Physiological and Perceptual Responses to Nintendo® Wii Fit™ in Young and Older Adults

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ABSTRACT

Int J Exerc Sci 5(1) : 79-92, 2012. Physically active video gaming (AVG) provides a technologically-modern, convenient means of increasing physical activity (PA). This study examined cardiovascular, metabolic, and perceptual responses in young adult (AP) and older adult (OP) participants engaging in Wii Fit™ AVG play, and compared PA levels during play to recommended PA levels. Heart rate (HR), percent heart rate reserve (%HRR), oxygen consumption (VO_2), energy expenditure (EE), rating of perceived exertion (RPE), enjoyment level (EL), and step count data were obtained from 10 YP and 10 OP during 15 minutes of rest and four 15-minute bouts of Wii Fit™ activities (yoga, balance, aerobics, strength). For all participants, AVG significantly increased HR, VO_2, and EE measures above rest, with significant between-activity differences. Responses were similar between YP and OP, except that the activities were more intense for OP, in terms of %HRR and RPE. Most games elicited responses consistent with light-intensity PA, though peak HR and VO_2 values for aerobic and strength games met or approached recommended PA intensities. Wii Fit™ appears to provide an enjoyable form of light PA for both YP and OP, which can reduce inactive screen time and provide beneficial cardiovascular, musculoskeletal, and metabolic stimulation.

KEY WORDS: Active video gaming, exergaming, physical activity, energy expenditure, screen time

INTRODUCTION

Consistent positive associations between sedentary 'screen time' behaviors and both low physical activity levels (23, 24) and chronic disease (65, 69, 70) support the importance of spending less inactive time watching television, using computers, and playing traditional video games. Statistics from the Entertainment Software Association (22) show that 72% of American households play video or computer games and that, contrary to common perceptions that video games are mainly for young people, 53% of gamers are 18-49 years old, 29% are 50 years or older, and only 18% are under age 18. Thus, the use of activity-promoting video games may be one effective means of reducing sedentary screen time, among all segments of the population. Pate (54, p. 895) has editorialized this possibility as fighting "fire with fire," in a contemporary society where "electronic entertainment is not going to go away." Several studies have now shown that active video game (AVG) play, also known as 'exergaming,' can significantly increase energy expenditure (EE) above that of resting, watching television, and playing traditional video games (25-29, 39, 44). Still, more research is needed to elucidate its health promotion potential.

The primary purpose of this study was to examine several physiological and perceptual responses in young (YP) and older adult participants (OP) during AVG play using the Nintendo® Wii Fit™ gaming system (Nintendo® Inc., Kyoto, Japan). A major underlying objective was to contribute to the literature on adult AVG play, wherein others are currently exploring potential physical (18, 60), psychological (12, 58), and social (71) benefits. Another objective was to compare observed, with recommended physical activity levels. Widely recommended physical activity minimums, agreed upon by several leading health and fitness authorities (2, 32, 51, 67, 73), encourage adults to accumulate at least 30 minutes of moderate-intensity, aerobic activity on most days of the week. This volume of physical activity has been equated to an approximate energy expenditure (EE) of 150 kilocalories per day ($kcal \cdot d^{-1}$) or 1,000 $kcal \cdot wk^{-1}$ (2). Resistance, flexibility, and balance exercises are recommended at least two days per week (2). It was hypothesized that AVG play would significantly increase participants' heart rate (HR), oxygen consumption (VO_2), and EE above the resting state, and that responses would vary among the four different Wii Fit™ activity categories (yoga, balance, aerobics, strength).

METHODS

Participants

Twenty volunteers were recruited from the university population for the YP (5M, 5F) and OP (5M, 5F) groups. The YP group consisted of university students, while the OP group consisted of seven faculty or staff members and three community volunteers. All volunteers underwent pre-participation health screening and were deemed free from conditions that would be aggravated by, or limit participation in Wii Fit™ play, involving upper, lower, and core body movements. During the initial screening participants were also asked to describe their playing experience with Nintendo® Wii™ gaming systems. Both YP and OP included five participants who had previously played games on Nintendo® Wii Fit™ or Wii Sports™, and five who had only seen others play (i.e., friends, grandchildren, etc.). All volunteers were familiarized with the study's procedures and provided written informed consent prior to participation. The study protocol was approved by the institutional review board at Youngstown State University.

