 group*<br>*Duration:* 13 wks (30 min, 3 sessions/wk) | *Balance:* Basic Step, Ski Slalom, Soccer Heading, Table Tilt | *Primary:* Balance (BBS)<br>Secondary: mobility (4-meter walk test), | The *Wii Fit* intervention increased balance and mobility. Some activities were more enjoyable than the others. Adherence was associated with |

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| | *Mean age:* 84 ±5 yrs | *Location:* Home | | enjoyment (PACES), feasibility (playing time), safety (interviews) | enjoyment.<br>*Adverse events:* hip and neck strain (N=1 and 2, respectively)<br><br>**BBS (no unit):**<br>***Wii Fit group***<br>**Pre-intervention: 49.0 ±2.1**<br>**Post-intervention: 53.0 ±1.8** |
| Bainbridge et al.<br>2011<br>USA<br>[10] | Elderly with perceived balance deficit (*F/M, N*=7/1)<br>*Age range:* 65-87 yrs<br>*Mean age:* 75 ±8 yrs | Intervention<br>*1 group*<br>*Duration:* 6 wks (30 min, 2 sessions/wk)<br>*Location:* Community dwelling | *Yoga:* Half Moon, Warrior*; Balance:* Penguin Slide, Ski Jump, Ski Slalom, Soccer Heading, Table Title, Tightrope Walk | Balance (BBS, ABC, MDRT), COP excursion measurements) and other parameters (ankle range of motion tests…) | No statistically significant changes, but 4 patients (over the 6 who finished the intervention) demonstrated improvements on the BBS, based on established clinical guidelines.<br>*Adverse events:* No |
| Jorgensen et al.<br>2012<br>Denmark<br>[111] | Elderly with perceived balance deficit (*F/M, N*=40/18)<br>*Mean age*: 75 ±6 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* passive control<br>*Duration:* 10 wks (35 min, 2 sessions/wk)<br>*Location:* Community dwelling | *Balance:* Penguin Slide, Ski Slalom, Table Tilt, Tightrope Walk; *training plus:* Perfect 10 | *Primary:* strength (maximal voluntary contraction of leg extensors (MVC), Rate of Force Development (RFD), static balance (COP velocity moment)<br>*Secondary:* mobility (TUG, STST), balance confidence (FES), motivation (questionnaire) | Compared to controls, the *Wii Fit* group exhibit higher strength after 10 weeks of training. Mobility and balance confidence parameters also showed an improvement in the *Wii Fit group* only. Motivation for *Wii Fit* training was found to be high.<br>*Adverse events:* No<br><br>**TUG (sec):**<br>***Wii Fit group***<br>**Pre-intervention: 10.3 ±3.8**<br>**Post-intervention: 9.0 ±3.2** |
| ***Seniors with acquired neurological alterations*** | | | | | |
| dos Santos et al.<br>2012<br>Brazil<br>[114] | Patients with Parkinson's disease (stages 1 and 2 on Hoehn & Yahr scale, *N*=16)<br>*Mean age:* 69 ±8 yrs | Intervention<br>*2 groups:* patients *vs.* healthy controls, *N*=11)<br>*Duration:* 7 wks (20-30 min, 2 sessions/wk) + follow-up after 2 months<br>*Location:* Rehabilitation center | *Strength:* Single Leg Extension, Torso Twists; *aerobics:* Basic Step*; balance:* Penguin Slide, Soccer Heading, Table Tilt*; training plus:* Basic Run Plus, Obstacle Course, Rhythm Parade, Tilt City | Stability (functional reach test) and motor learning (score performed in the selected games before and after the intervention) | 7 of the 10 tested games induced the same learning in Parkinson's disease patients compared with healthy subjects. These patients were also able to transfer and retained (+2-mths follow-up) their learning on a similar but untrained functional task.<br>*Adverse events:* No |

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| | | (supposedly: « Overseen by a physiotherapist ») | | | |
| Esculier et al. [c] 2012 Canada [113] | Patients with Parkinson's disease (*F/M, N*=5/6) *Age range:* 48-80 yrs *Mean age:* 62 ±11 yrs | Intervention *2 groups:* patients *vs.* healthy controls, *F/M, N*=4/5) *Duration:* 6 wks (40 min, 3 sessions/wk) *Location:* Home | *Yoga:* Deep Breathing; *aerobics:* Hula-Hoop; *balance:* Balance Bubble, Penguin Slide, Ski Jump, Ski Slalom, Table Tilt | Functional balance and mobility (ABC, STST, TUG, Tinetti test, 10-m walk test, CBM), static balance (single leg stance test[a], COP excursion) | Improvement in every outcome (except for ABC) in the two groups. A home-based *Wii Fit* can improve static and dynamic balance, mobility and functional abilities of people affected by Parkinson's disease *Adverse events:* No |
| Pompeu et al. 2012 Brazil [116] | Patients with Parkinson's disease (stages 1 and 2 on Hoehn & Yahr scale, *F/M, N*=15/17) *Age range:* 60-85 yrs *Mean age:* 67 ±8 yrs | Intervention (RCT) *2 groups: Wii Fit vs.* traditional balance training *Duration:* 7 wks (30 min, 2 sessions/wk) + follow-up 60 days after *Location:* Rehabilitation center | *Strength:* Single Leg Extension, Torso Twist; *aerobics:* Basic Step, Basic Run; *balance:* Penguin Slide, Soccer Heading, Table Tilt; *training plus:* Obstacle Course, Rhythm Parade, Tilt City | *Primary:* performance in daily activities *Secondary:* balance (static: single leg stance test [a], dynamic: BBS), cognition (Montreal cognitive assessment) | Same improvements in *Wii Fit* and traditional balance training groups (maintained at 60 days follow-up). No additional advantage for the *Wii Fit* group. *Adverse events:* No<br><br>**BBS (no unit)**<br>***Wii Fit group***<br>**Pre-/post- intervention delta: 1.4 ±2.6**<br>***Traditional therapy group***<br>**Pre-/post- intervention delta: 1.1 ±2.1** |
| Padala et al. 2012 USA [115] | Patients with an history of mild Alzheimer's Dementia (*F/M, N*=16/6) *Mean age:* 80 ±7 yrs | Intervention (RCT) *2 groups: Wii Fit vs.* walking *Duration:* 8 wks (30 min, 5 sessions/wk) *Location:* Assisted living center | *Yoga:* Chair, Half moon, Sun Salutation Warrior; *strength:* Lunge, Single Leg Extension, Torso Twist; *balance:* Balance Bubble, Penguin Slide, Ski Jump, Ski Slalom, Soccer Heading, Table Tilt | *Primary:* balance (BBS, TUG, Tinetti test) *Secondary:* functional ability (ADL & instrumental ADL), quality of life (quality of life in Alzheimer's disease scale), cognition (mini mental state examination) | Significant improvement for balance outcomes in the *Wii Fit* group only (trends for the walking group). No significant changes in other outcomes, except for quality of life (walking group only). *Adverse events:* No<br><br>**BBS (no unit)**<br>***Wii Fit group***<br>**Pre-intervention: 43.4 8.9**<br>**Post-intervention: 47.5 5.9**<br>***Traditional therapy group***<br>**Pre-intervention: 41.3 ±7.6**<br>**Post-intervention: 46.9 ±6.3**<br>**TUG (sec)**<br>***Wii Fit group***<br>**Pre-intervention: 14.7 ±7.2** |

