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Original Research

Do exergames allow children to achieve physical activity intensity commensurate with national guidelines?

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ABSTRACT

Int J Exerc Sci 4(4) : 257-264, 2011. The purpose of this study was to determine if two popular exergames, Wii Fit™ and EA Sports Active™, both games for the Nintendo Wii™ console, help children achieve intensity consistent with recommended physical activity guidelines. Thirty children (19 males and 11 females, Mean age = 9.4 ± 1.8 years) participated in this study by playing each game during one research session. During the session participants wore a heart rate monitor and accelerometer to measure exercise intensity. Perceived exertion (RPE) was measured with the children's run/walk OMNI scale. All three measures of exercise intensity (heart rate, accelerometer counts, and RPE) found that the EA Sports Active™ game session elicited higher exercise intensity. However, heart rate data found both games to achieve moderate intensity (65-68% age-predicted HR_{max}). When using heart rate as an indicator of exercise intensity it appears that both exergames were of sufficient intensity to achieve physical activity guidelines. Future studies should continue to investigate the utility of exergaming in helping children to become more physically active.

KEY WORDS: Children, physical activity, video games, accelerometer, perceived exertion

INTRODUCTION

In the United States, obesity is currently the second leading cause of preventable disease and death after smoking (19). According to the National Health and Nutrition Examination Study conducted in 2003-2004, 17% of U.S. children and adolescents were overweight (13). Childhood and adolescence are believed to be critical periods for the development of obesity (6). It is recommended that children become more physically active. According to the Centers for Disease Control and Prevention (CDC), children and adolescents 6 to 17 years of age should engage in 60 minutes or more of physical activity each day. The CDC recommends that most of the hour consist of moderate or vigorous-intensity activity (4). Moderate activity, according to the CDC, elicits heart rates between 50-70% of maximum heart rate, whereas vigorous activity elicits heart rates of 70-85% of maximum heart rate. Technology may be a major reason for the increased amount of sedentary behavior during these critical periods. Studies of physical activity and screen time, or time spent in front of a television or computer screen, show that the lifestyles of many children are not consistent with recommendations for healthy development. In U.S. children 4 to 11 years old, 37% had low levels of active play, 65% had high screen time, and 26% had both these behaviors (2). The American Academy of Pediatrics recommends no more than 2 hours per day of screen media for children, citing numerous behavioral, physical, and academic problems associated with higher levels (1). Children in nationally representative samples, however, report spending more than 3 hours per day looking at a screen (15, 21). In a study of 548 public school students, researchers found that each hour increase in television viewing was associated with an additional 167 kcal consumed per day (20). Screen media therefore contributes to the obesity epidemic both through the inactive nature of the activity and through an associated increase in caloric consumption.

Merely turning off televisions would be a logical step towards decreasing time spent engaging in sedentary video game play, but many parents likely use screen time as a way to occupy children. In recent years, video game companies such as Sony® and Nintendo™ have developed a potential solution to this problem: exergames, or video games in which players are required to move much more than in traditional video game play. Because of the high volume of time children spend engaging in screen-based activities, it is not likely that these activities can be easily eliminated. It is therefore important to evaluate if sufficient physiological responses are elicited by exergames before they are recommended as healthier alternatives to inactive game play. Dance Dance Revolution® (DDR®), a game initially popular in arcades but then made available for home use, has been demonstrated to engage players in moderate and/or vigorous physical activity (MVPA) (16, 17). A 28-week intervention study found that children (7.5 ± 0.5 years) with access to DDR® decreased sedentary screen time and increased vigorous physical activity (11).