Protocol

Each participant completed one experimental trial, which lasted approximately 2.5 hours. Participants arrived at the Youngstown State University Exercise Science Laboratory, having abstained from alcohol for at least 48 hours, caloric intake for at least three hours, and caffeine, nicotine, and strenuous physical activity on the day of the test. Upon arrival, they changed into shorts, t-shirts, and socks, to minimize metabolic effects of clothing during the trial, and underwent height and weight measurements. They were fitted with a Polar® HR monitor (Polar Electro Inc., Lake Success, NY), a Yamax® SW-701 Digi-Walker™ pedometer (Yamax USA, Inc., San Antonio, TX), and a face mask for the MedGraphics™ VO2000 Portable Metabolic System (Medical Graphics Corporation, St. Paul, MN). The lightweight (<1 kg) metabolic system, which attaches to the torso, enables the measurement of oxygen consumption (VO_2) during relatively unrestricted movement. The system was calibrated according to the manufacturer's instructions prior to each experimental trial. The pedometer was positioned on the right hip, above the anterior mid-line of the thigh, according to manufacturer illustrations.

All participants rested quietly for 10 minutes, in the supine position with the room lights dimmed, before resting HR and VO_2 were measured for 15 minutes. VO_2 was measured at 10-second intervals, and HR every minute, to obtain mean and peak values. Ambient temperature was maintained between 22 and 25° Celsius.

After resting measurements, participants played AVGs for four 15-minute bouts, each using a different Wii Fit™ activity category. The order of bouts was randomized and each consisted of three five-minute sub-segments of three games, indicated here: 1) yoga (Warrior, Tree, Standing Knee), 2) balance (Ski Slalom, Table Tilt, Balance Bubble), 3) aerobics (Advanced Step, Super Hula Hoop, Rhythm Boxing), and 4) strength (Single-Leg Extension, Plank, Rowing Squat). Before play, participants were briefly familiarized with all component games. During play, they were given periodic verbal encouragement and were cued to switch games at the five- and 10-minute marks. Once any game within a five-minute sub-segment ended, participants immediately restarted it, to maximize activity. VO_2 was measured continuously and HR every minute, to obtain mean and peak values for each 15-minute phase. Subjects were asked to indicate ratings of perceived exertion (RPE), at the mid-point of each five-minute sub-segment, and overall enjoyment level (EL) at the end of each 15-minute bout. Participants indicated RPE using Borg's original category scale (5), and EL using a modified version of Kendzierski and DeCarlo's (36) Physical Activity Enjoyment Scale (PACES; 1= "It's no fun/I hate it/I am bored," 10 = "It's a lot of fun/I love it/I am interested").

Each 15-minute bout was separated by a five-minute rest period, during which data from the portable metabolic unit was downloaded, step counts were recorded, equipment fit and function were checked and participants were provided with an opportunity to drink water and use the restroom.

Statistical Analysis
Relative VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$) was converted into absolute values ($L \cdot min^{-1}$) and then EE ($kcals \cdot min^{-1}$), using the conversion constant for a mixed diet ($4.825\ kcals \cdot L\ O_2^{-1}$) (46). Metabolic equivalents (METs) were calculated by dividing relative VO_2 by 3.5 (1). For the resting phase, mean and peak values for HR ($b \cdot min^{-1}$), VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$), METs, and EE were calculated, as well as

total EE (kcal) for the 15-min period. For the activity phases, the same parameters were quantified, along with mean RPE, total step counts, and overall EL. Heart rate reserve (HRR) values were calculated as the difference between individuals' mean resting HR and age-predicted maximum HR (220-age) (2, p. 160), and percent HRR (%HRR) as: {[(Wii Fit™ HR_{mean} – resting HR)/HRR] x 100}. Results are expressed as means and standard deviations (mean±SD).

Independent samples *t* tests were used to compare descriptive statistics between YP and OP, and mixed-design analyses of variance (ANOVA) to analyze HR, VO_2, EE, RPE, EL, and step count variables. A two-group mixed ANOVA was performed with *group* (YP, OP) as the between-subjects factor, and *activity* (rest, yoga, balance, aerobics, strength) as the within-subjects factor. Where significant main effects were found, post-hoc pairwise comparisons were investigated. Data analysis was performed using PASW Statistics 18.0 (SPSS; Chicago, IL), with statistical significance set at $P \leq 0.05$.

