Article

Journal of Aging and Health
1–24

DOI: 10.1177/0898264314551171
jah.sagepub.com

Effects of Using Nintendo Wii™ Exergames in Older Adults: A Review of the Literature

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Abstract

Objective: The purpose of this review is to summarize and synthesize the impact of using the Nintendo Wii™ exergames in older adults. **Method:** A database search was conducted to identify relevant studies. The search was limited to empirical studies, with particular attention paid to the effects of Wii exergames intervention on cognition, physical function, and psychosocial outcomes in older adults. **Results:** A total of 22 empirical studies met inclusion criteria and were included in this review. Positive effects included improving physical function, decreasing depression, and increasing cognition and quality of life in older adults. Improved socialization and motivation to exercise were also reported. **Discussion:** Using Wii exergames does show promise as an intervention to improve physical function, cognition, and psychosocial outcomes in older adults. Evidence supports that Wii exergames is a safe and feasible tool to encourage older adults to engage in exercise.

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Keywords
Nintendo Wii™, exergames, physical activity, older adults

Introduction

In the United States, approximately 39.6 million people were above the age of 65 in 2009. In 2000, older adults accounted for about 12.4% of the population, and this number is expected to increase to 19% of the population by 2030 (U.S. Department of Health and Human Services, 2010). Aging has been associated with anatomical and physiological changes in muscle tissue, including a reduction in the number and size of muscle fibers, muscle mass, and number of motor neurons (Knight & Nigam, 2008). The progressive degeneration in muscle strength, endurance, and power can lead to motor impairment, disability, and falls (Cayley, 2008; Nikolic, Vranid, Arbanas, Cvijanovic, & Bajek, 2010). In addition, aging could result in hippocampus shrinkage, neurotransmitter imbalance, and loss of neural plasticity in the brain, which can cause cognitive deficits and increased risk for dementia (Erickson et al., 2011; Vance, McNees, & Meneses, 2009). Moreover, aging could increase the risk of dysregulation and imbalance of hormones, which may be implicated in depressed mood. Other factors for older adults that can lead to depression include being retired, economic hardship, and widowhood (Dang, 2010).

Evidence supports that regular exercise can increase leg strength, improve balance, reduce the risk of falling (Hatch & Lusardi, 2010; Sung, 2009), and lower the probability of cognitive decline in frail older adults (Lautenschlager et al., 2008; Nelson et al., 2007). Studies have shown an association of exercise intervention with improved psychological well-being, life satisfaction, self-efficacy, and quality of life, as well as decreased symptoms of anxiety and depression (Netz, Wu, Becker, & Tenenbaum, 2005). However, it is difficult for older adults to commit to exercise over time because the modes of exercise delivery are often perceived as boring and not motivating. In recent years, the exergames (entertaining video games that combine game play with exercise) have become popular in health care to encourage older adults to engage in physical activity (Lange, Requejo, et al., 2010).

Nintendo Wii™ Exergames

Nintendo Wii™ exergames, such as Wii Sports and Wii Fit, are becoming more popular in rehabilitation and long-term care settings. The Wii console has a wireless handheld pointing device with embedded sensors that detect

changes in direction, speed, and acceleration in three dimensions. The games offer immediate visual and audio performance feedback as well as progress information. The games also offer various types of motivational feedback such as encouraging commentaries, bonuses, and music to facilitate training and task improvement. These features allow the gaming activities to be interactive and fun. It also allows for different activity levels, and can be played while the user is standing or sitting (Agmon, Perry, Phelan, Demiris, & Nguyen, 2011; Saposnik et al., 2010). Moreover, the Wii devices are relatively inexpensive and portable. As a result, the Wii exergames are increasingly being used as an alternative to traditional rehabilitation-based exercises to improve daily activity levels and increase physical fitness in older adults (Gil-Gomez, Llorens, Alcaniz, & Colomer, 2011).

There have been an increased number of studies examining the use of Wii exergames in older adults; however, a synthesis of this literature is lacking. Hence, it is necessary to review the published literature on the use of the Wii exergames as an intervention for older adults, so that effective exercise programs can be developed to promote physical activity in this population.

Method

Search Strategy

The purpose of this review is to summarize and synthesize the impact of using the Wii™ exergames on physical function, cognition, and psychosocial effects in older adults. To identify potentially relevant studies that were published from 2006 (Nintendo Wii™ gaming system released commercially) to December 2013, we conducted a database search using MEDLINE, CINAHL, PubMed, PsycINFO, Web of Science, and Google Scholar. Combinations of keywords included *older adults, aging, older persons, elderly, virtual reality, video games, health games, interactive computer games, commercial off-the-shelf, exergames, game-based rehabilitation, Avatar, Nintendo Wii™*, *Wii Fit, Wii Sports*, and *Wii balance board*. Studies were selected if they met the following criteria: (a) the study was published in English, (b) participants' mean age was above 60 years, (c) the study focused on physical exercise using Wii exergames and clearly described the exercise program, (d) the aim of the study focused on improving cognition, physical function, or psychosocial benefits. Studies such as editorials, letters to the editor, case studies, conceptual papers, opinions, study protocols, doctoral dissertations, and unpublished full-text were excluded. In all, 67 citations were identified in the literature search initially, and 39 were eliminated by reviewing the abstract if they were not intervention studies. Twenty-nine potentially relevant full-text articles

were evaluated. A total of 22 studies met the inclusion criteria and were carefully reviewed. Pertinent characteristics of the exercise programs were extracted and summarized (Tables 1 and 2).

