The Pennsylvania State University

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COMPARING ENERGY EXPENDITURE, EXERTION, AND ENJOYMENT

OF ADOLESCENTS PLAYING EXERGAMES

A Dissertation in

Kinesiology

by

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ABSTRACT

Significance: Current guidelines suggest adolescents accumulate at least one hour of moderate to vigorous physical activity (MVPA) daily. Unfortunately, 12.5 million children (>17%) are overweight in the United States today and the majority of these youngsters are not getting their recommended dose of physical activity daily. Furthermore, research shows that American teenagers are spending a lot more time in front of TV’s and computers than being physically active and 87% of 8 to 17-year-old children play video games at home. The problem is, other than organized sports, physical education classes and occasional after school programs there are not many alternative and enjoyable opportunities for children to obtain the recommended 60 minutes of MVPA daily. However, alternatives such as exergames (video fitness games) are gaining popularity, may have the potential to help our nation’s obesity crisis if properly implemented. Exergames require physical activity and moving your body as the controller rather than a traditional hand-held game controller. Purpose: The purpose of these studies was to determine the differences of time spent in MVPA, energy expenditure, ratings of perceived exertion and enjoyment while playing three fitness video games (XaviX tennis, EyeToy Kinetic, and Dance Dance Revolution). Methods: A series of studies was conducted on 23-27 adolescents ranging from 14 to 18-years-old from a community health center in Northeastern USA. Participants played each of the three games for at least fifteen minutes consecutively on the first day and up to an hour on three separate occasions. Participants wore a heart-rate monitor and Sensewear Armband, and at the end of each session they reported their level of enjoyment and
perceived exertion. **Analysis:** Using separate one-way repeated-measures ANOVAs on game conditions, differences were determined for duration, percentage of time spent in MVPA, perceived exertion, energy expenditure, and across five motives for physical activity (enjoyment, competence, fitness, appearance, social). Correlation analyses and Bland Altman plots were conducted to compare energy expenditure data from heart rate monitors and Sensewear Armbands. **Results:** Of the 27 participants that completed the studies, 82.5% were Non-Hispanic White, 14.9% were Non-Hispanic Black, and 3.7% were Hispanic of any race. All participants, ten females and 17 males, completed all portions of the protocol that was approved by the university’s Institutional Review Board. **Study 1:** ETK elicited a significantly higher mean heart rate, percentage of time spent in MVPA, and level of enjoyment. Both ETK and DDR were perceived to be more strenuous than XVT; **Study 2:** Given up to sixty minutes to play, ETK was played the longest, elicited the highest mean MVPA and was enjoyed the most. XVT recorded the lowest RPE and participants rated fitness a reason why they played ETK more than XVT; **Study 3:** Across all games and conditions (phase 1 vs. phase 2), ETK was consistently played at higher intensities (calories, calories per minute). In comparing calories and calories per minute measured by heart rate monitor and Sensewear Armband, Pearson correlation coefficients determined strong associations in Phase 2, and Bland Altman plots showed good agreement in the assessment of calories for both Phases. **Conclusion:** All three exergames were played at moderate to vigorous intensity levels, and were found to be enjoyable despite higher levels of perceived exertion. The SenseWear ArmBand was also found to be a comparable device to measure calories and calories per minute while playing exergames. The exploration to use exergames to decrease sedentary time
and assist community leaders, educators, and parents in providing healthy alternative programming is suggested.
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Karin, you are the most understanding and loving wife a guy could ask for and I am truly blessed. Thank you for our beautiful life and children.

Mom, I’m done. I love you.
Chapter 1

Introduction

The recommendations for adolescents to accumulate daily physical activity are clear: 1) Children and adolescents should do 1 hour (60 minutes) or more of physical activity every day; 2) Most of the 1 hour or more a day should be either moderate- or vigorous-intensity aerobic physical activity; 3) As part of their daily physical activity, children and adolescents should do vigorous-intensity activity on at least 3 days per week. They also should do muscle-strengthening and bone-strengthening activity on at least 3 days per week. (Physical Activity Guidelines Advisory Committee, 2008)

Despite these recommendations and the actions by the newly released National Physical Activity Plan (2010) less than 20% of adolescents participated in physical activities for at least 60 minutes daily (Ogden, Lamb, Carroll, & Flegal, 2010). The more time spent in sedentary behaviors, coupled with poor dietary habits contribute to an increased risk of obesity, diabetes and cardiovascular disease (Goran, Reynolds, & Lindquist, 1999; Molnar & Livingstone, 2000). In fact, the rates of obesity have increased seven-fold in the past forty years (Ogden et al., 2010). Although the importance of improving dietary habits cannot be overstated, this study will focus on examining out-of school voluntary physical activity levels in adolescents.

As adolescents grow older, their physical activity levels steadily decreases (Ogden et al., 2010) even though numerous organizations recommend that adolescents accumulate at least 60 minutes of moderate to vigorous physical activity each day (Institute of Medicine, 2002; National Association for Sport and Physical Education, 2004b; Physical Activity Guidelines Advisory Committee, 2008; U.S. Department of Health and Human Services, 2001; U.S. Department of
Health and Human Services and U.S. Department of Agriculture, 2005). Only 27% of students in grades nine through 12 engage in moderate physical activity for at least 30 minutes on most days of the week (U.S. Department of Health and Human Services, 2000) and 61.5% of children age nine to 13 years do not participate in any organized physical activity after school (Centers for Disease Control and Prevention, 2004). These low levels of activity are a concern because of the important role physical activity plays in weight management (Steinbeck, 2001; Strong et al., 2005). Physical activity also helps to regulate blood sugar levels, improve cholesterol levels, and positively impacts social and psychological well-being, and inactivity puts youth at risk for becoming overweight (Goran et al., 1999) (Sober, Loften, Suskind, Udal, & Blecker, 1999).