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| | | | | | **Post-intervention: 14.3 ±6.8**<br>***Traditional therapy group***<br>**Pre-intervention: 14.9 ±4.7**<br>**Post-intervention: 12.8 ±3.2** |
| Barcala et al.<br>2013<br>Brazil<br>[17] | Hemiplegic stroke patients (*F/M, N*=11/9)<br>Age range:<br>*Mean age:* 64 ±14 yrs | Intervention (RCT)<br>*2 groups:* conventional therapy + *Wii Fit vs.* conventional therapy + balance training<br>*Duration:* 5 wks (30 min, 2 sessions/wk)<br>*Location:* Rehabilitation center | *Balance:* Penguin Slide, Table Tilt, Tightrope Walk | Functional balance (BBS), static balance (stabilometry), functional mobility/independence (TUG, functional independence test) | Both groups showed significant improvements in all parameters. No statistical differences were noted between the two groups emphasizing the efficacy of the *Wii Fit* therapy for functional recovery in hemiplegic stroke patient.<br>*Adverse events:* No<br><br>**BBS (no unit)**<br>***Wii Fit group***<br>**Pre-intervention: 39.6 ±6.43**<br>**Post-intervention: 41.9 ±6.91**<br>***Traditional therapy group***<br>**Pre-intervention: 37.2 ±5.22**<br>**Post-intervention: 42.2 ±4.8**<br>**TUG (sec)**<br>***Wii Fit group***<br>**Pre-intervention: 27.9 ±8.22**<br>**Post-intervention: 24.3 ±8.64**<br>***Traditional therapy group***<br>**Pre-intervention: 28.1 ±3.10**<br>**Post-intervention: 25.2 ±2.78** |
| Mhatre et al.<br>2013<br>USA<br>[117] | Patients with Parkinson's disease (stages 2.5 or 3 on Hoehn & Yahr scale, *F/M, N*=6/4)<br>*Age range:* 44-91 yrs<br>*Mean age:* 67 yrs | Intervention<br>1 group<br>Duration: 8 wks (30 min, 3 sessions/wk)<br>*Location:* Rehabilitation center | *Balance:* "marble tracking", "skiing", "bubble rafting" (possibly: Table Tilt, Ski Slalom and Balance Bubble) | *Primary:* Balance (BBS; DGI; Sharpened Romberg; *Wii Balance Board*-assisted postural sway tests)<br>*Secondary:* Balance (ABC) and depression (GDS) | Significant improvement in BBS (3.3) and some other balance & gait outcomes, but not in balance confidence (ABC) or mood (GDS).<br>*Adverse events:* No<br><br>**ABC (no unit)**<br>***Wii Fit group***<br>**Pre-intervention: 83.5 ±5.3**<br>**Post-intervention: 82.5 ±3.6**<br>**BBS (no unit)**<br>***Wii Fit group***<br>**Pre-intervention: 48.8 ±3.2** |

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| Bower et al.<br>2014<br>Australia<br>[89] | Stroke inpatients<br>(*F/M, N*=13/17)<br>*Mean age:* 64 ±15 yrs | Intervention (RCT)<br>*2 groups: Wii Fit* balance training vs. *Wii Sports* upper limb training<br>*Duration:* 2-4 weeks (45 min, 3 sessions/wk)<br>*Location:* Rehabilitation center | A selection of 18 activities among the 66 activities proposed in the *Wii Fit Plus* software (including Deep Breathing, Ski Slalom, Basic Run and others…) | *Primary:* adherence (retention, attendance, playing time), acceptability (recruitment rate, questionnaire), safety (questionnaire)<br>*Secondary:* Balance (Step Test, *Wii Balance Board* Test), Functional autonomy (functional reach test, upper limb – motor assessment scale), mobility (TUG, STREAM), balance confidence (FES), | The recruitment rate (21%), eligibility rate (86%), retention rate (90 and 70% respectively at 2 and 4 wks) and adherence rate (99 and 87%) indicate that a *Wii Fit* intervention is feasible in stroke inpatients. All the patients enjoyed the intervention, which was described as safe. However, trends only were noted for improvement in some of the balance tests.<br>*Adverse events:* Falls (N=4), no subsequent injury<br><br>**TUG (sec):**<br>***Wii Fit group***<br>**Pre-/post- intervention delta: -11.2 ±10.3** |
| Esculier et al. [c]<br>2014<br>Canada<br>[118] | Patients with Parkinson's disease (stages 3.5 or more on Hoehn & Yahr scale, *F/M, N*=3/5)<br>*Mean age:* 64 ±12 yrs | Intervention<br>*2 groups:* patients *vs.* healthy controls, *F/M, N*=3/5)<br>*Duration:* 6 wks (40 min, 3 sessions/wk)<br>*Location:* Home | A selection of *balance* and *strength* activities involving lower limb muscles (i.e. using semi-squats<br><br>Positions) | Lower limb corticomotor excitability (transcranial magnetic stimulation) | A *Wii Fit* training improved lower limb corticomotor excitability in Parkinson's patients. Depending on the experimental conditions, these improvements were similar or more important compared to healthy subjects. Home-based interventions including visual feedbacks could be beneficial for functional improvement in Parkinson's patients.<br>*Adverse events:* No |
| Gonçalves et al.<br>2014<br>Brazil<br>[119] | Patients with Parkinson's disease (stages 2 to 4 on Hoehn & Yahr scale, *F/M, N=8/7*)<br>*Mean age:* 69 ±10 yrs | Intervention<br>*1 group*<br>*Duration:* 7 weeks (40 min, 2 sessions/wk)<br>*Location:* Hospital (supposedly, not specified) | *Balance:* Ski Jump, Ski Slalom, Soccer Header;<br>*aerobics*: Free Step, Rhythm Boxing;<br>*training plus*: Island Cycling, Rhythm Parade (supposedly), Segway Circuit<br>(+2 other activities that are not explicitly | Functional mobility (UPDRS, SE, FIM), gait (number of steps, walking speed) | The *Wii Fit* program induced gait improvement, but statistical significance is not indicated. Functional mobility was significantly improved (i.e. decrease in UPDRS score, and increase in SE and FIM scores)<br>*Adverse events:* No |

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| Hung et al.<br>2014<br>China<br>[90] | Chronic stroke patients<br>(*F/M, N=10/18*)<br>*Mean age:* 54 ±10 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* traditional weight-shift training<br>*Duration:* 12 wks (30 min, 2 sessions/wk) + follow-up at 3 months<br>*Location:* rehabilitation center (supposedly: according to pictures, “supervised by an occupational therapist”) | *Yoga:* Warrior; *balance:* Balance Bubble, Penguin Slide, Ski Slalom, Soccer Heading, Table Tilt; *aerobics*: Basic Step | Balance (a series of COP excursion tests, FES), function (forward reach, TUG), enjoyment (PACES) | At the end of the intervention, *Wii Fit* induced a higher increase in some COP excursion tests compared to the traditional weigh-shift training group. However, at 3-month follow-up, these effects were not maintained, while the traditional weight-shift group showed higher improvements. Both types of intervention showed significant improvements in balance and functional outcomes, and the enjoyment was higher in the *Wii Fit* group.<br>*Adverse events:* No<br><br>**<u>TUG (sec):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 26.06 ±12.05**<br>**Post-intervention: 20.88 ±7.77**<br>***Traditional therapy group***<br>**Pre-intervention: 29.45 ±16.22**<br>**Post-intervention: 26.61 ±12.92** |
| Liao et al.<br>2014<br>China<br>[120] | Patients with Parkinson’s disease (stages 1 to 2 on Hoehn & Yahr scale; *F/M, N=19/17*)<br>*Mean age:* 66 ±7 yrs | Intervention (RCT)<br>3 groups: *Wii Fit vs.* traditional therapy *vs.* passive control<br>*Duration:* 6 weeks (45 min, 2 sessions/wk + follow-up after 1 month<br>*Location:* Rehabilitation center (supposedly: “administrated by the same physical therapist”) | *Yoga (10 min):* Chair, Sun Salutation, Tree; *strength (15 min)*; *balance (20 min):* Balance Bubble, Soccer Heading, Ski Slalom, Table Tilt | *Primary*: mobility (obstacle crossing performance tests measured with the *Liberty* system), dynamic balance (LOS)<br>*Secondary:* balance (SOT, FES), mobility (TUG), quality of life (PDQ-39). | When compared with the passive control group, *Wii Fit* induced significant increases for the mobility, balance and quality of life outcomes. Interestingly, movement velocity evaluated with LOS test showed significant greater improvement in *Wii Fit* group compared to traditional therapy. These results should encourage the implementation of *Wii Fit* activities in patients with Parkinson’s disease.<br>*Adverse events:* No<br><br>**<u>TUG (sec):</u>**<br>***Wii Fit group***<br>**Pre-/post- intervention delta: -2.9** |