Results

Overview of Included Studies

This article provides a comprehensive review of current literature on study design, sample characteristics, intervention prescription, outcome measurements, and the effects of Wii exergames use in older adults. Studies with Wii exergames were found to have been conducted in different countries, including Australia, Canada, Denmark, France, Singapore, United Kingdom, and United States. The Wii exergames have been implemented in different settings, including hospitals, rehabilitation institutes, nursing homes, assisted living facilities, community care retirement facilities, and home. Randomized control trials were used in 10 of the studies. Inclusion criteria of subjects and outcome measurements varied depending on the study purpose and subjects' characteristics. Sample sizes ranged from 7 to 58, and the mean age of participants ranged from 61.3 to 86 years. The frequency of the exercise intervention ranged from two to five times a week, and lasted 10 to 60 min per session. Duration of exercise programs ranged from 2 to 20 weeks. Subject retention rate was 72% to 100%.

Physical Function

Upper extremity and hand function. Wii Sports have been used as an adjunct therapy to conventional physical therapy and standard exercise to improve upper extremity and hand function in stroke survivors (e.g., arm motor function, muscle power, and grip strength; Joo et al., 2010; Saposnik et al., 2010), and reduce stiffness or shoulder symptoms in long-term care residents with bothersome upper extremity dysfunctions (e.g., pain, weakness, and stiffness; Hsu et al., 2011). In addition to using Wii exergames as an adjunct therapy, the exergames was used independently to significantly improve functional ability and range-of-motion of upper extremities, and improve spasticity of upper limbs in stroke survivors (Mouawad, Doust, Max, & McNulty, 2011).

Mobility, balance, and falls. Older adults who fall or have developed a fear of falling may lead to activity restriction and avoidance (Delbaere, Crombez, Vanderstraeten, Willems, & Cambier, 2004). After Wii Fit training, older

Table 1. Characteristics of the Nintendo Wii™ Exergames Review: Single Group Design.

Study	Design/setting	Sample	Intervention	Outcome measures	Results
Agmon, Perry, Phelan, Demiris, and Nguyen (2011)	Pilot One group Pre–post test Four community care retirement facilities United States	Healthy older adults with impaired balance Age: 84 (78-92) Sample size (*N*): Baseline (7) → 3 months (7)	Intensity: 3 months; ≥3/week; ≥30 min/session Device: Wii Fit Games: Basic step, soccer heading, ski slalom, table tilt	BBS 4-m walk test Physical Activity Enjoyment Scale Semi-structure interview	High ratings of enjoyment Reported improvement in balance with daily activities BBS increased from 49 (2.1) to 53 (1.8) points (p = .017) Gait speed increased from 1.04 (0.2) to 1.33 (0.84) m/s (p = .018)
Albores, Marolda, Haggerty, Gerstenhaber, and ZuWallack (2013)	Pilot One group Four time tests Three hospital-based pulmonary rehabilitation centers United States	COPD with force expiratory volume in 1 s was 45 ± 16% Age: 68 ± 10 Sample size (*N*): Baseline (25) → 6 weeks of non-intervention (24) → 6 weeks of exercise training (20) → 12 weeks of exercise training (18)	Intensity: 12 weeks; 5.7 ± 10 days/week; 2.6-3.4 hr/week Device: Wii Fit Games: Basic run; bird's eye, bull's eye; free step; obstacle course	ESWT CPQ 5-point MRC dyspnea rating Number of sit-to-stand repetitions in 30 s Number of arm lift repetitions in 60 s	Significant improvements on ESWT time (ES = 0.56), arm lifts (0.6), sit-to-stand repetitions (0.72), CRQ emotion (0.451), and CRQ total score (ES = 0.54) from baseline to Week 12 test Men had significantly greater increases in the ESWTthan women (similar self-reported exercise durations)
Bainbridge, Bevans, Keeley, and Oriel (2011)	Pilot One group Pre–post test Community United States	Older adults with a perceived decline in balance Age: 75 ± 9.7 Sample size (*N*): Baseline (8) → 6 weeks (6)	Intensity: 6 weeks; 2 days/week; 30 min/session Device: Wii Fit Games: Half-moon, warrior, soccer heading, ski jump, ski slalom, table tilt, tightrope walk	ABC BBS Multi-directional reach test	Four of six subjects had clinically significant improvements on the BBS Three of six subjects improved in the ABC Three of six subjects improved in forward bending

(continued)

Table 1. (continued)