Between 1966 and 1970 only four percent of adolescents, ages six to 11 years old, and five percent of adolescents, age 12 to 17 years old, were overweight (Ogden, Flegal, Carroll, & Johnson, 2002) (Ogden, Flegal, Carroll, & Johnson, 2002). According to the 2009 Youth Risk Behavior Study (YRBS), however, 27.8% of adolescents were overweight or obese (Ogden et al., 2010) while recent NHANES data found similar levels (31.7%) of overweight or obese 2-19 year olds. Being overweight and physically inactive increases the chances of developing lifestyle-related diseases such as obesity (Rudolf et al., 2004; Tremblay & Willms, 2000; Yoshinaga et al., 2004), type 2 diabetes (Steinberger & Daniels, 2003), hypertension (Ribeiro et al., 2003; Soro, Lai, Turner, Poffenbarger, & Portman, 2004), and cardiovascular disease (Janz, Dawson, & Mahoney, 2000; Sothern et al., 1999) and metabolic syndrome (Pan & Pratt, 2008). Since physical activity levels are known to track from childhood to adulthood it is important to intervene early in life and establish healthy habits for preserving health and preventing chronic disease (Malina, 1996, 2001).

Over the past 25 years, public health researchers have attempted to increase physical activity levels of school-age youngsters in hopes of decreasing weight or body mass index (BMI), or increasing fitness variables (Stone, McKenzie, Welk, & Booth, 1998). Most interventions for
children and adolescents related to obesity and physical activity have been conducted in schools (Certain & Kahn, 2002) (Kahn et al., 2002) (Stone et al., 1998). A recent review of school-based physical activity interventions revealed varied levels of success (van Sluijs, McMinn, & Griffin, 2007). Of the 57 reviewed interventions, only two increased out-of-school physical activity. This weak effect on voluntary physical activity is problematic; therefore, it seems that researchers should look to establish more effective and powerful interventions in other environments. Many groups have advocated using more comprehensive and environmental approaches to increasing physical activity (Goran et al., 1999; Institute of Medicine, 2004; Reilly & McDowell, 2003; Sallis, Kraft, & Linton, 2002). One theory that seeks to explain how family and community environments can influence a child’s behavior is the Social Ecological Model (McElroy, 1988).

The Social Ecological Model (SEM) states that a child’s development is greatly influenced by internal factors (demographics, previous experiences, and psychological factors), as well as by surrounding factors (family/friends, school, neighborhood, state, and government policy) that make up her/his environment. Recent research has focused on the environmental influences of physical activity (Dowda, Ainsworth, Addy, Saunders, & Riner, 2001; Haerens, Vereecken, Maes, & De Bourdeaudhuij, 2010; Hume, Salmon, & Ball, 2005; Jago, Baranowski, Zakeri, & Harris, 2005; Sallis et al., 2003; Timperio et al., 2010; Timperio, Salmon, Telford, & Crawford, 2005) and there seems to be growing support that physical environments can impact adolescents’ activity levels. In a study of 80 neighborhoods in Chicago, children accumulated less physical activity when their parents were worried about safety in their neighborhoods (Molnar, Gortmaker, Bull, & Buka, 2004). In another large study, Timperio found children ten to 12 years old were four times more likely to be obese if their parents agreed that outside safety was a concern compared to those whose parents did not believe outside safety was a concern (2005). In a longitudinal study, Timperio also found that sedentary environments (social support, sibling modeling, and physical environments) were associated with significant increases in BMI (2008).
Clearly there are factors at home, and in the neighborhood, that influence levels of physical activity and weight gain; however, there are not many healthy alternatives for adolescents who cannot go outside to play. In the average American home, however, adolescents can interact with many forms of technology that does not require physical activity (Rideout et. al., 2010).

On average, American children and adolescents watch 4:29 hours of television daily and combined with video games and computers, spend 7:38 hours a day interacting with media (Rideout, Foehr, & Roberts, 2010). Clearly technology is appealing and playing video games seems to be one of the more enjoyable activities. Adolescents play video games an average of 50-73 minutes a day (Entertainment Software Association, 2010; Rideout et al., 2010). Some research has indicated that playing video games is directly associated with being overweight (Anderson, Economos, Must, 2008; Mendoza, Zimmerman, Christakis, 2007; Stettler, Signer, & Suter, 2004; Vandewater, Shim, & Caplovitz, 2004); however, others found no such relationship and reported that video game playing does not necessarily displace physical activity (Biddle, Gorely, Marshall, Murdey, & Cameron, 2004; Marshall, Biddle, Sallis, McKenzie, Conway, 2002; Marshall, Biddle, Gorely, Cameron, & Murdey, 2004; Wong, Ccerin, Ho, Mak, Lo. Lam, 2010).

The motivation behind adolescents playing video games is complex. One explanation can be found in the self-determination theory (SDT) literature. According to SDT, adolescents play video games because the games are fun, may be socially supporting, and provide performance feedback, which is thought to lead to higher levels of intrinsic motivation (Deci & Ryan, 2002; Ryan, Rigby, & Przybylski, 2006). Given the thousands of titles to play on consoles and the many online gaming options, adolescents have numerous types of games from which to choose, parents and educators should capitalize on their love for playing video games for educational and health related purposes (National Institute on Media and the Family, 2001).