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| | | | | | **±2.2**<br>***Traditional therapy group***<br>**Pre-/post- intervention delta: -1.1 ±0.1**<br>***Passive control group***<br>**Pre-/post- intervention delta: +0.7 ±1.7** |
| Morone et al.<br>2014<br>Italy<br>[5] | Subacute stroke patients (*N=50*)<br>*Mean age:* 60 ±10 yrs | Intervention (RCT)<br>*2 groups: Wii Fit* + traditional therapy *vs.* traditional balance exercises + traditional therapy<br>*Duration:* 4 wks (20 min, 3 sessions/wk) + follow-up after 1 month<br>*Location:* Rehabilitation center | *Balance:* Balance Bubble, Ski Slalom; *aerobics:* Hula Hoop | *Primary:* balance (BBS)<br>*Secondary:* mobility (10-m walk test, functional ambulatory category), independency (Barthel index) | *Wii Fit* was more effective than traditional balance exercises to improve balance and independency in subacute stroke patients. No significant differences were noted between groups for mobility outcomes (increase in both groups). Interestingly, benefits in balance ability were maintained 1 month after the intervention.<br>*Adverse events:* No |
| Omiyale et al.<br>2015<br>USA<br>[92] | Hemiparetic stroke patients (*F/M, N=4/6* )<br>*Age range:* 41-73 yrs<br>Mean age: 67 ±8 yrs | Intervention<br>*1 group*<br>*Duration:* 3 wks (60 min, 3 sessions/wk)<br>Location: not specified, but “supervised by a physical therapist” | *Balance:* Balance Bubble, Penguin Slide, Ski Slalom, Table Tilt, Tightrope Walk | Neural plasticity (interhemispheric symmetry through tibialis anterior corticomotor excitability using transcranial magnetic stimulation), balance, motor response and function (COP distribution and dynamic weight shifting, Soccer Heading’s score, BBS, TUG, and dual TUG, gait speed, ABC) | Interestingly, the *Wii Fit* intervention significantly improved the interhemispheric symmetry. Overall, but not for all parameters, patients also improved their balance abilities, motor responsiveness, and balance related functions. These results suggest that *Wii Fit* rehabilitation may be able to influence positively neural plasticity and functional recovery in chronic stroke patients.<br>*Adverse events*: No<br><br>**<u>ABC (no unit):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 65.9 ±13.49**<br>**Post-intervention: 73.4 ±13.32**<br>**<u>BBS (no unit):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 51.6 ±5.97**<br>**Post-intervention: 53.6 ±2.95** |

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| | | | | | **<u>TUG (sec):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 21.0 ±12.18**<br>**Post-intervention: 19.4 ±9.10** |
| Yatar & Yildirim 2015 Cyprus/Turkey [19] | Chronic stroke patients (*F/M, N*=13/17)<br>*Mean age:* 60 ±14 yrs | Intervention (RCT)<br>*2 groups:* neurodevelopmental training + *Wii Fit vs.* neurodevelopmental training + progressive balance training<br>*Duration:* 4 wks (30 min, 3 sessions/wk)<br>*Location:* Rehabilitation center (supposedly) | *Balance:* Balance Bubble, Ski Slalom, Soccer Heading | *Primary:* static balance (*Wii Balance Board*-assisted postural sway tests), dynamic balance (BBS, DGI, functional reach test, TUG)<br>*Secondary*: balance confidence (ABC, ADL) | Primary and secondary outcomes increased in both *Wii Fit* and progressive balance training groups. The increment was statistically higher in the *Wii Fit* group for: DGI. Functional reach test and ABC. Large differences in baseline values between the two groups limits the interpretation.<br>*Adverse events*: No<br><br>**<u>ABC (no unit):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 59.52 ±17.26**<br>**Post-intervention: 68.36 ±17.22**<br>**<u>BBS (no unit):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 45.60 ±5.26**<br>**Post-intervention: 50.33 ±4.09**<br>***Traditional therapy group***<br>**Pre-intervention: 39.60 ±9.31**<br>**Post-intervention: 44.80 ±7.48**<br>**<u>TUG (sec):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 17.96 ±7.77**<br>**Post-intervention: 16.17 ±8.23**<br>***Traditional therapy group***<br>**Pre-intervention: 26.36 ±11.60**<br>**Post-intervention: 22.11 ±11.88** |
| ***Orthopedic population*** | | | | | |
| Fung et al. 2011 Canada [11] | Adult outpatients following knee replacement (*F/M, N*=33/17)<br>*Mean age:* 68 ±11 yrs | Intervention (RCT)<br>*2 groups:* traditional therapy + *Wii Fit vs.* traditional therapy + additional lower limb exercise<br>*Duration*: until | *Yoga:* Deep Breathing, Half Moon; *Strength:* Torso Twist; *Aerobics:* Hula Hoop; *Balance:* Balance Bubble, Penguin | Function (range of motion), 2-min walk test, LEFS), pain (NPRS), Balance confidence (ABC) and length of rehabilitation | From baseline to discharge, the improvements were similar between the two groups for all the outcomes. The *Wii Fit* intervention might induce higher improvement for the LEFS. But the study was not powerful enough to obtain significance. |

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| | | discharge (≈ 6wks, 15 min/session)<br>*Location:* Rehabilitation center | Slide, Ski Slalom, Table tilt, Tightrope Walk | | *Adverse events:* No |
| Baltaci et al.<br>2012<br>Turkey<br>[72] | Young adults with anterior cruciate ligament reconstruction (N=30)<br>*Mean age:* 29 ±5 yrs | Intervention (RCT)<br>*2 groups: Wii vs.* conventional rehabilitation<br>*Duration:* 12 wks (60 min, 3 sessions/wk)<br>*Location:* Rehabilitation center (supposedly) | Not clear. Probably a combination of *Wii Sports* games (Bowling, Boxing) and *Wii Fit* activities (“skiing games”, “football”, “balance board”) | Balance (SEBT), function (functional squat test including coordination, proprioception, time response and strength measurements) | No difference between *Wii Fit* and conventional physical therapy. *Wii Fit* may be able to address rehabilitation goals for patients with anterior cruciate ligament reconstruction.<br>*Adverse events:* No |
| Sims et al.<br>2013<br>USA<br>[74] | Young active adults with an history of lower limb injury within 1 yr (*F/M, N*=16/12)<br>*Mean age:* 22 ±2 yrs | Intervention (RCT)<br>*3 groups: Wii Fit*, traditional balance training, passive control<br>*Duration:* 4 wks (15min, 3 sessions/wk)<br>*Location:* Rehabilitation center | *Yoga:* Chair, Half Moon, Tree; *Balance:* Balance bubble, Penguin Slide, Ski Slalom, Soccer Heading, Table Tilt; *Strength:* Lunge, Sideways Leg Lift, Single Leg Extension; *Aerobics:* Basic Step, Hula Hoop, Super Hula Hoop | *Primary:* balance (static: Time to Boundary test, dynamic: SEBT)<br>*Secondary:* function (LEFS) | *Wii Fit* improved static balance to a larger extend than the traditional balance training. Dynamic balance was improved in all groups.<br>*Adverse events:* No |
| Punt et al.<br>2015<br>Switzerland<br>[75] | Adults ankle sprain patients (*F/M, N*=39/51)<br>*Mean age:* 34 ±11 yrs | Intervention (RCT)<br>*3 groups: Wii Fit vs.* traditional balance training *vs.* passive control<br>*Duration*: 6 wks (30 min, 2 sessions/wk)<br>*Location:* Home | *Balance:* Balance Bubble, Penguin Slide, Ski Slalom, Table Tilt | Function (FAAM), pain (visual analogue scale), time to return to sport, satisfaction (questionnaire) | Foot and ankle ability score increased and pain decreased in all groups. A *Wii Fit* intervention is as effective as traditional therapy or no therapy. In the *Wii Fit* group, the average time to return to sport was 27 ±20 days and 82% of patients were satisfied.<br>*Adverse events:* No |
| | ***Multiple sclerosis*** | | | | |
| Brichetto et al.<br>2012<br>Italia<br>[81] | Patients with multiple sclerosis (*F/M, N*=22/14)<br>*Mean age:* 42 ±11 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* traditional rehabilitation<br>*Duration:* 4 wks (60 min, 3 sessions/wk) | *Balance :* Lotus Focus, Ski Slalom, Snowboard Slalom, Soccer Heading, Table Tilt, Tightrope Walk | *Primary:* balance (BBS)<br>*Secondary:* fatigue (MFIS), posture (stabilometry) | More important balance improvement in the *Wii Fit* group. Fatigue was reduced and posture improved. A *Wii Fit*-based program might be more efficient than the standard rehabilitation procedure in multiple |

