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A Preliminary Study on the Effectiveness of Exergame Nintendo "Wii Fit Plus" on the Balance of Nursing Home Residents

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Abstract

Objective: This study investigated the effect of playing Nintendo® "Wii Fit™ Plus" (Nintendo of America, Inc., Redmond, WA) on body balance and physical activity of nursing home residents.
Subjects and Methods: In a nonrandomized controlled trial within a nursing home, two intervention groups (both $n=8$) were exposed to the same treatment and compared with a control group ($n=13$). Intervention Group 1 consisted of elderly individuals with regular Nintendo "Wii Fit" experience for at least 1 year. Elderly persons who were novices to the Nintendo "Wii Fit (Plus)" participated in intervention Group 2. Control participants had no experience with the Nintendo "Wii Fit (Plus)" and did not participate in the Nintendo "Wii Fit Plus" sessions. Outcome measurements were taken at baseline and after the intervention, using the Berg Balance Scale and the LASA Physical Activity Questionnaire. Participants of both intervention groups played the Nintendo "Wii Fit Plus" for 10 minutes twice a week during 12 weeks.
Results: Although balance improved for all three groups, there was no effect of playing "Wii Fit Plus" ($P=0.89$). On physical activity, the intervention did have a positive effect ($P=0.005$); physical activity levels increased with a median of 54.3 (interquartile range, 63.1) minutes/day for intervention Group 1 and a median of 60.7 (interquartile range, 56.8) minutes/day for intervention Group 2.
Conclusions: This study showed an effect of Nintendo "Wii Fit Plus" gaming on physical activity of nursing home residents, but not on their balance. The effect of physical activity should be consolidated in a randomized controlled trial in a broader population.

Introduction

Between 2011 and 2040, the number of Dutch citizens 65 years of age and older will increase from 2.4 million (14.4%) to 4.6 million (25.8%).[1] Increasing age is associated with functional decline, lower mobility, impaired balance, frailty, and difficulties with activities of daily living.[2–4] Aging and impaired balance are intrinsic risk factors for falling.[5] Nursing home residents fall more often compared with community-dwelling elderly.[6,7] Especially for nursing home residents, falls can have major consequences, like morbidity, immobility, and mortality.[8] Fall injury or fear of falling again is associated with further functional decline and depression,[8] and functional decline should be prevented for the sake of people's independence.[2] Therefore, it is important to focus on ways to improve the balance of nursing home residents.

It is well known that physical activity is beneficial for overall health.[6] It has been demonstrated that physical activity can treat and prevent a further decline in disability, physical fitness, functional performance, and activities of daily living in the elderly.[9,10] It has been associated with less cognitive decline and dementia and a better quality of life in elderly people.[11,12] Physical activity is also suggested to prevent falling.[13] To make sure that the nursing home residents are motivated to perform physical activities, the activities should be interesting, sociable, and fun for them.[6,14] Specially developed videogames, usually referred to as activity games or exercise games (exergames), are increasingly popular tools to make people exercise.[15] Exergames are interactive videogames in which game play is combined with physical exercise,[16] while the players' movements are being tracked by a set of sensors embedded in controllers or boards

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or by recordings of a videocamera.[17] Popular exergames are Nintendo® "Wii™ Sports" and Nintendo "Wii Fit"[18] (Nintendo of America, Inc., Redmond, WA).

Nintendo "Wii Fit"

The Nintendo "Wii Fit" is a set of games that target one's balance and strength, developed for people of all ages, including the elderly.[19] Franco et al.[20] conducted a randomized controlled trial comparing the Nintendo "Wii Fit" to a traditional exercise program, called "Matter of Balance," and a control group in a population of independently living persons 60 years of age or older. The intervention group took individual Nintendo "Wii Fit" sessions twice a week for 3 weeks with a mean playing time of 13 minutes per session. In addition, participants performed some supplementary home exercises. Balance improved in all three groups, but the most in the Nintendo "Wii Fit" group. However, differences were not significant.[20] Significant improvements in balance were found by Williams et al.[21] in a noncontrolled study. Community-dwelling elderly individuals 70 years of age or older who had fallen at least once in the previous year participated in "Wii Fit" sessions twice a week for 12 weeks. Balance improved significantly after 4 weeks compared with their baseline score on the Berg Balance Scale. However, improvements did not hold after 12 weeks.[21]