Traditional video games have been played in front of a screen by pushing buttons or moving a joystick, however a new generation of video games, exergames, requires more than
sitting and pushing buttons. Exergames are video games and/or game controllers that require the player to move their body in order to play the game. In essence, the player becomes the character in the video game and interacts with the game on screen. Dance Dance Revolution (DDR) is probably the most well known exergame (Konami Digital Entertainment, Inc., Redwood City, CA, USA). It requires players to step to the beat and rhythm of various types of music. Arrows flash on the TV screen and cue the players to step on the arrows on a touch-sensitive dance pad. Players receive points and cheers when they step in time (in sync) with the flashing arrows and may boo when they miss. It can be a physical workout of low, moderate and even moderate to vigorous intensity, according to the many studies that have documented the intensity while playing DDR for short periods of time (i.e. 15 minutes or less) (Lanningham-Foster et al., 2006; Marks et al., 2005; McGraw, Burdette, & Chadwick, 2005; Olmstead, 2007; Savoye et al., 2007; Steiner, 2007; Tan, Aziz, Chua, & Teh, 2002; Unnithan, Houser, & Fernhall, 2006; White, Lehmann, & Trent, 2007). Only two studies have analyzed participants DDR playing longer than 15 minutes (Yang & Foley, 2008; Yang & Graham, 2005) and both of these studies allowed the players to play as long as they wanted for up to 45 minutes. No study has allowed adolescents to play for 60 minutes on a single exergame to see if they could obtain most of the recommended amount of moderate to vigorous physical activity.

EyeToy Kinetic™ is another video game played on the PlayStation® 2 video game system created by Sony Corporation. EyeToy uses a small video camera that displays the players’ movements on-screen. The movements of the player, in response to the video game, result in a score for each game played. In most EyeToy Kinetic games, the object is to touch (with any body part) certain colored objects and avoid others. To date there have been three studies that have investigated EyeToy Kinetic’s impact on energy expenditure (Alsac, Johnson, & Swan, 2007; Böhm, Hartmann, & Böhm, 2008; Thin, Howey, Murdoch, & Crozier, 2007). All three studies found that people who played EyeToy Kinetic engaged in moderate to vigorous intensity physical
activity; however, each study was conducted on undergraduate populations. Furthermore, no study has investigated the amount of time adolescents would play if given an hour and if the time they accumulate while playing would meet the daily recommendation of moderate to vigorous physical activity.

XaviX® PORT™ is a third popular video game system created by SSD COMPANY LIMITED (Japan) and is played on a television. There are a number of game options that are part of the XaviX game system. In XaviX® Tennis, small tennis racquets equipped with motion sensing reflectors relay the speed, direction and angle of a player’s swing to the XaviX® PORT™. Players must follow the ball and adjust to hitting it at the appropriate time and with sufficient force in order to keep it in play. Players can swing the racquet to the side, or a number of other ways including overhead, underhand, and backhand. There are no studies that have assessed moderate to vigorous physical activity while playing XaviX Tennis.

These three commercially available exergames require to player to use three different motions (primarily arms, primarily legs, arms and legs). They were chosen because of: a) the different motions required to play, b) the different technology (dance pad vs. USB webcam vs. infrared motion sensors), c) they represent three of the most well-known exergames, d) they are all very affordable, and e) can all be played at home. While studies have been completed on the energy expenditure associated with playing two of these games, none of them have been used to examine if they help individuals meet the daily MVPA recommendations. Additionally, very little is known about the motivation for adolescents to play these games for extended periods of time.

The field of exergames is relatively new and to date, over 30 research studies involving exergames have been completed, and only four studies have compared more than one type of exergame interaction (Bausch, Beran, Cahanes, & King, 2008; Lanningham-Foster et al., 2006) (Böhm et al., 2008; Yang & Foley, 2008) and no studies have compared three or more different
exergame interactions. Despite not knowing all the effects of playing exergames, the state of
West Virginia recently implemented DDR in all middle school physical education classes
(Murphy, 2007; Murphy et al., 2009). One large organization that has been at the forefront of
finding novel ways to improve health is the Robert Wood Johnson Foundation (RWJF).

Since 2005, RWJF has been supporting the use of video games for educational purposes
and has developed an initiative called the Serious Games Initiative, supporting the annual Games
for Health conference (www.gamesforhealth.org) with an exergaming research track. In 2008, the
RWJF Pioneer Portfolio set aside $8.25 million to support researchers investigating the potential
health benefits from playing exergames. Under this newly created Health Games Research grant,
the RWJF is the first foundation to recognize the potential role exergames may play in getting
adolescents to be more active. Besides the Health Games Research and Serious Games Initiative,
the Robert Wood Johnson Foundation’s mandate is to improve the health and healthcare of all
Americans and as such have several program areas including: childhood obesity, public health,
and vulnerable populations.

Although several studies have investigated some of the physiological outcomes
associated with participating in exergames, there are no studies that describe adolescents’
percentage of time spent in MVPA during an exergame session, or examined differences in
MVPA across several exergames. Additionally, there is a lack of evidence with respect to why
adolescents enjoy playing different exergames. If in fact adolescents who are playing exergames
are engaging in sufficient amounts of moderate to vigorous physical activity, then exergames may
be an option to accumulate the recommended amounts of daily physical activity and health
benefits out by Healthy People 2020, the National Physical Activity Plan, and the USDA Dietary
Guidelines.
Purpose of the Study

The primary purpose of this study is to examine differences in duration and percent times spent in MVPA for adolescents playing three different exergames (Dance Dance Revolution, EyeToy Kinetic, and XaviX Tennis). The secondary purpose is to examine motivation and moderators for duration and intensity of physical activity during three exergames.

Research Questions

1. Is there a significant difference in percentage of total time spent at moderate to vigorous physical activity (MVPA) by adolescents when they play three different exergames for 15 minutes?
   
   Hypothesis 1 (H1): There will be significant differences in percentage of total time spent in MVPA between DDR, EyeToy Kinetic, and XaviX Tennis when given 15 minutes to play. (EyeToy Kinetic > DDR > XaviX Tennis)

2. Is there a significant difference in duration of time spent playing by adolescents when they play each of the three exergames for up to 60 minutes?
   
