Published in final edited form as:
Open Sports Sci J. 2009 January 1; 2: 42–46. doi:10.2174/1875399X00902010042.

The Addition of a Video Game to Stationary Cycling: The Impact on Energy Expenditure in Overweight Children

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Abstract

Introduction—The prevalence of obesity in children has reached epidemic proportions with over 37% of children aged 6–11 years in the U.S. being classified as “at risk for overweight” or “overweight.” Utilization of active video games has been proposed as one possible mechanism to help shift the tide of the obesity epidemic.

Purpose—The purpose of this study was to determine if riding a stationary bike that controlled a video game would lead to significantly greater energy expenditure than riding the same bike without the video game connected.

Methods—Twenty children, 7–14 years old, with a BMI classification of “at risk for overweight” or “overweight” participated in this study. Following familiarization, energy expenditure was evaluated while riding a stationary bike for 20 minutes. One test was performed without the addition of a video game and one test with the bike controlling the speed of a car on the video game.

Results—Oxygen consumption and energy expenditure were significantly elevated above baseline in both conditions. Energy expenditure was significantly higher while riding the bike as it controlled the video game (4.4 ± 1.2 Kcal·min^{-1}) than when riding the bike by itself (3.7 ± 1.1 Kcal·min^{-1}) ($p<0.05$). Perceived exertion was not significantly different between the two sessions ($p>0.05$).

Conclusion—Using a stationary bike to control a video game led to greater energy expenditure than riding a stationary bike without the video game and without a related increase in perceived exertion.

Keywords

Obesity; Oxygen consumption; Kcal; BMI

INTRODUCTION

The prevalence of obesity in children has continued to increase in recent years. According to the Center for Disease Control’s (CDC) classification system, the prevalence of children in the United States, aged 6–11 years, classified as “overweight” has reached 18.8%, while the prevalence of those classified as either “overweight” or “at risk for overweight” is at 37.2% [1,2]. Although there is some evidence that the increased prevalence of obesity is leveling off in children, the prevalence is still considered excessively high [3]. This increased prevalence of overweight in children has become a global epidemic [4–9] and has been shown to be associated with multiple cardiovascular risk factors, including higher levels of cholesterol, triglycerides, systolic and diastolic blood pressure, and fasting insulin [10].

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Children spend a large amount of time watching television and playing computer games [11]. The time children spend on these tasks has often been blamed for the increased prevalence of overweight in children [12–19]. Previous efforts to reduce the amount of screen time (television and video games) in children have proven to be successful in helping children decrease their weight and improve their body composition [20,21].

In recent years, interest has risen as to the efficacy of interactive video games (exergaming). Several studies have examined the level of energy expenditure while playing these exergames [22–26]. The level of energy expenditure has been shown to increase significantly above resting levels [22–24], or above the level of energy expenditure while playing sedentary video games [25,26] and watching television [25]. Generally these studies have shown that energy expenditure will increase over resting levels to an intensity that is similar to moderate intensity exercise, with a VO_2 during activity of approximately 14–24 $ml \cdot kg^{-1} \cdot min^{-1}$.

A study of wheelchair bound athletes found that utilizing an arm ergometer to control a video game increased energy expenditure compared to utilizing the same arm ergometer without the video game interaction. This enhanced energy expenditure was found without a corresponding increase in perceived exertion [27]. No published research has compared the energy expenditure of overweight children while performing a traditional exercise (e.g., stationary cycling) to their energy expenditure while exercising on the same equipment with interactive gaming. Therefore, the purpose of this study was to determine if adding an interactive video game component to traditional cycle ergometry would impact the energy expenditure and rating of perceived exertion (RPE) in overweight children.

METHODS

Subjects

Twenty children (13 boys, 7 girls), between the ages of 7 and 14 years participated in this study. The participants were recruited from a local weight management program and were generally sedentary. Each participant's height and weight were measured with a portable stadiometer (SECA 214; Hamburg, Germany) and calibrated digital scale (TANITA; Arlington Heights, Illinois), to the nearest 0.5 cm and 0.1 kg respectively. All participants had a Body Mass Index (BMI) that put them at the 85th percentile or above for their age and sex according to the CDC guidelines.[1] All participants were free of diabetes, thyroid disorders, heart disease, or hypertension. The research protocol was approved by the Institutional Review Board (IRB) of the California State University, San Bernardino. Child assent and written parental informed consent was obtained prior to participation.

Procedures

Each participant was scheduled for three appointments: (1) familiarization with the equipment, (2) testing session #1, and (3) testing session #2. At least one parent was required to be in attendance at each session.

