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Active Video/Arcade Games (Exergaming) and Energy Expenditure in College Students

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Abstract

Video games have become increasingly popular among young adults. The purpose of this pilot study was to determine if interactive video/arcade games, requiring physical activity to play, increase the energy expenditure (EE) and heart rate (HR) of young adults enough to elicit a training response. Thirteen male and female participants 26.6 ± 5.7 years of age were in the study. Participants were familiarized with equipment and allowed to practice with three games: (1) moving and striking lighted pads, (2) riding a bike to increase the pace of a race car, and (3) boxing against a video simulated opponent. A portable metabolic cart and HR monitor were attached to participants to measure baseline and exercise values. Participants could play any of the three games for 30 minutes while metabolic and HR data were collected. Exercise data were compared to baseline measures, and the 3 games were compared for EE. Paired sample t-tests showed baseline and exercise values differed for HR ($t(12) = -18.91$, $p < 0.01$), and EE ($t(12) = -15.62$, $p < 0.01$). The boxing game provided the highest VO2 (17.47 ± 4.79 ml·kg^{-1}min^{-1}). Participants achieved 60% or better of their HR reserve (162.82 ± 10.78 beats·min$^{-1)}$, well within the ACSM guidelines for a training HR. Caloric expenditure during the 30-minute exercise session (226. 07 ± 48.68) is also within the ACSM recommendations for daily physical activity. Thus, interactive video/arcade games that require physical activity to play can be utilized as part of an overall aerobic exercise program.

Keywords

Physical activity; exercise Intensity; obesity; cardiovascular risk

INTRODUCTION

While television viewing has long been a popular choice as a sedentary pastime, video game usage has become increasingly prevalent among individuals of all ages. In the US, 65% of American households play computer or video games (7). The trend for increased video game playing is not only in the US (5), but apparent in many other countries of the world as well (13,16). While 25% of those in the US who are 'gamers'- those who play video/computer games on a regular basis- are under 18 years of age, 49% are 18-49 years, and 26% are over 50 years. Forty percent of those who own and play video games in the US are female, with women older than 18 years of age representing a greater portion of the game playing population (33%) than males 17 years of age or younger (25%) (7). Frequent television viewing and the playing of video games have also been linked to increased rates of

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overweight and obesity (6,3,24,15). Recent data from the Centers for Disease Control (CDC) show that over 30% of US adults are overweight or obese (18). Being overweight or obese increases the risk or worsens the conditions of hypertension, Type II diabetes, cardiovascular disease, stroke, osteoarthritis, and certain cancers (4). As heart disease, stroke and diabetes are in the top ten causes of death in the US, reducing the risk of these diseases is paramount (12,22).

Given that it is not possible to go back in time, nor discount the millions that play video games, the use of interactive video games (exergames) may provide part of the solution to increasing physical activity. The idea of using these activities that individuals enjoy to improve their fitness is a logical progression. Much of the previous research examining energy expenditure (EE) while playing these games has primarily examined the popular Dance Dance Revolution (DDR®) game (19-21), with one study examining both DDR® and the utilization of the Sony Eye Toy® (14). In addition to using the simulation dance type games to determine EE, fitness and exercise adherence were examined using the Sony PlayStation Cat Eye Electronics® (23). The Nintendo Wii® has also been assessed for energy expenditure in adolescents (8-9); however, neither study found the intensity high enough to contribute to the recommended daily amount of exercise for youth. Various other researchers have used a myriad of exergames to assess everything from energy expenditure (11) and motivation for activity (15), to rate of perceived exertion (10,17). The American College of Sports Medicine (ACSM) recommends an energy expenditure of 150-400 kcals per day for adults to maintain a healthy lifestyle (2). The sparse information available for adults has shown that energy expenditure from interactive games falls in the ACSM recommended range (20).

It is unknown if young adults with the opportunity to play a variety of interactive games will expend a similar amount of energy compared to what they would expend in more traditional exercise, such as walking or jogging. Further, many exergames require full body activity to achieve the highest scores, and it is unknown if this increased recruitment of muscles as well as the cardiovascular component will be sufficient to achieve recommended energy expenditure. Therefore, the purpose of this study was to determine if young adults, given access to three different interactive games, would expend an adequate amount of energy to meet the ACSM's recommended intensity for exercise bouts.