Only a few studies have investigated the effects of the Nintendo "Wii Fit" on nursing home residents, a frailer population than community-dwelling elderly.[22] In a pilot study, Agmon et al.[15] assessed the safety and feasibility of the Nintendo "Wii Fit" for elderly persons 78–92 years of age with an impaired balance and living in continuing care retirement communities. Participants felt comfortable when using the Nintendo "Wii Fit" and perceived their balance to be improved. After 3 months significant improvements were found on the Berg Balance Scale and timed 4-m walk test, a measurement tool to measure gait speed.[15] Williams et al.[21] reported positive results in a noncontrolled study with the Nintendo "Wii Fit" in occupational therapy for elderly individuals from a nursing home and retirement communities, also with significant improvements on the Berg Balance Scale.

In 2009, Nintendo released a newer version of the Nintendo "Wii Fit" in The Netherlands, the Nintendo "Wii Fit Plus."[18] We found only one study with this Nintendo "Wii Fit Plus" so far. Ainsworth et al.[23] used it as a treatment device for balance improvement for rehabilitation of patients with different vestibular and neurological disorders; participants enjoyed playing the games, but no balance measurements were conducted. Although the popularity of Nintendo "Wii Fit (Plus)" is increasing, there is still not enough evidence that it is an effective device for targeting age-related disabilities[19,24,25] and improving associated physical health, like balance,[26] among elderly people living in a nursing home.

The objective of this study was to investigate the effects of the Nintendo "Wii Fit Plus" on the balance of nursing home residents and their level of physical activity. The intervention was introduced as a social activity, as something enjoyable and motivating, to ensure compliance with the activity.[20]

Subjects and Methods

A nonrandomized controlled trial was conducted in a nursing home in Maastricht, The Netherlands, with 195 residents. Randomization was not possible because of the limited number of elderly people in the nursing home. There were two intervention groups. Participants of intervention Group 1 already had regular experience with the Nintendo "Wii Fit"–2 hours a week for at least 1 year. Participants of intervention Group 2 were novices; they did not have hands-on experience with the Nintendo "Wii Fit (Plus)." The control group consisted of nursing home residents who had no experience and did not participate in the Nintendo "Wii Fit Plus" sessions. There was no blinding of the participants and the interventionist.

Participants in any group had to be able to play the game without physical support and needed to be medically fit (as determined by the activity worker of the nursing home). Excluded were people with bad vision and those who were bedridden or wheelchair-bound. Also, elderly with cognitive impairment (i.e., a score of 22 or less measured on the Mini-Mental State Examination) were not eligible.[27] Cognitive impairment can limit the understanding of the purpose of the interactive videogames. All participants signed an informed consent and kept the right to withdraw at any time during the intervention period. The study received a positive review from the Medical Ethical Committee of Maastricht University Medical Centre.

Intervention

Both intervention groups attended two Nintendo "Wii Fit Plus" sessions per week, on Wednesday and Friday morning. Sessions lasted 1 hour per group, giving a play time of 10–15 minutes per participant per session. The intervention lasted 12 weeks. To avoid contamination of the control group, all equipment was stored between the sessions. During the sessions, a log book was kept by the researcher, containing information about the games played and a list of attendance.

In Week 1, participants were introduced to the Nintendo "Wii Fit Plus." From Week 2 onward, participants played the game "Table Tilt Plus" and at least two other games, every session. "Table Tilt Plus" is a balance game in which the player has to direct a ball through a hole in a table by shifting his or her weight on the Wii Balance Board™. Each player played the game three times. There were two sets of devices installed, so two players could play at the same time. A chair was put in front of each Wii Balance Board as a safeguard for participants who were afraid of falling from the Board. Every session was closely supervised by the researcher and a volunteer.

Outcome measures

Outcome measures were balance and physical activity. Balance was measured by a physiotherapist using the Berg Balance Scale.[28] The Berg Balance Scale consists of 14 items, each of which corresponds with a simple mobility task (e.g., transfers, standing unsupported, sit-to-stand) and more difficult tasks (e.g., tandem standing, turning 360°, single-leg stance).[29] Items are scored from 0 (unable to perform the task) to 4 (able to complete the task). A maximum score of 56 can be achieved.[28] The physiotherapist was blinded as to which group participants belonged.