Study	Design/setting	Sample	Intervention	Outcome measures	Results
Chao, Scherer, Wu, Lucke, and Montgomery (2013)	Pilot One group Pre–post test Assisted living facility United States	Assisted living residents Age: 86 ± 5 (80-94) Sample size (*N*): Baseline (7) → 8 weeks (7)	Intensity: 8 weeks; 2 days/week; 60 min/session Device: Wii Fit Games: Jogging, lunge, penguin slide, table tilt, chair, deep breathing	BBS 6-min walk test TUG FES Self-efficacy for Exercise Scale Outcome expectations for Exercise Scale	Significant improvement in balance Large ES on mobility (ES = 0.5), walking endurance (ES = 0.5), and balance (ES = 0.64)
Joo et al. (2010)	Pilot Single group Pre–post test Rehabilitation Institute Singapore	Upper limb weakness (<3-month post stroke) Age: 64.5 Sample size (*N*): Baseline (20) → 2 weeks (16)	Intensity: 2 weeks; 3 days/week; 30 min/session Device: Wii sports Games: Baseball, bowling, boxing, golf, tennis Conventional therapy + Wii Sport	Fugl-Meyer Assessment Motricity Index Modified Ashworth Scale Visual Analogue Scale	Significant improvements in upper limb motor power and function Improvements in upper limb muscle tone Enjoyed gaming and would like to recommend to others
Rosenberg et al. (2010)	Pilot Single group Senior centers and retirement communities United States	Sub-syndromal depression Age: 78.7 (63-94) Sample size (*N*): Baseline (22) →12 weeks (19) → 20-24 weeks f/u (17)	Intensity: 12 weeks; 3 days/week; 35 min/session Device: Wii Sports Games: Baseball, bowling, Boxing, golf, tennis	Quick Inventory of Depression Symptoms Beck Anxiety Inventory SF-36 Repeatable battery for assessment of neurocognitive status	Significant improvements in depressive symptoms (ES = 0.802), mental health-related quality of life (ES = 0.335) and cognitive performance (ES = 0.263) Decreased anxiety level

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Table 1. (continued)

Study	Design/setting	Sample	Intervention	Outcome measures	Results
. Williams, Doherty, Bender, Mattox, and Tibbs (2011)	Pilot Single group Three facilities (independent retirement communities or skilled nursing facilities) United States	Healthy older adults Age: 83.86 (74-94) Sample size (*N*): Baseline (22) → 4 weeks (22)	Intensity: 4 weeks; 3 days/week; 20 min/session Device: Wii Fit Games: Subjects select their own games from balance and aerobic categories	BBS	Significant improvements in balance ($p < .01$; ES = 1.663) 98.11% attendance
Wollersheim et al. (2010)	Pilot Single group Pre–post test Community Australia	Female with a disability or who is socially isolated Age: 73.5 (56-84) Sample size (*N*): Baseline (15) → 6 weeks (11)	Intensity: 6 weeks; 2 days/week; 51 (9-130) min/session Device: Wii Sports + Wii Sports Resort Games: Archery, table tennis, bowling, boxing, cycling, frisbee, golf, sword fighting, tennis	Accelerometers Focus group: Social effects, physical effects, psychological effects, motivation for participation	Large positive changes in self-perception on psychological effects Game provided social connections within the group and family members Significant improvement in maximum energy expenditure ($p < .05$)

Note. BBS = Berg Balance Scale; COPD = chronic obstructive pulmonary disease; ESWT = Endurance Shuttle Walk Test; ES = effect size; CPQ = Chronic Respiratory Questionnaire, self-administered form; MRC = medical research council; ABC = Activities-Specific Balance Confidence Scale; TUG = time up and go; FES = Falls Efficacy Scale; SF-36 = 36-item short form health servey

Table 2. Characteristics of the Nintendo Wii™ Exergames Review: Comparison Groups (EG = Experimental Group; CG = Control Group).

Study	Design/setting	Sample	Intervention	Outcome measures	Results
Bieryla and Dold (2013)	Two groups Pre-test with 1-week, 1-month f/u after 3-week program Community United States	Age: 81.5 (70-92) Sample size (*N*): Baseline (EG = 6; CG = 6) → 1 week (EG = 5; CG = 5) → 1 month (EG = 5; CG =4)	Intensity: 3 weeks; 3 days/week; 30 min/session Device: Wii Fit Games: Half-moon, chair, warrior, torso twists, soccer heading, ski jump *Note* EG: Wii Fit CG: No intervention	BBS TUG Fullerton Advance Balance Functional Reach	EG: Significant increase in BBS from the pre-test to the 1-month f/u, but not the 1-week f/u No significant change for either group with TUG, Fullerton Advance Balance, and Functional Reach
Esculier, Vaudrin, Bériault, Gagnon, and Tremblay (2012)	Pilot Two groups Pre–post test with midterm test at Week 4 Community Canada	EG: Parkinson (age: 61.9) CG: Healthy subjects (age: 63.5) Sample size (*N*): Baseline (EG = 11; CG = 9) → 3 weeks (EG = 10; CG = 8) → 6 weeks (EG = 10; CG = 8)	Intensity: 6 weeks; 3 days/week; 40 min/session Device: Wii Sports + Wii Fit Games: Hula hoop, table tile, ski Slalom, ski jump, balance bubble, penguin slide, deep breathing, golf, bowling *Note* EG: Wii Sports + Wii Fit CG: Wii Sports + Wii Fit	Sit-to-stand test TUG POMA CBM ABC 10-m walk test Unipodal stance duration Force platform	EG: Significantly improved in 10-m walk test, POMA, and force platform Both groups had significantly improved in TUG, sit-to-stand test, unipodal stance, and CBM
Franco, Jacobs, Inzerillo, and Kluzik (2012)	RCT Three groups Pre–post test Community United States	Age: 78.3 (63-90) Sample size (*N*): Baseline (EG1 =14; EG2 = 13; CG = 9) → 3 weeks (EG1= 11; EG2 = 11; CG =10)	Intensity: 3 weeks; 2 days/week; 10-15 min/session Device: Wii Fit Games: Soccer heading, table tile, ski slalom, ski jump, tightrope, balance bubble *Note* EG1: Wii Fit + supplemental home exercises EG2: Matter of Balance program CG: No intervention	BBS Tinetti Gait and Balance Assessment SF-36 Wii Fit Enjoyment Questionnaire	EGs: Significantly improved more in BBS than CG No significant differences of all outcomes among three groups EG1: 81% reported high levels of enjoyment of playing Wii games