   Hypothesis 2 (H2): There will be significant differences in number of minutes playing DDR, EyeToy Kinetic, and XaviX Tennis. (EyeToy Kinetic > DDR > XaviX Tennis)

3. Is there a significant difference in the percentage of total time spent at MVPA by adolescents when they play three exergames for up to 60 minutes?
   
   Hypothesis 3 (H3): There will be significant differences in percentage of total time spent MVPA between DDR, EyeToy Kinetic, and XaviX Tennis if given up to 60 minutes. (EyeToy Kinetic > DDR > XaviX Tennis)

4. Is there a significant difference in the amount of MVPA recorded by two separate
devices operationalized as calories and calories per minute (heart-rate monitor vs. SenseWear Armband) while playing three exergames for up to 60 minutes?

Hypothesis 4 (H4): There will be significant differences in calories spent (SenseWear Armband > heart rate monitor) between the two devices across each game condition (DDR, EyeToy Kinetic, and XaviX Tennis).

5. Are there moderating effects of gender or BMI, on total time or percentage of time in MVPA during a 60-minute session?

Hypothesis 5 (H5a): Gender will not have a moderating effect on total time percentage time spent in MVPA. (H5b) BMI will have a moderating effect on percentage time spent in MVPA.

6. Are there differences in MPAM-R enjoyment scores between DDR, EyeToy Kinetic, and XaviX Tennis? Hypothesis 6a (H6a): There will be a significant difference between MPAM-R enjoyment subscale scores (EyeToy Kinetic > DDR > XaviX Tennis).

Are there moderating effects of reasons for playing (MPAM-R) on total time or percentage of time in MVPA during a 60-minute session?

Hypothesis 6b (H6b): MPAM-R scores will have a moderating effect on percentage time spent in MVPA.

Significance of the Study

Obesity in youth has significantly increased in the past four decades, yet most of the school-based interventions have failed to increase physical activity levels outside of school hours. Adolescents’ environments can influence their physical activity levels; yet little research has been done on enjoyable physical activities that adolescents can do individually that may lead to the 60
minutes of MVPA recommendation. Commercially available and inexpensive exergames may be one alternative for adolescents to voluntarily engage in physically demanding activities outside of the school setting.

This study will be one of the first to describe adolescents’ MVPA levels in three exergames for an extended period of time (60 minute sessions). Previous exergame studies reviewed by Foley & Maddison (2010) primarily use short protocols (5-15 minute bouts) to determine MVPA. This study has contributed to the literature by exploring the reasons why participants played as long as they did, and any moderating effects of gender or weight status on MVPA. If in fact adolescents enjoy playing exergames and they are engaging in MVPA, exergames could be an alternative for adolescents who do not enjoy other physical activities/sports and/or do not have a safe place to be active.

**Limitations**

This study is one of the first attempts to simultaneously determine the impact of exergames on the heart rate of adolescents and also understand their reasons for participating, or not participating, in exergames. The study has the following limitations:

1. Participants are volunteers who self-select to participate in the study therefore no assumptions of randomization can be made.
2. It is not possible to control for participant interest, skill, or motivation to play exergames. Thus it is expected there will be a range of motivation levels to play exergames.
3. The study is limited by the measurement methods and procedures selected for this study.
Delimitations

In addition, this study has the following delimitations:

1. Participants will be delimited to adolescents aged 13-18 years.

2. The sample consisted only of adolescents who are members at a YMCA in the Northeastern United States who give their permission to participate.

3. Only three exergames will be used: Dance Dance Revolution, EyeToy Kinetic, and XaviX Tennis.

4. Participants must not have more than 10 hours of playing experience in any of three exergames, therefore it may not generalize to populations with more experience with these games.
Definition of terms

1. AB = SenseWear Armband PRO
2. CAL = Calories
3. CPM = Calories per Minute
4. DDR = Dance Dance Revolution™
5. ETK = EyeToy™ Kinetic
6. HRM = Heart Rate Monitor
7. MET = Metabolic equivalent = 3.5 mL O2/min/kg or 1 MET
8. MPAM-R = Modified Physical Activity Measures – Revised
9. MVPA = Moderate to Vigorous Physical Activity
10. RPE = Ratings of Perceived Exertion
11. VPA = Vigorous Physical Activity
12. XVT = XaviX® Tennis
Chapter 2

Review of Literature

The purpose of this study is to describe the heart rates of adolescents who play three different exergames; Dance Dance Revolution, EyeToy Kinetic, and XaviX Tennis. The primary outcome measures will be percentage of time spent at moderate to vigorous physical activity (MVPA) levels and duration of playing time. Secondary outcomes will include differences between their responses to the Modified Physical Activity Measures – Revised (MPAM-R). This chapter reviews the literature that serves as the foundation for this study. It is organized into four sections. The first section is a discussion of the literature of overweight children, levels of physical activity and methods to assess physical activity. Second, a review of the theoretical underpinnings for this study as it applies to children and physical activity will include Deci & Ryan’s Self-Determination Theory and Bronfenbrenner’s Ecological Systems Theory. Section three is an examination of children’s use of electronic media, especially video games. The final section addresses possible solutions to increase physical activity in children.

Physical activity

The health benefits of regular physical activity for youth are clear (Sothern et al., 1999), yet many children and adolescents are insufficiently active to prevent lifestyle-related diseases. The Surgeon General and other organizations recommend children accumulate at least 60 minutes of moderate to vigorous physical activity each day (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2010). Despite these evidence-based recommendations, recent reports indicate that only eight percent (8%) of adolescents accumulate 60 or more minutes a day of physical activity when measured using objective assessment.
techniques (Troiano et al., 2008). A sensible place to help youth attain the recommended amount of physical activity is through schools in physical education; however, daily physical education is not a part of the daily curriculum for many schools.

