Energy Expenditure of Middle School Children While Playing Wii Sports Games

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Abstract

According to a study from the Kaiser Family Foundation, total media use among all 8- to 18-year-olds was seven hours and thirty-eight minutes on a typical day (Rideout, Foehr, & Roberts, 2010). The large amount of time spent in media use has been implicated as one of the causes of the increased prevalence of obesity. The purposes of this study were to measure: 1) the total level of energy expenditure (EE) while middle school children played the Wii Sports games when given free access to all of the games, 2) the length of time they played each game, and 3) the differences in EE between games. Thirty-seven children (15 males and 22 females) with an average age of 12.4 ± 1.0 years participated in this study. Each had experience with Wii Sports. Participants were given 20 minutes to play any of the Wii Sports games they desired while their expired gases were captured by a calibrated portable metabolic cart. Heart rate was monitored with a Polar® heart rate monitor. Baseball and bowling were the most popular games. Energy expenditure was greater after playing the Wii for each game except golf. The average EE during the game playing time was 2.8 ± 0.9 kcal/min, compared to 1.4 ± 0.4 kcal/min while at rest prior to testing. Playing Wii Sports can moderately increase the EE of children over rest.

Keywords: Obesity, Exergaming, Heart Rate, Exercise

Childhood obesity has become a worldwide concern (Raymond, Leeder, & Greenberg, 2006; Reilly & Dorosty, 1999; Rössner, 2002; Rudolf, Sahota, Barth, & Walker, 2001; World Health Organization, 1998). When obesity is present in childhood, it is likely to persist into adulthood (Freedman, Khan, Serdula, Dietz, Srinivasan, & Berenson, 2005; Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007) and cause an increase in the number of cardiovascular risk factors in adulthood (Berenson, Srinivasan, Boa, Newman, Tracy, & Wattigney, 1998; Lauer & Clarke, 1988, 1989; Rees, Thomas, Brophy, Knox, & Williams, 2009). The latest data in the United States show an obesity rate of 17% for 6-11 year olds and 17.6% for 12-19 year olds. The prevalence of obese and overweight categories combined in these age groups is 33.3% and 34.1%, respectively, with Non-Hispanic, Black and Mexican American children having a greater prevalence than Non-Hispanic Whites (Ogden, Carroll, & Flegal, 2008).

According to a review and critique of 90 studies examining the prevalence of television viewing, video game playing, and computer use, it is no surprise to find that children spend an excessive amount of time watching television, playing video games, and using computers (Marshall, Gorely, & Biddle, 2006). The time spent in inactive pursuits greatly outweighs the time spent in active pursuits including sports participation (Gorely, Marshall, Biddle, & Cameron, 2007; Gorely, Biddle, Marshall, & Cameron, 2009). According to the Third National Health & Nutrition Examination Study (NHANES) and several other studies, the large amount of time children spend on sedentary activities such as television viewing and video game playing is related to the increasing levels of obesity observed over last two decades. (Andersen, Crespo, & Bartlett, 1998; Crespo, Smit, Troiano, Bartlett, Macera, & Anderson, 2001; Dietz & Gortmaker, 1985; Gortmaker, Must, Sobol, Peterson, Colditz, & Dietz, 1996;

Hesketh, Wake, Graham, & Waters, 2007; Janz, Levy, Burns, Torner, Willing, & Warren, 2002; Marshall, Biddle, Gorely, Cameron, & Murdey, 2004; Stettler, Signer, & Suter, 2004; Vandewater, Shim, & Caplovitz, 2004). The Generation M2: Media in the Lives of 8- to 18-Year-Olds, a Kaiser Family Foundation Study from January 2010, reports that total media use time in a typical day is seven hours and thirty-eight minutes (Rideout, et al., 2010).

