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Wii Tennis Play for Low-Income African American Adolescents' Energy Expenditure

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Abstract

Exergames, which are video games that require gross motor activity, are popular activities that produce energy expenditure. Seventy-four low-income African American 12- to 18-year-old adolescents were randomly assigned to a 30-minute condition: 1) solitary Wii tennis exergame play against virtual peers; 2) social Wii tennis exergame play against a real peer; or 3) control group with sedentary computer activity. Adolescents were tested for caloric expenditure after exposure to treatment conditions as well as on a tennis court using Actical accelerometers. Adolescents who played the social exergame against a peer expended significantly more energy than those who played alone. Both exergame groups expended more energy than the control group. Adolescents who played the social exergame also expended comparable calories to actual tennis court play during a simulated lesson. Exergames, then, could promote physical activity, thereby becoming a tool to combat the obesity crisis that is affecting many youth.

Keywords: physical activity, video games, exergames, accelerometer

Introduction

Obesity has reached epidemic proportions throughout the world. For instance, the rate of adolescent obesity in the United States has tripled in the past 30 years (World Health Organization, 2003). These obesity rates, particularly rampant among low-income minority populations, portend future health issues that will diminish life spans, decrease the quality of life, and increase the demands on national health care systems.

Physical activities that expend calories and sustain youth's enjoyment are necessary to combat this obesity crisis, particularly given most physical activity interventions for adolescents are ineffective (Summerbell et al., 2005). One popular indoor physical activity that may replace indoor sedentary activity is the exergame, a type of video game that requires gross motor movement. The purpose of this study was to examine: 1) how much energy was expended when playing exergame tennis compared to actual tennis court play, and 2) how varying social factors within exergame play affected energy expenditure. We focused on low-income African American adolescent males and females, a group at high risk for obesity (McGinnis, Gootman, & Kraak, 2006).

Gaming and Obesity

Video game play is often cited as a cause of obesity in adolescents and a cause of social isolation from family members or peers. Two reasons for these purported negative effects have been suggested. One is that too much time is spent in sedentary rather than physically vigorous or socially engaging activities (Vandewater & Cummings, 2008). The other is that physically active face-to-face social activities are displaced with non-human, virtual ones (Cummings & Vandewater, 2007).

The evidence linking physical and social impairment with video game use, however, is far from clear. Specifically, studies have indicated an association between amount of electronic media use and childhood obesity for only certain populations, such as post-menarchal females and children at risk for obesity (Vandewater & Cummings, 2008). Thus, the amount of time spent playing video games per se is not an adequate explanation for weight gain for all children and adolescents. Video games could potentially encourage youth to spend time with friends or family members.

Mainstreaming of exergames comes at a time when youth are participating in fewer physical activities. For instance, only 15.3% percent of U.S. adolescents met the amount of physical activity recommended in the Healthy People, which is 60 minutes or more every day (Fulton et al., 2011). The prevalence of adolescents meeting recommended activity amounts was lower for females than males (8.4% vs. 21.9%, respectively) and for African American than Caucasian students (15.0 vs. 16.9%, respectively) (Fulton et al., 2011).

One new innovative game console, the Nintendo Wii, may bridge the gap between electronic entertainment and certain developmental needs of adolescents, including the needs for daily exercise and social interaction (Staiano & Calvert, 2011a). The Nintendo Wii Sports exergames are innovative in that they require gross motor physical movement to play. During play with Nintendo Wii exergames, movement in 3D space is translated onto the 2D screen of a video monitor. Movement is captured and translated via a unique interface through which the system "reads" a player's physical movements through communication between the WiiMote controller and a sensor bar placed above or below the video screen. For example, in a "real" tennis game, a player holds and swings a racket at about waist height, using either forehand or backhand movements. In "screen" tennis, a player can hold and swing a WiiMote "racket" with the same movements used in a "real" game of tennis, and the motion-sensing technology of the WiiMote translates those movements to an animated on-screen character.

Exergames in general, such as the Sony EyeToy, produce light to moderate energy expenditure that is similar to walking, skipping, and jogging, on average more than 129% and 400% the energy expenditure produced from sedentary video game play (Maddison et al., 2007). Other exergames, including Dance Dance Revolution and ShadowBoxer, produce energy expenditure and heart rate levels that meet standards for cardio-respiratory fitness (Tan et al., 2001; Hoysniemi et al., 2004; Luke, 2005; Unnithan, Houser, & Fernhall, 2006).