With decreasing participation in physical education classes (Centers for Disease Control and Prevention, 2004a) and lack of activity outside of school, adolescents around the world are less active and more overweight than ever before (U.S. Department of Health & Human Services. Health Resources and Services Administration, 2003; World Health Organization, 2004). Some of the long-term psychological obstacles overweight childhood face include teasing (Neumark-Sztainer et al., 2002), bullying (Janssen, Craig, Boyce, & Pickett, 2004), low self-esteem (Hesketh, Wake, & Waters, 2004; R. S. Strauss, 2000), and isolation (Strauss & Pollack, 2003). Besides the psychological scars, overweight children are more likely to be overweight as adults (Charney, Goodman, McBride, Lyon, & Pratt, 1976; Freedman, Khan, Dietz, Srinivasan, & Berenson, 2001; Serdula et al., 1993).

The importance of physical activity cannot be overstated. The benefits of regular physical activity include a reduction in low-density lipoproteins and in increase in high-density lipoproteins, and improvements to glucose metabolism, strength, self-esteem, body image, and immune system (Sothern et al., 1999). Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Malina, 1996; Pate et al., 1995). Physical activity may take the form of structured exercise or sport, but may also include other lifestyle activities such as riding a bike or walking the dog. Exercise is a sub-component of physical activity that is structured and can improve one or more components of physical fitness (Freedson, 1992). Despite the plethora of information relating to the benefits of physical activity, physical inactivity is still prevalent among youth (Grunbaum et al., 2002; Ogden et al, 2010; Trost et al., 2002).
Obesity in school-aged adolescents

The Centers for Disease Control and Prevention (CDC) define obesity as a body mass index (BMI) of 30 or more. BMI is a relationship between a person’s body weight in kilograms divided by the square of their height in meters. When using BMI with children and adolescents, the CDC use age-specific growth charts to assess underweight, healthy weight, overweight, and obese (See Table 2-1). CDC recommends using these cut-off points because they are gender and age specific and take into account the changes in body fatness with age (Kuczmarski et al., 2000).

<table>
<thead>
<tr>
<th>Category</th>
<th>Cut-off points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>Less than the 5th percentile</td>
</tr>
<tr>
<td>Healthy Weight</td>
<td>5th percentile to less than the 85th percentile</td>
</tr>
<tr>
<td>Overweight</td>
<td>85th percentile to less than the 95th percentile</td>
</tr>
<tr>
<td>Obese</td>
<td>Equal to or greater than the 95th percentile</td>
</tr>
</tbody>
</table>

Rates of obesity

The United States government routinely gathers data on a large amount of American children and adolescents through population-level surveys. The Youth Risk Behavior Surveillance (YRBS) System is the largest ongoing survey administered to adolescents biannually to a nationally representative sample of ninth through 12th graders. According to the 2009 YRBS data, 27.8% of adolescents were overweight (15.8%) or obese (12%) (Ogden et al., 2010).

Another large-scale survey, the National Health and Nutrition Examination Survey (NHANES) found between 1966 and 1970 only 4% of children six to 11 years old and 5% of adolescents 12 to 17 years old were overweight; whereas in 2009, 31.7% of 2-19 year olds were overweight or
obese. Figure 2-1 illustrates these increases in obese children and adolescents over approximately 50 years of NHANES data.

![Figure 1. Trends in obesity among children and adolescents: United States, 1963–2008](image)

Collectively, poor diet and physical inactivity is the second most common cause of death in the United States (Mokdad, Marks, Stroup, & Gerberding, 2004). Despite their age, children are also at risk for developing chronic diseases from poor diet and physical inactivity (Cullen, Ash, Warneke, & de Moor, 2002; Troiano, Briefel, Carroll, & Bialostosky, 2000). National data suggest that school-aged adolescents are not physically active enough to prevent lifestyle-related diseases such as obesity (Ludwig, Peterson, & Gortmaker, 2001; Rudolf et al., 2004; Tremblay & Willms, 2000; Yoshinaga et al., 2004), diabetes (Steinberger & Daniels, 2003), hypertension...
(Ribeiro et al., 2003; Sorof, Lai, Turner, Poffenbarger, & Portman, 2004), and cardiovascular disease (Janz, Dawson, & Mahoney, 2000; Sothern et al., 1999).

**Measuring physical activity**

Quantifying physical activity is a challenge for researchers, clinicians, and the general public. Researchers routinely use subjective and objective techniques to measure physical activity levels. The most common and cost effective form of subjective physical activity assessment is the self-report physical activity recall. Obtaining accurate measures of physical activity levels in children and adolescents is essential when designing and implementing physical activity interventions. For larger scale studies, researchers primarily use self-report measures of physical activity. For smaller studies and for more objective measures of physical activity, researchers might use heart rate monitors and motion sensing devices such as pedometers and accelerometers.

**Self-report**

Researchers often use self-report recall questionnaires to assess physical activity levels of large groups because they are relatively easy to administer, cost effective and acceptable to participants. Using self-reports with children is problematic because the results are dependent on their memory of past events, which is limited by the cognitive capability of the child (LaPorte, Montoye, & Caspersen, 1985). Researchers have validated several recall questionnaires with children and adolescents including the Previous Day Physical Activity Recall (PDPAR). When the PDPAR was used to compare self-reported physical activity to criterion measures of heart rate accelerometers activity counts among youth in grades seven through 12, it was found to be a valid
(r = 0.77 and r = 0.53) and reliable (r = 0.98) measure of moderate to vigorous physical activity 
(Weston, Petosa, & Pate, 1997).

