

The Physical Activity Energy Cost of the Latest Active Video Games in Young Adults

Cheryl A. Howe, Marcus W. Barr, Brett C. Winner, Jenelynn R. Kimble, and Jason B. White

Background: Although promoted for weight loss, especially in young adults, it has yet to be determined if the physical activity energy expenditure (PAEE) and intensity of the newest active video games (AVGs) qualifies as moderate-to-vigorous physical activity (MVPA; > 3.0 METs). This study compared the PAEE and intensity of AVGs to traditional seated video games (SVGs). **Methods:** Fifty-three young adults (18–35 y; 27 females) volunteered to play 6 video games (4 AVGs, 2 SVGs). Anthropometrics and resting metabolism were measured before testing. While playing the games (6–10 min) in random order against a playmate, the participants wore a portable metabolic analyzer for measuring PAEE (kcal/min) and intensity (METs). A repeated-measures ANOVA compared the PAEE and intensity across games with sex, BMI, and PA status as main effects. **Results:** The intensity of AVGs (6.1 ± 0.2 METs) was significantly greater than SVGs (1.8 ± 0.1 METs). AVGs elicited greater PAEE than SVGs in all participants (5.3 ± 0.2 vs 0.8 ± 0.0 kcal/min); PAEE during the AVGs was greater in males and overweight participants compared with females and healthy weight participants (p 's $< .05$). **Conclusions:** The newest AVGs do qualify as MVPA and can contribute to the recommended dose of MVPA for weight management in young adults.

Keywords: exergaming, physical activity, obesity, accelerometry

The transition from high school to college can be a pivotal period of time in the lives of young adults, especially with the customary weight gain during the college years. Some of this weight gain has been affectionately quantified as the “freshman 15” or the “sophomore 20.” The average weight gain by college students ranges from as little as 8.1 lb in the freshman year¹ to as much as 36.7 lb for a 4-year degree.² This weight gain can persist throughout a student's college career, including graduate school, resulting in approximately 35% of students being overweight.^{3,4} This level of weight gain is significantly greater than that of the general population of relatively the same age.^{2,5}

The explanation for weight gain in college is not exactly clear, but researchers propose the reduction in physical activity (PA) as a possible explanation. PA has been shown to decrease 24% from high school to college,⁶ and has been negatively associated with weight gain in this population as indicated by self-report questionnaires.^{1,7} A recent study of 101 women makes a case for inadequate PA as a possible explanation for weight gain while in college.⁷ Even though total caloric intake decreased over the 12-month study, some women still experienced weight gain, which they attributed to the concomitant reduction in physical activity energy expenditure (PAEE).⁷

Along with a decrease in PA, the transition from high school to college has also been associated with an increase in sedentary activities.⁸ In college, a considerable amount of time is spent sitting in the classroom and studying. A 2008 study measured the amount of electronic game play in 209 college students (18 to 32 y) to find that, on average, they spent 10 h/wk playing video games, with a small percentage (8.5%) of students playing up to 35 h/wk.⁹ Other studies have found that 39% of surveyed college students reported playing video games for more than 2 h/wk, and that the mean time spent playing video games was 8.5 ± 12.2 h/wk.^{10,11} This time that

college students devote to video games provides an opportunity for PA if they would replace the traditional seated games with a more active substitute.

According to the 2008 PA guidelines,¹² acquiring 2.5 to 5 h/week (150 to 300 min/wk) of moderate-to-vigorous PA (MVPA; > 3 METs) is recommended for provoking substantial health benefits, including weight management, in young adults. The question remains as to whether the latest version of active video games (AVGs), specifically the newest Xbox 360 Kinect (Microsoft, Redmond, WA) games, elicit sufficient PAEE to qualify as MVPA and contribute to this recommended dose. Previous studies on older AVGs versions have reported mixed results. One such study determined the energy cost of 19 college males playing Dance Dance Revolution (DDR; Konami Digital Entertainment, El Segundo, CA) was equivalent to MVPA (4.8 to 10.5 kcal/min). DDR requires the player to step on a large floor mat to the beat of the music. It was found that greater DDR experience, where players achieved higher levels within the game and therefore experienced faster music, positively influenced energy expenditure.¹³ While DDR is still available for the newer gaming consoles (eg, Wii, PS2, and Xbox 360 Kinect), the game is limited to repetitive stepping and does not take into account upper body movements.

Unlike DDR, the Nintendo Wii system (Nintendo, Kyoto, Japan) requires interaction with either a wireless handheld controller or a balance board to play the games. The Wii console estimates the movements of the entire body by tracking the location and movement of the triaxial accelerometer contained within the handheld controller or by detecting changes in the center of pressure from the player performing exercises on the balance board. Either way, this system merely presumes the movement patterns of the whole body from a single point rather than measuring the actual movements, thus presuming the energy cost of the games. The energy cost of playing the Wii handheld games was only 1.1 ± 0.1 METs in young adults (21–38 y) and therefore did not qualify as MVPA.¹⁴ It was also found that the Wii balance board games (eg, yoga, balance,

Howe (howec@ohio.edu), Barr, Kimble, and White are with the School of Applied Health Sciences and Wellness, Ohio University, Athens, OH. Winner is with Healthways, Columbus, OH.