At the familiarization session, each participant was shown the portable metabolic cart (Cosmed K4b^2 – Rome, Italy) including the mask and heart rate (HR) monitor that they would be wearing during the two testing sessions. Each participant was then allowed to ride on the cycle ergometer (CatEye™ Gamebike - USA) and play the games that would be utilized in the study. Participants were allowed to play the games during this session for as long as they wanted. All of the participants had previous experience with the ergometer, having utilized the system in their weight management program. The video game utilized for this study was Disney's "Cars" (Pixar Entertainment) on a PlayStation®2 console.

For each testing session, the children were instructed not to eat for a minimum of two hours prior to their appointment time, although water was allowed. All testing was done in a private room so that only the participant, parents, and researchers were present. Upon arriving, the participants were reminded of the testing procedures. The participants were then connected to the calibrated portable metabolic cart and HR monitor. The O_2 and CO_2 sensors were calibrated prior to each test with a known gas concentration of 16% O_2 and 5% CO_2. In addition, volume calibration was performed with a 3-Liter Syringe. Participants were then seated in a comfortable chair. Breath by breath oxygen consumption (VO_2) and carbon dioxide production (VCO_2) were collected for 10 minutes, with the last 5-minutes of collection averaged for determination of baseline energy expenditure.

After collection of the baseline data, participants stepped up to the cycle ergometer for one of two testing sessions: (1) a 20-minute exercise session with no video game (NV) or (2) a 20-minute exercise session with the cycle ergometer controlling the video game (V). Breath by breath VO2 and CO2 were measured continuously over the 20-minute session to determine energy expenditure. The order of the two testing sessions was randomized and counterbalanced. The testing days were separated by a minimum of two days so that the participants would not experience left over fatigue from the prior test. A couple of participants were tested a full week later, with no significant change in their activity in between sessions. The ergometer seat height was adjusted to the proper height with the same seat height utilized for both exercise sessions. The resistance on the flywheel was standardized for both tests. Once seated on the ergometer, the participant was again reminded of the procedure. The participants were asked to ride the bike for 20 minutes, with the stated goal to get as much exercise in as possible, but they were free to slow down and rest at any time they desired. In order to keep a consistent pattern of encouragement, the researchers gave positive feedback every two minutes during both exercise sessions. The participants would be told they were doing well and asked how they were feeling. Heart rate, oxygen consumption, and carbon dioxide production were measured continuously throughout the test in order to determine energy expenditure. At the end of the 20 minutes of riding, the participants stepped off of the ergometer and walked around the room to cool down or sat in a chair and rocked their feet to prevent blood pooling. During the cool-down period, the participants were asked to rate their perceived level of exertion based on the OMNI perceived exertion scale (RPE) (See Fig. 1) that was specifically designed for children [28].

All data were analyzed using SPSS 14.0. Descriptive data (Mean ± SD) were calculated for the age in years, height in centimeters, weight in kilograms, BMI (kg/m^2), and energy expenditure at baseline and during the exercise time. A paired sample *t*-test was utilized to determine differences between NV and V conditions. A one-way ANOVA was utilized to determine if any differences existed between males and females. Pearson product-moment correlations were performed on continuous variables to determine whether any significant relationships existed.

RESULTS

Descriptive data of the participants are provided in Table 1. All participants had a BMI that was above the 85^{th} percentile for their age and sex based on the CDC guidelines.[1] No significant differences existed between boys and girls on baseline characteristics ($p>0.05$). In addition there were no significant differences at baseline for the two different exercise conditions, V and NV ($p>0.05$).

Oxygen consumption ($ml \cdot kg^{-1} \cdot min^{-1}$) was significantly elevated above baseline conditions in both exercise sessions ($p<0.001$). Table 2 summarizes the difference between the two exercise conditions. The net increase in energy expenditure (Gross energy $Kcal \cdot min^{-1}$ minus resting $Kcal \cdot min^{-1}$) was significantly higher ($p<0.01$) in the V session (4.4 ± 1.2 Kcal/min) than the

NV session (3.7 ± 1.1 Kcal·min^{-1}). Participants expended a total of 98.7 ± 27.2 Kcal during the NV session and 113.2 ± 31.6 Kcal during the V session.

The average HR was not significantly different in the two testing sessions. The average HR during the NV session reached 142.4 ± 18.8 bpm, or 68% of age predicted max HR. During the V session, the average HR was 146.0 ± 21.4 bpm, or 70% of age predicted max HR. The peak HR achieved during the entire session was significantly higher in the V session than the NV session ($p<0.01$).