In recent years an alternative to sedentary video gaming – called "exergaming" - has emerged. Exergaming is defined as the use of the individual's body movements to improve his/her score on video games. The first and most popular of these exergames is Dance Dance RevolutionTM (DDR). Several studies have shown that playing DDR can lead to a level of energy expenditure (EE) that would be considered moderate exercise based on the American College of Sports Medicine (ACSM) guidelines (Lanningham-Foster, Jensen, Foster, Redmond, Walker, Heinz, & Levine, 2006; Tan, Aziz, Chua, & Teh, 2002; Unnithan, Houser, & Fernhall, 2006). In addition, other exergaming products have been shown to increase EE above resting conditions while the participants play the games (Graves, Ridgers, & Stratton, 2008; Graves, Stratton, Ridgers, & Cable, 2007; Haddock, Brandt, Siegel, Wilkin, & Han, 2008; Lanningham-Foster, et al., 2006; Maddison, Mhurchu, Jull, Jiang, Prapavessis, & Rodgers, 2007; Mellecker & McManus, 2008). More recently, a study of overweight children, aged 7-14 years, has shown that using a stationary bike to control a video game led to greater EE than riding the same bike without the video game interaction. This increased EE occurred without a corresponding increase in perceived exertion (Haddock, Siegel, & Wilkin, 2009).

Several investigators have examined EE associated with one popular gaming system: the Nintendo Wii Sports (Graf, Pratt, Hester, & Short, 2009; Graves et al., 2008, 2009; Lanningham-Foster, Foster, McCrady, Jensen, Mitre, & Levine, 2009). All of these studies found EE to increase above baseline values when playing Wii Sports games. However, all of these studies predetermined the games the children would play and the amount of time they would play each game. It is unknown which of the Wii Sports games children would play when given the opportunity to choose between the games provided.

The purpose of this study was to test two research hypotheses: 1) When given free access to the Wii Sports game, will middle school children increase their heart rate (HR) and EE above baseline values, regardless of which game they are playing? and 2) Will certain Wii Sport games be more popular than others in this sample?

Methods

Participants

Thirty-seven children (15 males and 22 females) were recruited for this study. Participants were recruited from a local middle school's after school program. All participants were shown the metabolic cart, the Wii Sports games (baseball, bowling, boxing, golf, and tennis), and given an explanation of the study at a familiarization session. Participants filled out a questionnaire regarding their experience with Wii Sports and their participation in the actual sports. Each participant had previously played the Wii Sports games.

Procedures

After parental informed consent and child assent were obtained, each participant came to a room that was designated for testing at the middle school. Participants were instructed to not eat for at least two hours prior to their testing session; however, water was allowed. Height was measured using a stadiometer and weight was measured using a physician's scale, both to the nearest 0.1 centimeters and 0.1 kilograms, respectively. Body Mass Index (BMI) in kg/m2 was calculated for each participant and they were categorized according to Centers for Disease Control and Prevention (CDC) growth charts (CDC, 2000) as healthy (<85th percentile), overweight (≥85th percentile), or obese (≥95th percentile). Participants were then connected to a calibrated portable metabolic cart (Viasys Oxycon mobile; Yorba Linda, CA) and a heart rate (HR) monitor (Polar, Inc., USA).

Once the participant stated that he/she was comfortable with the mask and HR monitor, he/she sat in a chair and relaxed for 10 minutes while expired gases were being captured breath-by-breath. Baseline oxygen consumption (VO2) and carbon dioxide production (VCO2) were measured in order to determine a baseline level of EE. In addition, HR was monitored to determine a baseline HR. After the 10 minute resting session, while remaining connected to the metabolic cart and the HR monitor, the participants were allowed to choose which of the games they would play. The 20 minute game playing session started when they took their first swing with the Wii remote controller. After completing a Wii Sport game, the participant could choose to replay the same game or go to a different game. The total time for each game was determined as the time from the first swing until they clicked the quit button for that particular game. The participants were allowed to switch between games whenever they desired during the 20 minute game playing session. The total time played for each game along with the metabolic and HR data for each game was recorded.

Statistical Analyses

All data were entered into the Statistical Package for the Social Sciences (SPSS) Version 17.0 (SPSS Inc., Chicago, IL) for data analyses. Descriptive data were calculated for age, height, weight, BMI, and metabolic and HR data. EE and HR data were separated and analyzed by BMI category. Mean EE and HR were calculated for the 20 minute game playing session as a whole and for the games individually. A multivariate analysis of variance (MANOVA) test assessed differences in the mean EE and HR between Wii Sport games, and a Scheffé's post hoc test determined which games differed statistically from one another. An analysis of variance (ANOVA) tested differences between participants of the varying BMI categories and EE and HR. A Scheffe's post-hoc test was used to show between which BMI groups the differences in EE and HR existed. An alpha level of .05 was set to determine statistical significance.

Results

When separated by BMI classification, there were a total of 16 participants in the healthy group (mean age 12.8 ± 1.0 yrs.), ten participants in the overweight category (mean age 12.2 ± 0.9 yrs.), and 11 participants in the obese category (12.1 ± 1.1 yrs.).