muscle conditioning, and aerobics) ranged in PA intensity from light to moderate intensity, with only Wii aerobics being classified as MVPA (3.6 ± 0.8 METs).¹⁴ The low energy cost of the Wii games stems from the more experienced player “cheating” the system by learning to play the games with less and less movement.¹⁵

The gaming industry has taken this “cheating” potential into account and has made significant advances in gaming technology. Rather than using a floor mat or a handheld controller to estimate the body’s movements, as in DDR or the Nintendo Wii console, the Xbox 360 Kinect gaming console uses a 2-camera system to identify and track the movements of the whole body to achieve the objectives of each game.^{16,17} The Kinect system is identified as the first generation of whole-body interactive gaming. Studies have shown that incorporating whole-body movements while playing AVGs is necessary to elicit sufficient PAEE to be classified as MVPA.^{18,19} Although, the energy cost of playing these interactive games on the Kinect system has yet to be quantified (PAEE) or qualified (METs). This study first measured the PAEE of playing Xbox 360 Kinect games compared to traditional seated video games (SVGs) in young adults. Once quantified, the average intensity of each game was classified to determine if playing AVGs on the Xbox 360 Kinect could contribute toward the recommended dose of MVPA for young adults.

Methods

Subject Recruitment

Graduate and undergraduate students (18–35 y) were recruited to participate in this study. Eligible students were those considered apparently healthy, operationally defined as free from cardiovascular, pulmonary, and metabolic diseases or physical injuries, and currently not taking any medications that would affect metabolism, appetite, blood pressure, or heart rate. Before participating, all subjects read and signed the informed consent documents approved by the university’s institutional review board.

Participants were recruited in pairs, preferably with a friend, classmate, roommate, teammate, or spouse. This pairing was done to give participants the option to choose their own playmate in an attempt to create a similar social atmosphere to their living room or dorms where these games would normally be played. The pair of participants reported to the Resting Metabolism Laboratory for 2 separate visits. During one visit they served as the measured participant (MP) and during the other visit they served as the non-measured playmate (NP).

Game Selection

Before conducting the study, a menu of popular SVGs and AVGs was selected from the available games on the market. To aid in the selection of popular video games, all students enrolled in the same large state university were invited to take part in an anonymous online survey. A link to the online survey, which was approved by the university’s institutional review board, was sent in a campus-wide e-mail announcement. The survey included questions about general video game use as well as how often the student played each game from a list of 30 popular Xbox 360 (SVG) and Xbox 360 Kinect (AVG) video games. Of the 1021 responses to this online survey, 59.8% reported playing video games at least 1 to 2 times per week. The percentage of student responders who played each game at least once ranged from 0.7% (least popular) to 29.3% (most popular). From the list of over 30 games, *Madden NFL 12* (Electronic Arts,

Redwood City, CA) was the most popular traditional SVG and was matched with a similar Kinect version of the game, *Kinect Sports Football* (Microsoft, Redmond, WA). *Kinect Adventures! Reflex Ridge* (Microsoft, Redmond, WA) was matched with a similar SVG racing game, *Sonic Racer* (Sega, Tokyo, Japan). The remaining two Kinect games included the popular dance game, *Dance Central 2* (Harmonix, Cambridge, MA), and the fitness game, *Zumba Fitness* (Majesco Entertainment, Edison, NJ).

Resting and Anthropometric Measures

All measurements for the study were performed by trained research assistants. Before each visit, both participants were asked to follow the standard resting metabolic rate (RMR) protocol: fast for 4 hours (avoid all caffeine, nicotine, and food or beverage products, except for water) and abstain from exercise for at least 8 hours.²⁰ If pretesting requirements were met, both participants were asked to complete a paper version of the online video game use survey, as described above, and the Physical Activity Status (PAS) questionnaire.²¹ The PAS questionnaire is a 0 to 7 scale (sedentary to very active) that corresponds to a person’s PA level over the past month and is valid for this population. These questionnaires were used to categorize the participants’ game use and overall activity levels.

After the paperwork was complete, the MP was asked to relax in a supine position in a dimmed, quiet, and temperature-controlled room for 15 minutes before measuring his/her RMR. To measure RMR, subjects were asked to breathe through a portable metabolic analyzer (MedGem, Microlife USA, Dunedin, FL) for up to 10 minutes, at which time RMR was recorded as daily energy expenditure (EE; kcal/day). The MedGem has been shown to be valid for measuring RMR compared with the gold standard Douglas bag method.²² While still in a relaxed position, resting blood pressure and heart rate were measured on the right arm using an automated device (Omron HEM-907XL, Omron Healthcare, Inc., Lake Forest, IL) as a final screening measure. The participant’s blood pressure had to be within the healthy range (below 190/80 mm Hg) to participate in the study.

Following the resting procedures, the subject’s weight was measured to the nearest 0.1 kg using a digital scale, and height was measured to the nearest 0.1 cm using a stadiometer. These measures were used to calculate the participant’s body mass index (BMI) as kg/m². BMI was then used to classify the participants as healthy weight (HW; BMI < 25 kg/m²) or overweight (OW; BMI ≥ 25 kg/m²).