RESULTS

Descriptive characteristics of the 20 participants are presented in Table 1. There were no significant differences between groups, except in age (YP: 21.4±2.3 y; OP: 58.0±6.58 y; P<0.05).

HR and EE

The two-way mixed factor ANOVA showed significant activity main effects ($P<0.001$; Table 2) for HR_{mean} (F=35.61), HR_{peak} (F=37.27), EE_{mean} (F=21.67), EE_{peak} (F=19.02), and EE_{total} (F=21.69), with post-hoc tests showing all variables to be higher during aerobics and strength than during yoga and balance ($P<0.001$; Table 2). All activity-related HR and EE measures were significantly higher than resting values ($P<0.001$). There were no significant between-groups differences for HR_{mean} (YP: 99.49±21.61; OP: 96.08±20.55 b·min^{-1}), HR_{peak} (YP: 112.46±27.49; OP: 109.36±26.58 b·min^{-1}), EE_{mean} (YP: 2.21±1.21; OP: 2.34±1.19 kcals·min^{-1}), EE_{peak} (YP: 3.24±1.79; OP: 3.47±1.94 kcals·min^{-1}), or EE_{total} (YP: 33.21±18.10; OP: 35.07±17.80 kcal), and no significant interactions.

Table 1. Mean (SD) descriptive characteristics of young (YP) and older adult (OP) participants.

	YP (n=10)	OP (n=10)
Age (yrs) *	21.4 ± 2.27	58.0 ± 6.58
Height (m)	1.7 ± 1.2	1.7 ± 0.9
Weight (kg)	84.1 ± 20.77	83.8 ± 14.95
BMI (kg·m^{-2})	27.9 ± 5.27	29.4 ± 3.82

* $P<0.05$

Heart Rate Reserve

During Wii Fit™ activity, %HRR was significantly higher ($P<0.01$) in OP (39.7%) than in YP (28.8%; Figure 1). There was also a significant activity main effect (F=4.39; $P<0.01$), with post-hoc tests showing that that %HRR was significantly higher during aerobics and strength than yoga and balance ($P<0.05$; Table 2). There were no significant interactions.

VO_2

The two-way mixed factor ANOVA revealed a significant activity main effect for VO_{2mean} (F=43.42; $P<0.001$) and VO_{2peak} (F=34.63; $P<0.001$; Table 2). Participants'

VO_{2mean} and VO_{2peak} were significantly higher during aerobics and strength than during yoga and balance ($P<0.001$), and were significantly lower during strength than aerobics ($P<0.01$). All activity-related VO_2 measures were significantly higher than resting values ($P<0.001$). There were no significant between-groups differences for VO_{2mean} (YP: 5.37±2.43; OP: 5.75±2.65 ml·kg^{-1}·min^{-1}) or VO_{2peak} (YP: 7.84±3.57; OP: 8.55±4.40 ml·kg^{-1}·min^{-1}), and there were no significant interactions.

METs

Analyses revealed that there was a significant activity main effect ($P<0.001$;

Table 2. Mean (SD) heart rate (HR), percent heart rate reserve (%HRR), oxygen consumption (VO2), metabolic equivalents (METs), energy expenditure (EE), rating of perceived exertion (RPE), enjoyment level (EL), and step counts for Wii Fit™ activities for all participants.