In an examination of the Nintendo Wii Sports games, Graves and his colleagues (2007) exposed eleven 13- to 15-year-old male and female athletes for 60 minutes total to Wii games and an XBOX 360 sedentary game. Youth expended more energy when playing the Wii Sports games of boxing, tennis, and bowling than when playing the sedentary video game, and boys' energy expenditure was significantly greater than girls' for Wii Sports tennis. A similar study exposed 12 college-aged students to Nintendo Wii Sports and compared energy expenditure to common daily activities, finding that Wii tennis play provided energy expenditure comparable to moderate walking at 3.0 miles per hour (Bausch, 2008).

Role of Competition

Although youth expended energy and increased heart rate when playing Wii Sports exergames, little is known about the underlying processes that lead to beneficial physiological outcomes for certain players, such as why males expended more energy than females during Wii Sports play, particularly tennis (Graves et al., 2007). Competition, which is valued in male more so than female activities (Meaney et al., 2002), may be one reason for this difference. Sports often require teams to work together to win as they compete against an opponent, and enjoyment increases when there is a competitive element in a game (Vorderer, Hartmann, & Klimmt, 2003).

In game-play situations, competitive elements can foster interactivity and elicit social competition, as well as increase the intensity of physical activity. Specifically, competition can arise from social situations that require a player to compete against either a computer-generated or an actual peer, so that the player attempts to maintain his or her own interests (i.e., winning) at the expense of the opponent. Competition within a multiplayer exergame class using a dance simulation exergame increased attendance and decreased attrition compared to at-home solitary exergame play for 27 9- to 12-year-olds (Paw et al., 2008), although difference in energy expenditure was not reported.

Enjoyment is an affective intention that significantly predicts adolescent girls' intentions to engage in physical activity (Raudsepp et al., 2010). Yet video game play is more prevalent among boys than girls, with 8- to 18-year-old boys spending an average of 56 minutes per day playing video game consoles, compared to 14 minutes daily for girls (Rideout, Foehr, & Roberts, 2010). Girls also report less motivation to play video games in social situations that require competition against a peer compared to playing alone against the video game (Lucas & Sherry, 2004). Competition and athleticism traditionally are valued masculine personality traits (Meaney et al., 2002), suggesting that males may find athletic, competitive athletic games more engaging than females do; hence males may be more motivated to play them. The sex difference in game use may be an interpersonal communication phenomenon, whereby girls see video game play as male-centered and thus do not seek out game play for social interaction (Lucas & Sherry, 2004).

The Present Study

The purpose of this study was to compare the energy expenditure of a group of adolescents at high risk for obesity when hitting tennis balls in a simulated lesson compared to exergame tennis play (social or solitary) or a sedentary computer activity. The Wii tennis exergame involved doubles play with two on-screen virtual characters on each team. We compared 1) solitary interaction in which a player controlled a doubles team and played against two virtual peers (the machine); 2) competitive interaction in which a player controlling a doubles team played against another player controlling a doubles team; and 3) a control group who worked on a computer. In assessing energy expenditure across conditions, we also included sex and adiposity (body mass index percentile) in our analyses. We assessed enjoyment levels following exergame play since positive feelings about games may translate into a sustainable intervention.

Our hypotheses were as follows:

1) Based on a prior study of videogame versus exergame play, we predicted that youth who played Wii tennis exergame would expend more calories than a control group did.

2) Because the essence of sports is competition against peers, we predicted that caloric expenditure would be greater when playing against a real peer than against solely virtual characters.

3) Based on our knowledge of energy expenditure during actual sports activity, we predicted that hitting tennis balls on a real court in a simulated lesson would result in more caloric expenditure than would playing exergames on a screen or participating in a screen-based sedentary computer control activity.

4) Because boys play videogames more often than girls do and typically enjoy competitive games more than girls do, we predicted that boys would enjoy playing the Wii tennis exergame more than girls would.

Methods

Recruitment Procedures

Seventy-four low-income African American adolescents (45 females) from a large metropolitan U.S. city were recruited from an academic summer program targeting low-income students. Participants ranged in age from 12- to 18-years-old (M = 14.45, SD = 1.67). Participants and parents signed assent/consent forms per the University's Institutional Review Board policy. Participants were awarded a movie gift certificate for participation.