Study Protocol

Following the preliminary testing, both participants were moved to a small room with 2 comfortable living room chairs and a coffee table to resemble a dorm room or apartment atmosphere. Before playing the games, the research assistant explained the instructions and objectives of each game and allowed time for the participants to watch the helpful tips provided by the Xbox 360 and Kinect games. The 6 games were played in random order for 6 to 10 minutes with at least 4 minutes rest in between; a methodology established by Freedson and colleagues.^{23–25} Each MP played against his/her chosen NP, and they were instructed to play the games as they would at home. To encourage a natural level of play during the games similar to how they would play when not being measured or observed, all participants were informed that they had the opportunity to win one of two \$50.00 gift cards; one for the highest cumulative score of all 6 games combined and one from a random drawing of all participants.

PA Energy Expenditure

During the games, the MP wore the Oxycon Mobile (Carefusion, Yorba Linda, CA) to measure total oxygen consumption. The Oxycon Mobile (OM) is a wireless, portable, breath-by-breath analyzer for measuring gas exchange that is accurate to 3% or 0.05 L/min of O₂ consumption.²⁶ The OM system consists of a face mask (Hans Rudolf, Inc., Kansas City, MO) connected to a volume sensor, a gas analyzer (Sbx), and a data storage device (Dex). The system fits into a small backpack worn by the MP that allows freedom of movement during the games. The data from the OM system was collapsed using an established protocol, with all valid data points for each student for each game used in the analyses, excluding the first minute and the last 10 seconds of play time.^{23,25} The remainder of play time (ie, 4:50–8:50) of OM data were used to calculate the average total oxygen consumption (VO₂; ml/kg/min) and EE (kcal/min) for each game. Physical activity oxygen consumption (PAVO₂) for each game was calculated as the average total VO₂ (ml/kg/min) minus the measured RMR for each student. Similarly, PAEE (kcal/min) for each game was calculated as total EE – RMR for each student. The MET value for each game was calculated as total VO₂/RMR for each student.²⁵ The MET was then used to classify the PA intensity according to the standard cut-points as light (< 3.0 METs), moderate (3.0 to 5.9 METs), or vigorous (≥ 6.0 METs) intensity.²⁷ Heart rate was measured using the Polar RS400 (POLAR Electro Inc., Lake Success, NY). Heart rate was recorded in 1-second intervals and averaged over the same time period as the OM data for each game.

PA Level

During the games, the MP also wore an accelerometer (GT3X+, ActiGraph, Pensacola, FL) on the right hip to measure PA levels. The GT3X+ is a triaxial accelerometer that measures acceleration (g) in all 3 planes of human movement: vertical, anteroposterior, and mediolateral.²⁸ Using ActiLife software (version 6.5.3), the GT3X+ was initialized to record activity at a sampling rate of 30 Hz and downloaded in 1-second epochs. Using the same time-stamp as the metabolic data, excluding the first minute and the last 10 seconds of play time, the remaining data from the vertical axis were used to

calculate the average counts/min for each game. The average counts/min were compared with established cut-points to classify the PA of each game as light (< 1952 counts/min), moderate (1952–5724 counts/min), and vigorous (> 5724 counts/min) intensity.²⁹

Data Analysis

A general linear model ANOVA was performed to determine if subject characteristics differed between sex and BMI groups. A repeated-measures ANOVA was used to compare PAEE and PA intensity (kcal/min and METs, respectively) with sex and BMI classification, and PAS as main effects for all games combined and by game type (AVGs vs SVGs). The significance was set at $P < .05$.

Results

Participant Characteristics

Sixty-four young adults were enrolled in the study between January and August 2012 from a local university. Of this enrollment, 7 students served only as a NP and were not able to schedule a second visit to serve as the MP (no metabolic data), while 4 students were not able to participate in any portion of the study due to scheduling conflicts. The remaining 53 students (21.8 ± 1.9 y) completed the MP visit to be included in the analyses for a total of 318 game sessions (53 MP $\times$ 6 games). The MP characteristics are reported in Table 1. The study sample represented a range of academic years (sophomore [9.4%]; junior [24.5%]; senior [45.3%]; and graduate students [20.8%]), an even sample of men (49%) and women (51%), and a representative sample of HW (71.7%) and OW (28.3%) participants. The students enrolled in the study also represented the racial profile of the university (87.6% white) with 92.4% of the students reporting their race as white and the remaining students either reported their race as Asian or other. It should also be noted that the average self-reported PAS score was 5.15 ± 1.7 on a 0 to 7 scale, indicating a more active group of participants. The sample population also represented a range of video game use, with 57% reported playing once a month or less and 43% reported playing at least once a week.

