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Active Video Games and Energy Expenditure in Overweight Children

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Abstract

The prevalence of overweight in children has increased significantly in recent years. Frequent television viewing and the playing of video games have often been linked to the high prevalence of overweight. The purpose of this study was to determine if overweight children, given access to active video games, will play them at an intensity that will significantly increase energy expenditure. Twenty-three children, classified as "at risk for overweight" or "overweight," participated in this study. After a 10-minute baseline period in which the children watched a cartoon, the participants played the Jackie Chan Fitness Studio® (Xavix, Hong Kong) games for 30 minutes while rotating through the games as desired and resting whenever needed. Energy expenditure significantly increased from a mean at baseline of 1.15 ± 0.32 kcal/min to 4.08±1.18 kcal/min during the 30-minutes that the participants were given access to the games (p <.001). The total energy expenditure during the 30-minute time frame was 122.30 ± 35.40 kcal. The energy expenditure varied between individuals, with a low value of 75.00 kcal to a high of 205.86 kcal. Although a modest level of energy expenditure, this level of exertion could contribute to an overall weight control program in children.

Keywords

obesity; oxygen consumption; kcal; BMI

1. Introduction

The prevalence children being classified as overweight continues to increase. In the United States the Centers for Disease Control and Prevention (CDC) developed growth charts in which children greater than the 85th percentile for their age and sex are classified as "at risk for overweight," and children greater than the 95th percentile are classified as "overweight" (CDC, 2000) Based on these cutoff points an estimated 37.2% of children aged 6-11 in the U.S. are "at risk for overweight" or "overweight," and 18.8% of children are "overweight" (Ogden, Carroll, Curtin, McDowell, Tabak, and Flegal, 2006). This high prevalence of overweight in children is not an issue only in the U.S. It has become a global problem (Raymond, Leeder, and Greenberg, 2006; Reilly and Dorosty, 1999; Rossner, 2002; Rudolf, Sahota, Barth, and Walker, 2001; World Health Organization, 1997).

Frequent television viewing and the playing of video games have often been linked to increased rates of overweight and obesity (Andersen, Crespo, Bartlett, Cheskin, and Pratt, 1998; Crespo, Smit, Troiano, Bartlett, Macera, and Anderson, 2001; Dietz and Gortmaker, 1985; Gortmaker, Must, Sobol, Peterson, Colditz, and Dietz, 1996; Hesketh, Wake, Graham, and Waters, 2007; Janz, Levy, Burns, Torner, Willing, and Warren, 2002; Stettler, Signer, and Suter, 2004; Vandewater, Shim, and Caplovitz, 2004). The prevalence of overweight is highest in those who watch greater than four hours of television per day and lowest in those who watch less than one hour per day (Crespo, Smit, Troiano, Bartlett, Macera, and Anderson, 2001). In addition, the number of hours a child watches television, is significantly associated with the individual's body mass index (BMI) (Hancox and Poulton, 2006). Previous efforts to reduce the amount of time children watch television or play video games have proven to be successful in helping children decrease their weight and improve their body composition (Robinson, Killen, Kraemer, Wilson, Matheson, Haskell, Pruitt, Powell, Owens, Thompson, Flint-Moor, Davis, Emig, Brown, Rochon, Green, and Varady, 2003; Robinson, 1999).

An alternative approach to reducing the time children spend watching television and playing video games is to promote games that require physical activity in order to play. Previous research has shown that playing these active games will increase energy expenditure above sedentary conditions (Lanningham-Foster, Jensen, Foster, Redmond, Walker, Heinz, and Levine, 2006; Maddison, Ni Mhurchu, Jull, and Jiang, 2007; Tan, Aziz, Chua, and Teh, 2002; Unnithan, Houser, and Fernhall, 2006). Two of these studies included ten children who would be classified as “at risk for overweight (Lanningham-Foster, Jensen, Foster, Redmond, Walker, Heinz, and Levine, 2006) or “overweight” (Unnithan, Houser, and Fernhall, 2006). In each case, the participant's energy expenditure was monitored while playing a particular game for a specified period of time (15 minutes or less). It is unknown if “at risk for overweight” and “overweight” children, who are given free access to play a serious active video games for 30 minutes, would play at a level that would be significant in terms of a weight management. Therefore, the purpose of this study was to examine the energy expenditure of children who are classified as “at risk for overweight” or “overweight” while given 30 minutes of access to a series of active video games.