The average RPE was not significantly different between the two sessions (3.6 ± 2.3 in the NV session and 3.2 ± 2.8 in the V session; $p>0.05$). RPE was significantly correlated to the participant's BMI following the NV session ($r = 0.55$; $p<0.05$), but not following the V session ($r = 0.29$; $p>0.05$). BMI was significantly correlated to the energy expenditure in both the V ($r = 0.78$) and NV ($r = 0.70$) exercise sessions ($p<0.001$).

DISCUSSION

It is clear that the prevalence of children who are classified as "overweight" or "at risk for overweight" has reached a level that requires the examination of creative ways to combat this trend. Although the cause of the increased prevalence of overweight in children is multifaceted, a lack of adequate physical activity is accepted as one of these causes [29]. Increasing physical activity through exergaming has been postulated as a potential mechanism for increasing physical activity in children. Previous research has demonstrated that interactive video games can lead to a moderate increase in energy expenditure [22–26]. The level of energy expenditure in the current study (4.9 ± 1.4 Kcal·min^{-1}for the NV session and 5.7 ± 1.6 Kcal·min^{-1} for the V session) is similar to what might be expected with leisurely bike riding [30]. Unlike the majority of the previously published work, the current study examined the use of exergaming in overweight children. Only one of the previous studies examined the response in overweight children and the children were a little older (13.5 ± 3.3 yrs) and had a lower mean BMI (27.4 ± 3.3 kg/m^2) [23]. The overweight participants in this previous study expended an average of 4.6 ± 1.3 Kcal·min^{-1} while playing a dance simulation game for 12 minutes. The participants in the current study (10.9 ± 2.2 years, 30.9 ± 8.3 kg/m^2) expended a greater amount of energy both with and without the utilization of the video game.

As seen in Table 2, the participants increased their oxygen consumption and energy expenditure above baseline in both exercise conditions. However, the addition of a video game to the stationary biking condition significantly increased energy expenditure ($p<0.01$). When examining the total energy expended over the 20 minutes of exercise, the participants metabolized an extra 14.5 Kcal in the V session. Although statistically significant, this extra expended energy is probably of minimal clinical significance, unless the participants would be more likely to perform the activity with the video game and/or exercise for a longer period of time.

A previous study has demonstrated that overweight children are likely to exercise longer if they have something to distract them from their exercise session [31]. Therefore, it would be expected that the addition of an interactive video game to a traditional exercise (stationary cycling in the current study) would distract overweight children from their perceived effort. The current study seems to bear this out. As shown in Table 2, the energy expenditure in the V session was significantly higher than in the NV session. However, the RPE was not significantly greater and in fact tended to be lower in the V session (3.6 ± 2.3 in the NV session and 3.2 ± 2.8 in the V session). It would appear likely that children would be more likely to exercise regularly and for a longer period of time while playing a game compared to riding a stationary bike without the interactive video game component. However, a study comparing the reinforcing value of interactive video games found that an interactive bike game was no more reinforcing than biking alone, whereas, interactive dance was more reinforcing [32]. A further evaluation of the utilization of interactive video games to increase the amount of time children will exercise is warranted.

The participants in this study exercised at an intensity that raised their HR to an average of 142.4 ± 18.8 beats per minute (68% of age predicted max HR) and 146.0 ± 21.4 beats per minute (70% of age predicted max HR) for the NV and V sessions respectively. This level of exertion is classified as moderate intensity exercise and therefore in line with what would be recommended to children [33]. Likewise, the oxygen consumption is 14.7 ± 4.3 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ in the NV session and 16.8 ± 4.2 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ in the V session. This is equal to 4.2 and 4.8 METS for the NV and V sessions respectively. This is similar to leisurely bike ride according to the compendium of physical activities [30].

CONCLUSION

Adding an active video game component to standard stationary biking led to a modest increase in energy expenditure in this group of overweight children. However, this modest increase in energy expenditure occurred without a related increase in perceived exertion. Therefore, adding an active video game component to traditional exercise such as stationary cycling could lead to an increase in total energy expenditure, especially if the video game made the children more likely to exercise or to exercise for a longer period of time.

Acknowledgments

This study was supported in part by the National Institutes of Health (NIH grants # GM073842; HD052368; MD002722), and by the United States Department of Agriculture (USDA grant # 2008-55215-18837).