Table 1 The Physical Characteristics of the Study Participants

Sample Size	All Participants N = 53	Male n = 26	Female n = 27	HW n = 38	OW n = 15
Age (y)	21.8 $\pm$ 1.9 (19–28)	22.0 $\pm$ 1.8 (20–28)	21.5 $\pm$ 2.0 (19–28)	21.7 $\pm$ 1.7 (19–28)	22.0 $\pm$ 2.3 (19–28)
Weight (kg)	70.2 $\pm$ 12.7 (46.5–100.9)	79.0 $\pm$ 9.1 ^a (62.3–100.9)	61.7 $\pm$ 9.7 ^a (46.5–81.9)	65.6 $\pm$ 10.4 ^b (46.5–82.1)	81.9 $\pm$ 10.7 ^b (61.7–100.9)
Height (cm)	171.2 $\pm$ 10.0 (151.2–189.7)	178.8 $\pm$ 5.8 ^a (167.1–189.7)	164.0 $\pm$ 7.3 ^a (151.2–177.4)	170.5 $\pm$ 9.9 (151.2–188.2)	173.2 $\pm$ 10.1 (153.2–189.7)
BMI (kg/m ²)	23.8 $\pm$ 2.7 (19.6–32.8)	24.7 $\pm$ 2.7 ^a (19.9–32.8)	23.0 $\pm$ 2.5 ^a (19.6–27.9)	22.4 $\pm$ 1.5 ^b (19.6–25.0)	27.2 $\pm$ 1.8 ^b (25.4–32.8)
RMR (kcal/day)	1498 $\pm$ 331 (870–2560)	1706 $\pm$ 273 ^a (1090–2560)	1297 $\pm$ 250 ^a (870–1860)	1447 $\pm$ 280 (910–2000)	1626 $\pm$ 419 (870–2560)
PAS score	5.2 $\pm$ 1.7 (1–7)	5.7 $\pm$ 1.3 ^a (3–7)	4.7 $\pm$ 1.9 ^a (1–7)	5.2 $\pm$ 1.7 (1–7)	4.9 $\pm$ 1.6 (1–7)

Note. Means $\pm$ SD (min–max). HW = healthy weight (BMI < 25 kg/m²); OW = overweight or obese (BMI $\geq$ 25 kg/m²); BMI = body mass index; RMR = resting metabolic rate; PAS = physical activity status.

^a Significantly different between male and female students.

^b Significantly different between HW and OW students.

PA Energy Expenditure

The PAEE results are reported in Table 2. The intensity of all the games combined (AVGs + SVGs) was classified as moderate PA (4.6 ± 0.2 METs; Figure 1) and elicited a PAEE of 3.8 ± 0.2 kcal/min (Figure 2). The intensity of the AVGs combined was classified as vigorous PA (6.1 ± 0.2 METs), significantly greater than the light PA (1.8 ± 0.1 METs) of the SVGs in all subjects. When considered separately, the *Kinect Sports Football*, where subjects are required to take turns, elicited the lowest intensity (3.8 ± 0.1 METs) of the 4 AVGs measured.

Males elicited greater PAEE than females for all games (4.63 ± 0.3 vs 2.99 ± 0.2 kcal/min; $P < .05$), but when corrected for

individually-measured RMR (METs) only *Zumba Fitness* remained significantly different between males and females ($P = .04$). OW students also expended more PAEE than HW students (6.5 ± 0.4 vs 4.8 ± 0.2 kcal/min; $P < .05$) while playing all of the AVGs, but only for *Zumba Fitness* and *Dance Central 2* when expressed as METs ($P < .05$).

PA Level

According to established cut-points for accelerometry,²⁹ the SVGs *Sonic Racer* and *Madden NFL 12* were classified as sedentary PA (< 100 counts/min), with the counts/min ranging from 5 to 14 counts/min for both games. In contrast, 3 of the 4 AVGs (*Dance Central 2*,

Table 2 The Energy Cost of the Games

	N	Time	Heart Rate	PAEE		PAVO ₂
		(min)	(b/min)	(METs)	(kcal/min)	(ml/kg/min)
All activities	318	6.2 ± 0.1	111.0 ± 1.7	$4.6 \pm 0.2^{a,c}$	$3.8 \pm 0.2^{a,b,c}$	$11.0 \pm 0.4^{a,b}$
Sedentary games	106	5.8 ± 0.1	83.1 ± 1.7	1.8 ± 0.1	$0.8 \pm 0.0^{b,c}$	2.3 ± 0.1
Sonic Racer	53	5.3 ± 0.1	86.1 ± 2.5	1.8 ± 0.1	0.9 ± 0.1^b	2.5 ± 0.1
Madden NFL 12	53	6.4 ± 0.2	80.1 ± 2.3	1.8 ± 0.1	0.8 ± 0.1^b	2.1 ± 0.1^b
Active games	212	6.3 ± 0.1	124.9 ± 1.8	6.1 ± 0.2^c	$5.3 \pm 0.2^{b,c}$	15.4 ± 0.4^b
Kinect Sports Football	53	6.7 ± 0.2	100.7 ± 2.9	3.8 ± 0.1	$2.9 \pm 0.2^{b,c}$	8.4 ± 0.3
Dance Central 2	53	5.4 ± 0.1	128.0 ± 3.1	6.0 ± 0.2^c	$5.3 \pm 0.3^{b,c}$	15.4 ± 0.5^b
Reflex Ridge	53	6.0 ± 0.1	132.0 ± 3.1	7.0 ± 0.3	$6.2 \pm 0.3^{b,c}$	18.1 ± 0.7
Zumba Fitness	53	7.2 ± 0.2	138.8 ± 3.0	$7.4 \pm 0.3^{b,c}$	$6.8 \pm 0.4^{b,c}$	19.6 ± 0.7^b

Note. Means $\pm$ SEE. PAEE = physical activity energy expenditure; PAVO₂ = physical activity oxygen consumption (above resting). Sample size (N) = participants $\times$ number of games played.

^a Significantly different between game type (active vs sedentary games).

^b Significantly different between males and females.

^c Significantly different between overweight and healthy weight young adults.