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| | | *Location:*<br>Rehabilitation center | | | sclerosis patients.<br>*Adverse events:* No<br><br>**BBS (no unit):**<br>***Wii Fit group***<br>**Pre-intervention: 49.6 ±4.9**<br>**Post-intervention: 54.6 ±2.2**<br>***Traditional therapy group***<br>**Pre-intervention: 48.7 3.3**<br>**Post-intervention: 49.7 ±3.9** |
| Nilsagard et al.<br>2013<br>Sweden<br>[82] | Patients with multiple sclerosis (*F/M, N*=64/20)<br>*Mean age:* 50 ±11 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* passive control<br>*Duration:* 6-7 wks (30 min, 2 sessions /wk)<br>*Location:*<br>Rehabilitation Center ("physical therapist supervised session") | *Aerobics:* Skateboard Arena<br>*Balance:* Balance Bubble, Penguin Slide, Ski Slalom, Soccer Heading, Snowboard Slalom, Table Tilt, Tightrope Walk; *Training plus:* Balance Bubble plus, Perfect 10, Table Tilt Plus | *Primary:* balance (TUG)<br>*Secondary:* other functional tests ($TUG_{cognitive}$, four square step test, 25-foot walk test, DGI, MSWS-12, ABC, STST) | Improvement in several balance-related outcomes for the *Wii Fit* group. However, same improvements have been observed in the controls (because of spontaneous exercise). *Wii Fit* can be recommended in adults with multiple sclerosis<br>*Adverse events:* No<br><br>**ABC (no unit):**<br>***Wii Fit group***<br>**Pre-/post- intervention delta: 5.0 ±14.4**<br>**TUG (sec):**<br>***Wii Fit group***<br>**Pre-/post- intervention delta: -0.8 ±2.4** |
| Prosperini et al.<br>2013<br>Italy<br>[84] | Patients with multiple sclerosis (*F/M, N*=25/11)<br>*Mean age:* 36 ±9 yrs | Intervention (cross-over RCT)<br>*2 groups: Wii Fit vs.* passive control<br>*Duration*: 12 wks (30 min, 5 sessions/wk)<br>*Location:* Home | Supposedly all balance activities included in *Wii Fit Plus* (for the 4 first weeks, patients were allowed to play Zazen, Table Tilt and Ski Slalom only) | Balance (COP excursion, 4-step square test), mobility (25-foot walk test), self-perceived disability (MSIS-29) | *Wii Fit* was effective to improve balance, mobility and self-perceived health status/quality of life.<br>*Adverse events:* knee pain (N=2), lower back pain (N=3) |
| Robinson et al.<br>2015<br>UK<br>[86] | Patients with multiple sclerosis (*F/M, N*=38/18)<br>*Mean age:* 52 ±6 yrs | Intervention (RCT)<br>*3 groups: Wii Fit vs.* traditional therapy *vs.* passive control<br>*Duration*: 4 wks (40- | *Balance:* Heading Soccer, Ski Slalom, Table Tilt, Tightrope Walk; *Strength:* Rowing Squats, Torso | *Primary:* balance (postural sway), gait (gait speed), acceptability (UTAUT), FSS) | Balance but not gait was improved by both the *Wii Fit* and traditional therapy interventions. *Wii Fit* was acceptable and induced positive changes in self-perceived disability. |

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| | | 60 min, 2 sessions/wk)<br>*Location:* Rehabilitation center | Twist; *aerobics*: Boxing, Hula Hoop, Advanced Steps (supposedly) | *Secondary:* self-perceived disability (MSWS-12, WHODAS) | *Adverse events:* No |
| ***Spinal cord injury patients*** | | | | | |
| Wall et al.<br>2015<br>USA<br>[6] | Individuals with incomplete spinal cord injury (> 1-yr post-injury, *M, N=5*)<br>*Age range*: 50-64 yrs<br>*Mean age:* 59 ±5 yrs | Intervention<br>*1 group*<br>*Duration:* 7 wk (60 min, 2 sessions/wk) + follow up after 4 wks<br>*Location:* Home or University (and "supervised") | *Balance:* Balance Bubble, Basic Run (or another running activity), Penguin Slide, Ski Slalom, Ski Jump, Tightrope Walk, Table Tilt; *training plus*: Island Bike, Obstacle Course, Segway Circuit, | Walking ability (gait speed), balance (TUG, functional reach), well-being (SF-36) | Gait speed and functional reach tests score both significantly increased after the *Wii Fit* intervention and the effect were maintained at 4-week follow-up. However, the program failed to induce statistical improvements in wellness (SF-36) and TUG.<br>*Adverse events:* No |
| ***Children with developmental delay*** | | | | | |
| Salem et al.<br>2012<br>USA<br>[12] | Children with developmental delay (*F/M*, *N=18/22*)<br>*Age range:* 39 to 58 mths<br>*Mean age:* 49 ±6 mths | Intervention (RCT)<br>*2 groups: Wii vs.* passive control<br>*Duration:* 10 wks (30min, 2 sessions/wk)<br>*Location:* Rehabilitation center | *Strength:* Lunges, Single Leg Stance; *aerobics:* Basic Run, Basic Step, Hula Hoop; *balance*: Penguin Slide, Soccer Heading, Tightrope Walk; *Wii Sports'* Baseball, Bowling and Boxing games were also used | *Primary:* balance and gait (gait speed, TUG, single leg stance test[a], STST, TUDS, 2-min walk test)<br>*Secondary:* grip strength (dynamometer) | *Wii Fit* induced a significant improvement for the single leg stance test and grip strength only<br>*Adverse events:* No |
| Esposito et al.<br>2013<br>Italia<br>[31] | Children with migraine without aura (*F/M, N*=32/39)<br>*Mean age:* 9 ±2 yrs | Intervention<br>2 groups: patients *vs.* healthy controls, *F/M, N*=44/49)<br>Duration: 12 wks (30 min, 3 sessions/wk)<br>*Location:* Home | A choice of 18 *balance* oriented *Wii Fit Plus* activities (e.g. Balance Bubble, Hula Hoop, Obstacle Course, Penguin Slide, Rhythm Activities, Segway Circuit, Snowboard Slalom, Skateboard Arena, Ski Jump, Ski Slalom, Soccer | Motor coordination (MABC), fine visuomotricity (Berry-VMI) | A 3-month *Wii Fit* training in children with migraine without aura improved all parameters: motor coordination (including balance skills), and fine visuomotricity. *Wii Fit* might be used in this population to counterbalance associated developmental delays or other deleterious effects.<br>*Adverse events:* No |

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| | | | Heading, Table Tilt, Tilt City…) | | |
| Ferguson et al.<br>2013<br>South Africa<br>[27] | Children with developmental coordination disorders (*F/M, N*=22/24)<br>*Age range:* 6-10 yrs<br>Mean age: 8 ±1 yrs | Intervention<br>*2 groups: Wii Fit vs.* established neuromotor task training<br>*Duration:* 6 wks (30 min, 3 sessions/wk)<br>*Location:* School | 18 of the *Wii Fit* games mimicking the act of cycling, soccer, skateboarding and skiing or played with the hand controller | Motor coordination (MABC), physical fitness (functional strength, strength measured with dynamometer, muscle power sprint test, 20-m shuttle run test, adherence | Motor performance improved in the two groups, but more important changes were noted in the traditional training group. The latter was also true for functional strength and cardiorespiratory fitness measurements. Adherence was near 100% in both groups. The choice of one or the other intervention may depend on resources and time constraints.<br>*Adverse events:* No |
| Hammond et al.<br>2013<br>UK<br>[28] | Children with developmental coordination disorders (*F/M, N=4/14*)<br>*Age range:* 7-10 yrs<br>*Mean age:* 8 ±1 yrs | Intervention (cross-over RCT)<br>2 groups: *Wii Fit*-regular motor training *vs.* regular motor training-*Wii Fit*<br>*Duration:* 4 wks (3 sessions/wk)<br>*Location:* School | A selection of 9 *Wii Fit* games focusing on coordination and balance | *Childs:* motor proficiency (BOT), self-perceived ability and satisfaction with motor task (coordination skills questionnaire)<br>*Parents:* emotional and behavioral development (strengths and difficulties questionnaire) | *Wii Fit* induced significant gains in motor proficiency and other outcomes for many, but not all the children. Including *Wii Fit* in children with developmental disorders therapy have to be considered.<br>*Adverse events:* No |
| Mombarg et al.<br>2013<br>The Netherland<br>[29] | Children with balance alterations (*F/M, N*=6/23)<br>*Age range:* 7-12 yrs<br>*Mean age:* 10 ±1 yrs | Intervention (RCT)<br>*2 groups: Wii Fit vs.* passive control<br>*Duration:* 6 wks (30 min, 3 sessions/wk)<br>*Location:* School | 18 activities identified as balance games (mainly from the *balance* and *training plus* categories: Ski Jump, Ski Slalom, Snowboard Slalom, Table Tilt, Obstacle Course, Segway Circuit, Skateboard Arena, Tilt City, Rhythm activities…) | Balance (MABC & BOT) | Significant improvement in the *Wii Fit* group. Effective intervention for children with poor motor development.<br>*Adverse events:* No |
| Jelsma et al. | Children with | Intervention | 18 “balancing | Motor coordination | A *Wii Fit* intervention significantly |