Measures

Media use. All participants completed questions adapted from national surveys on children's media use conducted by the Kaiser Family Foundation (Rideout, Foehr, & Roberts, 2010) to assess their familiarity with video games, particularly the Wii exergames. Additional questions measured participants' prior exposure to actual tennis play.

Experimental Design and Procedure

Within academic grade, participants were randomly assigned to one of three conditions: social Wii tennis exergame play against a real peer (n = 25), solitary Wii tennis exergame play against virtual characters only (n = 24), and control (n = 25). The control group participated in a sedentary computer activity. Wii tennis exergame was selected because it produced the second most caloric expenditure among the Wii Sports games next to boxing (Graves et al., 2007), yet does not contain the aggressive element found in boxing. Also, tennis is perceived by adolescents as a game to be played and enjoyed by both males and females (Meaney et al., 2002).

Participants attended two one-hour sessions on the campus of a private University. The first session involved tennis play on an indoor court at the University recreational center. Trained adult tennis players hit balls to students individually in ways that approximate a beginner tennis lesson. Using the Actical monitor, players' energy expenditure was measured as students hit forehands, backhands, serves, and volleys for approximately 10 minutes.

The second session contained the treatment of exergame play or sedentary control activity for approximately 30 minutes. This intervention is consistent with the average of 36 minutes of daily adolescent videogame play (Rideout, Foehr, & Roberts, 2010). The exergame conditions took place in a large classroom in which there were 5 Wii consoles, 10 WiiMote controllers, and 5 TV monitors to play the game. Game play was monitored by research assistants. Self-reported enjoyment of game play was recorded. The control condition was held in a computer lab in the University library.

Physical health outcomes. Energy expenditure was measured by a hip-mounted omni-directional tri-axial Actical Physical Activity Monitor (Philips Respironics, Bend, Oregon, USA) during exergame play or the control sedentary computer activity as well as during actual tennis play. Epoch lengths were 15 seconds, and energy expenditure was calculated as activity above resting metabolic rate. The Actical accelerometer has shown positive predictive values for sedentary, light, moderate, and vigorous activity categories when validated against a respiratory room calorimeter (81, 68, 72, and 74%, respectively), proving to be a valid measure of children's average energy expenditure and physical activity ratio (Puyau et al., 2004). Hip activity has been demonstrated to be a very good predictor of energy expenditure in Wii Sports exergame play (Graves, Ridgers, & Stratton, 2008).

A trained same-sex experimenter measured height and body mass in a private space. Participants were fully clothed and did not wear shoes. Height was measured with a measurement tape, and body mass was measured using a Tanita scale. Body mass index (BMI) was calculated with the formula defined by the U.S. Centers for Disease Control and Prevention (CDC) as body mass in kilograms divided by height in meters squared. BMI was converted into BMI percentile based on age- and sex-specific CDC BMI growth reference charts for 2- to 20-year-olds, where a percentile under 85% indicates normal weight, between 85% and 95% indicates overweight, and over 95% indicates obese (Kuczmarski et al., 2000). Almost 42% of the sample was overweight or obese. See Table 1 for descriptive statistics of physiological measures for the sample.

Table 1. Sample Characteristics.

	Females (n = 45)	Males (n = 29)	Total (n = 74)
Body mass (kg)	64.10 (16.25)	66.40 (18.52)	65.01 (17.09)
BMI Percentile (%)	71.04 (27.81)	66.55 (28.72)	69.28 (28.06)
BMI (kg/m^2)	24.33 (5.84)	23.42 (5.21)	23.97 (5.58)
Proportion Overweight (%)	22.22	13.79	18.92
Proportion Obese (%)	22.22	24.14	22.97

Note. Mean scores with standard deviations in parentheses for continuous variables or percentages for proportions. BMI is body mass index. A BMI percentile between 85% and 95% indicates overweight and over 95% indicates obese.

Statistical Procedures

Activity counts were converted to activity energy expenditure using the proprietary regression equation in the Actical software. Using activity counts yielded the same results as using the Actical-derived activity energy expenditure. Therefore, for ease of interpretation, the energy expenditure data are reported. To compare activity between conditions, an analysis of covariance (ANCOVA) was conducted for energy expenditure, as measured by the Actical accelerometer, in a 2 (sex) by 3 (condition: solitary, social, or control) ANCOVA with BMI percentile as the covariate. Condition was a between-subjects factor. Simple planned contrast tests located pairwise differences when there was a significant difference.