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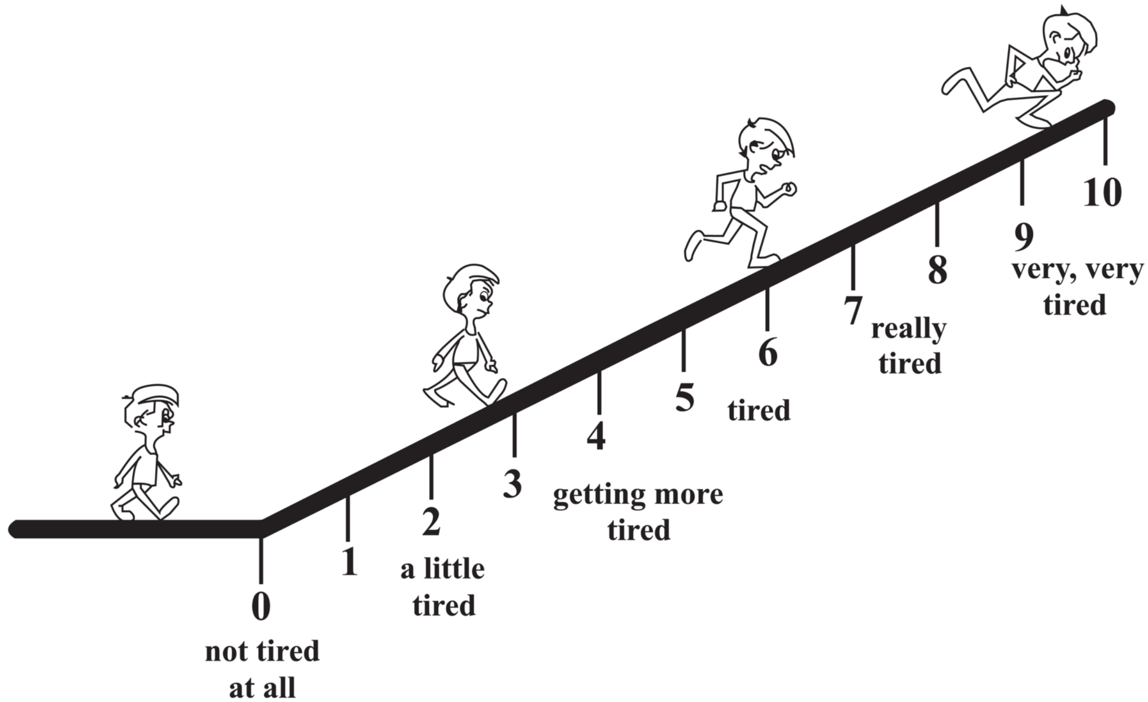

Fig. 1.
Validated OMNI Rating of Perceived Exertion Scale.

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Table 1

Baseline Descriptive Data (Mean ± SD)

	Boys (n=13)	Girls (n=7)	Pooled Data (n=20)
Age (yrs.)	10.8 ± 2.3	11.2 ± 2.3	10.9 ± 2.2
Height (cm.)	151.2 ± 17.3	153.9 ± 7.4	152.1 ± 14.5
Weight (kg.)	72.8 ± 39.6	76.7 ± 14.9	74.1 ± 32.6
BMI (kg/m^2)	29.2 ± 9.2	34.0 ± 5.5	30.9 ± 8.3

Table 2

Physiological Effect of Exercise: With and Without Video Games (Mean ± SD; n=20)

Variable	No Video Mean ± SD	Video Mean ± SD	*t*-value
Resting Values			
H.R. (beats/min)	90.9 ± 13.4	91.5 ± 14.5	−0.157
VO_2 (ml·kg^{-1}·min^{-1})	3.5 ± 0.8	3.6 ± 0.9	−0.446
RER	0.92 ± 0.14	0.94 ± 0.29	−0.369
Kcal/min	1.3 ± 0.6	1.3 ± 0.5	−0.328
Exercise Values			
Average HR (beats/min)	142.4 ± 18.8	146.0 ± 21.4	−0.889
Max HR (beats/min)	159.8 ± 22.8	173.3 ± 18.6	−2.973†
AverageVO_2 (ml·kg^{-1}·min^{-1})	14.7 ± 4.3	16.8 ± 4.2	−3.175†
Peak VO_2 (ml·kg^{-1}·min^{-1})	19.3 ± 5.7	21.9 ± 6.2	−2.815*
Average RER	0.88 ± 0.06	0.92 ± 0.11	−1.847
Kcal/min	4.9 ± 1.4	5.7 ± 1.6	−3.240†
Total Kcal (20 min.)	98.7 ± 27.2	113.2 ± 31.6	−3.238†
RPE	3.6 ± 2.3	3.2 ± 2.8	0.666

* $p<0.05$;

† $p<0.01$.