The Nintendo Wii™ game system requires that players use their body motions to control and play the game rather than the traditional buttons-and-joystick method. Since its release, Nintendo™ has sold more than 15.2 million units in North America (12). Although more recently developed than most of its competitors, its sales make the Nintendo Wii™ arguably the most popular of the exergames thus far. In a comparative study, researchers had children play Wii boxing™, Wii tennis™, DDR®, and a sedentary video game for fifteen minutes. It was found that children (11.1 ± 0.4 years) expended twice as much energy with the exergames than the sedentary game (3). Another study with children, 8 – 12 years, compared Wii Sports boxing™ to a sedentary video game and treadmill walking. The Nintendo Wii™ game was found to elicit a higher heart rate, VO_2, and enjoyment of the activity than both the sedentary game and treadmill walking at 1.5 mph (14). Research has found that active video game play, such as the Nintendo Wii™ boxing and DDR®, requires energy expenditure as measured by indirect calorimetery comparable to moderate-intensity walking in children 10 – 13 years (8). Although this is significantly higher than sedentary video game play, it is not as much energy as playing the sport itself and may not contribute to the daily recommendation of 60 minutes of MVPA each day (9). Further research is needed to explain the ways in which exergames like

Nintendo Wii Fit™ can be used to positively influence children's engagement in physical activity.

We sought to determine the difference between two popular exergames, Wii Fit™ and EA Sports Active™, on the basis of heart rate, accelerometer counts, and perceived exertion in order to determine if the games helped children to achieve the recommended physical activity guidelines. This information can provide important information about the use of exergames in exercise prescriptions and positively influence children's engagement in physical activity.

METHODS

Participants

Thirty children (19 males and 11 females, Mean age = 9.4 ± 1.8 years; Mean height = 1.4 ± 0.2 m; Mean weight = 35.0 ± 9.6 kg; Mean BMI = 18.0 ± 2.4 kg/m^2) participated in this study. Participants were recruited through a University-wide faculty email asking for their children's participation. In accordance with our Institutional Review Board, all participants provided written assent and their legal guardians provided written informed consent. Participants were given a gift card for completion of the session.

Protocol

The children's run/walk OMNI scale was used to measure perceived exertion during exercise. Its use with children has been validated by Utter and colleagues (2002), among others (18). This scale uses a numerical scale from 0 to 10, with a score of 4 indicating "getting more tired" and 9 indicating "very, very tired." In addition to the numbers, it has pictures of a child trying to go up an incline with increasing difficulty. Because it offers a pictorial depiction of perceived effort, it is thought to be an effective scale for use with children (18).

Participants completed one research session lasting approximately 60 to 75 minutes. The participants were initially briefed on the purpose and procedures of the research. They were told the general instructions for each game session, and instructed to follow the game procedures as close as possible. Researchers then obtained height and weight information for each participant using a Seca® stadiometer. Participants wore during the height and weight measurements. Measurements were taken once. The participant was then fitted with a heart rate monitor (Polar, Lake Success, NY) and accelerometer (Actigraph model GT1M). The accelerometer was worn on a belt on the right hip of the participant and objectively measured exercise intensity during the session. This was chosen because previous research in 11 to 17 year old adolescents showed this to be the best predictor of energy expenditure (9).

Next, participants were randomly assigned to play games on either the Wii Fit™ or EA SPORTS Active™, both games created for the Nintendo Wii™ game console. The activities selected for each of the games were estimated to take about 20-25 minutes each, but due to the activity, fitness levels and familiarity with the games, the times varied between participants. It is also important to note that the activities for EA Sports Active™ were chosen in an attempt to mimic the intensity and type of energy consumption that occurs in normal children's play. As such, the EA Sports Active™ activities were chosen from a preset routine called "Marathon (hard)." The game session alternated between mainly aerobic (running, dancing, etc.) to mainly anaerobic (boxing, volleyball, etc.) to give an overall workout of varying intensities. The Wii Fit™ activities were chosen by the researchers to match the intensity of the game session for EA Sports Active™.

During the Wii Fit™ game session, participants played nine pre-determined activities (run, boxing, hula hoop, ski slalom, soccer, ski jump, single leg extension, run, and basic step). In the middle of the game session, after playing soccer, participants completed the OMNI scale. Heart rate was recorded after every individual game. At the end of the game session, the OMNI scale was again reported.