	Activity			
	Yoga	**Balance**	**Aerobics**	**Strength**
HR_{mean} (b min^{-1})	99.0 ± 15.4	98.1 ± 16.5	112.5 ± 12.5 *	111.8 ± 12.7 *
HR_{peak} (b min^{-1})	109.8 ± 17.0	109.4 ± 17.6	132.9 ± 20.5 *	129.1 ± 18.8 *
%HRR	28.85 ± 16.04	27.93 ± 17.12	40.46 ± 13.41 ‖	39.75 ± 13.76 ‖
VO_{2mean} (ml kg^{-1} min^{-1})	4.79 ± 1.68	4.64 ± 1.36	8.44 ± 2.03 *	7.21 ± 1.59 †
VO_{2peak} (ml kg^{-1} min^{-1})	6.77 ± 2.26	7.00 ± 2.82	12.85 ± 3.99 *	10.24 ± 2.20 †
$METs_{mean}$	1.37 ± .48	1.33 ± 0.39	2.41 ± 0.58 ¶	2.06 ± 0.45 ‖
$METs_{peak}$	1.94 ± 0.65	2.00 ± 0.80	3.67 ± 1.14 ¶	2.93 ± 0.63 ‖
EE_{mean} (kcals min^{-1})	1.98 ± 0.91	1.90 ± 0.70	3.44 ± 1.17 *	2.95 ± 0.98 *
EE_{peak} (kcals min^{-1})	2.79 ± 1.23	2.84 ± 1.25	5.24 ± 2.10 *	4.20 ± 1.41 *
EE_{total} (kcals)	29.68 ± 13.66	28.44 ± 10.44	51.67 ± 17.54 *	44.23 ± 14.76 *
RPE (6-20)	9.57 ± 1.77	8.56 ± 1.38	11.37 ± 1.79 *	12.12 ± 2.41 *
Enjoyment Level (1-10)	6.30 ± 2.16	7.60 ± 1.96	7.40 ± 2.21	5.90 ± 2.38 §
Step Count	40.74 ± 34.06	32.05 ± 37.78	627.63 ± 188.15 ‡	33.89 ± 29.93

* $P<0.001$ different from yoga and balance activities

† $P<0.01$ different from yoga, balance, and aerobics activities

‡ $P<0.001$ different from yoga, balance, and strength activities

§ $P<0.05$ different from balance and aerobic activities

‖ $P<0.05$ different from yoga and balance activities

¶ P<0.05 different from yoga, balance, and strength activities

Table 2) for both $METs_{mean}$ (F=43.44) and $METs_{peak}$ (F=34.67). Post-hoc tests revealed that participants' MET values (mean and peak) were significantly higher during aerobics than strength, yoga, and balance (P<0.02), and that strength activities elicited higher mean and peak METs than yoga and balance (P<0.02). There was no group main effect, and no interaction effect.

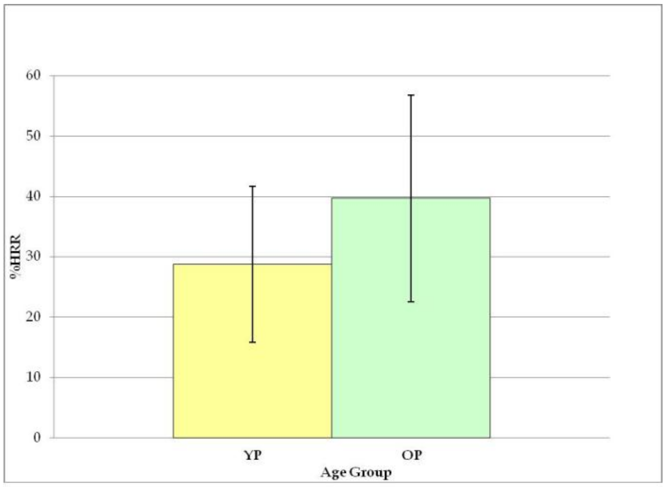

Figure 1. Mean (SD) percent heart rate reserve (%HRR) of young (YP) and older (OP) participants during Wii Fit™ activities. Group values are significantly different at the P<0.01 level.

RPE

There was a significant activity main effect for RPE (F=19.54; P<0.001; Table 2), with post-hoc tests revealing significantly higher RPEs for aerobics and strength compared to yoga and balance (P<0.001). There was also a group main effect for RPE (F=24.71; P<0.001; Figure 2), with OP reporting significantly higher RPE for the Wii Fit™ activities as a whole compared to YP (OP: 11.32±2.25; YP: 9.49±2.04; P<0.001). No significant interactions emerged.

Step Count

There was a significant activity main effect for step count (F=165.87; P<0.001; Table 2), with post-hoc analyses indicating that aerobics elicited a significantly greater step count than yoga, balance, and strength (P<0.001). No group main effect (YP: 182.28±15.26 steps·min^{-1}; OP: 184.82±16.47 steps·min^{-1}), and no interactions emerged.

Enjoyment Level

There was a significant activity main effect for EL (F=2.84; P<0.05; Table 2), with the participants, as a whole, finding the strength activities to be less enjoyable than the balance and aerobics activities (P<0.05). There was no group main effect (YP: 7.03±2.12; OP: 6.57±2.40), and there were no interactions.