Physical activity was assessed by the researcher using the LASA Physical Activity Questionnaire (LAPAQ).[30] The LAPAQ is a face-to-face questionnaire assessing frequency and duration of several types of physical activity (walking outside, bicycling, gardening, light household activities, heavy

household activities, and a maximum of two sport activities) during the previous 2 weeks.[30] Each LAPAQ activity has a standard score for intensity, required muscle strength, mechanical strain, and hip rotation.[31] In this study the level of physical activity was presented in minutes per day.

Besides the outcome measures, the following baseline characteristics were collected by questionnaire: age, gender, use of a walking aid, number of falls in the last 6 months, receiving physiotherapy, and attendance to physical activity at the nursing home. Weight and height were measured by the physiotherapist.

Data collection and data analysis

Baseline measurements took place in February 2012, before the start of the intervention; post-intervention measurements was done 12 weeks later. Data were analyzed using SPSS version 19.0 software (SPSS Inc., Chicago, IL). An intention-to-treat approach was used to analyze the data. The data failed to meet the distribution criteria of normality and homogeneity for parametric testing, so the Kruskal–Wallis test[32] was used to test differences between groups on both baseline characteristics and outcome measures. The required significance level was 5% ($P < 0.05$). A *post hoc* univariate analysis of covariance was conducted to test the influence of age on the difference in balance. For *post hoc* testing, the Mann–Whitney U test[33] was used. *Post hoc* tests were corrected for the number of tests ($n = 3$), so the required significance level there was 1.7% ($P < 0.02$).

Results

The CONSORT[34] flow chart in Figure 1 shows the allocation of participants to the study. Initially, 48 elderly persons were considered eligible for participation. Nine participants already playing "Wii Fit" games every Friday morning for at least 1 year were enrolled in intervention Group 1. One female group member with a score of 20 on the Mini-Mental