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Table 2. (continued)

Study	Design/setting	Sample	Intervention	Outcome measures	Results
Fung, Ho, Shaffer, Chung, and Gomez (2012)	Pilot RCT Two groups Measured on admission and every 2 weeks Outpatient Canada	Outpatients following total knee replacement Age: 68 ± 11 (EG = 67.9; CG = 68.2) Sample size (*N*): EG = 27; CG = 23	Intensity: Until discharge; 2 days/week; 15 min/session Device: Wii Fit Games: Penguin slide, table tile, ski slalom, tightrope, balance bubble, hula hoop, deep breathing, half-moon, torso twist *Note* EG: 1-hr PT + 15-min Wii Fit CG: 1-hr PT + 15-min lower extremity exercise	Length of outpatient rehab 2-min walk test Knee ROM Timed standing ABC Lower Extremity Functional Scale Numeric Pain Rating Scale	No significant differences of all outcomes between two groups EG: Less pain, better balance confidence, and more improvements in lower extremity function (ES = 0.5) than CG
Hsu et al. (2011)	Pilot RCT Two groups with crossover at Week 4 Two long-term care centers Canada	Upper extremity dysfunction Age: 80 (52-97) Sample size (*N*): Baseline (EG = 19; CG = 15) → 4 weeks (EG = 19; CG =15) → crossover (EG =15; CG = 19)	Intensity: 4 weeks; 2 days/week; 20 min/session Device: Wii Sports Games: Bowling *Note* EG: Standard exercise + Wii bowling CG: Standard exercise	Nursing home physical performance test Modified Physical Activity Enjoyment Scale Numeric Pain Rating Scale Standard goniometer	All had improvements in functional ability (ES = 1.77) and active ROM Less stiffness/shoulder symptoms, but more hand symptoms Significant difference in enjoyment (ES = 1.38) of physical activity between groups

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Table 2. (continued)

Study	Design/setting	Sample	Intervention	Outcome measures	Results
Jorgensen, Laessoe, Hendriksen, Nielsen, and Aagaard (2013)	RCT Two groups Pre–post test Community Denmark	Older adults with self-report poor to average balance Age: 75 ± 6 Sample size (*N*): Baseline (EG = 28; CG = 30) → 10 weeks (EG = 27; CG =30)	Intensity: 10 weeks; 2 days/week; 35 ± 5 min/session Device: Wii Fit Games: table tilt, slalom ski, perfect 10, tight rope tension, penguin slide *Note* EG: Wii Fit + standing rowing squat CG: Daily use of ethylene vinyl acetate copolymer shoe insoles	Maximal isometric contraction strength Postural balance capacity TUG FES-international 30-s repeated Chair Stand Test	EG: Significant improvements in maximal leg muscle strength, TUG (p = .01), FES-I (p = .03), and 30-s chair stand test (p = .01) EG: No changes in static bilateral postural balance EG had higher maximal voluntary contraction strength (18%) than CG
Kahlbaugh, Sperandio, Carlson, and Hauselt (2011)	RCT Two groups Pre–post test Independent living apartment United States	Age: 82 ± 9.8 Sample size (*N*): Baseline (EG = 14; CG = 14) → 10 weeks (EG = 14; CG = 13)	Intensity: 10 weeks; 1 hr/week Device: Wii Sports Games: Bowling *Note* EG: Wii Sports CG: Watching TV	Weekly Physical Activity Scale UCLA Loneliness Scale PANAS SF-36	EG: Lower loneliness and a pattern of greater positive mood than CG Loneliness predicted positive mood Positive mood predicted physical activity
Laver et al. (2012)	Pilot RCT Two groups Pre–post test Geriatric rehabilitation unit in an acute hospital United Kingdom	Age: 85 Sample size (*N*): Baseline (EG = 22; CG = 22) → post-test (EG = 22; CG = 22)	Intensity: Duration varied based on subject's unit stay; 5 days/week; 25 min/session Device: Wii Fit Games: Based on subject's abilities and treatment needs *Note* EG: Wii Fit CG: CT	TUG SPPB Modified BBS Timed instrumental ADL FIM ABC Quality of life (EQ-5D)	EG: Significant improvement on average 1.26 s/session on the TUG (p = .048), and better performance per session on the Modified BBS (p = .042) compared with CG TUG (ES = 0.087), Modified BBS (ES = 0.232), and ABC (ES = 0.05) between groups at post-test