Another validated self-report measure for children is the Physical Activity Questionnaire 
for Older Children (PAQ-C). The PAQ-C has been used extensively to assess physical activity 
levels in older children eight to 14 years of age (Bailey, McKay, Mirwald, Crocker, & Faulkner, 
1999; Crocker, Bailey, Faulkner, Kowalski, & McGrath, 1997; Ernst & Pangrazi, 1999; Moore, 
Yin, Trevino, & Gutin, 2004; Thompson, Baxter-Jones, Mirwald, & Bailey, 2003; Welk & 
Eklund, 2005). It was developed to assess general levels of physical activity in elementary 
school students and provides a summary physical activity score from nine items. There are ten 
questions on the PAQ-C that are rated on a five point scale with higher numbers meaning greater 
volume of physical activity. Using the PAQ-C to compare activity levels Kowalski found a 
moderately correlation to activity counts from the Caltrac accelerometer (r = 0.39) and to 
teacher’s rating of physical activity among girls aged eight to 13 (r = 0.45) (1997). The PAQ-C 
was also found to have good test-retest reliability with Pearson moment correlations ranging from 
0.75 to 0.82. An attractive feature of using the PAQ-C is that it is relatively short (3 pages) and 
self-administered.

Another form of self-reported physical activity assessment is a physical activity log or 
diary. Participants fill in a physical activity log whenever they finish a certain activity or shortly 
thereafter. An example would be children filling in a physical activity log after they play outside 
or ride their bicycle. As in the case with recall questionnaires, physical activity logs/diaries are 
subjective and are dependent on the compliance and cognitive ability of the participants. Physical 
activity logs and diaries are valid and reliable instruments to use with children (Timperio, 
Salmon, Rosenberg, & Bull, 2004). Bratteby et al. (1998) compared adolescents’ activity diaries 
and doubly labeled water (DLW) for seven days. They found activity diaries to be a valid method
of assessing total energy expenditure, as there was only a 1.2% mean difference between measures. Ekelund (1999) compared minute-by-minute heart rate with an activity diary for 30 adolescents. Both heart rate monitoring and the activity diary measured moderate and vigorous physical activity and group energy expenditure equally.

**Objective Monitoring**

Pedometers provide an objective assessment of physical activity based on the number of steps taken of a period of time. A pedometer is a small device that typically clips to a person’s belt or pants at the front of the hip. Using pedometers is a valid and reliable method to assess physical activity levels in children (Barfield, Rowe, & Michael, 2004; Eston, Rowlands, & Ingledeiw, 1998; Vincent & Pangrazi, 2002). Eston compared the number of step counts to oxygen consumption while doing a variety of activities from 30 Welsh children (1998). The Digiwalker DW200 pedometer correlated significantly with oxygen uptake (r = 0.806) across all activities but was more highly correlated when measuring unregulated play activities (r = 0.921).

To examine the reliability of pedometers with children, Barfield measured 71 children in grades three to five (2004). Over seven days of observations and between two simultaneously worn pedometers, the interclass correlations were highest during recess (r = 0.98) and lowest during physical education(r = 0.92). Pedometers have also been compared to other motion detecting devices such as accelerometers. In a systematic review of literature, Tudor-Locke (2002) found that pedometers were strongly correlated with uniaxial accelerometers (r = 0.86). Despite their convenience, low-cost, and effectiveness, pedometers also have a couple of limitations. Most pedometers do not record the duration (time), intensity, or type of activity and therefore cannot calculate energy expenditure. Pedometers are best suited for large population studies that require objective measures of physical activity (Lamonte, Ainsworth, Reis, 2006).

Another form of objective physical activity assessment is heart rate monitoring. Typically, heart rate monitors consists of a chest strap worn across the sternum and a wristwatch
type display. The wristwatch unit displays heart rate, stores heart rate data, and when finished the data can be downloaded to a computer. Heart rate monitors can provide information (minute-by-minute or even second by second) that is a direct indication of the physiological responses associated with physical activity. At steady-state exercise, there is a linear relationship between heart rate and energy expenditure (Welk, 2002). Heart rate monitors have been validated to use on children and adolescents. An early validation study by Treiber and colleagues simultaneously compared heart rate to ECG data and found a correlation of at least 0.98 for six different activities (1989). In this study, children four to ten years old performed tasks on treadmills, ergometers, and free-living tasks such as running, walking and throwing objects. Another study validated its use by comparing heart rate to a 12 hour recall (Janz, Golden, Hansen, & Mahoney, 1992). To measure the reliability of using heart rate telemetry, DuRant and colleagues measured children twice for two consecutive days over a span of three to six months (1992). They found heart rate was reliably (r = 0.65-0.66) measured between the two readings.

One disadvantage of using heart rate data is that heart rate and oxygen consumption are not always related. For example, a child’s heart could start beating quickly because they are getting excited. In this case, the elevated heart rate is not related to increase oxygen consumption. To obtain more accurate data and minimize any potential confounders, some experts recommend using more than one device including motion detectors (Freedson & Miller, 2000; Saris, 1985).