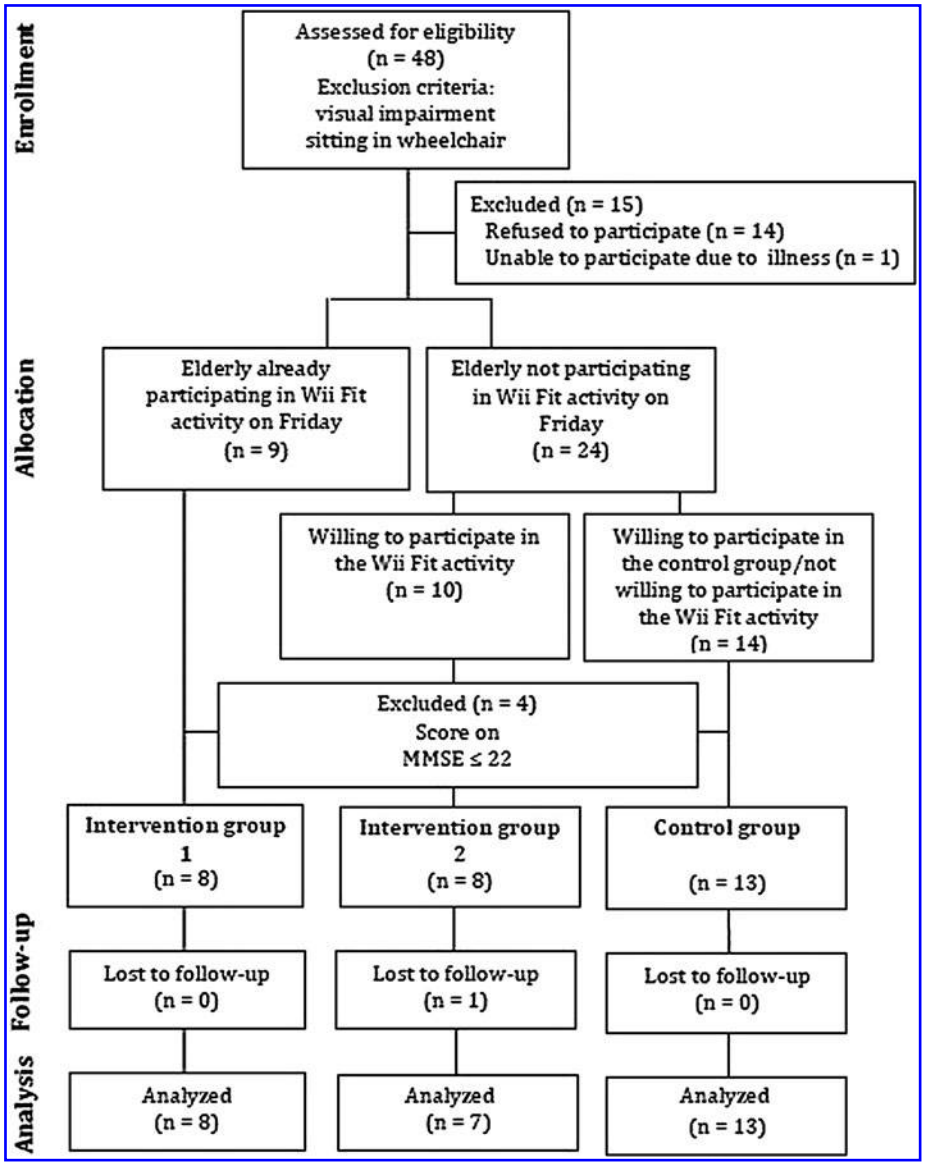

FIG. 1. Flow chart of participants from baseline to the end of the 12-week intervention. MMSE, Mini-Mental State Examination.

State Examination was excluded, so Group 1 remained with eight participants. Intervention Group 2 consisted of eight nursing home residents, and the control group contained 13 participants.

Baseline characteristics

The baseline characteristics of the three groups are presented in Table 1. Participants of intervention Group 1, compared with intervention Group 2 and the control group, were on average older (84.5 versus 81.5 and 80.0 years old, respectively) and more often male (50 percent versus 25 percent and 23 percent, respectively), but these differences were not significant. The only significant group difference was seen for the participation in weekly activities provided in the nursing home ($H_2 = 7.69$, $P = 0.021$). The fact that intervention Group 1 participated 100 percent was due to the fact that they participated in the Friday "Nintendo Wii" activity. There were no significant differences for the primary outcome measurements of balance and physical activity at baseline (Table 1).

Intervention

Both intervention groups started with eight participants (Fig. 1). All participants of intervention Group 1 completed the 12-week intervention. In intervention Group 2 one female participant discontinued after 1 week because of complaints related to her osteoarthritis. Because an intention-to-treat approach was used, her end measurements were included in the analysis. After 3 weeks another female participant of intervention Group 2 discontinued because of a hip fracture. This accident did not occur during the intervention. She was therefore lost to follow-up, and only her baseline measurements could be used for comparison. In the control group no participants were lost to follow-up. Attendance to the intervention was high. On average, participants of intervention Group 1 attended 22.5 (interquartile range, 6) sessions, and participants of intervention Group 2 attended 21 (interquartile range, 14.3) sessions of the 24 sessions.

Balance and physical activity

The average within-subject changes in outcome measurements (subtracting the baseline outcome from the end outcome) are shown and compared in Table 2 and visualized in Figure 2. Intervention Group 1, intervention Group 2, and the control group all improved on the Berg Balance Scale, but improvements did not differ significantly ($P = 0.89$). A univariate analysis of covariance showed no significant effect of age ($F_{1,24} = 0.19$, $P = 0.829$). All groups also increased in total physical activity levels, but here there was a significant difference among groups ($H_2 = 10.65$, $P = 0.005$) (Fig. 2). *Post hoc*

Table 1. Baseline Characteristics

	Intervention Group 1	*Intervention Group 2*	*Control group*	P
Total (male)	8 (4)	8 (2)	13 (3)	0.41
Age (years) [median (IQR)]	84.5 (5.0)	81.5 (12.8)	80.0 (8.5)	0.07
Age range (years)	79–90	68–78	65–88	
Weight (kg) [median (IQR)]	64 (17.5)	73.0 (8.8)	81.5 (23.8)[a]	0.29
Height (cm) [median (IQR)]	159.5 (11.8)	157.5 (7.8)	163.0 (10.5)	0.59
BMI (kg/m^2) [median (IQR)]	25.6 (1.3)	28.8 (5.9)	28.3 (8.7)[a]	0.13
Number of falls in last 6 months				0.24
0	6	8	9	
1	2	0	4	
Times participating in physiotherapy per week				0.41
0	6	6	12	
1	0	0	1	
2	2	2	0	
Participation in weekly activities at nursing home				0.02[b]
Yes	8	5	5	
No	0	3	8	
Use of walking aid				0.29
Yes	6	6	6	
No	2	2	7	
Berg Balance Scale score [median (IQR)]	46.5 (7.5)	48.5 (5.5)	49.0 (14.0)	0.66
Mini-Mental State Examination score [median (IQR)]	27.0 (1.0)	28.0 (2.0)	27.0 (1.5)	0.78
LAPAQ score (minutes/day) [median (IQR)]				
Total physical activity	57.7 (44.9)	59.6 (35.4)	70.7 (78.9)	0.43
Walking	17.1 (15.7)	14.6 (10.4)	30.0 (36.8)	0.42
Cycling	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.54
Sports	7.5 (22.8)	12.5 (36.4)	0.0 (13.6)	0.15
Light household activities	12.5 (35.0)	18.6 (48.4)	30.0 (45.0)	0.34
Heavy household activities	0.0 (2.4)	0.0 (0.0)	0.0 (15.7)	0.11
Gardening	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.54

