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Original Research

The Physiologic and Behavioral Implications of Playing Active and Sedentary Video Games in a Seated and Standing Position

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ABSTRACT

International Journal of Exercise Science 7(3) : 194-201, 2014. Previous studies have assessed physiologic response while playing video games per manufacturer instructions with participants standing during active video game play and seated during sedentary game play. It is not known whether an assigned seated or standing position affects positional preference and oxygen consumption (VO2) while gaming. The purpose of the study was to assess VO2 and preference of playing active and sedentary video games in a seated and standing position. VO2 was assessed in 25 participants during four, 20-minute conditions; resting, PlayStation 2 Madden NFL Football 2011, Nintendo Wii-Sports Boxing and Nintendo Wii Madden NFL Football 2011. Each condition was divided into two positional conditions (10 minutes seated, 10 minutes standing) and each participant indicated their positional preference after each 20-minute condition. Standing VO2 (4.4 ± 0.2 ml•kg-1•min-1 PS2, 4.6 ± 0.1 ml•kg-1•min-1 Wii Madden, 6.8 ± 0.3 ml•kg-1•min-1Wii Boxing) was significantly ($p \leq 0.001$) greater than seated VO2 (4.0 ± 0.1 ml•kg-1•min-1 PS2, 4.2 ± 0.1 ml•kg-1•min-1 Wii Madden, 6.1 ± 0.3 ml•kg-1•min-1Wii Boxing) for each gaming condition. Participants preferred ($p \leq 0.001$) to sit for all gaming conditions except Wii Boxing. Playing video games while standing increases VO2 to a greater extent than playing the same games in a seated position. Standing was only preferred for the most physiologically challenging game, Wii Boxing. Gaming position should be considered when assessing the physiologic and behavioral outcomes of playing video games.

KEY WORDS: Physical interactive, gaming, activity, behavior, health

INTRODUCTION

Playing active video games (AVG) for the Nintendo Wii (Wii) has repeatedly been shown to increase energy expenditure to a greater extent than playing other video games for traditional, sedentary gaming systems (e.g., Sony Playstation 2 (PS2)) (1, 6, 7, 9, 12). Previous studies have indicated that some AVG's (e.g., Wii Sports Boxing) are physiologically challenging enough to be considered a moderate intense physical activity (i.e., > 3.0 metabolic equivalents (MET's)) (1, 9), while other AVG's (e.g., Wii Madden NFL Football 2011 (Wii Madden)) are not challenging enough to achieve a 3.0 MET intensity (12). Wii Madden is still considered an active video game because it requires simple upper body motions that

mimic football movements (e.g., throwing, catching, etc.). A previous study reported that these simple upper body motions needed to play Wii Madden do still increase energy expenditure to a greater extent than playing the same game (PS2 Madden NFL Football 2011 (PS2 Madden)) on a traditional sedentary gaming system (12). The authors also concluded that small yet significant increases in MET levels could equate to potentially beneficial energy expenditure over time, primarily for individuals who meet or exceed the reported average of 7.5 hours·week-1playing video games (8, 12).

While previous studies examined the physiologic cost of playing active and traditional, sedentary video games, each of these studies share the same methodological flaw in that the participants' physiological responses were measured in a seated posture during the resting and sedentary gaming conditions and were then directly compared to an AVG condition which required the participants to play in a standing posture (1, 6, 9, 12) . Anecdotal observations of children at day cares, college adults, and senior citizens playing the Wii suggests that participants, regardless of age, may play AVGs in a seated position, which is contrary to the manufacturers recommendation for successful game play. It is currently unknown how much of the difference in energy expenditure between AVGs and traditional, sedentary video games is due to the physically interactive nature of AVGs or simply the fact that these AVGs are played in a standing versus seated position.

In addition to physiologic responses, previous research has measured liking and preference to better understanding an individual's enjoyment of a particular activity (10-12). In these studies, liking of an activity was positively associated with greater amounts of physical activity (5, 10, 11). Also, an AVG study by Sanders et al. (12) assessed liking and found that college adults better liked the most physiologically challenging AVG (e.g., Wii Boxing). Similar to liking, preference refers to an individuals liking for one alternative over another and has been used to predict the likelihood that one may engage in a certain behavior (i.e., physical or sedentary activities) (11). It is reasonable to suggest that physiologic and behavioral responses may be different when playing AVGs in a seated or standing position.