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| 2014<br>The Netherlands<br>[30] | probable developmental coordination disorders and balance problems (*F/M=10/18*)<br>*Age range:* 71-136 mths<br>*Mean age:* 100 ±15 mths | *2 groups*: *Wii Fit vs.* waiting period-*Wii Fit*<br>*Duration:* 6 weeks (30 min, 3 sessions/wk)<br>*Location:* Laboratory (supposedly) | activities" from the *Wii Fit Plus* software (not including Ski Slalom, which was used for test) | (MABC), balance (BOT, Ski Slalom), enjoyment (home-made scale) | increased motor and balance skills in children with coordination disorders and balance problems. After 6 weeks of intervention, 20 children (out of 28) still rated Wii Fit as "super fun" and 4 as "fun".<br>*Adverse events:* No |
| ***Children with cerebral palsy*** | | | | | |
| Ramstrand & Lygnegard<br>2012<br>Sweden<br>[35] | Children with hemiplegic or diplegic cerebral palsy (*F/M*, *N*=10/8)<br>*Age range:* 8-17 yrs<br>*Mean age:* 13 ±3 yrs | Intervention (cross-over RCT)<br>*2 groups*: *Wii Fit*-no intervention *vs.* no intervention-*Wii Fit*<br>*Duration:* 5 wks (>30min, 5 sessions/wk)<br>*Location:* Home | *Balance*: Balance Bubble, Ski Jump, Ski Slalom, Soccer Heading, Table Tilt, Tightrope Walk, | *Primary:* balance (modified SOT, reactive balance test, weight shift test)<br>*Secondary:* adherence (playing time) | No improvement after the *Wii Fit* intervention period. A 30-min home-based *Wii Fit* intervention is not effective to improve balance in children with cerebral palsy. 4 children did not complete the required 30 min/day sessions.<br>*Adverse events:* No |
| Jelsma et al.<br>2013<br>South Africa<br>[36] | Children with spastic hemiplegic cerebral palsy (*F/M, N*=6/8)<br>*Age range:* 7-14 yrs<br>*Mean age:* 11 ±2 yrs | Intervention (A-B)<br>*1 group* (*cf.* details in the paper)<br>Duration: 3 wks (25min, 4 sessions/wk) + follow-up after 2 months<br>*Location:* Rehabilitation center | *Aerobics*: Hula Hoop*; balance:* Balance Bubble, Penguin Slide, Snowboard Slalom, Slalom Ski, Soccer Heading | Balance (BOT), functional mobility (BOT and TUDS) | Balance score improved significantly (sustained at 2 months follow-up), but not the functional scores (BOT and TUDS). 10 children only preferred to play *Wii Fit* instead of conventional physiotherapy. *Wii Fit* may not be used in place of conventional therapy.<br>*Adverse events:* No |
| Tarakci et al.<br>2013<br>Turkey<br>[37] | Children with ambulatory cerebral palsy (*F/M*, *N*=3/11)<br>*Mean age:* 12 ±3 yrs | Intervention<br>*1 group*<br>*Duration:* 12 wks (40min, 2 sessions/wk)<br>*Location:* Rehabilitation center | *Balance:* Ski Slalom, Soccer Heading, Table Tilt, Tightrope Walk | Balance (single leg stance test[a], functional reach test, TUG, 6-min walk test) | Balance improved significantly (all outcomes)<br>*Adverse events:* No<br><br>**<u>TUG (sec):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 18.26 ±8.95**<br>**Post-intervention: 14,57 ±5.39** |
| ***Other populations with balance impairments*** | | | | | |
| Meldrum et al.<br>2015 | Patients with unilateral peripheral | Intervention (RCT)<br>*2 groups: Wii Fit vs.* | *Yoga:* Deep Breathing, Palm Tree, | *Primary:* Gait (self-preferred gait speed) | Both the *Wii Fit* and traditional balance trainings induced improvement in gait |

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|---|---|---|---|---|---|
| Ireland [21] | vestibular loss (*F/M, N=27/44*) *Mean age:* 54 ±15 yrs | traditional balance rehabilitation *Duration*: 6 wks (15 min, 5 sessions/wk) + follow-up after 6 months *Location:* Home | Standing Knee, Tree Pose; *strength*: Sideways Leg Lift, Single Leg Extension; *balance*: Balance Bubble, Ski Slalom, Heading Soccer, Penguin Slide, Table Tilt; *aerobics*: Advanced Step, Basic Step, Free Step; *training plus*: Skateboard, Snowball Fight, Table Tilt Plus | *Secondary*: gait parameters (various tests performed eyes open or close, including DGI), balance (ABC, SOT), dynamic visual acuity (computerized dynamic visual acuity system), self-perceived benefit (vestibular rehabilitation benefit questionnaire), mental health (Hospital Anxiety and depression Scale), adherence (diary) | speed. No difference was noted between the two groups for gait parameters and other outcomes at the end of the intervention. Adherence was high for the two interventions but *Wii Fit* was described as more enjoyable. *Adverse events*: low back pain (N=1)<br><br>**<u>ABC (no unit):</u>**<br>***Wii Fit group***<br>**Pre-intervention: 64.82 ±18.74**<br>**Post-intervention: 74.36 ±21.25** |

[a] Many different single leg stance tests have been used in the *Wii Fit* literature for balance assessment purposes. In this table "single leg stance test" describe any test requiring subjects to stand on one leg. [b] Many different sit-to-stand tests (STST) have been used in the *Wii Fit* literature for balance, strength or functional assessment purpose. In this table "STST" describe any test that requires the subject to sit and stand repeatedly. [c] Esculier et al. (2012 & 2014) report results obtained with the same group of subjects during the same trial [113, 118].

ABC: activities-specific balance confidence scale; BBS: Berg balance scale; BMI: body mass index; BOT: Bruininks-Oseretsky test; ADL: activities of daily living scale; CHAMPS: community healthy activities model program for seniors; CBM: community balance and mobility scale; COPD: chronic obstructive pulmonary disease; Beery-VMI: Beery visual-motor integration test; CRQ-SR: chronic respiratory questionnaire; CTSIB: clinical test of sensory interaction and balance; DGI: dynamic gait index; EE: energy expenditure; ESWT: endurance shuttle walk test; FAAB: foot and ankle ability measure; FAB: Fullerton advanced balance scale; FES: Falls Efficacy Scale; FIM: functional independence measure; FSS: flow state scale; GDS: geriatric depression scale; HR: hear rate (beats/min); IMI: Intrinsic Motivation Inventory; LASAPAQ: LASA Physical Activity Questionnaire; LEFS: lower extremity functional scale; LLFDI: late life function and disability index; LOS: limits of stability; MABC: movement assessment battery for children; MCTSIB: modified clinical test for sensory interaction in balance; MDRT: multidirectional reach test; METs: metabolic equivalent; MFIS: modified fatigue impact scale; MSIS-29: 29-item multiple sclerosis impact scale; MSWS-12: 12-items multiple sclerosis walking scale; MVC: maximal voluntary contraction of leg extensors; MVPA: moderate-to-vigorous physical activity;

NPRS: numeric pain rating scale; OEE: Outcome expectations for exercise scale; PA: physical activity; PACES: physical activity and exercise questionnaire; PAID: problem areas in diabetes scale; PDQ-39: 39-question Parkinson's disease questionnaire; RFD: rate of force development; RPP: rate pressure product; SE: Schwab & England daily living activities scales; SEE: self-efficacy exercise scale; SEES: subjective exercise experience scale; SF-8: short form-8 health survey; SF-36: short form-36 health survey; SFT: senior fitness test; SOT: sensory organization test; STREAM: stroke rehabilitation assessment of movement; STST: sit-to-stand-test; TD2M: type 2 diabetes mellitus; TUDS: time up and down stairs; TUG: time up and go; UPDRS: unified rating scale for Parkinson's disease; UTAUT: unified theory of acceptance and use of technology questionnaire; VPA: vigorous physical activity; $VO_2$: oxygen consumption; $VO_2max$: maximal oxygen consumption; WHO-5: five-item WHO well-being index; WHODAS: world health organization disability assessment schedule

For the same test, unit may vary from one paper to another.