To make caloric scores comparable for comparison purposes, caloric expenditure during actual tennis play was transformed to a 30 min time frame. A 2 (sex) by 3 (condition: social, solitary, control) ANCOVA was conducted to compare differences in energy expenditure between tennis court lesson play and the treatment condition, with difference scores as the dependent variable and with BMI percentiles as the covariate. Condition was a between subjects factor.

A Chi square analysis was conducted to compare how much boys and girls liked playing the Wii tennis game. For this analysis, the Likert scale self-report scores were collapsed using a median split, so that scores of 1 and 2 were classified as “did not enjoy” and scores of 3 and 4 were classified as “enjoyed.”

Results

Physical Activity during Treatment Conditions

Average energy expenditure (kCal) during Wii tennis play significantly differed by condition, $F(2,74) = 21.33$, $p < .0001$, and by sex, $F(1,74) = 11.06$, $p < .001$. Energy expenditure also significantly differed by BMI percentile, $F(1,74) = 20.22$, $p < .001$. Those with higher BMIs expended more calories than those with lower BMIs. Males expended more kilocalories than females did ($p < .001$). Simple planned contrast tests revealed that the social exergame condition expended more kilocalories on average than the solitary exergame condition ($p = .047$), which, in turn, expended more kilocalories than the control condition did ($p < .0001$). On average, over the 30 min period the social exergame condition expended 62.93 kCal above resting metabolic rate, the solitary exergame condition expended 54.83 kCal, and the control condition expended 37.69 kCal. See Table 2.

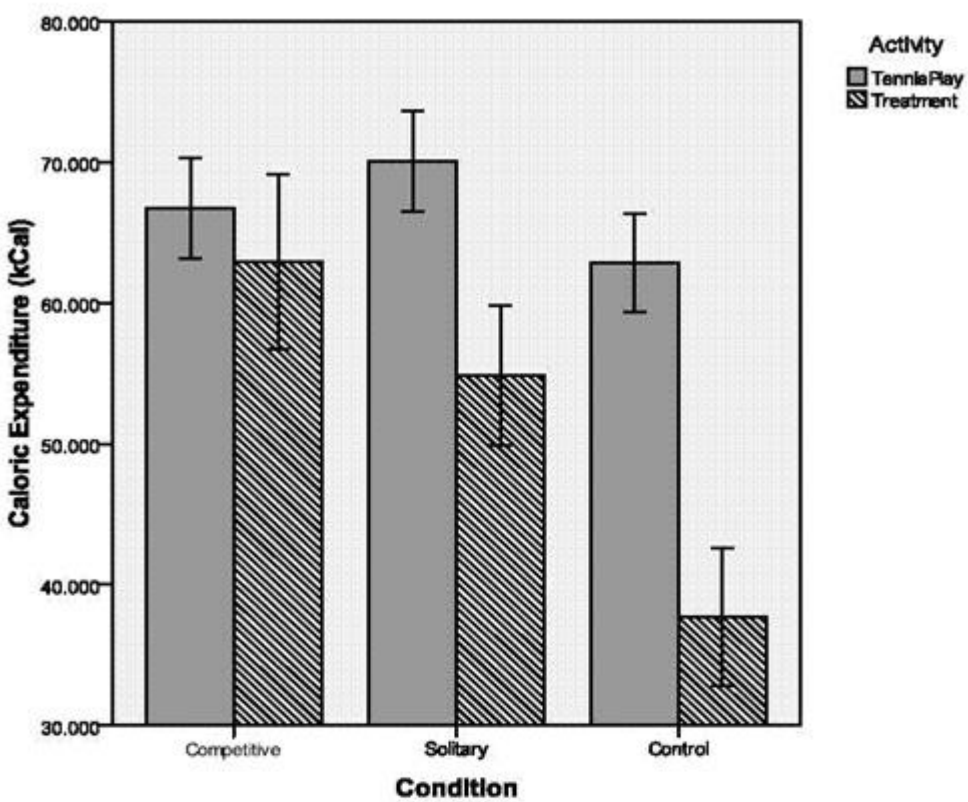
	Treatment			Tennis Court Play		
	Social Exergame	Solitary Exergame	Control	Social Exergame	Solitary Exergame	Control
Females (n=45)	59.79 (18.09)	52.73 (9.39)	34.31 (9.01)	65.99 (10.29)	69.67 (10.19)	63.02 (8.10)
Males (n=29)	65.40 (12.20)	59.04 (15.27)	46.38 (14.45)	67.29 (7.39)	70.76 (3.13)	62.40 (10.13)
Total (n=74)	62.93 (15.00)	54.83 (11.74)	37.69 (11.85)	66.72 (8.61)	70.03 (8.43)	62.85 (8.50)

Table 2. Mean energy expenditure (kCal, with standard deviations in parentheses) across conditions during exergame play and tennis play.