Accelerometers are small motion detecting devices that sense movements of the body in one or more directions and record each movement as an activity count. Since accelerometers measure a person’s acceleration over time, researchers can interpret the intensity of the subject’s movements. There are two types of accelerometers, uniaxial (vertical plane) and triaxial (vertical, horizontal and transverse planes) (Welk, 2002). Several different models, including the
CSA/MTI and Caltrac (uniaxial) and the RT3 (triaxial) have been validated to use with children and adolescents. Trost (1998) measured thirty subjects age ten to 14 on a treadmill at three different speeds using the CSA/MTI accelerometer (MTI Health Services, Fort Walton Beach, FL, USA). They found activity counts were strongly correlated with energy expenditure ($r = 0.86$) when compared to gas analysis. When compared to room respiration calorimetry (Puyau, Adolph, Vohra, & Butte, 2002), energy expenditure derived from the CSA was moderately to highly correlated ($r = 0.66 - 0.78$). Janz (1994) tested the validity of the CSA/MTI accelerometer in the field with children by comparing heart rate data of 31 children to activity counts. The CSA was moderate to highly correlated ($r = 0.50 - 0.74$) to heart rate data. Similarly, Eston (1998) and Eisenmann (2004) found the CSA strongly correlated with oxygen consumption ($r = 0.78$) across a series of free living activities.

Another uniaxial accelerometer is the Caltrac (Muscle Dynamics, Torrence, CA). Although previously validated in adults (Nichols, Patterson, & Early, 1992), the Caltrac has also been validated to use with children under laboratory and field settings. Significant correlations of $r = 0.80 - 0.85$ and $r = 0.82$ was found between the Caltrac and energy expenditure measured on treadmills (Bray, Wong, Morrow, Butte, & Pivarnik, 1994) and in the field (Eisenmann et al., 2004) respectively. Sallis compared simultaneous heart rate to the Caltrac and found the Caltrac to be moderately correlated ($r = 0.42 - 0.54$) to heart rate and highly correlated to short-term activity recall (1990). The Caltrac is also a highly reliable objective monitoring device in adults ($r = 0.95 - 0.98$) (Nichols et al., 1992), and children ($r = 0.89 - 0.96$) (Sallis et al., 1990).

The RT3 accelerometer (Stayhealthy, Inc., Monrovia, CA) is a triaxial accelerometer and was preceded by Tritrac R3D. When comparing the Tritrac R3D with self-report diary and heart rate monitor over a 24 hour period Rodriguez (2002) found a high correlation between vector magnitude and energy expenditure. In another study, Eston (1998) found the R3D the most
accurate (82.5% of the variance in energy expenditure) when compared to a heart rate monitor and a pedometer. Welk and Corbin also compared the Tritrac R3D to other physical activity monitoring devices (1995). They found the R3D highly correlated to the Caltrac monitor ($r = .88$) and moderately correlated to the heart rate monitor ($r = 0.58$). Many validation studies for the new model RT3 were performed on adults (DeVoe, Gotshall, & McArthur, 2003; King, Torres, Potter, Brooks, & Coleman, 2004) but Rowlands et al. (2004) concluded that the RT3 is a good measure of physical activity for boys. RT3 activity counts correlated significantly with VO$_2$ ($r = 0.87$) as measured by gas analysis. The RT3 is also highly reliable when measuring activity events as Powell discovered less than 6% variation between monitors (2004).

**SenseWear Armband**

A fairly new device is BodyMedia’s Sensewear Armband that consists of an array of sensors that approximates energy expenditure without a cumbersome setup like indirect calorimetry. The device that sits on the back of the arm is able to measure movement via a dual-axis accelerometer, galvanic skin response the conductivity of the skin which is dependent on water content), skin temperature as very comfortable to wear for extended periods of time.

Besides caloric expenditure, the Armband can measure active energy expenditure, and metabolic equivalents (METs). The Armband has been validated with college age subjects (Fruin & Rankin, 2004; King, Torres, Potter, Brooks & Coleman, 2004) and in children and adolescents (Arvidsoon, 2007; Backlund, 2010; Calabro, 2009; Crawford, 2005). Although originally designed and calibrated for adults, BodyMedia has refined its original algorithms to be a valid instrument with children and adolescents. Becklund (2010) compared energy expenditure using the SenseWear Pro2 Armband to doubly labeled water method, and found that when using InnerView Professional software versions 5.1 (SWA 5.1) in free-living overweight and obese children, it was a valid assessment. When used in healthy children ($n=21$) across multiple
sedentary (sitting, coloring) and physical activities (treadmill walking, stationary biking), Calabro only found 1.7% measurement error across 41-minute testing bouts (2009) using InnerView Professional software versions 6.1 (SWA 6.1).

The following section is the second in this review of literature. It outlines the theoretical basis for this study by analyzing Self-Determination Theory (SDT) to explain children’s motives in physical activity settings.

**Children’s motivation in physical activity settings**

Children are naturally active in their younger years, however as children age, their activity levels begin to decline. This decline, especially in school-age adolescents, is of particular concern to parents and health experts (Malina, 2001; U.S. Department of Health and Human Services, 1996). Adolescents need to be physically active to gain health benefits like improvements to blood glucose levels, muscular strength, cardiovascular endurance, and immune system (Sothern et al., 1999; Strong, 2005) Through the school-age years, physical activity decreases for girls 7.4% per year and boys 2.7% per year (Sallis, 1993). Recent reports based on accelerometer monitoring indicate that 42% of children 6-11 years old obtain the recommended amount of physical activity, and only 8% of adolescents achieve this same target goal (Troiano, 2008).

**Self-determination Theory**

If adolescents are unmotivated to participate in physical activities and sports, it is unlikely they will take part in them. Intrinsic motivation is an important function of living a healthy and active lifestyle (Whitehead, 1993). Intrinsic motivation means to do an activity for
its own sake (Deci & Ryan, 1985). An intrinsically motivated adolescent rows on the club team because she loves the feeling of “cutting” through the water and being with her friends.

According to self-determination theory (SDT) literature there are three factors that positively influence intrinsic motivation: competence, autonomy and relatedness (See Figure 2-2).