Time played

Although all participants were given a total of 20 minutes to play the game(s) of their choice, the total amount of actual game playing time varied depending on the time each participant took to switch between the games. The mean playing time for participants was 18.7 ± 1.0 minutes. The mean time each game was played in total and by BMI category is listed in Table 1. Golf was played for the least amount of time while baseball was played for the greatest amount of time (F (4, 176) = 14.12, $p < .001$; partial eta-squared (η_p^2) = 0.24). There were no differences for mean length of time played by BMI category. The games the participants chose to play, the number of all participants that played each game, and the number of participants that played each game by BMI category is listed in Table 1. There were no differences between the three BMI categories as to which games they chose to play.

Table 1

Mean time in minutes ± SD each game was played and the number of participants who chose to play each game, by BMI category

	All	Healthy	Overweight	Obese
Tennis	3.6 ±3.7 (n = 23)	4.0 ±4.3 (n = 10)	4.3 ±3.3 (n = 8)	2.3 ±3.0 (n = 5)
Boxing	2.3 ±4.1 (n = 11)	2.3 ±4.5 (n = 4)	0.9 ±1.8 (n = 2)	3.5 ±4.7 (n = 5)
Bowling	5.1 ±4.3 (n = 27)	5.3 ±4.1 (n = 13)	6.8 ±5.4 (n = 7)	3.4 ±3.1 (n = 7)
Baseball	7.1 ±5.3 (n = 29)	6.7 ±6.0 (n = 11)	5.7 ±4.3 (n = 8)	8.9 ±5.2 (n = 10)
Golf	0.6 ±2.2 (n = 3)	0.6 ±1.6 (n = 2)	1.2 ±3.8 (n = 1)	NA (n = 0)

Table 2

HR (beats/min.) Mean ± SD at baseline and during play of all participants and by BMI category

	All (n = 35)	Healthy (n = 14)	Overweight (n = 10)	Obese (n = 11)
Baseline	90.9 ±9.8	90.3 ±10.6	90.7 ±11.9	91.8 ±7.4
Tennis	108.2 ±14.4*	104.9 ±15.2	112.4 ±14.9	107.6 ±13.5
Boxing	126.9 ±16.0*	130.0 ±16.1	127.5 ±29.0	124.8 ±15.0
Bowling	102.8 ±11.2	104.8 ±13.1	101.0 ±11.4	101.3 ±8.6
Baseball	108.4 ±10.9*	107.8 ±7.7	111.0 ±16.4	106.9 ±9.1
Golf	105.7 ±8.3	101.0 ±2.8	115.0	NA
Total time	109.8 ±12.3	108.6 ±12.6	108.5 ±13.5	112.5 ±11.7

Note: HR data are not available for two of the subjects therefore the n for all is smaller. See Table 1 for the number of participants who played each game by BMI category.
* Significantly higher than baseline values $p < .05$.
No significant differences existed between the values in the three BMI categories $p > .05$.

The average HR at baseline and during game play is listed for all participants and by BMI category in Table 2. Each game led to an increase in HR over baseline (F (5, 124) = 11.43, $p \leq .000$; $\eta_p^2 = 0.32$) except for golf and bowling. Mean HR did not vary by BMI category.

Energy Expenditure

Differences in EE between all participants and the participants in the three BMI categories both at baseline (rest) and during the activity time are presented in Table 3. All games except golf resulted in an increase in EE above baseline (F (5, 124) = 29.96, $p \leq .000$; $\eta_p^2 = 0.56$). The mean EE differed in tennis (F (2, 20) = 6.06; eta-squared (η^2) = 0.38), bowling (F (2, 24) = 5.00; $\eta^2 = 0.29$), and baseball (F (2, 26) = 4.75; $\eta^2 = 0.27$) by BMI category ($p \leq 0.05$). In tennis, the healthy group expended fewer calories than both the overweight and obese groups. In addition, EE for bowling and baseball differed for the healthy and obese groups, with the obese participants expending a greater number of calories.

Discussion

The primary purpose of this study was to determine energy expenditure (EE) while playing the Wii Sports Games when given free access to all of the games for a duration of 20 minutes. Previous studies that have investigated the Wii Sports games examined a specified number of minutes playing a particular game while being monitored for energy expenditure with a short rest interval between games (Graf, et al., 2009; Graves, et al., 2007, 2008; Lanningham-Foster, et al., 2009). The previous studies specified the choice of game and the length of time each of those specified games would be played. This study provided free access in order to simulate what might occur under normal (non-research) circumstances where children have the ability to choose the games they play, and to evaluate the popularity of the different games in this age group.