Physical Activity during Actual Tennis Play vs. Treatment Conditions

Difference in energy expenditure (kCal) in tennis play on a court versus treatment was predicted by condition, $F(1,74) = 8.91$, $p < .0001$. Figure 1 reveals that participants in the social exergame condition expended about the same amount of kilocalories as when they hit tennis balls in a simulated lesson on a tennis court, $t(24) = -1.23$, $p = .229$ (average difference of 6.02%). By contrast, those in the solitary exergame, $t(23) = -5.02$, $p < .0001$ (average difference of 27.72%), and control conditions, $t(24) = -8.10$, $p < .0001$ (average difference of 66.76%), expended significantly fewer kilocalories than when hitting tennis balls in a simulated lesson on a tennis court. The difference in caloric expenditure was significantly higher for males than for females, $F(1,74) = 6.18$, $p = .015$, and for participants with a higher BMI percentile compared to those with a lower BMI percentile, $F(1,74) = 13.47$, $p < .0001$.

Figure 1. Caloric expenditure when hitting tennis balls vs. treatment conditions.



Prior Video Game, Wii Sports Tennis, and Tennis Exposure

Youths' self-reported video game play at home revealed exposure patterns that were consistent with prior research: 56.0% of boys reported video game play just about every day or a few times a week compared to 9.1% of girls. In addition, 93.8% of boys reported playing Nintendo Wii before, compared to 54.7% of girls. Approximately 55.6% of our sample had played the Wii tennis exergame before. Of these students, the majority (70.3%) had only played once or twice, with only 5.4% playing about every day.

Contrary to prediction, a Chi square analysis of the enjoyment scale found that girls enjoyed playing Wii tennis significantly more than boys did, $\chi^2(1, N = 49) = 4.97$, $p = .026$ ($M = 3.80$, $SD = 0.41$ for females; $M = 3.27$, $SD = 1.08$ for males). One hundred percent of the girls either sort of liked or really liked playing Wii tennis compared to 82% of boys. Most of these youth (64.7%) had played the sport of tennis before, but tennis play was infrequent. Only 1.4% played tennis just about every day and 6.5% played about once a month. Of students who had played tennis before, 22.7% really liked playing tennis, 59.1% sort of liked playing tennis, but 18.2% did not particularly like tennis.

Discussion

The purpose of this study was to examine energy expenditure during exergame play against peers versus alone, or when participating in a control sedentary computer activity, for low-income African American adolescents. Energy expenditure was also compared between treatment conditions and hitting tennis balls on a court in a simulated lesson. Enjoyment of exergame play was measured for implications of sustainability.

While past research has shown that youth expend more calories when playing Wii exergames rather than traditional video games (Graves et al., 2007), our study is the first to document the beneficial aspects of playing exergames competitively against a peer. Not only did youth expend more calories when playing against a peer than when playing against virtual characters, the number of calories expended during social game play against a peer was very similar to that expended when hitting tennis balls on a court in a beginner tennis lesson.

The results demonstrate benefits of social exergame play for caloric expenditure, which makes sense since competition against peers is embedded in traditional athletic experiences (Smith, 2003). Indeed, the challenge from a live peer seems to provide an incentive for playing harder, and hence burning more calories, during adolescent exergame play. Transforming sedentary video game play into exergame play is most likely to reach levels of moderate intensity activity if the adolescent plays in a social setting against a peer, rather than alone.

Youth in the solitary exergame experience, who competed only against virtual peers, also expended more calories than the control group. Thus, any exergame play is better than working on a computer for caloric expenditure. This finding is consistent with previous research in which Wii tennis exergame play provides an increase in energy expenditure above resting levels, which could help adolescents meet physical activity recommendations (Bausch et al., 2008). Hitting tennis balls on a court in a simulated lesson, however, led to more caloric expenditure than playing against the machine when a live peer was not a part of the exergame experience.

