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## Physiologic Responses, Liking and Motivation for Playing the Same Video Game on an Active Versus a Traditional, Non-Active Gaming System

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### ABSTRACT

*Int J Exerc Sci* 5(2) : 160-169, 2012. Evidence suggests that individuals playing certain video games on the Nintendo Wii® (Wii) exhibit increased energy expenditure versus traditional video games, although little research examines non-Wii Sports/Fit games. The purpose of this study is to assess physiologic responses, liking, and the relative reinforcing value (RRV) of a popular, non-Wii sports video game for the Wii relative to the same game played on a traditional, non-active system. Twenty-four college-aged students participated. Heart rate and oxygen consumption ( $\dot{V}O_2$ ) was assessed during rest and when playing the following games: Madden NFL 2011® for Playstation 2 (PS2 Madden) and the Wii (Wii Madden), and Wii Sports Boxing. The RRV was assessed for Wii Madden versus PS2 Madden. Analysis of variance demonstrated a main effect for condition ( $p \leq 0.01$ ) as  $\dot{V}O_2$  ( $5.2 \pm 0.2$  ml  $\text{kg}^{-1} \text{min}^{-1}$  Wii,  $4.1 \pm 0.1$  ml  $\text{kg}^{-1} \text{min}^{-1}$  PS2,  $3.7 \pm 0.1$  ml  $\text{kg}^{-1} \text{min}^{-1}$ , rest) and heart rate ( $89.2 \pm 2.7$  bpm Wii,  $79.7 \pm 2.5$  bpm PS2,  $79.1 \pm 2.5$  bpm, rest) was greater for Wii Madden than PS2 Madden and rest. Heart Rate ( $105.4 \pm 5.3$  bpm) and  $\dot{V}O_2$  ( $10.4$  ml  $\text{kg}^{-1} \text{min}^{-1}$ ) for Wii Sports Boxing was significantly greater than all other conditions ( $p \leq 0.003$ ). The RRV was not significantly different between Wii Madden and PS2 Madden ( $p = 0.50$ ). Compared to the same game on a traditional system, Wii Madden is more physiologically challenging and equally reinforcing. However, Wii Madden would not be categorized as moderate-intensity physical activity.

**KEY WORDS:** Sedentary behavior, physical activity, caloric expenditure

### INTRODUCTION

Recent survey research indicates that 65% of college-aged adults play video games daily and report spending an average of 7.5 hours·week<sup>-1</sup> playing video games (23, 34). Historically, video game play has been considered a sedentary activity. It is often grouped together with other square-screen

sedentary activities such as watching television or movies and using computers (25). Participation in these sedentary square-screen activities is associated with a lack of physical activity and obesity (7, 16, 23, 34, 36).

Physically-interactive video game systems such as the Nintendo Wii® (Wii) have been

shown to increase energy expenditure over traditional, non-active video game systems (1, 17, 18, 19, 20, 24, 27, 30). These previous examinations of the Wii have primarily examined only the Wii Sports and Wii Fit games (1, 17, 18, 19, 20, 24, 27, 29, 30). Wii Sports Boxing (Wii Boxing), which is a game within Wii Sports, is the most widely studied Wii game and has repeatedly been shown to be more physiologically challenging than non-active video games for adults and children (1, 17, 18, 19, 20, 24, 27, 29, 30). In these previous studies, Wii Boxing has regularly produced a metabolic equivalent (MET) level ( $\geq 3.0$  METs) that meets or exceeds the American College of Sports Medicine's (ACSM) threshold for moderate intensity physical activity (35). This intensity is greater than a leisurely walking pace (2.5 miles  $\text{hour}^{-1}$ ) and can increase energy expenditure 41% above resting values (1, 18, 30). In addition to this elevated energy expenditure, adults and children have both reported greater liking (i.e., enjoyment) of Wii Boxing than a similar non-active video game and non-overweight children were more motivated to play Wii Boxing than the non-active alternative (1, 30).

The initial studies examining the Wii suggest that it has potential value as a healthier and enjoyable alternative to traditional non-active video games. However, while Wii Sports (which is included with the Wii system) is a popular game there are an increasing number of Wii games available for purchase. Many of these other games appear less focused on physical activity than either Wii Sports or Wii Fit (which are both designed to mimic sport and/or exercise) and are also available on other traditional non-active

video game systems. Such games may therefore be less physiologically challenging than some of the previous evaluated Wii games (e.g., Wii Boxing) and allow for direct comparisons between playing a version of the game on the Wii and playing the same game on a non-active video game system.