Therefore, the purpose of the current investigation was to assess energy expenditure (assessed via oxygen consumption (VO2)), liking, and preference of two different gaming positions (seated, standing) during two AVG conditions using the Wii (Wii Boxing and Wii Madden), a traditional, sedentary video game (PS2 Madden) condition using the PS2, and a resting condition.

METHODS

Participants

A total of 25 college-aged adults (N = 11 females) with no contraindications to physical activity volunteered to participate in the study. Participants were recruited using flyers that were posted around Kent State University's campus. Upon arrival to the laboratory and prior to participation, each participant read and signed an informed consent for the study. The university Institutional Review Board approved the current study.

Protocol

Participants came to the Exercise Physiology Laboratory for a single visit. To stay consistent with other AVG studies and to make immediate and direct comparisons across conditions, a single visit, relative to multiple visits were used (1, 9, 12). Upon arrival to the laboratory, informed consent was obtained from each participant. Next, trained research personnel measured each participant's height and weight using a stadiometer and balance beam scale, respectively (Health O Meter, Alsip IL, USA). Researchers explained and demonstrated how to play each game for the Wii and PS2. Participants then completed a familiarization period for 5-minutes per game, during which they sampled the game and asked the researchers questions regarding game play until they felt comfortable playing each game. After completing the familiarization periods for each game, all participants rested in a seated position for 10 minutes before beginning the four conditions. Each of the four conditions consisted of two, 10-minute positional stances, seated and standing. Between each positional condition (i.e., seated and standing for each condition), participants rested in a seated position to allow VO2 to return to resting levels. The four conditions included; resting, playing PS2 Madden NFL Football 2011 (Electronic Arts Inc., 2010), Wii Madden NFL Football 2011 (Electronic Arts Inc., 2010) and Wii Sports boxing (Nintendo Co Ltd. Minami-ku Kyoto, Japan).

The two positional stances (seated, standing) for the resting condition were completed first for each participant and then the order of the three remaining gaming conditions (i.e., PS2 Madden, Wii Madden, Wii Boxing) were randomized across participants. The order of positional stance (seated, standing) was randomly selected for each participant prior to the start of the resting condition and maintained throughout the other three conditions. For example if a participant began the resting condition seated first and then standing, that positional stance order was maintained for the other gaming conditions. Throughout each condition, VO2 was recorded via indirect calorimetry (Parvo Medics, Truemax 2400). VO2 was recorded as the average ml · kg-1 · min-1 over each 10-minute postural stance and was used to calculate METs (3.5 ml · kg-1 · min-1 = 1 MET) (13). VO2 was used as the dependent variable for energy expenditure in all statistical analysis. Upon completion of each 10-minute positional stance condition, participants reported their undifferentiated ratings of perceived exertion (RPE) using a validated BORG scale (3, 4) and their liking of the condition by making a vertical mark on a 10-cm horizontal line anchored by "Do not like it at all" on the left and "Like it very much" on the right (5, 10). Finally, participants were asked to indicate positional stance preference (i.e., seated or standing) upon completion of each 20-minute condition.

Statistical Analysis

Means and measures of variability were calculated for all variables including physical characteristics. Three, two positional stance (seated, standing) by four activity condition (rest, Wii Madden, PS2 Madden, Wii Boxing) repeated measures ANOVAs were utilized to examine differences in VO2, liking and RPE. Sex (males, females) was originally included in the ANOVA models; however, there were no main or interaction effects ($p \geq .265$) of sex for any of the dependent variables;

therefore, sex was removed from the analysis. Post-hoc analyses of any significant main effects of conditions were performed utilizing T-tests with the Benjamini and Hochberg False Discovery Rate correction for multiple comparisons (2). Lastly, a chi-squared analysis was utilized to assess any differences in the number of participants who preferred to sit versus stand for each activity condition. The significance level was set a priori at $p \leq 0.05$. All statistical analyses were conducted using SPSS for Mac (Version 21.0, IBM SPSS).

RESULTS

Participant physical characteristics are listed in Table 1.

Table 1. Participant physical characteristics

Variable	Males (n =14)	Females (n = 11)
Age (years)	22.9 ± 2.0	22.0 ± 1.9
Height (cm)	179.6 ± 7.7*	168.1 ± 7.9
Weight (kg)	83.8 ± 12.5*	63.8 ± 8.5
BMI ($kg \cdot m^{-2}$)	25.9 ± 3.0*	22.6 ± 2.4

Data are mean ± SD
* $p \leq 0.006$ Significantly different between sexes.