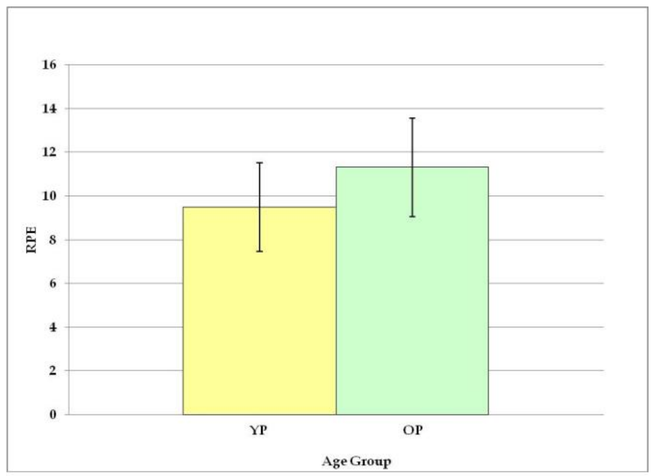

Figure 2. Mean (SD) rating of perceived exertion (RPE) of young (YP) and older (OP) participants during Wii Fit™ activities. Group values are significantly different at the P<0.001 level.

DISCUSSION

The present study examined physiological and perceptual responses in YP and OP engaging in Nintendo® Wii Fit™ AVG play. Results support the hypotheses that AVG play would significantly increase participants' HR, VO_2, and EE above the resting state, and that Wii Fit™'s four activity modes would differentially affect these parameters. All four modes, for all participants, elevated HR, VO_2, and EE significantly above rest, with the aerobics and strength activities stimulating greater responses than yoga and balance. The findings of significant increases in HR, VO_2, and EE above rest are in accord with several other AVG studies (6, 25-28, 39, 44, 48, 50, 66), and could have meaningful implications for some individuals, in terms of cardiovascular health and weight management.

In terms of %HRR, the aerobics (40.5%) and strength (39.8%) activities were significantly more intense for all participants than yoga (28.9%) and balance (27.9%), and the activities as a whole were more intense for OP (39.7%) than for YP (28.8%). Relative to American College of Sports Medicine (ACSM) (2) recommendations that exercise be at least as intense as 40%-<60%HRR to promote health and fitness benefits, the overall intensity of Wii Fit™ game play was low for YP, but approached recommended levels for OP. The aerobics (45.6%HRR) and strength (44.8%HRR) games, for OP, did elicit intensities within the recommended range. Notwithstanding recommendations, it is important to note that, while the ACSM encourages striving towards greater intensities of activity, on the basis of the "positive continuum of health/fitness benefits with increasing exercise intensity," (p.155) it also recognizes that those as low as 30%HRR may benefit those who engage in "no habitual activity" (p. 166). Thus, while the AVG-induced effects on HR were modest, they could still help those with low initial fitness levels improve cardiorespiratory health.

Perceived effort involved in AVG play largely mirrored the %HRR results, with all participants reporting greater RPE during the aerobics (11.4) and strength (12.1) activities, than during yoga (9.6) and balance (8.6), and with OP (11.3) perceiving the games, as a whole, to require more effort than YP (9.5). To our knowledge, this is the first report of a difference in RPE between young and older adults playing the same AVGs. In light of some reports of inverse relationships between physical activity intensity and adherence (11, 40, 55), a greater sense of effort could have implications for continued participation. However, while OP rated the exergaming as more difficult than YP, their overall RPE rating still only corresponds to "light" on Borg's scale (5).

Another common means of classifying physical activity intensity uses MET values as follows: <3 METs = light, 3-6 METs = moderate, >6 METs = vigorous (32). Current, widely endorsed recommendations state that adults should strive to accumulate at least 30 minutes of moderate-intensity physical activity on most days of the week (2, 32, 51, 67, 73). In the present study, no gaming mode, for either age group, elicited mean intensities within the moderate range of 3-6 METs. The highest mean MET values were achieved during the aerobics activities, with YP and OP averaging 2.3 METs and 2.5 METs, respectively. However, both the aerobics and strength activities elicited peak MET values within or very near the moderate-intensity range ($YP_{aerobic}$: 3.5±0.99; $OP_{aerobic}$: 3.9±1.29; $YP_{strength}$: 3.0±0.73; $OP_{strength}$: 2.9±0.54), indicating the potential to meet recommendations using some Wii Fit™ activities. Note that as players practice games over longer periods of time, they are likely to reach more advanced skill levels, which, in some Wii Fit™ games, involves performing movements at faster paces and for longer durations.