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Table 2. (continued)

Study	Design/setting	Sample	Intervention	Outcome measures	Results
Mouawad, Doust, Max, and McNulty (2011)	Pilot Two groups Pre–post test Two hospitals Australia	Age: 65.3 EG: 15.3-month post stroke (age: 42-83) CG: Healthy (age: 41-71) Sample size (*N*): Pre-test (EG = 7; CG = 5) → 2 weeks (EG = 7; CG = 5)	Intensity: 2 weeks; 10 weekdays; 60 min/session Device: Wii Sports Games: Baseball, bowling, boxing, golf, tennis *Note* EG: Wii training + home practice CG: Wii training	WMFT FMA Box and Block Test Passive and active ROM Modified Ashworth Scale BBS Quality of Movement Scale Wii Age	EG: Significantly decreased time from 3.2 s to 2.8 s on WMFT, and increased scores from 42.3 to 47.3 on FMA EG: Increased by 20.1° for passive ROM and 14.33° for active ROM EG: Improved on spasticity and balance Both groups had significantly improved in Wii Age CG: No significant improvement in any outcomes except Wii Age
Padala et al. (2012)	Pilot RCT Two groups Pre–post test with midterm test at Week 4 Assisted living facility United States	Mild Alzheimer's disease Age: EG = 79.3; CG = 81.6 Sample size (*N*): Pre-test (EG = 11; CG = 11) → 4 weeks (EG = 11; CG =11) → 8 weeks (EG = 11; CG = 11)	Intensity: 8 weeks; 5 days/week; 30 min/session Device: Wii Fit Games: Half-moon, warrior pose, chair; sun salutation, single leg extensions, lunges, torso twists, soccer heading, ski slalom, ski jump, table tilt, balance bubble, penguin slide *Note* EG: Wii Fit/CG: Walking	BBS Tinetti test TUG The index of ADL Instrumental ADL QOL-AD MMSE	EG: Significant improvement in BBS (p = .003; ES = 0.83) and Tinetti test (p = .013; ES = 0.549) CG: Improvement in BBS (p = .06; ES = 0.649) and TUG (p = .07; ES = 0.522) and significant improvement in Tinetti test (p = .006; ES = 0.661) No significant differences of all outcomes between two groups
Rendon et al. (2012)	RCT Pre–post test Retirement community United States	Age: 60-95 Sample size (*N*): Baseline (EG = 20; CG = 20) → 6 weeks (EG = 16; CG =18)	Intensity: 6 weeks; 3 days/week; 35-45 min/session Device: Wii Fit Games: Three balance games *Note* EG: Wii Fit/CG: No intervention	8-foot Up and Go ABC Geriatric Depression Scale	EG: Significant improvements in 8-foot Up and Go test (p = .038) and ABC (p = .038) compared with CG No significant differences of Geriatric Depression Scale between two groups

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Table 2. (continued)

Study	Design/setting	Sample	Intervention	Outcome measures	Results
Saposnik et al. (2010)	Pilot RCT Two groups Rehabilitation institute Canada	First stroke Age: 61.3 (41-83) Sample size (*N*): Baseline (EG = 11; CG = 11) → 2 weeks (EG = 9; CG = 8) → 4 weeks f/u (EG = 9; CG = 7)	Intensity: 2 weeks; 8 sessions; 60 min/session Device: Wii Sports Games: Bowling, cooking mama, tennis *Note* EG: CT + Wii Sports CG: CT + Recreational therapy	WMFT Box and Block Test Stroke Impact Scale	EG: Significant improvement in WMFT and grip strength EG performed a significant 7.4 s faster in mean motor function on the WMFT than CG Both groups had improvement in gross manual dexterity
Toulotte, Toursel, and Olivier (2012)	RCT Four groups Pre–post test Community France	Healthy older adults Age: 75.09 Sample size (*N*): Baseline (G1 = G2 = G3 = G4 = 9) → 20 weeks (G1 = G2 = G3 = G4 = 9)	Intensity: 20 weeks; 1 day/week; 60 min/session Device: Wii Fit Games: Heading soccer, ski jumping, yoga, downhill skiing, game balls, tightrope walker *Note* G1: Adapted physical activities G2: Wii Fit G3: Adapted physical activities + Wii Fit G4: No training	Tinetti test Unipodal tests Wii Fit tests	G1, G2, and G3: Significantly. improved static balance ($p < .05$) G1 and G3: Significantly increased dynamic balance ($p < .05$) G1 and G3: Significantly decreased the number of times the suspended foot touched the floor on the unipodal test G2 and G3: Significantly improved on Wii Fit tests (the position of the center of gravity)

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Table 2. (continued)