[a]One missing value.
[b]Significant at the $P = 0.05$ level.
BMI, body mass index; IQR, interquartile range; LAPAQ, LASA Physical Activity Questionnaire.

Table 2. Improvements (End Value – Baseline Value) on Berg Balance Scale and LASA Physical Activity Questionnaire for the Three Groups

	Median (interquartile range)			
	Intervention Group 1 (n = *8*)	*Intervention Group 2* (n = *7*)	*Control group* (n = *13*)	P
Berg Balance Scale score	3.0 (8.5)	1.0 (6.0)	1.0 (4.5)	0.89
LAPAQ (minutes/day)				
Total physical activity	54.3 (63.1)	60.7 (56.8)	−5.4 (37.0)	0.01[a]
Walking	21.4 (50.7)	10.7 (30.4)	0.0 (18.9)	0.02[a]
Cycling	0.0 (0.0)	0.0 (0.0)	0.0 (0.)	0.56
Sports	0.7 (5.4)	2.9 (10.7)	0.0 (0.0)	0.16
Light household activities	8.2 (20.7)	25.0 (45.0)	0.0 (28.9)	0.18
Heavy household activities	0.0 (3.2)	0.0 (2.9)	0.0 (5.7)	0.39
Gardening	0.0 (0.0)	0.0 (0.0)	0.0 (0.2)	0.37

[a]Significant at the $P = 0.05$ level.
LAPAQ, LASA Physical Activity Questionnaire.

analysis with Bonferroni's correction showed that both intervention groups improved more on total physical activity than the control group (U = 18.00, $z = -2.46$, $P = 0.014$ for Group 1 and U = 10.00, $z = -2.81$, $P = 0.005$ for Group 2). Intervention Group 1 and intervention Group 2 did not differ significantly on their differences in scores for total physical activity. Regarding the different subcategories of physical activity, only the increase in walking time differed significantly among the three groups ($H_2 = 8.46$, $P = 0.015$). Here, only intervention Group 2 improved significantly more than the control group (U = 14.00, $z = -2.50$, $P = 0.012$), whereas for intervention Group 1 it was borderline not significant (U = 20.50, $z = -2.29$, $P = 0.022$). One participant in the control group had an allotment*, and because of the season she increased her time spent on cycling and gardening. Analysis showed that this did not influence the overall results. Also, other subcategories did not show significant differences among the groups.

*An allotment (or allotment garden) is a small plot of land rented, typically from a local authority, by an individual for growing vegetables or flowers or for keeping small livestock, such as hens and rabbits.

Discussion

The Nintendo "Wii Fit" is a popular videogame to encourage people to exercise. Evidence regarding physical improvements in elderly individuals is weak because controlled trials are sparse. This intervention is one of the few, as it evaluates the effect of "Wii Fit Plus" on balance and physical activity levels of nursing home residents.

Balance

Baseline measurements did not demonstrate that experienced exergamers (intervention Group 1) had a better balance. A possible explanation could be found in age differences because research shows a negative correlation between balance and age.[35,36] However, we cannot confirm this. Although participants of intervention Group 1 were on average older, groups did not differ significantly in age. More likely is that participants did not use the device as intensely before the start of the intervention. There was no significant effect of the intervention on body balance. This is not what we expected. Analysis of covariance *post hoc* results showed that age also did not influence the differences in balance.