The OMNI scale was only asked at two times during the exercise sessions in an effort to minimize the breaks in activity while playing the games. The more breaks in action may have influenced the heart rate and accelerometer data and decreased the generalizability of the findings. The two times were chosen to represent a time mid-point of playing the game and then at the end of playing to get an overall perception of exertion. The participants were asked to make their rating based on what they were experiencing at that moment. For children it seemed that these would be the easiest instructions to use in comparison to using a session perceived exertion.

During the EA SPORTS Active™ portion of the research session, participants played nine pre-determined activities (run, boxing, run/high knees, side to side jumps, baseball, inline skating, volleyball, run, dance). In the middle of the game session, following playing baseball, participants completed the OMNI scale. Heart rate was recorded after every game. At the end of the game session, the OMNI scale was again reported.

Following completion of the first game session, participants rested until heart rate reached within 10% of resting heart rate before completing the next game session. This generally took less than 5 minutes. This rest allowed for heart rates to be normalized before the next session began. After completion of the other game session, the visit to the laboratory was completed.

Statistical Analysis

The accelerometer data was coded such that 60 second epochs of time for each game (e.g., the EA SPORTS Active™) was categorized as either light intensity or moderate to vigorous physical activity (MVPA) intensity based on previously determined cut points (7). It should be noted that very few minutes of vigorous activity were found; therefore, it was included in the MVPA intensity.

All analyses were run using SPSS statistical software. A Game by Time Repeated Measures General Linear Model (RM GLM) was used to determine main and interaction effects of condition and time (within-subjects repeated measure) for heart rate and OMNI scale. A least-significant difference test was performed for all post hoc analyses.

RESULTS

The total time that participants played the EA SPORTS Active™ and Wii Fit™ was 25.5 ± 2.9 and 28.0 ± 2.7 minutes, respectively. A RM GLM found that participants played a significantly greater amount of time on Wii Fit compared to EA SPORTS ACTIVE™ ($F(1, 28) = 27.02$, $p < .001$). To account for this difference, accelerometer data was analyzed by looking at percentage of time that participants were in either light or moderate to vigorous physical activity (MVPA) intensity.

A RM GLM found a significant difference for game ($F(2, 27) = 28.65$, $p < .001$) which was due to greater light activity occurring in the Wii Fit™ game at 59.8% of minutes ($F(1, 28) = 52.92$, $p < .001$) and MVPA in the EA Sports Active™ game at 64.6% of minutes ($F(1, 28) = 57.30$, $p < .001$).
A 2 (Game) x 10 (Time) RM GLM for heart rate revealed a significant game effect ($F(1, 28) = 15.16$, $p = .001$), time effect ($F(9, 20) = 42.37$, $p < .001$), and game*time interaction ($F(9, 20) = 13.20$, $p < .001$). The effect for game was due to a greater mean heart rate during EA SPORTS Active™, 144.0 ± 8.0 bpm, compared to Wii Fit™, 136.5 ± 9.6 bpm (LSD = .001). The interaction effect was due to a lower heart rate during the EA SPORTS Active™ during the boxing activity. The time effect was due to significantly elevated heart rate during activity compared to baseline (LSD < .001). See Table 1 for means and standard deviations.

A 2 (Game) x 2 (Time) RM GLM for OMNI scale showed a significant effect for time ($F(1, 29) = 60.23$, $p < .001$) and game*time interaction ($F(1, 29) = 4.59$, $p = .041$), but not an effect for game ($F(1, 29) = 2.53$, $p > .05$). The interaction was a result of a greater increase in perceived exertion in the EA SPORTS Active™ game at the end of the session (LSD < .001). See Table 1 for means and standard deviations.

Table 1. Heart rate and perceived exertion by game and activity.