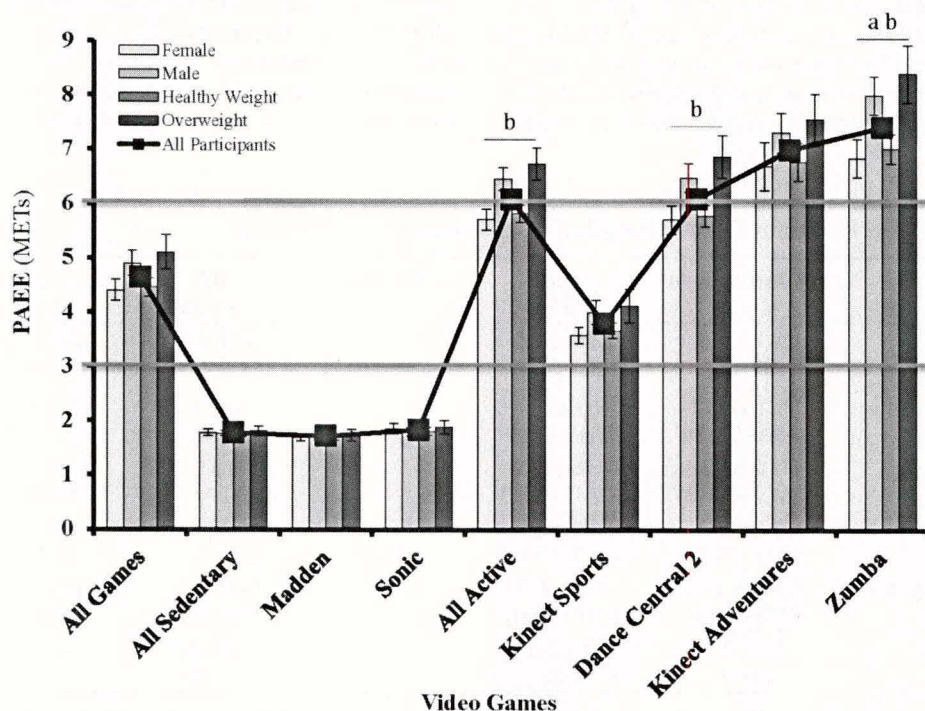


Figure 1 — The average PAEE (METs) for all of the games, active video games vs seated video games, and for all games separately (mean $\pm$ SEE). PAEE = physical activity energy expenditure. ^a Significant difference between males and females. ^b Significant difference between healthy weight and overweight students ($P < .05$).

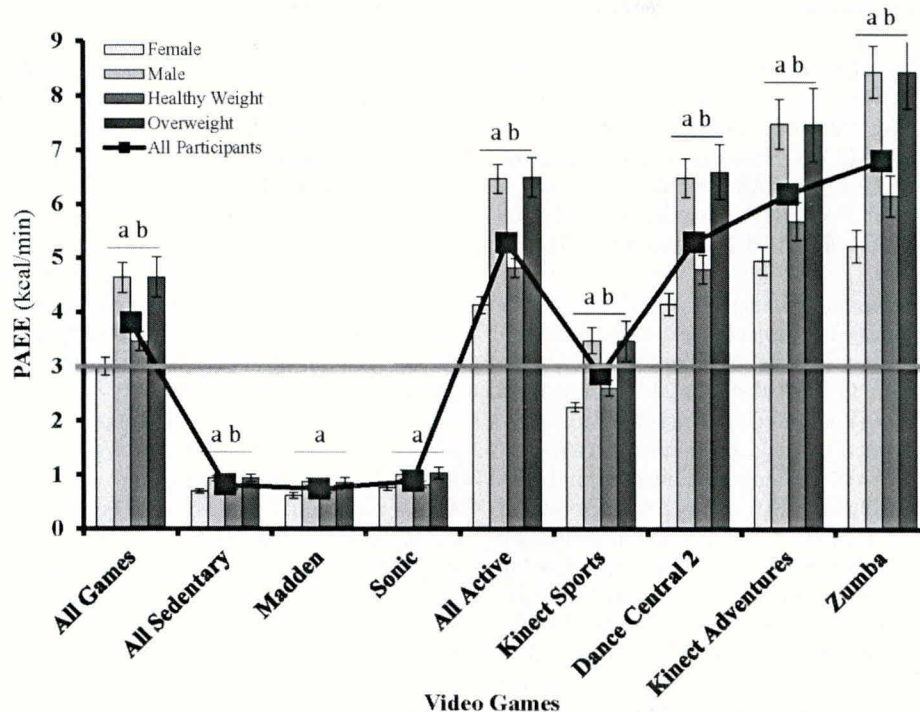


Figure 2 — The average PAEE (kcal/min) for all of the games, active video games vs seated video games, and for all games separately (mean $\pm$ SEE). PAEE = physical activity energy expenditure. ^a Significant difference between males and females. ^b Significant difference between healthy weight and overweight students ($P < .05$).

Zumba Fitness, and *Kinect Adventures! Reflex Ridge*) were classified as MVPA (> 1951 counts/min), with counts/min reported as 2527 ± 166 , 3089 ± 261 , and 4247 ± 279 counts/min, respectively. The PA level during *Kinect Sports Football* was classified as light intensity PA, with 549 ± 36 counts/min.