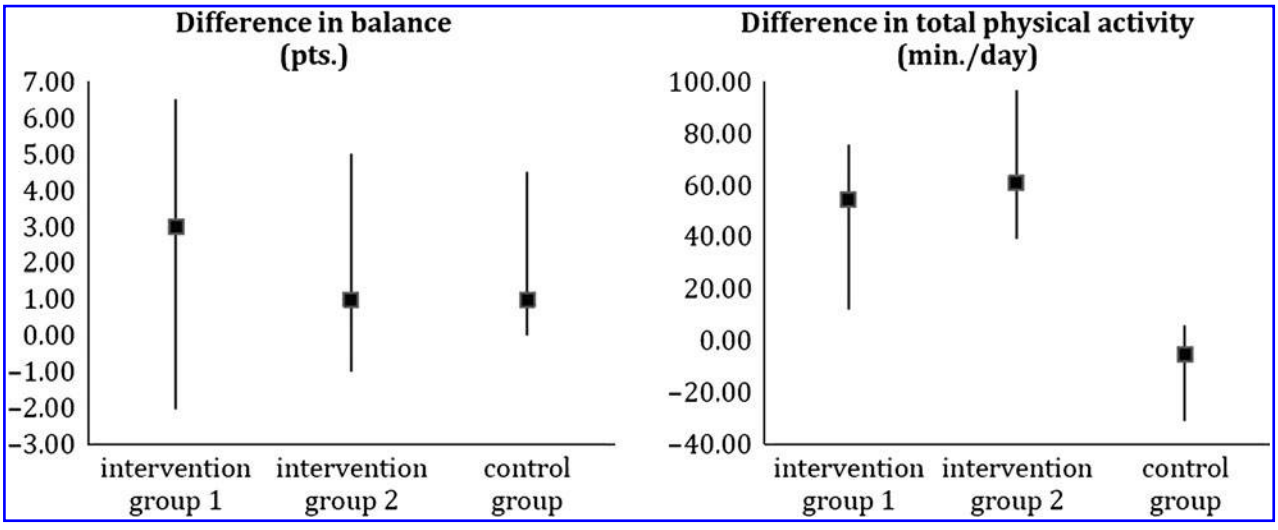

FIG. 2. Difference (end value – baseline value) in balance and total physical activity. Data are median (box) and interquartile range (line). pts, patients.

Post-intervention measurements showed that all participants improved their body balance. This suggests either a seasonal effect or a learning effect for the test we used. The upcoming spring during the intervention could lead to an increase of overall physical activity, which would contribute to a better balance for all three groups. It is known that physical activity and exercise can be beneficial for balance and overall functioning, even for the frail and extremely old.[35–37] However, this explanation would only hold if even the smallest increase in physical activity would result in better body balance because physical activity increased far less in our control group than in both intervention groups. Hence, a learning effect for the Berg Balance Scale test is more likely. Better scores on items with the more complex tasks support this explanation. Unfortunately, it appears that many of the known Nintendo "Wii Fit" interventions measured balance by the Berg Balance Scale, so it is difficult to confirm this suggestion. If a serious learning effect would indeed exist, it would weaken the evidence of the positive effects of the many uncontrolled studies.[15,26,37]

In conclusion, the improvements in balance were not due to playing the Nintendo "Wii Fit Plus," but possibly to a learning effect on the Berg Balance Scale. It is still possible that a more intense Nintendo "Wii Fit Plus" intervention (for example, three times per week each of 30 minutes playing time) would have the desired effect,[15,37] but more controlled research is needed to confirm this.

Physical activity

All groups increased their level of physical activity during the intervention, probably because of the changing season. Indeed, people are generally more physically active in spring than in winter.[38] But, participants of both intervention groups increased their activity significantly more, predominantly by putting more effort into walking (significant) and light household activities (not significant). This may seem odd because participants played balance games, not sporting games. A possible explanation for this "side effect" of the intervention might be that this gaming experience has invoked a hidden motivation to accomplish other activities. No matter if it was due to the exercise games themselves, social influence, a revival of competitive senses, or something else, any improvement in physical activity is welcome for the elderly. Be it with light intensity (walking) or moderate intensity (sporting), evidence shows that physical activity is beneficial for physical and mental health in the elderly.[23,39,40]

In conclusion, the Nintendo "Wii Fit Plus" intervention showed a positive effect on physical activity. Further research should explore which determinants of the gaming experience are responsible for this effect.