2. Materials and Methods

Twenty-three children (18 boys, 5 girls), between the ages of 7 and 14 participated in this study. The participants were recruited from a pediatric weight management program. All participants had a BMI that put them at the 85th percentile or above for their age and sex according to the CDC guidelines (CDC, 2000). The study protocol was approved by the Institutional Review Boards (IRB) of the California State University, San Bernardino and the Beaver Medical Group (Redlands, CA). Child assent was obtained from the children and informed consent was obtained from the parents. At least one parent was required to be at each testing session.

At the initial orientation meeting, the children and their parents were shown the metabolic cart (Cosmed K4b^2 – Rome, Italy) and how it works. All children had experience in playing the games of the Jackie Chan Studio Fitness® (Xavix, Hong Kong). However, each subject was given 30 minutes to re-familiarize themselves with the games at the orientation meeting. Playing the games required the participants to stand on a pad that had four distinct areas (in a horizontal plane) in which they would run in place, jump, or squat down and touch the mat with their hands. The names of the games and a brief description are provided in Table 1. Following completion of the familiarization session, the participants were scheduled for a data collection appointment approximately one week later.

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. Stature and body mass were measured with a stadiometer and a standard physician's scale to the nearest 0.5 centimeter and 0.1 kilograms. The participants were then connected to a calibrated metabolic cart (Cosmed

$K4b^2$ – Rome, Italy). The O_2 and CO_2 sensors were calibrated prior to each test with a known gas of 16% O_2 and 5% CO_2. In addition, volume calibration was performed with a 3-Liter Syringe. An age-appropriate cartoon was turned on for the participants to watch, while 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.

Following this period of baseline data collection, the children were allowed to play the video games. Each game was set up around the room so that the participants could switch between games whenever they desired. Therefore, the children did not have to exit one game and set up the next, they could just walk to the next game (a few feet away). The participants began a 30 minute time frame in which they were allowed to play the game of their choosing. They were free to switch between games whenever they desired, and they could stop and rest at any time. Each participant was verbally encouraged by the researchers (i.e., "good job, you are doing great!") throughout the protocol, and no negative feedback was given at any time. VO_2 and VCO_2 were measured continuously throughout the 30 minute time frame. At the end of the 30 minutes, the participants stopped the activity and were disconnected from the metabolic equipment. All data was downloaded into a computer and VO_2 and VCO_2 were averaged over 20 second intervals for analysis. Mean energy expenditure was calculated for the 30 minute time frame in which the participants were given access to the games.

All data were analyzed using SPSS 14.0. Descriptive data (Mean ± SD) were calculated for the age in years, stature in centimeters, body mass in kilograms, BMI (kg/m^2), baseline and game time energy expenditure. A paired sample *t*-test was utilized to determine metabolic differences between baseline and exercise time frames. In addition, the peak VO_2 observed during the exercise time was recorded. Pearson product-moment correlations were performed on continuous variables to determine whether any significant relationships existed.

3. Results

Descriptive data of the participants is provided in Table 2. All participants had a BMI that was at or above the 85^{th} percentile for their age and sex based on the CDC guidelines (CDC, 2000). While given access to playing the games the participants mean VO_2 was 14.03 ± 3.54 ml/kg/min, which was significantly elevated over the baseline value of 4.06 ± 0.86 ml/kg/min. The mean metabolic measures of the participants while at rest watching the cartoon and during the time devoted to playing the games are listed in Table 3.

As seen in Figure 1, the energy expenditure significantly increased from a baseline of 1.15 ± 0.32 kcal/min to 4.08 ± 1.18 kcal/min during the 30-minutes that the participants were given access to the games ($t(22) = -13.63$, $p < .001$).

The total energy expenditure during the 30-minute time frame was 122.30 ± 35.40 kcal, while the net energy expenditure (total minus baseline) was 87.77 ± 30.89 kcal. The energy expenditure varied between individuals with a low value of 75.00 kcal to a high of 205.86 kcal during the 30-minute time frame.

The energy expended, per minute of activity, was positively correlated with age ($r = .65$, $p < .01$) and body mass ($r = .68$, $p < .001$), but not with BMI ($r = .31$, $p > .05$). The maximal VO_2 during the activity ranged from a low of 14.18 ml/kg/min up to a high of 34.68 ml/kg/min. The maximal VO_2 was negatively correlated with body weight ($r = -.53$, $p < .01$).

4. Discussion

As described above, the energy expenditure during the time the children had access to the video games varied tremendously between individuals (range = 75.00 – 205.86 kcal during the 30-minute time frame). The mean energy expenditure of 4.08 ± 1.18 kcal/min while the participants were given access to the games was significantly greater than the 1.15 ± 0.32 kcal/min at baseline ($p<0.001$). Although every effort was made to make the children comfortable, it is likely that the recorded baseline energy expenditure is greater than the true value would be if the children were truly relaxed, without the metabolic equipment attached, and without the stimulation of the cartoon. Therefore, the differences between true resting and game playing energy expenditure are likely greater than recorded here.