Our study participants were not athletes, and 41.9% were overweight or obese, which is consistent with the 39.5% of non-Hispanic Black 2- to 19-year-olds who are overweight or obese in the U.S. (Ogden et al., 2010). In comparing the caloric expenditure in this study to prior studies, it is not surprising, then, that participants expended fewer calories playing Wii tennis than has been found in previous studies of athletic and physically fit individuals (Bausch et al., 2008; Graves et al., 2007).

Participants in the social exergame condition expended an average of 62.93 Kcal per 30 min (125.86 kCal per hour), which is less than the 90 kCal per 30 min (180 kCal per hour) that 13- to 15-year-old athletic youth expended playing Wii tennis in a prior study (Graves et al., 2007). Graves and colleagues (2007) used an accelerometer similar to the Actical, but it required five sensors to be placed on the player's body rather than one, which may detect more caloric expenditure. A target range of 150 to 400 kCal expenditure of physical activity per day is recommended (American College of Sports Medicine, 2005). Therefore, to reach recommended levels of physical activity, adolescents in our study would need to increase intensity of game play. A more sustained Wii exergame intervention might possibly increase energy expenditure over time as students became more fit if they were motivated to play.

Importantly, there was no correlation between BMI percentile and enjoyment of exergame play. Thus, regardless of being overweight or obese, participants generally enjoyed playing Wii tennis. Moreover, BMI percentile was positively related to caloric expenditure, such that overweight or obese individuals expended more calories than average weight individuals. The results suggest that anyone who weighs more will benefit more from exergaming in terms of caloric expenditure, making exergames a potential intervention for overweight and obese adolescents.

Consistent with the extant literature (Rideout, Foehr, & Roberts, 2010), boys in our study played more video games at home, including those on the Nintendo Wii system, when compared to girls, and boys also expended more calories during game play. However, girls reported enjoying the Wii tennis game more than boys did. Enjoyment, a measure of affective intention, has been found to predict sustained physical activity among adolescent girls more than instrumental intention (finding the activity beneficial) or perceived social pressure (Raudsepp et al., 2010). Therefore, enjoyment has implications for sustainability. This experience may be specific to the Wii tennis game, as adolescents label tennis as a uni-sex sport that may make adolescent females more likely to participate (Meaney et al., 2002). Girls' high rating of enjoyment indicates promise for sustainable exergame use among females.

Our findings have important implications for combating the obesity epidemic. Indoor physical activity tools such as exergames could replace indoor sedentary activities, such as traditional video game play, thereby increasing youth's daily energy expenditure. Moreover, exergames could provide physical activity when outdoor activity is not possible, particularly in extreme hot or cold weather and in unsafe neighborhoods. Low-income youth have fewer safe recreational spaces and could benefit from having in-home exercise equipment (Kerr et al., 2008). Also, recreational centers and schools could incorporate exergames into adolescents' physical activity experiences, focusing on competitive play against a peer. Despite rarely playing tennis on a court, the majority of adolescents who played Wii tennis in this study reported enjoying the game. If there is limited access to tennis courts in their neighborhoods, these low-income adolescents may be able to play the tennis exergames inside their home against their friends or family members.

One weakness of this study was the lack of a Wii exergame condition where a team of peers cooperated with virtual peers or real peers. The option for youth to play exergames with a peer on their team, instead of playing against them, is an integral part of team sports. There was also a lack of information about how each youth responded to social and solitary play. Instead, we had youth play either against a real peer or against a virtual peer. It would have been useful to have a within-subjects design in which youth played alone as well as against a friend, a direction for future research.

Furthermore, the tennis court experience was in a simulated tennis lesson where an adult hit balls to youth or where youth served tennis balls. Playing a competitive game of tennis could lead to more caloric expenditure than we found here. However, a tennis lesson, which was approximated here, can yield considerable caloric expenditure as movement was required and sustained over time. In a tennis game, by contrast, movement comes in bursts with frequent pauses in physical activity.