METHOD

Participants

A total of thirteen (6 male and 7 female) participants, 26.6 ±5.7 years of age, were recruited for this pilot study. Participants were recruited from the students at a southern California comprehensive university; all testing took place at an interactive video game and fitness facility (Xrtainment Zone, Redlands, CA). All participants were asked to report their health status, and all were essentially healthy with no known chronic disease or physical limitations that would be made worse by participating in interactive game play. Nevertheless, based on body mass index (BMI = 26.5 ± 4.8), this sample was overweight, on average. The protocol was approved by the university's Institutional Review Board.

Protocol

After signing an informed consent, participants were shown the three different games (Table 1) on which they would be evaluated; they were then given as much time as needed to familiarize themselves with the games. Most individuals used this familiarization time to play the games for 20-30 minutes. The three games were chosen for this study because of ease of usage and accessibility. In addition, each subject was shown the metabolic

equipment (Cosmed K4b^2 – Rome, Italy) they would wear during testing, and they were allowed to wear the mask so that they would know what to expect on testing day.

On a separate day, each subject entered the testing facility having not eaten for a minimum of two hours. Each participant's height and body mass were measured with a portable stadiometer (SECA 214; Hamburg, Germany) and digital scale (TANITA; Arlington Heights, Illinois), calibrated to the nearest 0.5 cm and 0.1 kg, respectively; the BMI was calculated. Participants were then connected to a portable metabolic cart (Cosmed) and a heart rate (HR) monitor (Polar, Inc., USA) for measurement of resting energy expenditure while they were sitting in a comfortable chair. Once the participant was comfortable, breath by breath oxygen consumption and carbon dioxide production were collected for 10 minutes to determine baseline energy expenditure. The energy expenditure was averaged over the last 10 minutes.

Following baseline data collection, the participants were escorted to the game area where they had access to play any of the three games they desired for a period of 30 minutes while being continuously monitored with the metabolic cart and HR monitor. In order to have the testing situation be as similar to “real life” as possible, the participants were told they could switch between games as they wished, and they could spend as little or as much time at a particular game as desired. Participants were also allowed to rest as needed. The researchers noted the amount of time the participants played each game, however, rest time was not assessed, just total time wearing the portable metabolic cart. In order to be consistent in testing, participants were verbally encouraged (i.e., ‘you are doing great’, ‘good job’) every three minutes during the testing.

At the end of the 30 minutes of monitoring during exercise, data collection was completed and the face mask and heart rate monitors removed from the participants. The participants were then allowed to walk around the room and cool down. The participants were monitored until their HR dropped below 110 beats per minute (bpm), and they were visibly comfortable. After the researchers reviewed individual results with them, participants were allowed to leave the testing area.

Statistical Analysis

All data were entered into an SPSS 15.0 file for data analyses. Descriptive data were calculated for age, height, weight, BMI, as well as baseline and game time energy expenditure (for the game time as a whole and separately for the three games). Levene's test for equality of variance showed equal variance across conditions. *A priori*, as this was a pilot study and sample sizes would likely be small, independent sample *t*-tests were used to test differences between males and females. Paired sample *t*-tests were utilized to assess individual differences between baseline and exercise metabolic rate within participants to determine if energy expenditure was significantly elevated in individuals when they were given the opportunity to play the interactive video games. A one-way ANOVA for related design was used to determine if there were any differences between the three different games, with a Scheffé post-hoc analysis used to show where these differences lay. Pearson product-moment correlations were performed on continuous variables to determine whether any significant relationships existed.

RESULTS

Thirteen participants completed all testing (7 females and 6 males), and the descriptive data on the participants are presented in Table 2. The overall mean BMI reveals an overweight, but not obese population, although when separated by gender, the males were overweight, the females were not. Males and females did not significantly differ by age or the BMI.

As shown in Table 3, the HR and EE increased significantly above baseline values while the participants were given access to play the games. Participants also reached a peak VO_2 of 28.87 ± 4.60 ml·kg^{-1}·min^{-1} during the activity. The average Rate of Perceived Exertion (RPE: 6-20 scale), was 14.0 ± 2.04 (between "somewhat hard" and "hard").

When assessed for gender differences, males mean EE was significantly higher than that of females, 9.10 ± 0.48 Kcal·min^{-1}, and 6.20 ± 0.74 Kcal·min^{-1}, respectively ($t = -8.23_{(11)}$, $p < .001$).