Comparing this level of exertion (4.08 kcal/min) to other more traditional exercises can be difficult in children. The American College of Sports Medicine (ACSM, 2005) developed a formula to predict oxygen consumption and energy expenditure while walking. These formulas were developed for adults and therefore may not be as accurate for children. Realizing that children are not as mechanically efficient as adults during walking, an alternate formula has been developed to estimate oxygen consumption and energy expenditure in children (Morgan, Tseh, Caputo, Keefer, Craig, Griffith, Akins, Griffith, Krahenbuhl, and Martin, 2002). However, the study was performed on children between the ages of 6 and 10 who were not overweight. The mean age of the children in the current study is 10.13 ± 2.20 years, which represents the upper end of the age range in the previously mentioned study. In addition, the mean body mass was quite different in the two studies. In the current study the mean body mass was 57.62 ± 15.84 kg compared to 39.4 ± 6.10 kg for the 10 year olds in the previous research.

The ACSM formula (ACSM, 2005) estimates that an individual would need to walk at 4.0 miles per hour (mph) (6.5 km/h) to achieve the same level of energy expenditure as found in the current study. Whereas, the formula developed for children (Morgan, Tseh, Caputo, Keefer, Craig, Griffith, Akins, Griffith, Krahenbuhl, and Martin, 2002) estimates that an individual would metabolize this level of energy expenditure at 3.0 mph (4.8 km/h). Therefore, it is relatively safe to assume that the energy expenditure found in 30 minutes of access to the games in the current study (4.08 ± 1.18 Kcal/min) would equate to walking at somewhere between 3.0 mph (4.8 km/h) and 4.0 mph (6.5 km/h) for 30 minutes. This is not necessarily the energy cost to play the games, since the children were given free access to play for 30 minutes, but they were also allowed to rest at their own discretion. Some participants sat down between games, some walked around the room, and some stood still while catching their breath. The mean energy expenditure (4.08 ± 1.18 Kcal/min) would likely be higher if a shorter time frame was given because the participants would likely not need as much rest, and may play the games at a higher intensity.

The increased energy expenditure in the present study is similar to that found in previous research on video games that require physical activity to play (Lanningham-Foster, Jensen, Foster, Redmond, Walker, Heinz, and Levine, 2006). The previous research examined energy expenditure in lean and overweight children, aged 8-12. In the overweight participants (n=10), they report an energy expenditure of 12.18 kJ/h per kg of body mass while the participants played an Eye Toy game (Sony Computer Entertainment) for 15 minutes, and 18.10 kJ/h per kg of body mass while playing Dance Dance Revolution ULTRAMIX 2™ (Konami Digital Entertainment) for 15 minutes. The participants in the current study were heavier than in the previous study; thus, if the energy expenditure in the current study is converted to kJ/h per kg of body mass, the current participants expended an average of 17.7 kJ/h per kg of body mass, which is similar to the previous study.

In another study of energy expenditure; while utilizing Dance Dance Revolution Mix 3™ (Konami Digital Entertainment), oxygen consumption increased to a level of 24.6 ml/kg/min during a 10 minute time frame (Tan, Aziz, Chua, and Teh, 2002). The participants in the DDR study were of similar body mass to the current study (56.4 kg vs. 57.6 kg); however, the participants were significantly older and were not overweight. If converting the energy expenditure to kcal/min (assuming 5 kcal/Liter of oxygen), the participants in the previous study consumed 6.9 kcal/min. There are, however, several factors which would relate to the greater energy expenditure in this previous work. The participants were older (17.5 ± 0.7 yrs.) and reasonably fit at baseline (VO_2 max of 51.3 ml/kg/min). In addition, the measurements were done at the end of an approximate 10 minute period of time in which the expressed purpose was to play the game at as high an intensity as possible, whereas our subjects were given free access to play at their own pace for 30 minutes.

Another study compared the metabolic response of overweight and non-overweight children (Unnithan, Houser, and Fernhall, 2006). The overweight children were slightly older than the participants in the current study. However, the mean BMI was similar (27.4 kg/m^2 in the previous study, vs. 26.7 kg/m^2 in the current study). During 12 minutes of playing DDR, the participants expended 4.6 ± 1.3 kcal/min. This is similar to the 4.08 ± 1.18 kcal/min expended in the current study. The slightly greater energy expenditure in the previous study is likely due to the fact that the participants were older (13.5 yrs vs. 10.13 yrs) and heavier (75.3 kg vs. 57.62 kg in the current study). In addition, the participants in the previous study exercised for only 12 minutes. It is possible that our participants may have exercised at a higher intensity if they were only going to exercise for 12 minutes, rather than 30 minutes.