Previous findings have been mixed, as to the efficacy of AVG play for meeting physical activity recommendations. Graves et al. (26) examined adolescents, young adults, and older adults, and reported that, for all groups, Wii Fit™ aerobics elicited EEs greater than 3.0 METs (adolescents 3.2±0.7, young adults 3.6±0.8, older adults 3.2±0.8), but not yoga, balance, or strength. Guderian et al. (28) studied middle-aged and older adults, and found that all three games chosen from the aerobics category elicited EEs greater than or equal to 3.0 METs, but only one of three selected balance games. Miyachi et al. (50), using metabolic chamber technology, examined 12 men engaging in 18 yoga, 16 balance, 14 aerobics, and 15 strength activities using Wii Fit Plus™, and found 46 (67%) activities to qualify as light-intensity, 22 (33%) to qualify as moderate, and none to qualify as vigorous.

With research classifying many exergaming activities as light-intensity, it is important to recognize that individuals who fall short of accumulating recommended levels of physical activity can still reap considerable health benefits by spending significant amounts of time engaged in light activities. Numerous studies have associated light-intensity physical activity with health benefits, including all-cause mortality. Woodcook et al. (72), in a recent meta-analysis, reported that spending approximately seven hours per week in light- and moderate-intensity physical activity was associated with 24% lower mortality rates than inactivity. Others have associated light physical activity with favorable blood lipid (56), blood pressure (10), and blood glucose profiles (33, 45), with improvements in muscular strength, gait, balance, and measures of functional independence (16), with psychosocial well-being (7), with lower barriers to participation (8), and with lower risks of gaining weight (35, 43), of sustaining musculoskeletal injuries (34), of exacerbating hypertension (68), and of developing type 2 diabetes (15). Light-intensity programming may be most important for those who can tolerate and adhere to it better than higher-intensity programming, such as those with fibromyalgia (9), peripheral arterial disease (4), COPD (14, 53), obesity (52), total joint replacements (38), and other limiting conditions. Powell et al. (57), elaborating on the dose-response relationship between physical activity and health benefits, stated that, “there is no lower threshold for benefits,” and that the, “belief that a threshold of activity must be achieved before benefits accrue is common but inaccurate” (p. 353). They added that, since “the rate of risk reduction is greatest at the lowest end of the activity scale,” and since large population subgroups are habitually inactive, even slight increases in activity levels can yield substantial health benefits.

It is difficult to make generalizations about the physiological responses to AVG play, not only because of variable research findings, but also because responses may vary with differences between gaming systems, between games within a given system, between skill settings within a given game, and between skill levels and movement techniques of individual players. With respect to different skill settings, Worley et al. (74) showed that oxygen consumption among female college students was significantly greater during Wii Fit™ step and hula activities using the intermediate, compared to the beginner skill settings. Regarding individual skill levels, Sell et al. (62) showed that male college students with experience playing Sony®'s Dance Dance Revolution (DDR) produced significantly higher exercise HR, VO_2, EE, RPE, and steps per minute than inexperienced players. As an example of differences in movement techniques, one may register 'a punch' in rhythm boxing by vigorously moving the whole arm and shoulder girdle, or by merely using a small wrist action to move the game controller. So, although very general, perhaps most important is the consistent finding that AVG play can stimulate the cardiovascular and musculoskeletal systems, and can increase EE above resting levels (6, 25-28, 39, 44, 48, 50, 66). Since sedentary screen time has been associated with increased risk for cardiometabolic disease, independent of physical activity levels (3, 13, 65), the conversion of any such screen time to time spent in any type of physical activity may reduce risk.

The present study's participants reported above average enjoyment of all Wii Fit™ activities, with EL scores for the combined groups ranging from 5.9-7.6, on a 1-10 scale. In this study and that of Graves et al. (26), both younger and older adults rated Wii Fit™ balance and aerobics to be more enjoyable than strength and yoga. The between-activity differences in enjoyment were not significant for Graves, but the parallels seem worth noting, since enjoyment is a key factor in physical activity affect (37, 61), or the overall sense of pleasure or displeasure associated with physical activity. Affect has been shown to be a significant determinant of both physical activity levels (30, 59) and physical fitness (19, 64). Salmon et al. (59) found enjoyment preferences among 1332 men and women to be significant predictors of participation in both physical and sedentary activities. Those who reported high enjoyment of physical activities were more likely to be physically active, while those who reported high enjoyment of sedentary activities were more likely to be inactive. In a controlled intervention study, Hagberg et al. (30) not only reported an association between enjoyment and exercise levels, but also between changes in enjoyment and changes in exercise levels. Thus, to increase physical activity among sedentary individuals, it seems important to make more types of physical activity enjoyable to them, and providing active versions of things that many already enjoy – video and computer games – may be one effective strategy.