A final limitation of this study is the use of accelerometry to measure physical activity rather than a gold standard such as portable indirect calorimetry. However, the equipment required for indirect calorimetry can be obtrusive and burdensome to participants (Staiano & Calvert, 2011b), proving impractical and ineffective in capturing caloric expenditure during a field experiment like ours. As an alternative tool to measure energy expenditure, the Actical accelerometer provides valid, reliable estimates of caloric expenditure (Esliger, Copeland, Barnes, & Tremblay, 2005) without distracting youth from the activities. Indeed, actical accelerometers provide a direct, objective, and detailed account of physical activity (Esliger, Probert, Gorber, Bryan, Laviolette, & Tremblay, 2007; Heil, 2006), demonstrating high interdevice and intradevice reliability (Esliger & Tremblay, 2006). Furthermore, the Actical allows for discrimination between individuals who vary in physical activity level (Bassett & Dinesh, 2010). A long-term intervention could determine the feasibility of exergame play for maintaining interest and caloric expenditure, which leads to weight loss, over time.

Conclusions

In conclusion, exergames show promise as a tool to increase physical activity, particularly if they replace indoor sedentary computer activity. Our sample of adolescents, who are in a high-risk population for developing obesity, expended as many calories when playing against a peer in an exergame as when participating in a beginner tennis lesson on a tennis court, which involved serving tennis balls and returning balls hit toward them. Video games are a part of many adolescents' daily experiences, and something that they voluntarily participate in and enjoy. As such, exergames could become part of the solution, not just a perceived part of the problem, in combating the obesity crisis.

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Ethical Standards

This experiment complies with the current laws of the United States. It complies with the Institutional Review Board of Georgetown University.

References

Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A. M., Strath, S. J., et al. (2000). Compendium of physical activities: An update of activity codes and MET intensities. *Medicine and Science in Sports and Exercise, 32*, S498-S516.

American College of Sports Medicine. (2005). *American College of Sports Medicine's Guidelines for Exercise Testing and Prescription.* 7th ed. Philadelphia: Lippincott Williams and Wilkins.

Bassett, D. R., & Dinesh, J. (2010). Use of pedometers and accelerometers in clinical populations: Validity and reliability issues. *Physical Therapy Reviews, 15*, 135-142.

Bausch, L., Beran, J., Cahanes, S., Krug, L. (2008). Physiological responses while playing Nintendo Wii Sports. *Journal of Undergraduate Kinesiology Research, 3*, 19-25.

Cummings, H. M., Vandewater, E. A. (2007). Relation of adolescent video game play to time spent in other activities. *Archives of Pediatrics and Adolescent Medicine, 161*, 684-689.

Esliger, D. W., Copeland, J. L., Barnes, J. D., & Tremblay, M. S. (2005). Standardizing and optimizing the use of accelerometer data for free-living physical activity monitoring. *J Phys Act Health, 3,* 366-383.

Esliger, D. W., Probert, A., Gorber, S. C., Bryan, S., Laviolette, M., & Tremblay, M. S. (2007). Validity of the Actical accelerometer step-count function. *Med Sci Sports Exerc, 39*, 1200-1204.

Esliger, D. W., & Tremblay, M. S. (2006). Technical reliability assessment of three accelerometer models in a mechanical setup. *Med Sci Sports Exerc, 38*, 2173–81.

Fulton, J. E., Carroll, D. D., Galuska, D. A., Lee, S. M., Eaton, D. K., Brener, N. D., & Song, M. (2011). Physical activity levels of high school students – United States, 2010. *Morbidity & Mortality Weekly Report, 60*(23), 773-777.

Graves, L. E. F., Ridgers, N. D., & Stratton, G. (2008). The contribution of upper limb and total body movement to adolescents' energy expenditure whilst playing Nintendo Wii. *European Journal of Applied Physiology, 104*, 1439-6319.

Graves, L., Stratton, G., Ridgers, N. D., Cable, N. T. (2007). Comparison of energy expenditure in adolescents when playing new generation and sedentary computer games: cross sectional study. *British Medical Journal, 335*, 1282-1284.

Heil, D. (2006). Predicting activity energy expenditure using the Actical activity monitor. *Research Quarterly for Exercise and Sport, 77*, 64-80.

Hoysniemi, J., Aula, A., Auvinen, P., Honnikoinen, J., & Homoloinen, P. (2004). Shadow boxer: A physically interactive fitness game. *Nordic Conference on Human-Computer Interaction, 82*, 389-392.

Kerr, J., Norman, G. J., Sallis, J. F., Patrick, K. (2008). Exercise aids, neighborhood safety, and physical activity in adolescents and parents. *Medicine & Science in Sports & Exercise, 40*, 1244-1248.

Kuczmarski, R. J., Ogden, C., Guo, S. S., et al. (2000). CDC growth charts for the United States: Methods and development. *Vital Health Stat 11*, 246, 1-190.