EA Sports Active			Wii Fit		
Activity	Heart Rate	OMNI	Activity	Heart Rate	OMNI
Baseline	107. 1 ± 18.6		Baseline	109.2 ± 16.9	
Run	164.1 ± 26.3		Run	159.9 ± 22.6	
Boxing	137.4 ± 26.5		Boxing	153.2 ± 27.3	
Run/High Knees	150.9 ± 26.4		Hula Hoop	144.5 ± 26.9	
Side to Side Jumps	158.3 ± 20.0		Ski Slalom	122.1 ± 16.8	
Baseball	130.4 ± 18.9	3.5 ± 2.5	Soccer	126.9 ± 15.7	3.4 ± 2.7
Skating	146.1 ± 13.2		Ski Jump	118.9 ± 18.1	
Volleyball	134.9 ± 17.7		Single Leg Extension	130.7 ± 15.3	
Run	170.8 ± 22.6		Run	162.4 ± 23.1	
Dance	140.0 ± 16.7	5.5 ± 2.7	Basic Step	136.9 ± 21.0	4.5 ± 2.9

DISCUSSION

The purpose of this study was to compare two different video games for the Nintendo Wii™ and determine the intensity of physical activity that occurred while playing in comparison to physical activity recommendations for children. When exercise intensity was measured by heart rate, both video games showed an increase in heart rate compared to baseline, but the EA Sports Active™ game showed a slightly higher heart rate than the Nintendo Wii Fit™, 144 and 136.5 bpm, respectively. Although the heart rates for EA Sports Active™ and Wii Fit™ are statistically different, they may not be practically significant because both fall within the

ranges for moderate intensity. These heart rates are equivalent to 68% and 65% age-predicated HR_{max} and are thus considered moderate intensity. When using the accelerometers, play on the EA Sports Active™ games resulted in a higher percentage of minutes classified as MVPA by accelerometer cut-points. The results of this study support previous research (8), which found that playing exergames was of an intensity equivalent to that of moderate intensity walking. Similarly, researchers found that playing Wii Sports Boxing™ resulted in a greater heart rate compared to treadmill walking and that the children enjoyed playing Wii Sports Boxing™ more than walking on the treadmill (14).
Graves and colleagues on the other hand, found that the intensity of exergames, although greater than sedentary video games, may not be high enough to achieve benefits in children (10). It should be noted, however, that Graves et al. measured expired gases to determine energy expenditure and do not report heart rate values. Therefore direct comparisons cannot be made to the present study.

The results of this study suggest that children playing exergames, such as those for the Nintendo Wii™, may be able to reach an intensity of physical activity sufficient to meet physical activity guidelines proposed by the CDC (4). Additional support besides the heart rate data also comes from the perceived exertion scales. It is suggested that a score of 5 or 6 on a 10 point scale would be equivalent to moderate intensity exercise. Therefore, the three measures used in this study serve to triangulate the exercise intensity for the both games and suggest that the play of these games can yield moderate exercise intensity.

It should be noted, however, that the accelerometer data did not completely support the findings that exercise reached moderate intensity. Previous research has shown accelerometers worn at the hip to be the best predictor of energy expenditure in 11 to 17 year old adolescents (9). In the current study, however, by utilizing the accelerometer only at the hip, it is possible that not all activity was sufficiently measured. Future studies may want to consider including accelerometers at more joints, such as the ankle and wrist, to get a better understanding of how much activity occurs when playing exergames. Another line of research may be to measure the expired gases of the participants while playing the Nintendo Wii™. This would enable the researchers to determine oxygen consumption while playing. The main limitation to acquiring this data is that it could be cumbersome to the participant and may influence their perceptions of difficulty or desire to play in the future. Additionally, future studies may want to examine the influence of fitness level on responses to exergaming. The current study did not include any measures of physical fitness.

If exercise intensity is determined to be sufficient to achieve health benefits, longitudinal studies need to be conducted to determine the benefits that occur (5). One study found that when participants played exergames, specifically DDR®, they were able to reduce the amount of sedentary screen time and slightly increase vigorous physical activity (11). More studies of this nature need to be conducted that examine whether physiological and psychological benefit come along with physical activity interventions which use exergames.

Another concern with using exergames is that over time participants may learn to participate in the game without doing as much activity or may become bored. Therefore, more research needs to examine the motivational level of participants to adhere to interventions utilizing exergames. If the motivational level becomes low, then it is doubtful that the participants will continue to do the program and accrue the benefits from it. This suggests that multiple games may be needed to keep the enjoyment high or the boredom low in hopes of participants maintaining their exercise program.

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