As is clearly shown in Table 1, the participants in this study chose baseball and bowling more than any of the other games and played them the longest. Golf was the least popular, with only three of the 37 participants choosing to play it at all. Boxing was also not chosen often, with only 11 participants choosing to play this game at any time during the 20 minute session. The popularity of certain games cannot be completely due to the amount of exertion required as golf and boxing were at the opposite ends of the spectrum in EE (Table 3). Anecdotally, it appears this lack of interest in both golf and boxing may be due to the level of exertion required to play boxing and the fact that golf is typically considered to be an adult sport. In addition, we observed no differences between the games chosen and BMI category of the game player.

One of the goals of this study was to determine HR and level of EE in middle school children who were given free access to play any of the Wii Sports games. The mean HR (109.8 ± 12.4 beats/min.) and EE (2.8 ± 0.9 Kcal/min.) found during the 20 minutes of activity might be

considered moderate intensity, at best. However, the observed intensity did not meet American College of Sports Medicine (ACSM) (2010) standards for moderate intensity, with the exception of boxing (ACSM, 2010). ACSM defines moderate intensity as 40 to 60% of heart rate reserve.

Table 3

EE (Kcal/min) Mean ± SD at baseline and during play for all participants and by BMI category

	All (n = 37)	Healthy (n = 16)	Overweight (n = 10)	Obese (n = 11)
Baseline	1.4 ±0.4	1.2 ±0.3	1.4 ±0.3	1.7 ±0.4
Tennis	2.7 ±0.8*	2.2 ±0.8**	3.1 ±0.6	3.2 ±0.1
Boxing	4.3 ±1.1*	3.6 ±1.3	5.0 ±0.3	4.6 ±0.8
Bowling	2.2 ±0.7*	1.9 ±0.6	2.4 ±0.6	2.8 ±0.7***
Baseball	2.7 ±0.7*	2.3 ±0.6	3.0 ±0.4	3.1 ±0.8***
Golf	1.6 ±0.3	1.5 ±0.1	2.0 ±NA	NA
Total Time	2.8 ±0.9	2.3 ±0.9	2.9 ±0.7	3.4 ±0.8

Note: See Table 1 for the number of participants who played each game by BMI category.
* Significantly higher than baseline values $p \leq .01$.
** Significantly fewer kcals than overweight or obese $p \leq .01$.
***Greater kcals than healthy $p \leq .05$.

When comparing the games to each other as shown in Table 2, HR increased overbaseline/resting values for all games except bowling and golf. As shown in Table 3, EE increased over baseline/resting values for all games except golf. Out of all the games, the boxing game elicited the highest value for EE while golf elicited the lowest value for EE during the time the participants played.

When comparing the findings of this study with other studies examining EE for the Wii Sports games, two other studies had participants of similar ages. The EE values from this study were similar to the values measured in the Lanningham-Foster et al. study from 2009 for boxing. The Graf et al. study from 2009 found lower EE values for their participants. However, the participants in the Graf et al. study were younger, weighed less, and the mean BMI was lower. Additional studies examining EE for Wii Sports games had older participants with similar BMI means and the EE for tennis, boxing, and bowling were similar the results of this study (Graves et al., 2007, 2008).

In conclusion, this study found similar EE values compared with previous work for Wii Sports games. According to the Institute of Medicine (IOM) of the National Academies, there is a need for real life research that can lead to programmatic change (2010). When compared with other similar work in this area, this study provided the option for the children to choose the game they would play thereby simulating a more realistic, real life environment. Therefore, the significance of this study is that it is the first study to demonstrate an increased level of energy expenditure when middle school children were allowed to play the Wii Sport game(s) of their choice. The amount of energy expended to play the games did not seem to have an impact on the choices the children made since they chose baseball and bowling most frequently and golf and boxing least frequently. In addition, there were no differences between BMI categories for the games the participants chose to play. This is significant to public health concerns as it suggests that regardless of BMI category, given free choice, children will play games that require an increase in EE above baseline. Playing these games could help with overall EE if replacing sedentary activity, but not if replacing traditional sport or exercise sessions.

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