Discussion

Academia encourages a sedentary lifestyle that is furthered by students spending their free-time playing the traditional SVG. This study measured the energy cost of the new and popular video games available for the Xbox 360 (SVGs) and Xbox 360 Kinect (AVGs) consoles to determine if they elicit sufficient PAEE to contribute toward the recommended MVPA in young adults. The current study confirmed that SVGs (*Sonic Racer* and *Madden NFL 12*) were correctly classified as sedentary to light PA intensity. In contrast, all of the AVGs, except for one (*Kinect Sports Football*), were classified as vigorous PA (≥ 6 METs). When comparing the PAEE by game type, playing the AVGs elicited 4.5 kcal/min (86%) more than playing the SVG, with male and OW students expending more kcal/min than their female and HW counterparts. This difference between sex and BMI groups is quite probably due to the greater body mass in males and OW students. Even though female and HW students achieved lower PAEE while playing the AVGs, the intensity still met the minimum cut-point for MVPA. These data support the hypothesis that young adults can increase their MVPA simply by substituting traditional SVGs with the latest AVGs.¹²

This study revealed that AVGs that require dynamic movements of the entire body to accomplish the game objectives, such as the latest AVGs available for the new Xbox 360 Kinect consoles, contribute to the recommended dose of MVPA to help combat the

“freshman 15” and beyond. However, there is no research indicating that substituting AVGs for more sedentary options would result in the same amount of play time. It remains to be seen if young adults would play AVGs long enough to prevent the customary weight gain observed during the college years.

The results of this study were similar to a study conducted in 18 youth (11–15 y) comparing the traditional SVGs with Kinect’s *Dance Central* and *Kinect Sports Boxing* (Microsoft, Redmond, WA).³⁰ However, Smallwood and colleagues³⁰ found that the Kinect games elicited lower PAEE than the current study, with *Dance Central* (3.0 ± 1.0 kcal/min) significantly lower than *Kinect Sports Boxing* (4.4 ± 1.6 kcal/min). The lower PAEE could be attributed to the study sample being much younger than the current sample (young adults). Another study also found more modest results than the current study when comparing single and multiplayer AVGs in college students (18–30 y).³¹ The researchers classified *Kinect Adventures! Reflex Ridge* and *Wii Boxing* (Nintendo, Kyoto, Japan), in single and multiplayer modes, as light intensity (3.1 to 4.5 METs) using the newest American College of Sports Medicine cut-points for moderate intensity (4.8 to 7.1 METs) for young adults (20–39 y), whereas they would be classified as moderate intensity PA when using the more traditional MET cut-points for moderate intensity (3–5.99 METs) as in the current study. The reported range of 4.96 to 7.19 kcal/min across all the AVGs was reported as total energy expenditure (including RMR), rather than PAEE (excluding RMR), and cannot be compared with the PAEE values obtained in the current study.

It has also been reported that the Kinect games, single and multiplayer modes, elicited a greater total EE compared with playing *Wii Boxing* in both single and multiplayer modes.³¹ Considerable variability was found in the PAEE between the single player and multiplayer AVGs. This was also observed in the current study.

While playing *Kinect Sports Football*, a single player game that required the participants to take turns, when not their turn, the participants sat and watched their opponent play the game. This single player AVGs resulted in a 36.7% to 48.9% lower PAEE compared with the multiplayer AVG, eliciting an average PAEE of 2.9 ± 0.2 kcal/min (3.8 ± 0.1 METs). However, when comparing the seated versus the active portions of *Kinect Sports Football* in one representative young adult, PAEE (PA intensity) ranged from 1.6 kcal/min (1.9 METs) while seated to 8.2 kcal/min (6.0 METs) while playing the game.

The Xbox 360 Kinect system, produced by Microsoft, uses a motion-detecting infrared camera and projector to create a 3-dimensional human model to track movements of the entire body while playing the games.¹⁶ This system is a substantial advancement in the field of active video gaming compared with previous consoles. An older version of active video gaming, the Nintendo Wii console, only tracks the movement of a handheld controller and then estimates the entire body's movements from this single point of the body. Previous studies have shown that playing Wii games are comparable in PAEE to the SVGs (0.8 ± 0.04 kcal/min) measured in the current study.¹⁴ This same study found that *Wii Yoga* (Nintendo, Kyoto, Japan) was classified as light intensity PA (1.9 ± 0.4 METs) whereas *Wii Aerobics* (Nintendo, Kyoto, Japan) was classified as moderate intensity PA (3.6 ± 0.8 METs). It was also found that *Wii Aerobics*, the most physically demanding of the AVGs measured, was significantly less intense than brisk treadmill walking (4.5 ± 1.0 METs) and jogging (8.0 ± 1.2 METs). Another study by White et al found comparable results for *Wii Sports* (Nintendo, Kyoto, Japan) with an energy cost ranging from 0.8 kcal/min for *Wii Sports Skiing* to 2.7 kcal/min for *Wii Sports Boxing* in boys (10–12 y).³² Compared with the current study, the lower kcal/min reported by White et al³² and Graves et al¹⁴ is attributed to the age difference (children vs adults) between the studies as well as the difference in gaming technology. Using a single point of reference (handheld controller) to estimate whole body movements allows the player to “cheat” the system, learning to achieve the game objectives with less movements and therefore less energy cost. The Kinect uses a more complex whole-body tracking system to ensure more whole-body movements to play the games, and therefore greater PAEE.