Study	Design/setting	Sample	Intervention	Outcome measures	Results
Williams, Soiza, Jenkinson, and Stewart (2010)	Pilot Two groups Pre–post test with midterm test at Week 4 Community United Kingdom	Community-dwelling fallers Age ≥ 70 Sample size (*N*): Baseline (EG = 15; CG = 6) → 4 weeks (EG = 12; CG = 3) →12 weeks (EG = 13; CG = 4)	Intensity: 12 weeks; 2 days/week; 30 min/session Device: Wii Fit Games: Jogging, step basics, hula Hoop, table tilt, ski slalom, ski Jump, deep breathing *Note* EG: Wii Fit CG: Standard care	BBS Tinetti Balance Assessment Tool FES Attitude to Falls Related Interventions Scale Wii Age	EG: 100% thought Wii Fit enjoyable and acceptable EG: Significant improvement in BBS at 4 weeks (p = .02; ES = 1.47) and in Wii Age at 12 weeks (p = .03) CG: No significant improvement in any outcomes

Note. BBS = Berg Balance Scale; TUG = time up and go; POMA = Tinetti performance-oriented mobility assessment; CBM = community balance and mobility assessment; ABC = Activities-Specific Balance Confidence Scale; RCT = randomized controlled trial; PT = physiotherapy; ROM = range-of-motion; FES = Falls Efficacy Scale; PANAS = Positive and Negative Affect Scale; SPPB = short physical performance battery; ADL = Activities of Daily Living Test; FIM = functional independence measure; CT = conventional therapy; WMFT = Wolf Motor Function Test; ES = effect size; FMA = Fugl-Meyer assessment; MMSE = mini mental state examination; QOL-AD = quality of life–Alzheimer's disease; UCLA = University of California, Los Angeles.

adults with perceived balance deficits reported improvements in balance confidence (Bainbridge, Bevans, Keeley, & Oriel, 2011; Rendon et al., 2012) and a significant reduction in fear of falling (Jorgensen, Laessoe, Hendriksen, Nielsen, & Aagaard, 2013). In addition, studies showed that receiving Wii exergaming training improved balance, lower extremity movement, strength, and function in outpatients after total knee replacement (Fung, Ho, Shaffer, Chung, & Gomez, 2012); functional mobility, and balance in patients in acute geriatric rehabilitation unit (Laver et al., 2012); walking endurance and the number of sit-to-stand repetitions in 30 s in patients with chronic obstructive pulmonary disease (COPD; Albores, Marolda, Haggerty, Gerstenhaber, & ZuWallack, 2013), static and dynamic balance, mobility, and functional abilities in subjects with Parkinson's disease (Esculier, Vaudrin, Bériault, Gagnon, & Tremblay, 2012).

Several studies also demonstrated that participating in Wii exergaming programs improved balance in stroke survivors (Mouawad et al., 2011), assisted living residents (Chao, Scherer, Wu, Lucke, & Montgomery, 2013; Padala, Padala, & Burke, 2011), and community-dwelling older adults (Toulotte, Toursel, & Olivier, 2012; Williams, Soiza, Jenkinson, & Stewart, 2010). Moreover, older adults living in various types of retirement facilities have been shown to have significant improvements in balance and walking speed (Agmon et al., 2011; Franco, Jacobs, Inzerillo, & Kluzik, 2012; Rendon et al., 2012; Williams, Doherty, Bender, Mattox, & Tibbs, 2011). Another study also reported that older adults living in a local senior living community retained significant improvement in balance at 1-month follow-up after a 3-week Wii Fit program (Bieryla & Dold, 2013). These studies support the use of the Wii exergames as a clinical intervention to promote physical activity and improve balance, balance confidence, mobility, walking speed, muscle strength, flexibility, and functional abilities in older adults.

Cognitive Function

Cognitive remediation is a method to improve or maintain global cognitive ability and domain-specific areas of cognition. Virtual reality gaming programs are an emerging and innovative approach to improve cognitive functioning in older adults (Vance et al., 2009). Studies have shown the effectiveness of using virtual reality cognitive training programs to improve general cognitive function in older adults, as well as short-term memory, orientation, attention, comprehension, repetition, naming, constructions, memory, and judgment (Chan, Ngai, Leung, & Wong, 2010; Optale et al., 2010). However, only two studies assessed the effects of Wii exergames on cognition in older adults in this review. A study was conducted in community-dwelling older adults with

subsyndromal depression. After a 12-week period of using the Wii Sports program, subjects had significant improvement in cognitive performance (Rosenberg et al., 2010). However, the other study reported that there was no significant improvement of cognitive function for assisted living residents with mild Alzheimer's dementia who engaged in an 8-week Wii Fit exergames program (Padala et al., 2011). Results of the studies are inconclusive regarding the use of Wii exergames for improving cognitive function in older adults.