*Goal 3: Meta-analyses outcomes*

For the pre-/post-intervention meta-analyses, seven groups out of six studies were included for ABC, 13 groups out of 12 studies for BBS, and 12 groups out of 12 studies for TUG. For the *Wii Fit* vs. traditional therapy meta-analyses, 14 groups out of seven studies for BBS, and 12 groups out of six studies for TUG. Studies included in the different meta-analyses involved 595 participants from both sexes (females: 332, males: 242, not specified: 21), with a wide age range (12 ±3 – 86 ±5 years [37, 100]) and various medical conditions. While these papers all include a measure of ABC, BBS or TUG, the intervention content and duration vary from study to study. The assessment of individual studies revealed low risk of bias (Figure 2). Detailed results for BBS and TUG are presented in Figure 3 and 4 and data included in the meta-analyses appears in tables 3 and 4. *Wii Fit* interventions do not induce any change in ABC (2.02, 95% CI: -4.01 – 8.04). For BBS, significant improvements were noted in both healthy subjects and patients (2.00, 95% CI: 0.41 – 3.60 and 2.99, 95% CI: 0.08 – 5.90, respectively; 2.23, 95% CI: 0.84 – 3.63, overall). In addition, there was no significant difference in changes induced by traditional training and those induced by *Wii Fit,* suggesting that *Wii Fit* is as valid as traditional training. Regarding TUG, no significant reduction was noted after the *Wii Fit* intervention in both healthy subjects and patients (-0.34 sec, 95% CI: -1.38 – 0.70 and -2.24 sec, 95% CI: -5.17 – 0.69, respectively; -0.55 sec, 95% CI: -1.53 – 0.43, overall). However, compared to traditional training programs, the *Wii Fit* induced a more significant reduction in TUG, especially in patients (-1.76, 95% CI: -2.13 – -1.39, in patients; -1.31, 95% CI:-1.62 – -1.01, overall). The sets of studies included in both BBS and TUG pre-/post-intervention meta-analyses were statistically homogenous ($I^2$ = 0.0%, p=0.961 and $I^2$ = 0.0%, p=0.969, respectively for the overall analyses). Various levels of heterogeneity were observed in the *Wii Fit* vs. traditional therapy meta-analyses ($I^2$ = 60.0%, p = 0.040 for BBS in patients and $I^2$ = 74.3%, p = 0.002 for TUG overall, see Fig 3 and 4 for more detailed results), indicating some inconsistencies in the literature. This was expected, however, since different populations were included in the analyses.

Meta-regression revealed no significant results (data not shown), suggesting no relationships between improvements in balance outcomes and intervention duration and/or volume.

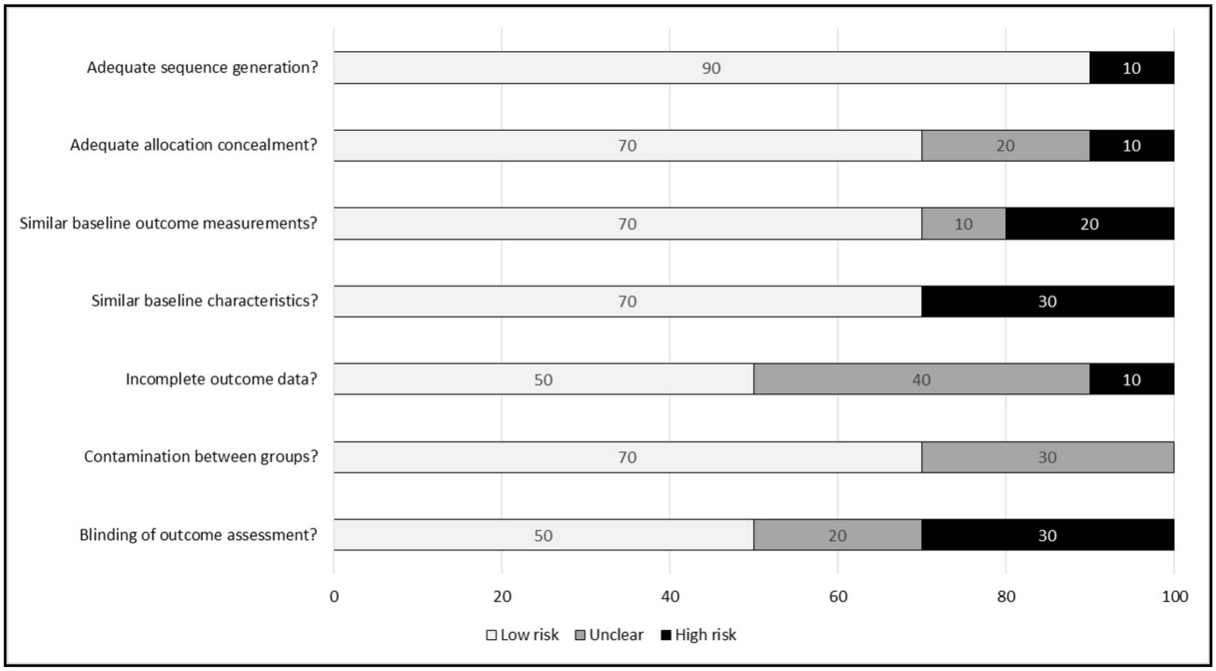
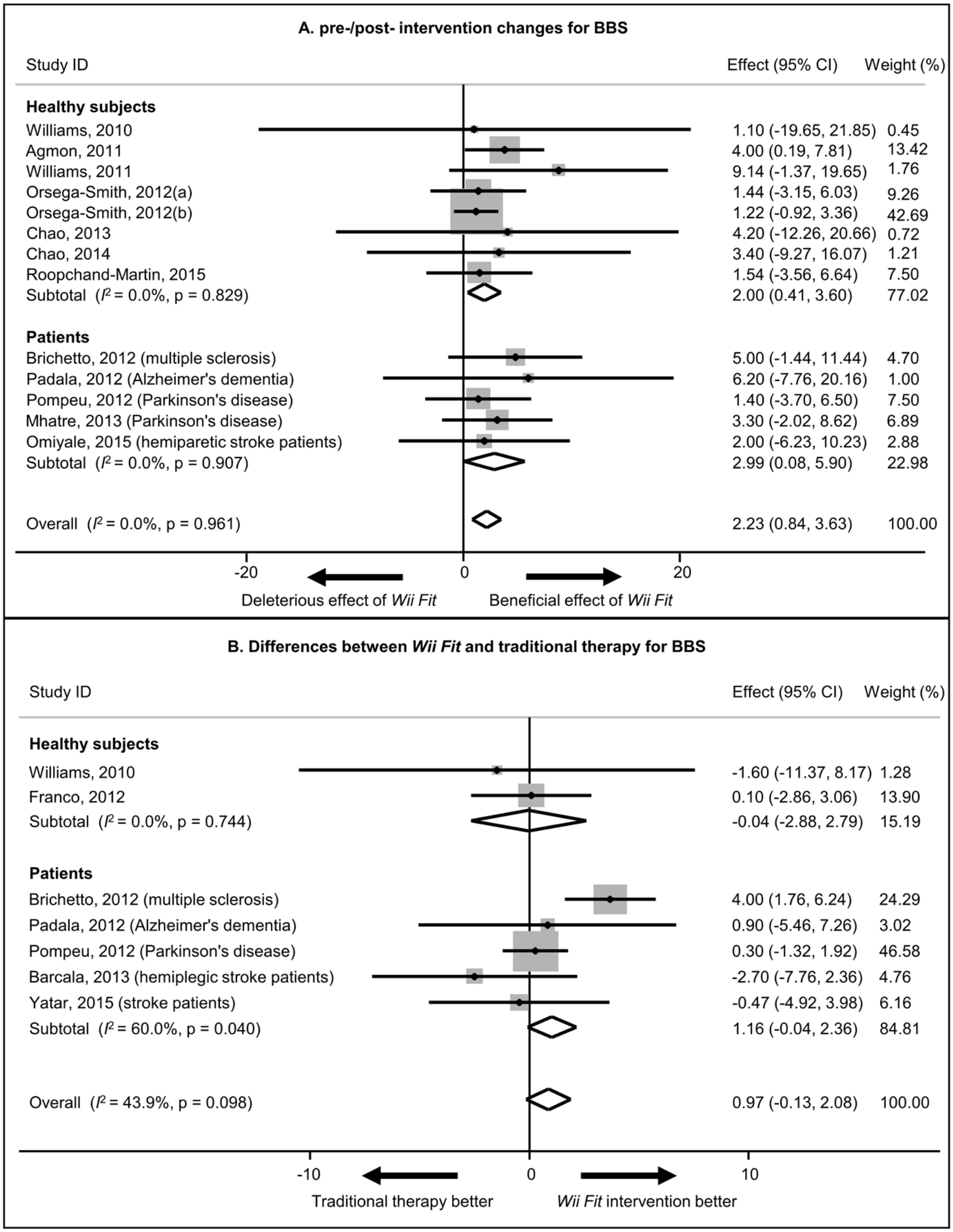