Total energy expenditure during the 30-minute time frame was 226.07 ± 48.68 kcal. The energy expenditure was positively correlated with body mass ($r = 0.73$, $p < 0.01$), but not with the BMI ($r = 0.32$, $p > 0.05$) or age ($r = 0.35$, $p > 0.05$).

As shown in Table 4, no significant differences were found between the three interactive games for average HR, kcal·min^{-1}, or total kcals. However, the VO_2 during the 3-Kick game was significantly greater than the VO_2 found during the boxing game, and the participants played the boxing game longer than the other two games ($F = 4.23_{(2, 11)}$, $p < 0.05$).

DISCUSSION

The goal of the current study was to determine whether young adults would expend an adequate amount of energy to meet the ACSM's recommended intensity for exercise bouts while they played three different interactive games. On average, the participants in this study did reach recommended exercise intensity.

Mean EE for the participants while playing the games in this study was 7.54 ± 1.62 kcal·min^{-1}. As expected, this was significantly greater than the 1.39 ± 0.33 kcal·min^{-1} at baseline. Participants were sitting and reasonably relaxed for baseline measure, however, many of them were excited to go and play the games. Thus, it is possible that the baseline value is above what it would be at if the participants were truly at rest, and not anticipating the game playing time. Therefore, the difference for net kcals expended could be even greater.

While the overweight status of the participants may have impacted their EE, it should also be noted that the BMI does have its limitations when used to determine overweight and obese in certain samples. Thus, the amount of lean mass may actually be assisting some of the participants in increasing their EE over the course of their active time. The BMI is not sensitive enough to account for differences in lean mass versus fat mass. It is unknown if a group with lower average BMI would have had different EE responses to the activities. Regardless, all but one individual achieved a total caloric output of 150 kcals or greater over the course of 30 minutes of activity (that individual burned 147. 9 kcals). Therefore, in this sample at least, the interactive video games provided a healthy option for increasing EE.

An earlier study in 2002 (19) assessed the energy cost of a dance simulation game in 40 teens (mean age = 17.5 ± 0.7 years), and found the EE to be slightly lower than in the current study. For the entire 2002 sample, estimated EE was 6.9 kcal·min^{-1}, with males expending 7.9 kcals·min^{-1} and females 5.8 kcals.min^{-1}. Overall, mean exercise VO_2 in the 2002 study was higher (24.6 ml·kg^{-1}min^{-1}), and mean exercise HR was lower (137 bpm) than in the current study (19). These differences could be related to the disparity in ages between the two study samples.

The increased EE while using interactive video games has also been tested using adults with disabilities (18). Controlling the video games via the propulsion of wheelchair wheels on

rollers, 15 adults with disabilities (mean age ± SD: 34.7 ± 9.04 years) had increased EE over a 20-min time period. Although, mean heart rate (127.03 ± 20.93 bpm) and mean VO_2 (12.09 ± 5.02 ml·kg^{-1}·min^{-1}) were lower than in the current study (18), this could be due to use of the upper body only in the exercise mode. Nevertheless, participants worked harder when given the opportunity to interact with the video game versus a non-interactive exercise condition.

Further, 26 male and female college students 18-30 years of age from a Northern California University were assessed while they played DDR® for 20 minutes (20). Males burned an average of 276.3 net kcals per 20-minute session playing DDR® (SE=14.2), and females burned 177.5 kcals (SE=13.2). While the current study assessed the participants over 30 minutes instead of using the 20-minute protocol (20), the net kcals burned for males in this study was 272.9 ± 14.4 and for females, 185.9 ± 22.1. As has been presented, the current study shows that interactive gaming, rather than just DDR, can also significantly increase EE.

If comparing the current participants' levels of energy expenditure to a traditional exercise such as walking, according to the ACSM formula, a 76.5 kg individual (the average body mass for the current sample) walking at 4.0 miles per hour (mph) (6.5 kph) would be burning approximately 5.36 kcals·min^{-1}. As the average energy expenditure of the participants in the current study was 7.54 ± 0.45 kcals·min^{-1}, it was higher than that needed for a brisk walk (1). The average HR during exercise reached 162.82 ± 10.78 bpm, or 84% of age predicted maximum HR (MHR), or 220-age. Mean exercise HR for males was 156.9 ± 11.9 bpm, and for females it was 167.9 ± 7.0 bpm. This translates into 81% and 86% of age predicted MHR for males and females, respectively, which fits within ACSM recommendations (2). Table 5 shows further EE values for various activities, including DDR and the video games used in the current study.