Limitations of the study

Our study was set up within one nursing home, which puts some restrictions to its design. The number of elective volunteers was limited, so we had to work with a small sample size and without randomization. First, the small sample size may have contributed to the nonsignificance of some results. Second, the pseudorandomization, arranged by the activity worker of the nursing home, may have introduced some selection bias, so there is a chance of confounding by indication.[41] Third, the duration of gaming activity was limited to 10 minutes per session, because of organizational constraints. More beneficial effects can be expected when increasing this intensity to, for example, a play time of 30 minutes each with sessions held three times per week.[7,15] Nonetheless, this study is a step forward to maturity of a research domain where uncontrolled studies are still in the majority. The following step will be a randomized controlled trial with a larger sample size in a larger population.

Conclusions

We evaluated the effects of a 12-week Nintendo "Wii Fit Plus" intervention on balance and physical activity levels of nursing home residents in a controlled study. We found improved balance in all groups, which, however, could not be attributed to the intervention. Instead, it may be related to a learning effect of the Berg Balance Scale test, which stresses the importance of a controlled design.

The single significant effect of this intervention was an increase of physical activity, especially walking. As the games played were not related to this kind of activity, other factors must play a role, for example, social influence. Further research is needed to confirm this.

Author Disclosure Statement

No competing financial interests exist.

References

1. Van Duin C, Garssen J. Bevolkingsprognose 2010–2060: sterkere vergrijzing, langere levensduur [Population prognosis 2010–2060: stronger ageing, longer life expectancy]. CBS Bevolkingstrends; 2001; 59(1):16–23.
2. Chen YM. Perceived barriers to physical activity among older adults residing in long-term care institutions. J Clin Nurs 2010; 19:432–439.
3. Van Rensbergen G, Nawrot T. Medical conditions of nursing home admissions. BMC Geriatr 2010; 10:46–54.
4. Graafmans WC, Lips P, Wijlhuizen GJ, et al. Daily physical activity and the use of a walking aid in relation to falls in elderly people in a residential care setting. Z Gerontol Geriatr 2003; 36:23–8.
5. Nowalk MP, Prendergast JM, Bayles CM, et al. A randomized trial of exercise programs among older individuals living in two long-term care facilities: The FallsFREE Program. J Am Geriatr Soc 2001; 49:859–865.
6. World Health Organization. *Ageing Life Course Unit. WHO Global Report on Falls Prevention in Older Age*. Geneva: World Health Organization; 2008.
7. Lord SR, Sherrington C, Menz HB, Close JCT. *Falls in Older People: Risk Factors and Strategies for Prevention.* Cambridge, UK: Cambridge University Press; 2007.
8. Rubenstein LZ, Josephson KR, Robbins AS. Falls in the nursing home. Ann Intern Med 1994; 121:442–451.
9. Fiatarone Singh MA. Exercise to prevent and treat functional disability. Clin Geriatr Med 2002; 18:431–462.
10. Weening-Dijksterhuis E, De Greef MHG, Scherder EJA, et al. Frail institutionalized older persons: A comprehensive review on physical exercise, physical fitness, activties of daily living, and quality-of-life. Am J Phys Med Rehabil 2011; 90:156–168.
11. Brandt K, Paniagua MA. The use of Nintendo Wii with long-term care residents. J Am Geriatr Soc 2011; 59:2393–2395.