Physical activity affect is also affected by intensity, albeit it in a complicated manner, depending on the nature of the activity, the environment in which it is performed, and the physiological and psychological characteristics of unique individuals (21, 47). Since many people, "do what makes them feel good and avoid what makes them feel bad," (20, p. 653) if individuals perceive intense physical activity as unpleasant, their adherence to programs involving it may be negatively affected. On the other hand, if they perceive intense activity as rewarding because it helps them prepare to meet future challenges and reflects diligent efforts toward achieving goals (31), it may enhance adherence. So, individuals who find exergaming in some way rewarding may continue to play, regardless of intensity. Wollersheim et al. (71) described several rewards reported by members of an older adult community health program, following a Wii Fit™ activity intervention. Participants, who were initially, "unsure of their ability to both understand the technology and to physically perform the Wii actions" (p. 88) reported developing closer relationships with other program members while playing, feeling more "technologically adept" and "connected to their grandchildren," (p. 90) and enjoying both body and mind involvement in the activities.

Exergaming can provide a means for physical activity participation within small spaces in homes, schools, locker rooms, senior centers, and rehabilitation facilities. By enabling physical activity within comfortable surroundings, at convenient times, AVG play may especially benefit adults for whom participation in group- or center-based activity programs is not feasible or desirable. Some may lack the financial means to join such programs, the transportation to attend, or the self-confidence or to participate. Miller and Miller (49), for example, found that overweight adults reported feeling more intimidated by health club exercise, more embarrassed while exercising, and more uncomfortable around fit people than those of normal weight. Home activity programs can provide non-threatening means to improve fitness and, once fitness improves, individuals may feel more confident to exercise in other venues. At the recent American Heart Association/Nintendo® of America-sponsored summit on the health promotion power of exergaming, leaders agreed that an emphasis-worthy advantage of AVG play is its potential to serve, for some, as a "gateway" to more active lifestyles, by increasing fitness, skills, confidence, and exposure to elements of real sports and recreational activities (41).

There are a number of factors that could mediate the health effects of AVG play, which call for further research. While the intent is that it consistently displaces more sedentary behaviors, like traditional video gaming, it could also displace more vigorous exercise behaviors, like sports participation or workout sessions. Play with some companions could increase active time, through fun interaction and dissociation from effort (42), while play with highly competitive others could decrease it (more skilled players play longer). In some settings, players could consume more-than-usual snacks while exergaming; in others, AVG play could interrupt habitual snacking. As with all types of physical activity, continued benefits of AVG play will depend on safety and regular participation. While generally viewed as safe, Shubert (63) has expressed concern over the risk of falls during Wii Fit™ play, particularly for older adults, due to the narrow dimensions and lightweight nature of the Wii Fit™ balance board, which make it easy to tip. It should also be noted that Nintendo® recommends a maximum weight of 150 kg (330 lbs) on the balance board, thereby rendering inadvisable its use by many potential beneficiaries of Wii Fit™ activities. Finally, since history shows that video game systems become quickly outdated by new ones (17), how long AVG systems will remain popular is unknown.

In summary, Nintendo® Wii Fit™ play by both young and older adults can stimulate the cardiovascular and musculoskeletal systems, increase energy expenditure, and provide an enjoyable means of accumulating a substantial amount of light-intensity physical activity. While leading health authorities strongly advocate regular engagement in moderate-intensity physical activities, they also recognize the healthful effects of light-intensity activities, especially where they displace sedentary activities, contribute to a substantial total daily dose of activity, and enable physical activity among those who are either unable or unwilling to participate at higher intensities. In summary, Wii Fit™ game play is popular and pervasive, and it provides a fun, convenient strategy for reducing sedentary screen time. It seems to provide one more means of increasing physical activity, within a modern society desperately in need of it.

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