The purpose of this investigation was to compare the physiologic responses [heart rate and oxygen consumption ( $\text{VO}_2$ )] and liking of a popular non-Wii Sports video game (i.e., Madden NFL 2011®) for the Wii versus the same game played on a traditional non-active video game system (i.e., Sony Playstation® 2) and the previously evaluated Wii Sports Boxing. The relative reinforcing (i.e., motivating) value (RRV) of Madden NFL 2011® for the Wii (Wii Madden) versus the same game for the Playstation 2 (PS2 Madden) was also assessed. We hypothesized that while Wii Madden would be more physiologically challenging than PS2 Madden it would be less challenging than Wii Boxing and not intense enough to be considered moderate intensity physical activity. Additionally, we hypothesized that participants would better like and be more motivated to play Wii Madden versus PS2 Madden due to the physically interactive nature (i.e., gesture-based game play) of playing the Wii.

## METHODS

### *Participants*

A total of 24 college-aged adults ( $n = 13$  males,  $n = 11$  females) with no contraindications to physical activity participated in the study. Participants were recruited using flyers that were posted

around campus and from a database of individuals who had previously contacted our laboratory for separate, unrelated studies. Each participant read and signed an informed consent form. The current study was approved by the Kent State University Institutional Review Board.

#### *Protocol*

Students came to the laboratory for a single visit. After attaining informed consent, each participant was measured for height and weight using a stadiometer and balance beam scale, respectively (Health O Meter, Alsip IL, USA). Participants then answered “yes” or “no” to the following questions pertaining to their Wii and PS2 playing experience: “Have you ever played the Nintendo Wii?”, “Have you ever played the Playstation 2?”, “Have you ever played Madden NFL Football for Nintendo Wii?” and “Have you ever played Madden NFL Football for PS2?” All participants reported having some experience playing the Wii and/or PS2 gaming systems. On the contrary, all participants had no previous experience playing Wii Madden while only 8% of the participants reported previous experience playing PS2 Madden. Due to the lack of experience playing the video games, researchers explained and demonstrated how to play each game for the Wii and PS2. Participants then completed a familiarization period for a minimum of 5-minutes per game, during which they sampled the game and asked the researchers questions regarding game play. After completing the familiarization periods for each game, all participants then rested in a seated position before completing the following four, 10-minute conditions:

*Resting:* Participants rested in a seated position.

*Wii Boxing:* Participants played Wii Sports boxing (Nintendo Co Ltd. Minami-ku Kyoto, Japan), while standing, on the least difficult setting against a computer-controlled opponent.

*Wii Madden:* Participants played Wii Madden NFL Football 2011 (Electronic Arts Inc., 2010), while standing, on the least difficult setting with the teams of their choice.

*PS2 Madden:* Participants played PS2 Madden NFL Football 2011 (Electronic Arts Inc., 2010), while seated, on the least difficult setting with the same teams chosen for Wii Madden.

NOTE: Madden NFL Football was selected for inclusion in the present study as it is available for both gaming systems and because the movement required for Wii Madden play is not as continuous (i.e., longer periods of inactivity) as the previously evaluated Wii Boxing game. This allowed for the direct comparison of the same game played on two systems, one active and one sedentary and also allowed for the comparison between a Wii game shown to simulate moderate-intensity physical activity and a Wii game that was not.

The resting condition was always completed first and the order of the three video game conditions was randomized across participants. Throughout each 10-minute condition, heart rate and  $\text{VO}_2$  were recorded via indirect calorimetry (Parvo Medics, Truemax 2400) and a telemetry monitor (Polar, Kempele, Finland), respectively.  $\text{VO}_2$  was recorded as the average  $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$  and  $\text{L}\cdot\text{min}^{-1}$  over each

10-minute condition.  $\text{VO}_2$  in  $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$  was used to calculate METS ( $3.5 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1} = 1 \text{ MET}$ ) (35).  $\text{VO}_2$  in  $\text{L}\cdot\text{min}^{-1}$  was used to calculate energy expenditure ( $\text{V O}_2 \text{ L}\cdot\text{min}^{-1} * 4.9 \text{ kilocalories (kcal)}\cdot\text{L of O}_2^{-1} = \text{kcal}\cdot\text{min}^{-1}$ ) (35). While  $\text{VO}_2$  was used as the dependent variable for energy expenditure in all statistical analysis, METS and kcal were used to classify the intensity of game play (i.e., moderate-intensity physical activity) and to extrapolate caloric expenditure of game play over a period of time (i.e., one year). At the completion of each 10-minute condition of video game play, participants reported their undifferentiated ratings of perceived exertion (RPE) using a validated BORG scale (8, 9), and also the liking of the game by making a mark on a 10-cm line anchored by "Do not like it at all" on the left and "Like it very much" on the right (11, 33).