A recent review of the various consoles that offer AVGs, Barnett et al found that none of the games resulted in a MET level higher than 6.0 METs, the cut-point for vigorous PA, with the average MET values ranging between 3.1 and 3.2 METs.³³ However, this review focused only on children and youth, whereas our study focused on young adults. Although, studies included in this review did find similar sex differences in energy cost, with males expending greater energy than females while playing the AVGs.^{14,34} A study by Sit and colleagues also found that boys and HW children expended more energy while playing interactive AVGs compared with females and OW children.³⁴ In Sit and colleagues' study, the children were allowed to switch between the different games freely during the measurement period. This is in contrast to the current study that found OW young adults expended more energy playing AVGs compared with their HW counterparts, due, in part, to the fact that equal time was spent on each game between the groups. In Sit and colleagues' study, the HW children spent on average 5 to 6 minutes more time playing the physically demanding interactive game compared with the OW children.

As always, this study has limitations. A fairly small sample size ($n = 53$) and predominately HW participants are two limitations. While HW and OW participants were recruited and both represented in the sample, a greater percentage of participants were

HW compared with OW; 71.7% and 23.3%, respectively. A larger sample size could allow for greater representation of both HW and OW participants, thus increasing the applicability of the results to the targeted young adult population. With the subjects only measured during a single bout of playing the games, there is no insight as to the persistence of this level of energy expenditure over time. Therefore, the results of this study do not provide evidence that using these games as a PA intervention would actually promote weight management. However, with the dramatic differences in the PA data (counts/min), this study does reveal that some PA and, thus energy expenditure, would incur while playing these games compared with the traditional SVGs. This would support the contention that some PA, as seen during AVGs, is better than none and can contribute to prevention of weight gain.

To conclude, the results of this study indicate that playing AVGs, especially the multiplayer games, contributes to the recommended dose of MVPA in young adults. However, it remains to be seen if these active games would be played the same amount of time as the more sedentary options and if this level of EE observed while playing the more active games would persist over time. Regardless of the intensity of the games, as the accelerometer data suggests, these games do provide the means for increased PA in an otherwise sedentary college lifestyle.

Acknowledgments

This research study was funded through Ohio University Faculty Research Funds. The authors would like to thank the student Research Assistants for their hard work in collecting these data and the many students who volunteered for the study. However, the biggest thank you goes to Jefferson A. Berryman, a budding young researcher, for asking the original question that instigated this project.

References

- Butler SM, Black DR, Blue CL, Gretebeck RJ. Change in diet, physical activity, and body weight in female college freshman. *Am J Health Behav.* 2004;28(1):24–32. PubMed doi:10.5993/AJHB.28.1.3
- Gropper SS, Simmons KP, Connell LJ, Ulrich PV. Changes in body weight, composition, and shape: a 4-year study of college students. *Appl Phys, Nutr, Metab = Phys Appl, Nutr et Metab.* 2012;37(6):1118–1123.
- Lowry R, Galuska DA, Fulton JE, Wechsler H, Kann L, Collins JL. Physical activity, food choice, and weight management goals and practices among US college students. *Am J Prev Med.* 2000;18(1):18–27. PubMed doi:10.1016/S0749-3797(99)00107-5
- Napolitano MA, Hayes S, Bennett GG, Ives AK, Foster GD. Using Facebook and text messaging to deliver a weight loss program to college students. *Obesity (Silver Spring).* 2013;21(1):25–31. PubMed doi:10.1002/oby.20232
- Levitsky DA, Halbmaier CA, Mrdjenovic G. The freshman weight gain: a model for the study of the epidemic of obesity. *Int J Obes Relat Metab Disord.* 2004;28(11):1435–1442. PubMed doi:10.1038/sj.ijo.0802776
- Kwan MY, Cairney J, Faulkner GE, Pullenayegum EE. Physical activity and other health-risk behaviors during the transition into early adulthood: a longitudinal cohort study. *Am J Prev Med.* 2012;42(1):14–20. PubMed doi:10.1016/j.amepre.2011.08.026
- Jung ME, Bray SR, Martin Ginis KA. Behavior change and the freshman 15: tracking physical activity and dietary patterns in 1st-year university women. *J Am Coll Health.* 2008;56(5):523–530. PubMed doi:10.3200/JACH.56.5.523-530
- Pullman AW, Masters RC, Zalot LC, et al. Effect of the transition from high school to university on anthropometric and lifestyle variables