Lucas, K. & Sherry, J. L. (2004). Sex differences in video game play: A communication-based explanation. *Communication Research, 31*, 499-523.

Luke, R. C. (2005). *Oxygen cost and heart rate response during interactive whole body video gaming*. Masters Thesis, California State University, Fresno.

Maddison, R., Mhurchu, C. N., Jull, A., Jiang, Y., Prapavessis, H., Rodgers, A. (2007). Energy expended playing video console games: An opportunity to increase children's physical activity? *Pediatric Exercise Science, 19*, 334-343.

McGinnis, J. M., Gootman, J. A., Kraak, V. I. (Eds.) and the Committee on Food Marketing and the Diets of Children and Youth, Food and Nutrition Board, Board on Children, Youth, and Families, Institute of Medicine of the National Academies. (2006). *Food Marketing to Children and Youth: Threat or Opportunity?* Washington, D.C.: The National Academies Press.

Meaney, K. S., Dornier, L. A., & Owens, M. S. (2002). Sex-role stereotyping for selected sport and physical activities across age groups. *Perceptual & Motor Skills, 94*, 743-9.

Ogden, C. L., Carroll, M. D., Curtin, L. R., Lamb, M. M., & Flegal, K. M. (2010). Prevalence of high body mass index in US children and adolescents, 2007-2008. *The Journal of the American Medical Association, 303*, 242-249.

Paw, M. C. A., Jacobs, W., Vaessen, E., Titze, S., & van Mechelen, W. (2008). The motivation of children to play an active video game. *Journal of Science and Medicine in Sport, 11*, 163-166.

Puyau, M. R., Adolph, A. L., Vohra, F. A., Zakeri, I., Butte, N. F. (2004). Prediction of activity energy expenditure using accelerometers in children. *Medicine & Science in Sports & Exercise, 36*, 1625-1631.

Raudsepp, L., Viira, R., & Hannus, A. (2010). Prediction of physical activity intention and behavior in a longitudinal sample of adolescent girls. *Perceptual & Motor Skills, 110*, 3-18.

Rideout, V. J., Foehr, U. G., & Roberts, D. F. (2010). *Generation M2: Media in the Lives of 8- to 18-year-olds.* The Henry J. Kaiser Family Foundation. Retrieved from http://www.kff.org/entmedia/upload/8010.pdf.

Ridley, K. & Olds, T. (2001). Video center games: Energy cost and children's behaviors. *Pediatric Exercise Science, 13*, 413-421.

Smith, A. L. (2003). Peer relationships in physical activity contexts: A road less traveled in youth sport and exercise psychology research. *Psychology of Sport and Exercise, 4*, 25-39.

Staiano, A. E. & Calvert, S. L. (2011a). Exergames for physical education courses: Physical, social, and cognitive benefits. *Child Development Perspectives, 5*, 93-98.

Staiano, A.E. & Calvert, S. L. (2011b). The promise of exergames as tools to measure physical health. *Entertainment Computing, 2*, 17-21.

Summerbell, C. D., Waters, E., Edmunds, L. D., Kelly, S., Brown, T., & Campbell, K. J. (2005). Interventions for preventing obesity in children. *Cochrane Database Syst Rev, 3*, CD001871.

Tan, B., Aziz, A. R., Chua, K., & The, K. C. (2002). Aerobic demands of the dance simulation game. *International Journal of Sports Medicine, 23*, 125-129.

Unnithan, V. B., Houser, W., & Fernhall, B. (2006). Evaluation of the energy cost of playing a dance simulation video game in overweight and non-overweight children and adolescents. *International Journal of Sports Medicine, 27*, 804-809.

Vandewater, E. & Cummings, H. (2008). Media use and childhood obesity. In S. L. Calvert & B. J. Wilson (Eds.), *Blackwell Handbook of Children, Media, and Development* (pp 355-380). Boston, Wiley-Blackwell.

Vorderer, P., Hartmann, T., & Klimmt, C. (2003). Explaining the enjoyment of playing video games: The role of competition. *ACM International Conference Proceeding Series, 38*. Proceedings of the second international conference on entertainment computing. Pittsburgh, Pennsylvania, 1-9.

World Health Organization. (2003). *Obesity and overweight.* Retrieved from http://www.who.int/dietphysicalactivity/media/en/gsfs_obesity.pdf.

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