Following the four, 10-minute conditions, participants completed a computer task designed to assess the RRV of Wii Madden versus PS2 Madden. Determining the RRV was accomplished by asking participants to perform work in the form of button presses on a computer mouse to earn additional access to Wii Madden, PS2 Madden or a combination of the two games. Participants had the option to perform work on either of two separate computer screens; one screen was designated for Wii Madden and the other screen was for the PS2 Madden. Each screen had three shapes that changed with each mouse click. A participant would earn a point for a given video game when all three shapes matched on the screen that corresponded to that video game. Each point earned translated into one extra minute of game play to the corresponding video game. Participants could switch from

working to earn points for one game to the alternative game as frequently as they wished. The computer task was performed until participants earned a total of 11 points from which they earned 11 minutes of video game play. The reinforcement schedule was the same for each game and was set to a fixed ratio (FR) of 1:1 (one point for one click) for the first point earned. The FR level then doubled with every point earned thereafter for each game (complete FR schedule; 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024). The FR schedules for each game were independent in that the FR levels for each screen only increased if work was performed for the video game option on the computer screen. Once a total of 11 points were earned, participants then played each video game or games for the amount of time they earned. The RRV of one behavior versus another behavior was quantified as the amount of motivated responding (work) an individual engaged in to earn access to one of the two behaviors (2, 3, 31). The outcome measure for the RRV for the present study was the output maximum ( $O_{\text{max}}$ ) which was defined as the maximum amount of responding for one minute of Wii Madden or PS2 Madden (6). Assessments of RRV have previously been shown to be a valid predictor of actual behavior and therefore may predict video game choice in college-aged adults (12, 13, 14, 15, 32, 33).

After completing the video game play time earned from the RRV task participants were given a \$10.00 gift certificate to a local store for participating in the study.

#### *Statistical analysis*

Means and measures of variability (i.e., standard deviation) were calculated for all

variables studied. Differences in participant physical characteristics (height, weight, age) between males and females were assessed utilizing independent samples T-tests. Gender was initially included as an independent variable in all analysis of variance (ANOVA) models used to examine primary dependent variables: heart rate,  $\text{VO}_2$ , liking, RPE and RRV. However, there were no significant main or interaction effects of gender ( $p \geq 0.07$ ) for any of the analyzed dependent variables. Therefore, gender was removed from all ANOVAs and from the discussion of the results.

Two, four condition (rest, Wii Madden, PS2 Madden, Wii Boxing) repeated measures ANOVAs were utilized to examine differences in gross heart rate and  $\text{VO}_2$ . Two additional, repeated measures ANOVAs were utilized to examine differences in the net change in heart rate and  $\text{VO}_2$  from the resting condition to the gaming conditions (Wii Madden, PS2 Madden, Wii Boxing). Two, three condition (Wii Madden, PS2 Madden, Wii Boxing) repeated measures ANOVAs were utilized to examine differences in liking and RPE. Finally, a single, two condition (Wii Madden & PS2 Madden) repeated measures ANOVA was utilized to examine differences in  $O_{max}$ . Post-hoc analyses of any significant main effects of condition were performed utilizing T-tests with the Benjamini and Hochberg False Discovery Rate correction for multiple comparisons (5). All statistical analyses were conducted using SPSS for Windows (version 17.0, SPSS Inc, Evenston, IL).

## RESULTS

### *Physical Characteristics*

Participant physical characteristics are listed in Table 1. Males were significantly older, taller and heavier than females ( $p \leq 0.03$ ).

Table 1. Participant physical characteristics

Variable	Males (n =13)	Females (n = 11)
Age (years)	24.2 ± 2.9*	21.8 ± 1.9
Height (cm)	179.8 ± 8.54*	163.0 ± 7.0
Weight (kg)	86.9 ± 16.6*	69.9 ± 15.1

Data are mean ± SD. \*  $p \leq 0.03$  Significantly different between gender.