Psychosocial Effects

Social isolation is a significant contributor to developing depression in older adults. Several factors may cause social isolation, including mobility limitations, medical illness, and economic constraints (Alpert et al., 2009). The social interaction that accompanies Wii exergaming program is beneficial and meaningful for older adults. Community-dwelling older adults with subsyndromal depression showed significant improvements in depressive symptoms and mental health-related quality of life, and had a decrease in anxiety level after 12-week program (Rosenberg et al., 2010). Older women living in the community expressed an improved sense of physical, social, and psychological well-being after a 6-week intervention (Wollersheim et al., 2010). In addition, one study found that there was a positive relationship between physical activity and positive mood among older adults living in an independent living residential apartment. Subjects who used the Wii bowling expressed decreased loneliness and improved mood compared with the television group (Kahlbaugh, Sperandio, Carlson, & Hauselt, 2011). Moreover, a recent study conducted on patients with COPD also demonstrated significant improvements in emotion after a 12-week Wii Fit training program (Albores et al., 2013). Findings from these studies provide support for the application of Wii exergames as a mechanism to increase social interaction, improve a sense of accomplishment and mood. In addition, older adults have reported that the Wii exergames was an enjoyable and acceptable method for exercise. Older adults stated that they enjoyed playing the Wii exergames with their peers and family members, as well as a desire to continue to exercise with the Wii exergames (Agmon et al., 2011; Esculier et al., 2012; Joo et al., 2010; Jorgensen et al., 2013; Wollersheim et al., 2010).

Discussion

These reviewed studies addressed the applications and effects of the Wii exergaming program. First, studies suggested that Wii exergames could be used as an adjunct therapy to conventional therapy, or as an adjunct to

standard exercise to augment the physical function in older adults (Fung et al., 2012; Hsu et al., 2011; Joo et al., 2010; Saposnik et al., 2010). The Wii exergames as an intervention was found to result in improvements in functional mobility and balance, as opposed to conventional therapy alone (Laver et al., 2012). Benefits from using the Wii exergames as an intervention that were identified from the literature review included improvements in upper extremity flexibility, hand function, mobility, and balance. Studies also demonstrated that the Wii exergames had a positive effect on decreasing anxiety, depression, increasing cognition, and improving quality of life among older adults.

Second, the American College of Sports Medicine and the American Heart Association (Nelson et al., 2007) suggest that older adults should perform aerobic, flexibility, muscle-strengthening, and balance activities to improve and maintain health (Nelson et al., 2007). In particular, the strength exercise has the strongest positive effect on improving functional performance, muscle strength, and muscle endurance (Gu & Conn, 2008). However, only four studies incorporated strength exercises into their activity programs among the 22 reviewed studies (Bieryla & Dold, 2013; Chao et al., 2013; Fung et al., 2012; Padala et al., 2012). A possible reason why other studies have not included strength exercises in their Wii-based program may be due to concerns about safety for the participants. In addition, most of the strength exercises found in the Wii Fit gaming activities are difficult for older adults with physical limitation to carry out. Modifications to the Wii Fit exergames routine should be made to prevent falls, while older adults perform the strengthening exercises, such as providing assistive devices (e.g., 4-point walker and supported frame) for stability and altering the exercise to accommodate physical limitations.

Third, high attendance rates were noted in Wii exergames programs, which could be interpreted as gaming activities having attributes to enhance motivation toward exercise adherence for older adults. Motivation attributes for the Wii exergames include attractive graphics and audio feedback that make exercise more fun and interesting for older adults, who are then more willing to continue to exercise (Joo et al., 2010; Jorgensen et al., 2013). An additional attribute of the Wii exergames that engages older adults is wide selection in gaming activities which allow older adults to perform individualized tasks. The choices available, as well as the various game levels, can result in a personalized intervention for older adults (Kahlbaugh et al., 2011; Williams et al., 2010). Finally, the Wii exergames provide opportunities for social interaction and connectedness with peers and family members (Agmon et al., 2011; Esculier et al., 2012). These characteristics increase interest among older adults who often lack the motivation to engage in exercise. In

addition, the Wii exergames can be used by older adults in a home setting, and do not require transportation to other facilities or a need to have gym accessibility. It may be especially beneficial for older adults with physical limitation or individuals who are unable to leave their home. However, a home-based Wii exergames program may require closer guidance and supervision to provide safety, while also improving physical function.

However, usability studies proposed that using Wii exergames may not be suitable for some individuals (e.g., survivors of stroke, spinal cord injury, and traumatic brain injury) who may not be able to achieve necessary therapeutic goals (Lange, Flynn, & Rizzo, 2009). The gaming system may provide negative auditory and visual feedback for subjects with certain levels of physical impairment, who may otherwise have effectively performed the gaming activity. In these cases, participants may need help in using the Wii remote controller (e.g., finding the correct buttons on the remote controller). Also, participants may not be able to move fast enough for some of the gaming activities, or cannot carry out some of the movements needed for a particular game. An additional limitation is that the present Wii technology is not sensitive enough to measure certain levels of function ability (Chao, Scherer, Montgomery, Wu, & Lucke, 2014; Lange, Flynn, Proffitt, Chang, & Rizzo, 2010; Lange et al., 2009). Hence, appropriate instructions and encouragement should be given to deal with the device performance feedback issues.