12. Laurin D, Verreault R, Lindsay J, et al. Physical activity and risk of cognitive impairment and dementia in elderly persons. Arch Neurol 2011; 58:498–504.
13. Nederlands Instituut Sport en Bewegen [Dutch Institute Sports and Physical Activity]. Nederlandse Norm Gezond Bewegen [Dutch Standard Healthy Movement]. www.nisb.nl/kennisplein-sport-bewegen/veel-gestelde-vragen.html (accessed June 18, 2012).
14. Lange B, Requejo P, Flynn S, et al. The potential of virtual reality and gaming to assist successful aging with disability. Phys Med Rehabil Clin N Am 2010; 21:339–356.
15. Agmon M, Perry CK, Phelan E, et al. A pilot study of Wii Fit exergames to improve balance in older adults. J Geriatr Phys Ther 2011; 34:161–167.
16. Staiano AE, Calvert SL. Exergames for physical education courses: Physical, social, and cognitive benefits. Child Dev Perspect 2011; 5:93–98.
17. Brox E, Fernandez-Luque L, Tollefsen T. Healthy gaming—Video game design to promote health. Appl Clin Inform 2011; 2:128–142.
18. Nintendo. www.nintendo.nl/Wii/Spellen/Spellen-634799.html (accessed January 17, 2012).
19. Graves LEF, Ridgers ND, Williams K, et al. The physiological cost and enjoyment of Wii Fit in adolescents, young adults, and older adults. J Phys Act Health 2010; 7:393–401.
20. Franco JR, Jacobs K, Inzerillo C, Kluzik JA. The effect of the Nintendo Wii Fit and exercise in improving balance and quality of life in community dwelling elders. Technol Health Care 2012; 20:95–115.
21. Williams MA, Soiza RL, Jenkinson AM, Stewart A. EXercising with Computers in Later Life (EXCELL)—Pilot and feasibility stiudy of acceptability of the Nintendo WiiFit in community-dwelling fallers. BMC Res Notes 2010; 3:238–245.
22. Bandeen-Roche K, Xue QL, Ferrucci L, et al. Phenotype of frailty: Characterization in the women's health and aging studies. J Gerontol A Biol Sci Med Sci 2006; 61:262–266.
23. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: An update of activity codes and MET intensities. Med Sci Sports Exerc 2000; 32:S498–S516.
24. Laver K, Ratcliffe J, George S, et al. Is the Nintendo Wii Fit really acceptable to older people?: A discrete choice experiment. BMC Geriatr 2011; 11:64–69.
25. Anderson-Hanley C, Arciero PJ, Brickman AM, et al. Exergaming and older adult cognition: A cluster randomized clinical trial. Am J Prev Med 2012; 42:109–119.
26. Clark R, Kraemer T. Clinical use of Nintendo Wii™ Bowling simulation to decrease fall risk in an elderly resident of a nursing home: A case report. J Geriatr Phys Ther 2009; 32:174–180.
27. Warnier RMJ. *TRAZAG Transmuraal Zorg Assessment Geriatrie Academisch Ziekenhuis* [*Multi-Agency Health Care Assessment Geriatric University Hospital*]. Maastricht: Academisch Ziekenhuis Maastricht [University Hospital Maastricht]; 2011.
28. Muir SW, Berg K, Chesworth B, Speechley M. Use of the Berg Balance Scale for predicting multiple falls in community-dwelling elderly people: A prospective study. Phys Ther 2008; 88:449–459.
29. Steffen TM, Hacker TA, Mollinger L. Age-and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and Gait Speeds. Phys Ther 2002; 82:128–137.
30. Stel VS, Smit JH, Pluijm SMF, et al. Comparison of the LASA Physical Activity Questionnaire with a 7-day dairy and pedometer. J Clin Epidemiol 2004; 57:252–258.
31. Verweij LM, Van schoor NM, Visser M. Distinguishing four components underlying physical activity: A new approach to using physical activity questionnaire data in old age. BMC Geriatr 2010; 10:20–26.
32. Kruskal WH, Wallis WA. Use of ranks in one-criterion variance analysis. J Am Stat Assoc 1952; 47:583–621.
33. Mann HB, Whitney DR. On a test of whether one of two random variables is stochastically larger than the other. Ann Math Stat 1947; 18:50–60.
34. Moher D, Schulz K, Altman D. The CONSORT statement: Revised recommendations for improving the quality of reports of parallel group randomized trials. JAMA 2001; 285:1987–1991.
35. Chou C, Hwang C, Wu Y. Effect of exercise on physical function, daily living activities, and quality of life in the frail older adults: A meta-analysis. Arch Phys Med Rehabil 2012; 93:237–244.
36. Prata MG, Scheicher ME. Correlation between balance and the level of functional independence among elderly people. Sao Paulo Med J 2012; 130:97–101.
37. Williams B, Doherty NL, Bender A, et al. The effect of Nintendo Wii on balance: A pilot study supporting the use of the Wii in occupational therapy for the well elderly. Occup Ther Health Care 2011; 25:131–139.
38. Shephard RJ, Aoyagi Y. Seasonal variations in physical activity and implications for human health. Eur J Appl Physiol 2009; 107:251–271.
39. Buman MP, Hekler EB, Haskell WL, et al. Objective light-intensity physical activity associations with rated health in older adults. Am J Epidemiol 2010; 172:1155–1165.
40. Rejeski WJ, Mihalko SL. Physical activity and quality of life in older adults. J Gerontol A Biol Sci Med Sci 2001; 56A(Spec No 2):23–35.
41. Jager K, Zoccali C, Macleod A, Dekker F. Confounding: What it is and how to deal with it. Kidney Int 2007; 73: 256–260.

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