### *Gross Heart Rate and $\text{VO}_2$*

A significant main effect of condition ( $p < 0.01$ ) was noted for both heart rate and  $\text{VO}_2$  (Table 2). Post-hoc analysis revealed that while there was no significant difference in heart rate during the resting and PS2 Madden conditions ( $p = 0.48$ ), there was a significant incremental increase from those two conditions to the Wii Madden condition ( $p < 0.001$ ) and from the Wii Madden condition to the Wii Boxing condition ( $p < 0.003$ ). Separate post hoc analysis revealed a significant incremental increase in  $\text{VO}_2$  from the resting condition to the PS2 madden condition ( $p < 0.001$ ), from the PS2 Madden condition to the Wii Madden condition ( $p < 0.001$ ), and from the Wii Madden condition to the Wii Boxing condition ( $p < 0.001$ ).

### *Net Heart Rate and $\text{VO}_2$*

Resting HR and  $\text{VO}_2$  values were subtracted from gross HR and  $\text{VO}_2$  values for all three gaming conditions to determine net HR and  $\text{VO}_2$  (Table 2). There was main effect of

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Table 2. Participants' physiological responses, liking and RPE for the resting, PS2 Madden, Wii Madden, and Wii Boxing conditions

Variable	Resting <sup>a</sup>	PS2 Madden	Wii Madden	Wii Boxing
Gross $\dot{V}O_2$ (ml kg <sup>-1</sup> min <sup>-1</sup> )	3.7 ± 0.1	4.1 ± 0.1 <sup>b</sup>	5.2 ± 0.2 <sup>b, c</sup>	10.4 ± 0.7 <sup>b, c, d</sup>
Net $\dot{V}O_2$ (ml kg <sup>-1</sup> min <sup>-1</sup> ) <sup>a</sup>	-	0.4 ± 0.1	1.5 ± 0.1 <sup>c</sup>	6.7 ± 0.6 <sup>c, d</sup>
Gross heart rate (beats min <sup>-1</sup> )	79.1 ± 2.5	79.7 ± 2.5	89.2 ± 2.7 <sup>b, c</sup>	105.4 ± 5.3 <sup>b, c, d</sup>
Net heart rate (beats min <sup>-1</sup> ) <sup>a</sup>	-	0.6 ± 0.8	10.1 ± 1.2 <sup>c</sup>	26.3 ± 5.0 <sup>c, d</sup>
Liking (cm) <sup>a</sup>	-	6.9 ± 0.5	6.4 ± 0.5	7.8 ± 0.4
RPE <sup>a</sup>	-	7.2 ± 0.3	8.3 ± 0.4 <sup>c</sup>	11.3 ± 0.4 <sup>c, d</sup>

Data are mean ± SEM.  $p < 0.05$  for all. <sup>a</sup>Liking, RPE, and net (i.e., value above resting) HR and  $\dot{V}O_2$  were not assessed during the resting condition. <sup>b</sup>Significantly different from the resting condition. <sup>c</sup>Significantly different from the PS2 Madden condition. <sup>d</sup>Significantly different from the Wii Madden condition.

condition ( $p < 0.001$ ) for net HR and  $\dot{V}O_2$ . Post-hoc analysis revealed that the net increase in  $\dot{V}O_2$  and HR from resting to Wii Boxing was significantly ( $p \leq 0.003$ ) greater than the net increase from resting to Wii Madden and resting to PS2 Madden. The net increase in  $\dot{V}O_2$  and HR from resting to Wii Madden was significantly ( $p \leq 0.003$ ) greater than the net increase from resting to PS2 Madden.

### Liking and RPE

There was not a significant main effect of condition for liking ( $p = 0.07$ , Table 2). There was a main effect of condition for RPE ( $p < 0.001$ , Table 2). Post-hoc analysis revealed that there was an incremental increase in RPE from the PS2 Madden condition to the Wii Madden condition ( $p = 0.001$ ) and from the Wii Madden condition to the Wii Boxing condition ( $p < 0.001$ ).

### RRV

There was no significant difference ( $p = 0.50$ ) in  $O_{max}$  between PS2 Madden (149.2 ± 294.7 presses) and Wii Madden (216.4 ± 377.4 presses).

## DISCUSSION

The present study was the first that we are aware of to compare physiologic responses of a non-Wii Sports or Wii Fit game for the Wii to the same game for a non-active gaming system (PS2) and the previously evaluated Wii Boxing. Heart rate,  $\dot{V}O_2$ , and RPE were significantly greater for Wii Boxing than all other conditions. Similar to previous studies, Wii Boxing elicited a MET level (2.95 METs) that was near the threshold for moderate-intensity physical activity (1, 17, 30). While less than Wii Boxing, heart rate,  $\dot{V}O_2$ , and RPE were significantly greater for Wii Madden than PS2 Madden. Although physiologic



responses were greater with Wii Madden play, the achieved MET level (1.47 METs) was well below the threshold for moderate-intensity physical activity.