Fourth, no serious adverse event or injury had been reported in any of the 22 reviewed studies, although a few subjects reported experiencing neck strain, mild muscle pain, and soreness of the limbs (Agmon et al., 2011; Laver et al., 2012; Rosenberg et al., 2010; Saposnik et al., 2010). However, there have been Wii-related injuries reported in the literature for the general population which should be noted. The majority of injuries were caused by excessive game play or falls, such as acute tendonitis of right infraspinatus, dislocation of left patella, medial meniscal tear, and acute onset of carpel tunnel syndrome (Taylor, McCormick, Shawis, Impson, & Griffin, 2011). Therefore, interventionists should consider the potential injuries that may occur when designing Wii exergaming programs for older adults.

The benefits and barriers of using different types of exercise games have been reported in the literature. Nintendo Wii™ is one of the most accessible and popular exergames for seniors. Interactive video dance games (e.g., Dance Dance Revolution system) is another exergames used for older adults. However, older adults often face problems while using video dance games, such as fast paced music, frequent jumping, information, and color overload on the screen. For example, as stimulus speed and step rate of dance games increased, the stepping performance of older adults decreased (Lange et al., 2011; Smith, Sherrington, Studenski, Schoene, & Lord, 2011). Sony

PlayStation® 2 EyeToy™ is the other exergame for older adults. However, some limitations of EyeToy have been reported in the study. One limitation is that there is restricted ability of EyeToy to grade the level of difficulty for players with more severely involved motor impairments. For example, players with hand mobility problems may be unable to interact with the EyeToy environments. No systematic recording of users' performance is another limitation of this exergame (Rand, Kizony, & Weiss, 2008). A newer released Microsoft Kinect delivers adaptable stepping exercises and simultaneously measures step performance. In addition, the capability of the Kinect-based system to quantify player's motor function has been applied for fall detection in older adults (Garcia, Felix, Schoene, Smith, & Pisan, 2012). Although different exergames have been used in older adults, most published studies were Nintendo Wii-related. Hence, more studies are needed to investigate the effects of exercise program using different exergames.

Limitations

The most common weaknesses among the reviewed studies were small sample sizes which lack the power to detect statistically significant differences. Hence, studies with larger sample sizes are needed in a variety of settings. Also, additional research is needed to investigate the optimal frequency and duration of Wii exergaming programs for different subgroups of older adults. Moreover, additional studies are needed with both experimental and longitudinal designs to better illustrate the short- and long-term benefits of using the Wii exergames among older adults.

Implications

Many older adults do not adhere to exercise regimen due to a lack of enjoyment. The Wii exergames makes exercise fun and engaging to older adults, thus making it more likely for them to continue to exercise over time. Health care professionals (e.g., recreational therapists, physical and occupational therapists, social workers, physicians, and other nursing personnel) should work as a team to design and develop the exergaming programs to promote physical activity in older adults. In particular, nurse aides play an important role in the care of assisted living and nursing home residents, and are in an excellent position to encourage these older adults to engage in physical activity in the long-term care settings. Teaching nurse aides about the benefits of exercise, the factors that influence older adults to exercise, and how to apply strategies to increase residents' self-efficacy to exercise are key to motivating these health care providers to carry out exercise activities with residents.

Most exergames on the market are targeted for the younger generation. Some of the features of these exergames have affected negatively on senior players, such as low-level controller issues, small font, too colorful images, complexity of menu structures, and difficulty to finish or make progress in a game (Gerling & Masuch, 2011; Nap, de Kort, & Ijsselsteijn, 2009). Hence, health care professionals should work with engineers and computer science professionals to design and invent senior-friendly exergames (e.g., simple menu structures and controllers, large font and slow moving images) to make the gaming activities more user-friendly for senior players.

Different self-regulatory behavioral procedures (e.g., goal setting, problem solving, decision making, and skill development) have been integrated into the structure of the exergaming development (Baranowski, Fiellin, Geri, & Thompson, 2014). These features accompanied by appropriate theory application might be beneficial. In our review, only one study used a theoretical framework to guide the exergaming program in older adults. The study suggested that combining self-efficacy theory with the Wii exergames serves as an effective way to motivate older adults to engage in exercise (Chao et al., 2013). However, more research is needed to evaluate the effects of integrating theoretical frameworks (e.g., self-efficacy theory, self-determination theory, and behavioral inoculation theory) into exergaming programs.

Conclusion

Exergames cannot only be used for entertainment but also can be applied to encourage older adults who lack motivation to engage in physical activity. Evidence supports that the Wii exergames have positive effects on cognition, physical function, and psychosocial outcomes in older adults, such as increasing physical activity, cognitive stimulation, social support, and enjoyment. In addition, exercising with the Wii exergames is safe and feasible for older adults. Understanding of the potential benefits of Wii exergames provides important guidance for future research in this area. Future studies using the Wii exergaming program should include evaluating different gaming activities, implementing the exergaming programs for older adults living in different levels of care, a randomized control trial with a larger sample size, a longitudinal study, and a theoretical framework to strengthen the existing body of evidence.

Acknowledgment

The authors would like to thank the dissertation committee (Kathleen T. Lucke, RN, PhD, and Yow-Wu Wu, PhD) and fellow classmates for reviewing this manuscript at the University at Buffalo, School of Nursing.

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

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