**Figure 2. Assessment of risk of bias in individual studies included in the *Wii Fit* vs. traditional therapy meta-analyses.** The absence of ABC, BBS or TUG excluded *de facto* the studies from the meta-analyses. Therefore, the usually reported "reporting bias" is not included in the present assessment. No "other bias" was identified.

262 


263 **Figure 3. Pre-/post- intervention meta-analytic effect (A) and *Wii-Fit* vs. traditional therapy**
264 **meta-analytic effect (B) for the Berg balance score (BBS).** A. The black point shows the

average change for each study, the diamonds describes the pooled values respectively for the changes in healthy subjects, patients and the overall population (from the top to the bottom of the figure), the vertical black line refers to no change. For each analysis (overall population) or sub-analysis (healthy subjects or patients), a significant effect is observed if the diamond does not touch the black line. B. The black point shows the difference of effect between *Wii Fit* and traditional therapy for each study, the diamonds describes the pooled values respectively for the difference of effect in healthy subjects, patients and the overall population (from the top to the bottom of the figure), the vertical black line refers to no difference between *Wii Fit*-induced change and traditional therapy-induced change. For each analysis (overall population) or sub-analysis (healthy subjects or patients), a significant difference is observed if the diamond does not touch the black line. A and B. The horizontal black line shows the 95% confidence interval and the grey square shows the study weight in percentage. Orsega et al. 2012(a): 4-week *Wii Fit* intervention group; Orsega et al. 2012(b): 8-week *Wii Fit* intervention group [98]. $I^2$: index of heterogeneity.

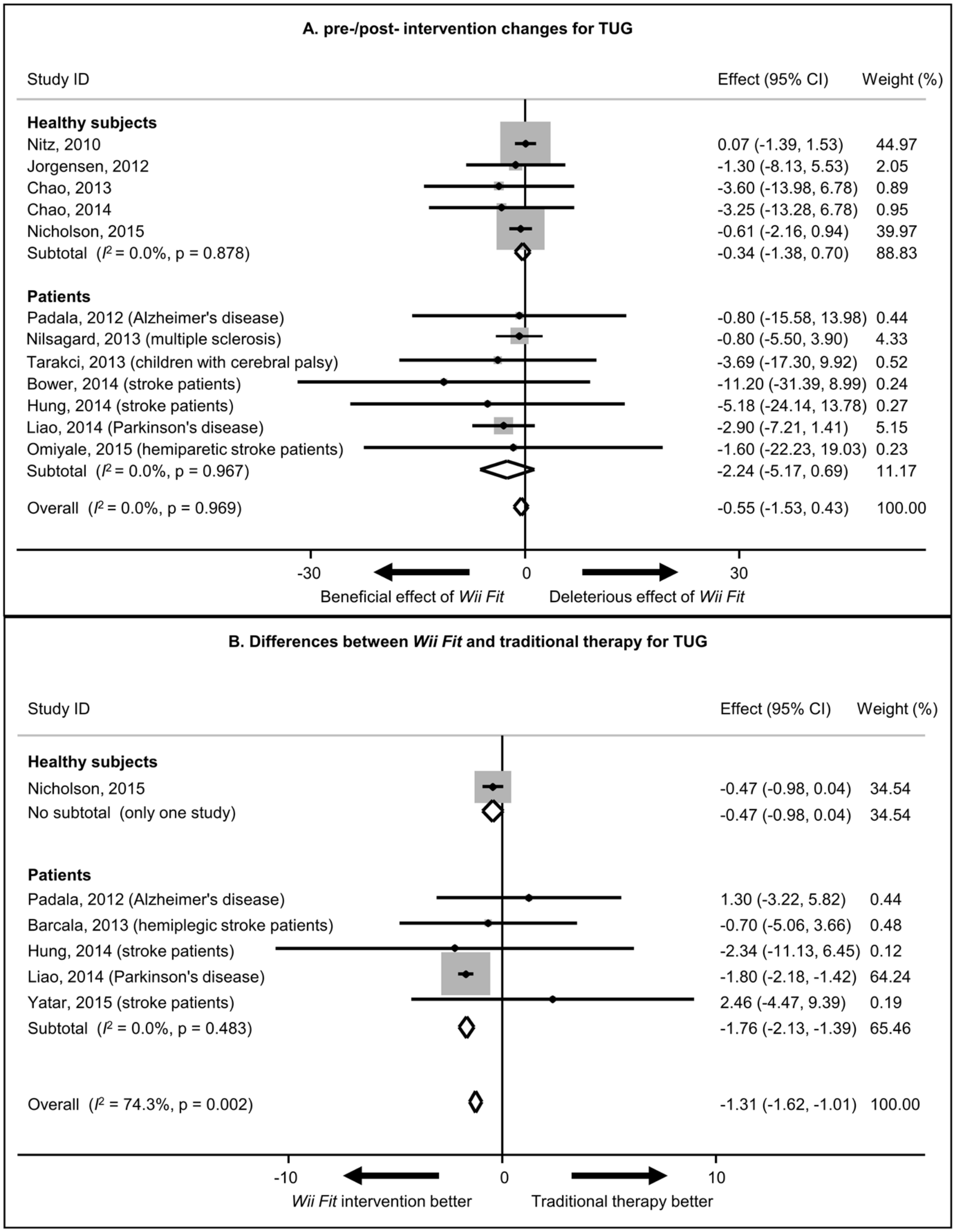



**Figure 4. Pre-/post- intervention meta-analytic effect (A) and *Wii-Fit* vs. traditional therapy meta-analytic effect (B) for the time-up-and-go test (TUG).** A. The black point shows the

average change for each study, the diamonds describes the pooled values respectively for the changes in healthy subjects, patients and the overall population (from the top to the bottom of the figure), the vertical black line refers to no change. For each analysis (overall population) or sub-analysis (healthy subjects or patients), a significant effect is observed if the diamond does not touch the black line. B. The black point shows the difference of effect between *Wii Fit* and traditional therapy for each study, the diamonds describes the pooled values respectively for the difference of effect in healthy subjects, patients and the overall population (from the top to the bottom of the figure), the vertical black line refers to no difference between *Wii Fit*-induced change and traditional therapy-induced change. For each analysis (overall population) or sub-analysis (healthy subjects or patients), a significant difference is observed if the diamond does not touch the black line. A and B. The horizontal black line shows the 95% confidence interval and the grey square shows the study weight in percentage. $I^2$: index of heterogeneity.