There was a significant positional stance by condition interaction ($p \leq 0.003$, Figure 1) for VO2. Post-hoc analysis revealed no difference between seated and standing VO2 at rest ($p = 0.208$); however, there was a significant ($p \leq 0.008$) increase VO2 from the seated to standing position for each gaming condition (PS2 Madden, Wii Madden, Wii Boxing). There were no significant differences ($p \geq 0.063$) in VO2 between the seated PS2 Madden and seated Wii Madden conditions, nor was there a difference between those conditions while standing. Interestingly, there was a significant difference ($p < 0.001$) in VO2 between seated PS2 Madden and standing Wii Madden. Standing Wii Madden was also significantly greater ($p < 0.001$) than both seated and standing resting conditions. Seated and standing VO2 for Wii Boxing was significantly greater ($p < 0.001$) than all other positional stance conditions. There was a significant main effect ($p < 0.001$, Figure 2) of condition as average VO2 for the Wii Boxing condition was significantly greater than all other conditions. There was also a significant main effect of positional stance ($p < 0.001$) as VO2 was significantly greater when standing (5.0 ± 0.1 ml · kg-1 · min-1) versus seated (4.6 ± 0.1 ml · kg-1 · min-1)

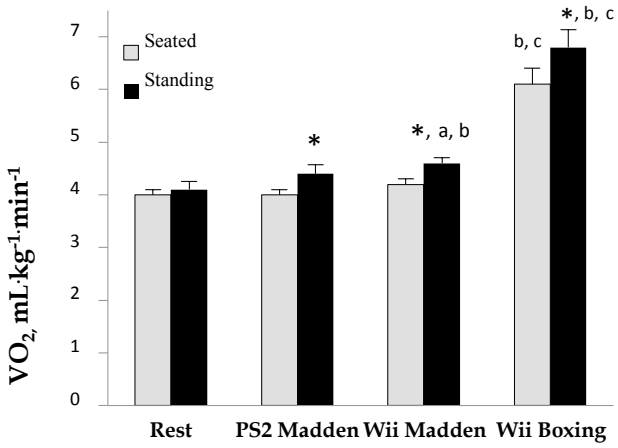

Figure 1. Seated and standing VO_2 for each condition. Data are means ± SEM.
*Significantly greater from the seated position.
[a] Significantly greater than seated PS2 Madden.
[b] Significantly greater than seated and standing rest conditions.
[c] Significantly greater than seated and standing PS2 Madden and Wii Madden conditions.
($p < 0.05$ for all)

There was a significant positional stance by condition interaction for liking ($p < 0.001$,

Table 2). Post-hoc analysis revealed there was a significant increase in liking from the seated to the standing conditions ($p = 0.027$) for Wii Boxing, while there were no differences in liking of positional stance for PS2 Madden ($p = 0.268$) and Wii Madden ($p = 0.343$). Liking was also significantly greater for the standing Wii Boxing condition ($p \leq 0.014$) compared to all other standing conditions. There was a significant main effect ($p < 0.001$) of condition for liking as participants better liked the gaming conditions (5.2 ± 0.5 cm Wii Madden, 5.8 ± 0.5 cm PS2 Madden, 6.7 ± 0.3 cm Wii Boxing, $p \leq .005$) than the resting condition (3.3 ± 0.5 cm). Wii Boxing was better liked than Wii Madden ($p = 0.01$) but not PS2 Madden ($p = 0.16$). There was no significant main effect of postural stance ($p = 0.265$) for liking.

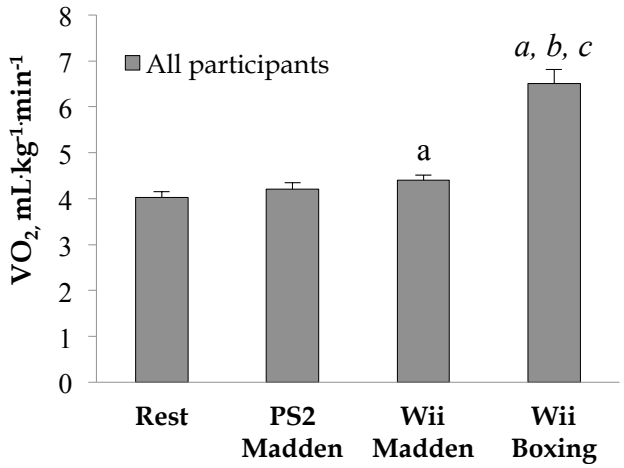

Figure 2. Average (seated and standing) VO_2 for each condition. Data are means ± SE. [a]Significantly different from Resting conditions. [b]Significantly different from PS2 Madden conditions. [c]Significantly different from Wii Madden conditions. ($p < 0.05$ for all)