This study has shown that interactive video game/exergame type exercise is effective in requiring sufficient energy expenditure to meet ACSM recommendations for intensity of exercise bouts. Both males and females were in the 150-400 kcals range recommended for healthy adults (2). Despite the BMI designated status of overweight in this sample, the participants did work hard when they were given access to the three exergames. Given the popularity of video gaming in general in the US population today, and the issues associated with overweight and obesity and inactivity, the importance of the energy expenditure associated with the use of these active video games cannot be ignored. The use of interactive games to improve energy expenditure in college age individuals has many implications. Whether college age students are more likely to be active and remain so if interactive games are available to them is a direction for future research.

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Table 1

Description of active video games used in this study.

Game	Description
3-Kick	An arcade game that has three different posts, each with three stacked pads. A single pad lights up and the participant has to either kick or hit the lighted pad.
Jackie Chan Studio Fitness Power Boxing	A video game that uses boxing gloves with sensors. The participants swing their arms and throw punches as if they were boxing in order to beat their opponent.
Disney's Cars Piston Cup Race	An interactive video game that uses a stationary bike to propel the car in the video game. The faster the participant pedals, the faster the car will go. The bike was set to a resistance of level four.

Table 2

Descriptive statistics of study sample.

	Entire sample	Males	Females
Variable	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Age (yrs)	26.6 ± 5.7	28.2 ± 6.6	24.4 ± 4.6
Height (cm)	169.7 ± 9.9	178.4 ± 5.9	162.0 ± 4.6
Body Mass (kg)	76.5 ± 17.1	90.1 ± 11.0	64.9 ± 11.9
BMI ($kg \cdot m^{-2}$)	26.5 ± 4.8	28.3 ± 3.7	24.8 ± 5.3

Table 3

Paired sample *t*-test results for calories burned and heart rate at rest and during exercise.

Variable	At Rest	During Exercise	t-value
	Mean ± SD	Mean ± SD	
Energy Expenditure (kcal·min^{-1})	1.39 ± 0.33	7.54 ± 1.63	−15.62*
Heart Rate (beats·min^{-1})	82.31 ± 11.39	162.82 ± 10.78	−18.91*

* $p < 0.01$

Table 4

Results of one-way ANOVA between average heart rate, VO_2, energy expenditure, and three interactive games.

Variable	Bike Game Mean ± SD	Boxing Game Mean ± SD	3-Kick Game Mean ± SD	F
Exercise Time (min)	9.18 ± 3.23	11.51 ± 3.73	6.33 ± 4.08	3.26*
Average HR (beats·min^{-1})	159.09 ± 16.96	161.04 ± 13.61	166.46 ± 14.28	0.84
VO_2 (ml·kg·$^{-1}$min^{-1})	15.60 ± 4.30	12.41 ± 4.36	17.47 ± 4.79**	4.23*
Average Energy Expenditure (kcal·min^{-1})	8.10 ± 1.57	6.85 ± 2.72	8.62 ± 2.61	1.94
Total kcal during 30 min	73.06 ± 25.40	80.31 ± 44.02	55.11 ± 36.04	1.69

* $p < 0.05$

** Scheffé Post Hoc analysis revealed that the 3-Kick game led to a higher average VO_2 than the Boxing game ($p < 0.05$).

Table 5

Energy Expenditure (kcals·min^{-1} and kcals·hour^{-1}) for various activities. (1)

Activity	Energy Expenditure kcals·min^{-1}	Energy Expenditure kcals·hour^{-1}
Walking (brisk pace)*	4.9	294
Bicycling (moderate effort)*	9.8	588
Jogging (10 min·mile^{-1})*	12.3	735
Swimming laps* (moderate effort)	9.8	588
Aerobics (general)*	7.4	441
DDR (20) Adults		
Males	13.8	829
Females	8.9	533
DDR (19)Youth		
Males	7.9	474
Females	5.8	348
Active video games (current study)		
Males	9.1	546
Females	6.2	373

*Based on a body mass of 70 kg.