## Discussion

*Wii Fit* has been used for numerous health purposes and in various populations (Table 2). Balance training has been identified as the most recurrent topic in the literature. The software is employed to prevent falls, to induce functional improvements in seniors or in subjects presenting neurodegenerative diseases, to treat orthopedic populations, *etc.* (Table 4). Another notable focus is the prevention of metabolic disorders as well as the improvement of health status in people with chronic disease (Table 3). Overall, observations on the effect of *Wii Fit* were mainly positive, with the software being recurrently described as being able to induce similar benefits to traditional therapies. Regarding balance training, the results of meta-analyses revealed that *Wii Fit* interventions had a positive impact on BBS and TUG. Interestingly, *Wii Fit* interventions also appear very safe, with very low levels of injuries being reported.

### *Wii Fit for the prevention of metabolic disorders and health status improvement in patients*

From light physical activity to moderate-to-vigorous physical activity, AVG elicit a wide range of intensities [23, 26, 41, 44, 45, 46, 48, 55, 56, 62, 64-66, 123]. However, it is difficult to state whether playing *Wii Fit* on a regular basis would allow one to meet the *American College of Sports Medicine's* recommendations for physical activity or could induce beneficial effects on health. Intervention studies reviewed in the present article indicate that playing *Wii Fit* is not a strategy to consider in young adults (and children) to prevent cardio-metabolic disease, because it does not induce any significant increase in physical activity or any improvement in physical fitness [24, 60]. One study showed a significant and rapid weight loss during a *Wii Fit* intervention in postpartum women [64]. *Wii Fit* may, however, be a promising tool to aid seniors in maintaining a healthy lifestyle. Intervention studies have reported an increase in physical activity [8], physical fitness [18], and functional skills [110]. Playing *Wii Fit* also clearly appears to be beneficial for various types of patients: Some studies have reported improvements to health status in chronic obstructive pulmonary disease, hemodialysis patients, diabetic subjects, and cancer patients [77-79, 87, 88]. While the preventive effects of *Wii Fit* remain to be demonstrated, the software may be of value in other clinical settings.

*Wii Fit for balance training*

Many of the intervention studies (55/68) are related to balance training or to the improvement of related functions, with a large majority of them (50/55, see result section and Table 4) describing a beneficial effect. The meta-analytic results support these promising observations. Significant improvements were observed for BBS in both healthy subjects and patients, while a trend was noted for TUG improvements in patients. Interestingly, the meta-analyses also revealed no difference in improvements induced by traditional therapies and *Wii Fit* interventions for BBS, while TUG showed greater improvements following the *Wii Fit* intervention compared to after traditional therapy. Taken together, these outcomes suggest a possible therapeutic application of the software, with *Wii Fit* potentially being as valid as traditional training in some situations. However, a careful look at the qualitative analysis outcome (Table 4) mitigates the overall positive impression for some populations. For instance, *Wii Fit* intervention outcomes in children with cerebral palsy can appear somewhat contrasted, sometimes being successful [37], sometimes unsuccessful [35], or sometimes inducing improvement in some but not all of the parameters [36].

In addition, BBS evaluates balance in isolated balance-related tasks, and TUG combines a limited set of very simple actions (standing-up, walking and sitting-down). With *Wii Fit*-induced improvements only being observed in BBS score and TUG, in a clinical setting, and not being associated with improvements in self-confidence in balance abilities (no changes in ABC), it is unclear whether these improvements can be transferred to activities that occur during daily-life and positively impact the quality of life. The general impressions about *Wii Fit* interventions are, however, currently positive. This should encourage further research in order to help physiotherapists and health professionals in their decision to incorporate the use of *Wii Fit* into their treatment regimes. Considering that some contrasted observations do exist, *Wii Fit* prescription should still be considered with caution.

*The Wii Fit therapeutic content and Wii balance Board*

It is not surprising that *Wii Fit* has been the object of much attention among physical therapists. The specificities of the *Wii Fit* games taken together with the technical features of the *Wii Balance Board* tend to promote medial-lateral and anterior-posterior movements, mimicking exercises that are commonly used in physical rehabilitation programs [2, 47, 96]. The board is composed of multiple pressure sensors able to work together to follow the displacement of the vertical projection of the center of gravity on the floor. Moreover, the device has been validated against the "gold standard" laboratory-grade force platform for assessing standing balance [1]. In addition, high levels of adherence have frequently been reported in the reviewed studies (Table 3 & 4). One may therefore hypothesize that a key feature of the *Wii Fit* are the ludic elements that promote adherence in individuals who are not interested in traditional training programs. However, Deutsch et al. emphasizes one limitation of the *Wii Fit*, which favors the "knowledge of results" rather than the "knowledge of performance" model, i.e. subjects are focused on scores rather than on the quality of movements [41]. This is an important finding, since this would limit the relevance of using *Wii Fit* at home without the supervision of a therapist checking the quality of movement. One difference with the traditional proprioceptive rehabilitation material is that the *Wii Balance Board* is not able to tilt. Medial-lateral and anterior-posterior displacements are the result of exteroceptive adaptive mechanisms triggered by visual and auditory feedback/stimuli that depend on the game scenario.

### *Limitations*

The sub-analyses performed in patients included various pathologies. This was highlighted by the high level of heterogeneity between studies in the *Wii Fit vs*. traditional therapy meta-analyses (see $I^2$ in Fig 3B and 4B). While the overall meta-analyses observation described a positive effect, the results cannot be predictive of *Wii Fit* intervention-related changes in one specific population. This emphasizes the need for more research in order to determine the optimum usage of *Wii Fit* for each medical domain.

### *Conclusions*

Originally designed as a ludic health and fitness promotion software, the *Wii Fit* series grabbed the attention of physical therapists due to a panel of features favoring balance training. Initial promising observations encouraged physicians from various medical fields to test *Wii Fit* in various populations. The present review suggests promising applications of the *Wii Fit* in a wide range of medical fields. The unexpected entry of a video game in the health device market could create innovative healthcare strategies, however, more research is required to validate these claims.

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**S1 Checklist. PRISMA checklist.**

| Section/topic | # | Checklist item | Reported on page # |
|---|---|---|---|
| **TITLE** | | | |
| Title | 1 | Identify the report as a systematic review, meta-analysis, or both. | 1 |
| **ABSTRACT** | | | |
| Structured summary | 2 | Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number. | 2 |
| **INTRODUCTION** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of what is already known. | 4 |
| Objectives | 4 | Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS). | 5 |
| **METHODS** | | | |
| Protocol and registration | 5 | Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number. | N/A |
| Eligibility criteria | 6 | Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale. | 5-10 |
| Information sources | 7 | Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched. | 5-8 |
| Search | 8 | Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. | 5-8 |
| Study selection | 9 | State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis). | 5-10 |
| Data collection process | 10 | Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators. | 9-10 |
| Data items | 11 | List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made. | 9-10 |
| Risk of bias in individual studies | 12 | Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis. | 10, 42 |
| Summary measures | 13 | State the principal summary measures (e.g., risk ratio, difference in means). | 9-10 |
| Synthesis of results | 14 | Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., $I^2$) for each meta-analysis. | 10 |

| Section/topic | # | Checklist item | Reported on page # |
|---|---|---|---|
| Risk of bias across studies | 15 | Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies). | 10 |
| Additional analyses | 16 | Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified. | 9-10 |
| **RESULTS** | | | |
| Study selection | 17 | Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram. | 5-7, 11 |
| Study characteristics | 18 | For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations. | 15-19, 21-39 |
| Risk of bias within studies | 19 | Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12). | 41, 42 |
| Results of individual studies | 20 | For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot. | 15-19, 21-39<br>42-45 |
| Synthesis of results | 21 | Present results of each meta-analysis done, including confidence intervals and measures of consistency. | 42-45 |
| Risk of bias across studies | 22 | Present results of any assessment of risk of bias across studies (see Item 15). | 40, 41 |
| Additional analysis | 23 | Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]). | 40, 41 |
| **DISCUSSION** | | | |
| Summary of evidence | 24 | Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers). | 46 |
| Limitations | 25 | Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias). | 49 |
| Conclusions | 26 | Provide a general interpretation of the results in the context of other evidence, and implications for future research. | 46-49 |
| **FUNDING** | | | |
| Funding | 27 | Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review. | N/A |