There was a significant main effect of condition for RPE ($p < 0.001$, Table 3). Post hoc analysis revealed that participants reported a greater RPE for each standing position, relative to a seated position ($p < 0.05$). Participant's reported a step increase in RPE from rest to PS2 Madden, then again to Wii Madden, and then finally RPE increased again when playing Wii Boxing for each positional stance. There were no other significant main effect or interaction effects ($p > 0.883$) for RPE.

Table 2. Liking of positional stance for each condition

Liking (cm)	Seated	Standing
Rest	3.9 ± 0.6*	2.7 ± 0.5
PS2 Madden	6.0 ± 0.5[a]	5.7 ± 0.5[a]
Wii Madden	5.3 ± 0.5	5.0 ± 0.5[a]
Wii Boxing	6.2 ± 0.4*, [a]	7.2 ± 0.3 [a, b, c]

Data are means ± SEM. *Significantly different from standing position. [a]Significantly different from Resting condition. [b]Significantly different from PS2 Madden condition. [c]Significantly different from Wii Madden condition.
($p < 0.05$ for all)

Table 3. Rating of perceived exertion for each positional stance for each condition.

RPE	Seated	Standing
Rest	6.0 ± 0.0	6.2 ± 0.1*
PS2 Madden	6.4 ± 0.2[a]	6.8 ± 0.2*, [a]
Wii Madden	6.7 ± 0.1[a, b]	7.2 ± 0.2 *, [a, b]
Wii Boxing	8.1 ± 0.4[a, b, c]	8.9 ± 0.4*, [a, b, c]

Data are means ± SE. *Significantly greater than the seated position. [a]Significantly different from the same positional stance Rest condition [b]Significantly different from the same positional stance PS2 Madden condition. [c]Significantly different from the same positional stance Wii Madden condition. ($p < 0.05$ for all)

A chi-square analysis revealed a significantly greater ($p \leq 0.009$) number of participants preferred the seated position during the resting (N = 25 seated, N = 0 standing), PS2 Madden (N = 23 seated, N = 2 standing), and Wii Madden (N = 19 seated, N = 6 standing) conditions, while a significantly greater ($p < 0.001$) number of participants preferred to stand during the Wii Boxing (N = 6 seated, N = 19 standing) condition.

DISCUSSION

To our knowledge this is the first study to assess the effect of a seated and standing position on VO2, liking, and preference of playing AVGs and traditional, sedentary video games. The results of the current study reveal that standing while playing video games increased VO2 8.7% more than playing the same game in a seated position. Playing Wii Boxing standing increased VO2 to a greater extent than the seated and standing position for the Wii Madden, PS2 Madden and the resting conditions. Participants preferred to sit for every condition except Wii Boxing, which was better liked, prompted the greatest RPE and, as expected, elicited a significantly greater VO2 than any other activity condition regardless of a seated or standing position. These results suggest that the previously reported (1, 9, 12) increases in VO2 while playing "less active" AVG's such as Wii Madden, relative to traditional, sedentary video games, may only be true if the "less active" AVG is played while standing. This is problematic as the majority (76%) of the participants indicated that they would prefer to play Wii Madden while seated. It is reasonable to suggest that the preference to sit while playing "less active" AVG's may also extend to other games.

Previous research by Sanders et al. (12) compared Wii Madden in a standing position to PS2 Madden in a seated position. The current findings that standing VO2 for Wii Madden was greater than seated VO2 for PS2 Madden is similar to the previous study. However, when comparing the seated-to-seated and standing-to-standing positions, Wii Madden VO2 was not significantly greater than PS2 Madden and due to the fact participant's preference was to sit during Wii Madden play means it is unlikely that there is a significant benefit, from an energy expenditure standpoint, to playing a "less active" Wii game such as Wii Madden versus a traditional sedentary video game (i.e., PS2 Madden).

In the present as well as previous studies, Wii Boxing consistently increases VO2 to a greater extent than other non-Wii Sports/Fit and traditional, sedentary video games (1, 9, 12). Therefore, Wii Boxing should be recommended to individuals, regardless of age, to increase energy expenditure while playing active video games. Additionally, this is the first study to reveal that participants preferred to play Wii Boxing in a standing, relative to a seated, position. This is intriguing since the standing Wii Boxing condition was more physiologically challenging better liked and even perceived to be the most difficult than any other condition. This suggests that not only is energy expenditure the greatest when playing Wii Boxing, it may also be valid to assess this game with participants playing in a standing position.