As can be seen in the results, the current study demonstrates that the energy expenditure while playing the Jackie Chan Studio Fitness® is similar to that found in other studies where children played DDR™ or Eye Toy™, in spite of the fact that the participants in the current study were given the freedom to play or rest as desired for 30 minutes. In addition, this is the first study demonstrating that overweight children given free access to several active video games for a 30-minute time frame will have a level of energy expenditure comparable to the level of energy expenditure that would be expected in more traditional activities such as walking.

In conclusion, if an overweight child played games such as these for 30 minutes, five times a week, they would have a cumulative energy expenditure of 611.5 kcal per week (gross energy expenditure of 122.3 kcal × 5 days), or a net energy expenditure of 438.9 kcal per week (net energy expenditure of 87.77 × 5 days). Although a moderate level of energy expenditure, it is a high enough level of energy expenditure to help in an overall weight management program. It is unknown if overweight children are more likely to be consistent with this type of activity compared to traditional exercise, and if the intensity level they played at would change with increasing fitness, leading to more energy expenditure. These are areas for future research.

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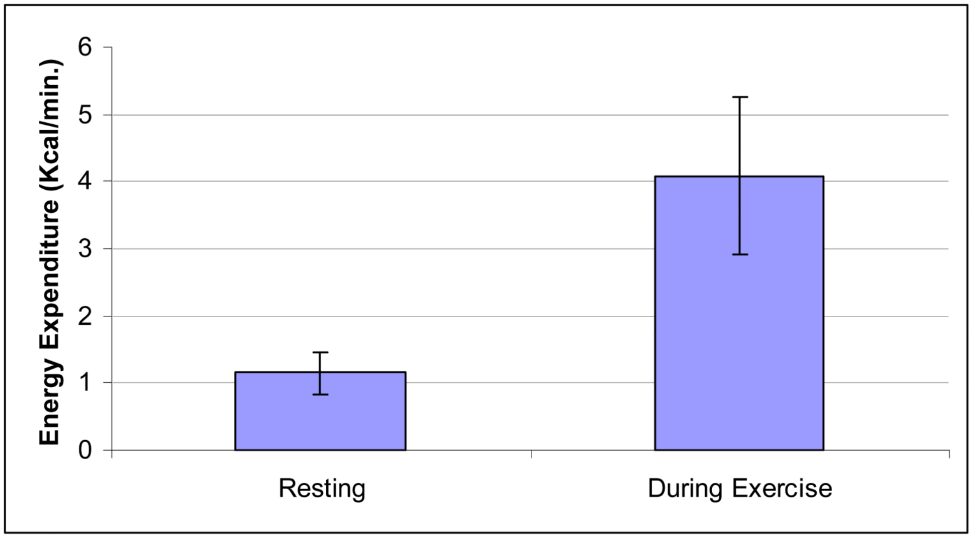

Figure 1.
Resting Kcal per minute vs. Kcal expenditure per minute during the 30-minutes of exercise.

Table 1

Description of the Jackie Chan Studio Fitness Game

Game	Description
Jackie Chan Action Run	Running down the streets, moving side to side to avoid obstacles; jumping, dodging hurdles, and fighting ninjas (stomping on the appropriate place on the mat)
Vigorous Step	Stepping on pads in sequence with music to keep balls floating in the air
Step Lively	Step aerobics class led by Jackie Chan
Dash	A ten second game counting the maximum number of steps taken during the ten seconds
Reaction Time	Stimulus to jump and measure length of time it takes the individual to jump

Table 2

Participant Characteristics.

Variable	Mean (± S.D.)
Age (yrs.)	10.13 (2.20)
Stature (cm)	146 (14)
Body Mass (kg)	57.62 (15.84)
BMI (kg/m^2)	26.66 (3.49)

Table 3

Metabolic Measurements (mean ± SD): At rest while watching the cartoon and during 30-minute time frame that participants were given access to the games (*n*=23)

Variable	Resting Mean (SD)	During Exercise Mean (SD)	*t-value*	*p*
VO_2 (L/min)	0.23 (.07)	0.77 (.25)*	-11.17	.000
VO_2 (ml/kg/min)	4.06 (.86)	14.03 (3.54)*	-13.92	.000
RER (VCO_2/VO_2)	1.02 (.22)	1.12 (.22)	-1.78	.089
Peak VO_2 (ml/kg/min)	--	24.17 (5.12)	-	-

*significantly different from resting conditions (p<0.001).