- in males. *Appl Physiol Nutr Metab*. 2009;34(2):162–171. PubMed doi:10.1139/H09-007
9. Wack ER, Tantleff-Dunn S. Cyber sexy: electronic game play and perceptions of attractiveness among college-aged men. *Body Image*. 2008;5(4):365–374. PubMed doi:10.1016/j.bodyim.2008.06.003
 10. Ogletree SM, Drake R. College students' video game participation and perceptions: gender differences and implications. *Sex Roles*. 2007;56:537–542. doi:10.1007/s11199-007-9193-5
 11. Lucas K, Sherry JL. Sex differences in video game play: a communication-based explanation. *Communic Res*. 2004;31:499–523. doi:10.1177/0093650204267930
 12. U.S. Department of Health and Human Services. Physical Activity Guidelines Advisory Committee report, 2008. To the Secretary of Health and Human Services. Part A: Executive summary. *Nutr Rev*. 2009;67(2):114–120. PubMed doi:10.1111/j.1753-4887.2008.00136.x
 13. Sell K, Lillie T, Taylor J. Energy expenditure during physically interactive video game playing in male college students with different playing experience. *J Am Coll Health*. 2008;56(5):505–511. PubMed doi:10.3200/JACH.56.5.505-512
 14. Graves LE, Ridgers ND, Williams K, Stratton G, Atkinson G, Cable NT. The physiological cost and enjoyment of Wii Fit in adolescents, young adults, and older adults. *J Phys Act Health*. 2010;7(3):393–401. PubMed
 15. Graves LE, Ridgers ND, Stratton G. The contribution of upper limb and total body movement to adolescents' energy expenditure whilst playing Nintendo Wii. *Eur J Appl Physiol*. 2008;104(4):617–623. PubMed doi:10.1007/s00421-008-0813-8
 16. Tong J, Zhou J, Liu L, Pan Z, Yan H. Scanning 3D full human bodies using Kinects. *IEEE Trans Vis Comput Graph*. 2012;18(4):643–650. PubMed doi:10.1109/TVCG.2012.56
 17. Taylor MJ, McCormick D, Shawis T, Impson R, Griffin M. Activity-promoting gaming systems in exercise and rehabilitation. *J Rehabil Res Dev*. 2011;48(10):1171–1186. PubMed doi:10.1682/JRRD.2010.09.0171
 18. Jordan M, Donne B, Fletcher D. Only lower limb controlled interactive computer gaming enables an effective increase in energy expenditure. *Eur J Appl Physiol*. 2011;111(7):1465–1472. PubMed doi:10.1007/s00421-010-1773-3
 19. Ridley K, Olds T. Video centre games: energy cost and children's behaviors. *Pediatr Exerc Sci*. 2001;13(4):413–421.
 20. Comphe C, Frankenfield D, Keim N, Roth-Yousey L. Best practice methods to apply to measurement of resting metabolic rate in adults: a systematic review. *J Am Diet Assoc*. 2006;106(6):881–903. PubMed doi:10.1016/j.jada.2006.02.009
 21. Jackson AS, Blair SN, Mahar MT, Wier LT, Ross RM, Stuteville JE. Prediction of functional aerobic capacity without exercise testing. *Med Sci Sports Exerc*. 1990;22(6):863–870. PubMed doi:10.1249/00005768-199012000-00021
 22. Nieman DC, Austin MD, Chilcote SM, Benezra L. Validation of a new handheld device for measuring resting metabolic rate and oxygen consumption in children. *Int J Sport Nutr Exerc Metab*. 2005;15(2):186–194. PubMed
 23. Howe CA, Freedson PS, Feldman HA, Osganian SK. Energy expenditure and enjoyment of common children's games in a simulated free-play environment. *J Pediatr*. 2010;157(6):936–942.
 24. Alhassan S, Lyden K, Howe C, Kozey Keadle S, Nwaokemele O, Freedson PS. Accuracy of accelerometer regression models in predicting energy expenditure and METs in children and youth. *Pediatr Exerc Sci*. 2012;24(4):519–536. PubMed
 25. Kozey SL, Lyden K, Howe CA, Staudenmayer JW, Freedson PS. Accelerometer output and MET values of common physical activities. *Med Sci Sports Exerc*. 2010;42(9):1776–1784. PubMed doi:10.1249/MSS.0b013e3181d479f2
 26. Perret C, Mueller G. Validation of a new portable ergospirometric device (Oxycon Mobile) during exercise. *Int J Sports Med*. 2006;27(5):363–367. PubMed doi:10.1055/s-2005-865666
 27. Pate RR, Pratt M, Blair SN, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA*. 1995;273(5):402–407. PubMed doi:10.1001/jama.1995.03520290054029
 28. Chen KY, Bassett DR, Jr. The technology of accelerometry-based activity monitors: current and future. *Med Sci Sports Exerc*. 2005;37(11 Suppl):S490–S500. PubMed doi:10.1249/01.mss.0000185571.49104.82
 29. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. *Med Sci Sports Exerc*. 1998;30(5):777–781. PubMed doi:10.1097/00005768-199805000-00021
 30. Smallwood SR, Morris MM, Fallows SJ, Buckley JP. Physiologic responses and energy expenditure of Kinect active video game play in schoolchildren. *Arch Pediatr Adolesc Med*. 2012;166(11):1005–1009. PubMed
 31. O'Donovan C, Hirsch E, Holohan E, McBride I, McManus R, Hussey J. Energy expended playing Xbox Kinect and Wii games: a preliminary study comparing single and multiplayer modes. *Physiotherapy*. 2012;98(3):224–229. PubMed doi:10.1016/j.physio.2012.05.010
 32. White K, Schofield G, Kilding AE. Energy expended by boys playing active video games. *J Sci Med Sport*. 2011;14(2):130–134. PubMed doi:10.1016/j.jsams.2010.07.005
 33. Barnett A, Cerin E, Baranowski T. Active video games for youth: a systematic review. *J Phys Act Health*. 2011;8(5):724–737. PubMed
 34. Sit CH, Lam JW, McKenzie TL. Direct observation of children's preferences and activity levels during interactive and online electronic games. *J Phys Act Health*. 2010;7(4):484–489. PubMed

Copyright of Journal of Physical Activity & Health is the property of Human Kinetics Publishers, Inc. and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.