While this is the first study to assess the effect of a seated and standing position while playing AVGs and traditionally, sedentary video games, it is not without limitations. The current study assessed physiologic responses of only two games that were played across two different gaming systems. While these games and systems are popular with consumers and well researched, there are additional AVG systems (e.g., Xbox Kinect, Playstation® Move, etc.) and different AVGs that are available and may require a different amount of physical movement for

successful game play. Also, at the beginning of the study, we did not assess if the participants had experience playing each game and it is possible that previous experience could have influenced how much an individual liked and preferred a particular game. Lastly, only college students, relative to children and older adults, were assessed. Children in day cares and older adults in senior centers commonly play AVGs; therefore, oxygen consumption, liking, and preference of position should be assessed in these settings. Future research is needed to continue to assess the impact of this continuously evolving gaming technology across the life span.

Playing AVGs and traditional, sedentary video games in a standing position increases energy expenditure to a greater extent than playing the same games in a seated position. The previously reported increase in energy expenditure while playing certain non-Wii Sports/Fit games (e.g., Wii Madden), relative to the same game on a traditional, sedentary gaming system, is likely due to the fact that participants played the AVG in a standing position and then played the traditional, sedentary games in a seated position. Other AVGs may not increase energy expenditure over traditional, sedentary games unless the game is played in a standing position. Therefore, it appears that simply playing the Wii may not equate to increased energy expenditure as the physiologic cost of playing some Wii games (e.g., Wii Madden), which will likely be played in a seated position, is not different from traditional, sedentary video games. Playing an AVG in a standing position will maximize an individual's physiologic cost of playing that particular game.

REFERENCES

1. Barkley JE, Penko A. Physiologic responses, perceived exertion, and hedonics of playing a physical interactive video game relative to a sedentary game and treadmill walking in adults. Am Soc of Exer Physiol 12(3):12-23, 2009.

2. Benjamini Y, Hochberg Y. Controlling the False Discovery Rate: a Practical and Powerful Approach to Multiple Testing. J Royal Stat Soc 57(1):289-300, 1995.

3. Borg G. Perceived exertion as an indicator of somatic stress. Scand J Rehabil Med 2(2):92-8, 1970.

4. Borg G, Hassmen P, Lagerstrom M. Perceived exertion related to heart rate and blood lactate during arm and leg exercise. Eur J Appl Physiol Occup Physiol 56(6):679-85, 1987.

5. Craig S, Goldberg J, Dietz WH. Psychosocial correlates of physical activity among fifth and eighth graders. Prev Med 25(5):506-13, 1996.

6. Graves L, Stratton G, Ridgers ND, Cable NT. Comparison of energy expenditure in adolescents when playing new generation and sedentary computer games: cross sectional study. BMJ 335(7633):1282-4, 2007.

7. Graves L, Stratton G, Ridgers ND, Cable NT. Energy expenditure in adolescents playing new generation computer games. Br J Sports Med 42(7):592-4, 2008.

8. Jones S. Let the games begin: Gaming technology and college students In: PEW Internet & American Life Project Web site; 2003.

9. Penko AL, Barkley JE. Motivation and physiologic responses of playing a physically interactive video game relative to a sedentary alternative in children. Ann Behav Med 39(2):162-9, 2010.

10. Roemmich JN, Barkley JE, Lobarinas CL, Foster JH, White TM, Epstein LH. Association of liking and reinforcing value with children's physical activity. Physiol Behav 93(4-5):1011-8, 2008.

11. Salmon J, Owen N, Crawford D, Bauman A, Sallis JF. Physical activity and sedentary behavior: a

population-based study of barriers, enjoyment, and preference. Health Psychol 22(2):178-88, 2003.

12. Sanders GJ, Santo AS, Peacock CA, Williamson ML, von Carlowitz KP, Barkley JE. Physiologic responses, liking and motivation for playing the same video game on an active versus a traditional, non-active gaming system. Int J Exerc Sci 5(2):160-9, 2012.

13. Thompson WR. ACSM's guidelines for exercise testing and prescription: 8th edition. In. American College of Sports Medicine. Baltimore: Lippincott Williams and Wilkins; 2010.