While playing Wii Madden alone would not constitute moderate-intensity physical activity, the greater energy expenditure required to play, relative to PS2 Madden, may be of importance. A chronically positive energy balance of 15 to 50 kcal day<sup>-1</sup> has been shown to result in weight gain over time (10, 22, 26). Therefore, making slight behavioral changes that result in increased energy expenditure may help prevent weight gain. Previous research has noted that standing while typing can increase energy expenditure by 4.1 kcal hour<sup>-1</sup> compared with sitting in an office chair while typing at a desk (4). This could result in an additional 8,528 kcal year<sup>-1</sup> expended for individuals who would type while standing versus sitting for 40 hours week<sup>-1</sup>. Based upon the average VO<sub>2</sub> data from the present study, students participating in the previously reported average video game play of 7.5 hours week<sup>-1</sup> would expend 37,087 kcal year<sup>-1</sup> playing PS2 Madden compared with 46,472 kcal year<sup>-1</sup> while playing Wii Madden (34). This results in a difference of 9,385 kcal year<sup>-1</sup> playing Wii Madden versus PS2 Madden. This difference in caloric expenditure could equate to a net metabolic cost of 2.7 pounds of body weight (3,500 kcal pound<sup>-1</sup>) over a one year period (21).

How reinforcing an individual finds a particular activity or behavior versus alternate activities or behaviors is a powerful predictor of actual behavior (13, 28, 30, 32, 33). Therefore, it is plausible to

suggest that college student's video game choices can be predicted by their motivation to play one game versus another. Presently participants were equally motivated to play either Wii Madden or PS2 Madden. These results are contrary to our hypothesis and somewhat different from a previous study that found a Wii game (Wii Boxing) to be more motivating than a traditional, non-active video game for normal-weight children but not overweight/obese children (30). Additionally, both adults and children have previously reported greater liking for a Wii game (Wii Boxing) relative to a traditional, non-active alternative (1, 30). The lack of differences in motivation and liking in the present study may be due to differences in current methodology versus previous studies. Previous studies compared the motivation to play and the liking of Wii Boxing to a different, non-active boxing game (Punchout!), whereas the current study compared a game on the Wii (Wii Madden) to the non-active version of the same video game (PS2 Madden) (1, 30). Furthermore, these previous studies either examined children or a group of adults that were, on average, older than the college-aged adults examined in the present study. Nevertheless, because participants liked each game equally and were equally motivated to play both Wii Madden and PS2 Madden it is reasonable to suggest participants would be willing to play Wii Madden instead of the non-active alternative.

While this was the first study to compare the energy expenditure, heart rate, liking and motivation for playing a non-Wii Sports/Fit Nintendo Wii game to the same game on a traditional, non-active gaming

system, there are limitations to this study. Presently, physiologic responses were assessed in only a single, non-Wii Sports/Fit game and there are many games available for the Wii. Future research may consider examining physiologic responses and the motivation to play different types of games for the Wii (i.e., “quest” and “first-person shooter” games). Furthermore, in order to simulate a more realistic gaming experience, the length of each condition could be increased beyond 10 minutes. Limiting the amount of time for game play may have an effect on physiologic responses in that participants may not play Wii games as vigorously for a longer period of time. Additionally, participants were required to play these games alone opposed to playing with a friend. It is possible that the presence of a friend may alter energy expenditure, heart rate, liking and motivation when playing video games. Finally, in the present study participants were required to stand while playing the Wii. While standing during Wii play follows manufacturer guidelines; it is possible that individuals may sit while playing the Wii if given the option. This would likely reduce the caloric expenditure for Wii play. Also, resting HR and VO<sub>2</sub> in the current study were assessed while participants were seated which is likely less than standing rest. Therefore, future studies should examine the difference in energy expenditure while playing the Wii in a standing versus seated position and compare that to both seated and standing rest.

In summary, playing a video game on the Nintendo Wii was more physiologically challenging than playing the same game on a traditional non-active gaming system.

Assuming individuals play the Wii as directed (standing), the greater energy expenditure associated with Wii play, even during less intense games such as Wii Madden, may have positive benefits on preventing weight gain who play video games for several hours per week to play the active version of a game (i.e., versus playing on a traditional, non-active gaming system. It may therefore be advisable for individuals Nintendo Wii) over a traditional, non-active version the game (i.e., Playstation 2). However, while some Wii games (i.e., Wii Boxing) are intense enough to be considered moderate intensity physical activity other Wii games (i.e., Wii Madden) appear to be poor substitutes for traditional physical activity.

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