Competence is the feeling of being self-confident in actions within a particular environment. Adolescents who take on challenging tasks and receive positive feedback increase their feelings of competence. Autonomy refers to the perception of being the source of one’s actions. Relatedness is the sense of belonging to a group or community. The more needs a person satisfies while doing an activity, the more likely she/he will be motivated to repeat it. For example, a girl, who lifts weights for thirty minutes three times a week and enjoys the experience of moving and feeling stronger, is more likely to repeat it because of the needs she satisfied. The most influential mediator of intrinsic motivation is competence (Deci & Ryan, 2002).

Figure 2-2. Adapted self-determination theory model (Deci & Ryan, 1985)
**Competence**

Adolescents who feel competent while doing activities are also more intrinsically motivated to continue doing that activity (Ferrer-Caja & Weiss, 2000; Fredenburg, Lee, & Solmon, 2001; Goudas, Dermitzaki, & Bagiatis, 2001; Miller, Ogletree, & Welshimer, 2002; Ntoumanis, 2001; Wang, Chatzisarantis, Spray, & Biddle, 2002). Highly motivated adolescents usually have high levels of competence in physical activity settings and are interested in the activities (Centers for Disease Control and Prevention, 2000; Hassandra, Goudas, & Chroni, 2003). Typically, perceived competence is the strongest predictor of intrinsic motivation (Sallis, 1991). In a two year study, girls who had high levels of intrinsic motivation also reported high levels of competence even though their physical activity levels decreased each semester (Cuddihy, Costin, Davies, Hill, & Parker, 1998). Another study qualitatively explored the factors associated with intrinsic motivation (Hassandra et al., 2003). Using the Intrinsic Motivation Inventory and in-depth interviews, student motivation was associated with competence, interest, and effort specific to physical activity. Wang et al. investigated 881 middle school children and found the most active adolescents were the ones with the highest levels of competence and intrinsic motivation (2002). Ntoumanis also positively associated competence of 14-16 year olds to their teacher’s emphasis on improving one’s own skill level using individualized criteria (2001). In this study of 424 British students, positive perceived competence in physical education was the major mediator of intrinsic motivation. The role of competence is pivotal; however, autonomy also influences both intrinsic motivation and future behaviors.
**Autonomy**

Autonomy is the need to feel ownership of one’s actions. Adolescents who freely choose to play a sport or activity are more likely to have higher levels of intrinsic motivation. In their school and home lives, adolescents generally feel their lives are structured and they have little decision making power (Crawford, 1982). Leisure-time activities and hobbies give adolescents the freedom to control their actions and subsequently have high levels of motivation (Larson & Seepersad, 2003). Even in school, studies have shown youth with higher levels of intrinsic motivation are more willing to try the more difficult tasks (Morgan & Carpenter, 2002; Treasure & Roberts, 2001).

**Enjoyment & social support**

Research has shown that that young people learn best when they are interested and engaged with their peers; therefore, social settings like physical education and sport are important to youth development (Larson, 2000). Factors like cooperation, a positive social environment, and self-referenced criteria can enhance self-determined behavior (Ames, 1992; Ntoumanis, 2001; Standage, Duda, & Ntoumanis, 2003; Vallerand & Losier, 1999). Adolescents who enjoy participating in physical activity are more likely to remain physically active (Sallis, Prochaska, & Taylor, 2000). Students who felt encouraged to participate in physical education had higher levels of skill competence, enjoyed class because it was inherently fun, and deliberately attempted the more challenging tasks (Digelidis, Papaioannou, Laparidis, & Christodoulidis, 2003; Ntoumanis, 2001). Another component of SDT that enhances intrinsic motivation is the type of feedback adolescents receive when in engaged in physical activity.
Feedback

Adolescents are more intrinsically motivated when feedback focuses on their abilities and not based on other students’ performances (Pellett, Henschel-Pellett, & Harrison, 1994; Shea & Wulf, 1999). Positive performance feedback enhances intrinsic motivation because it informs the learner about their performance but is not a controlling factor. The opposite is also true; a student who receives negative feedback will be less likely to repeat that action and have lower levels of intrinsic motivation. Intrinsically motivating environments should enhance competence, provide positive feedback and include socially supportive and fun atmospheres.

Positive feedback in a non-threatening environment predicts higher levels of intrinsic motivation in students. In a classic study, Whitehead & Corbin (1991) gave seventh and eighth grade students feedback to students taking a fitness test, but the feedback was bogus. Students who received positive feedback reported higher levels of intrinsic motivation and competence than those who received negative feedback. A teacher can foster an environment that enhances competence; but it is unclear how this would translate to a real world situation.

Positive feedback in a physical education class can influence outside physical activity levels. According to a study by Goudas (2001), participants who enjoyed physical education also had higher levels of competence for physical activity. Highly competent and intrinsically motivated students who enjoy physical education were more likely to participate in after-school sports. Two separate studies support Goudas’ work and found that enjoyment of physical education was a significant predictor of outside vigorous physical activity (Sallis, Prochaska, Taylor, Hill, & Geraci, 1999; Trost et al., 2003). There is considerable evidence to suggest that physical educators can provide feedback that supports competence; however the role of other sources of feedback, including technology, is not well documented.
Some might argue that it might be possible to receive positive feedback from a computer or electronic device (Yang, Vasil, Graham, Elliott, & Manross, 2004). In a pilot study of fifth grade children (n = 73) who wore pedometers and used a website (www.Log It.com) to track their steps for six weeks, the majority of students reported that the website (72%) or their pedometer (76%) encouraged them to take more steps. In this study, the researchers asked the teachers not to encourage students to wear the pedometers or log onto the website. The purpose of the study was to examine the effects the pedometers and website had on the students’ physical activity levels and log on rates. While logging their own daily step counts, students could see how many steps they took but not the individual results of other students. These self-referenced norms may have strengthened their perception of competence and intrinsic motivation as previously suggested by Ntoumanis (2001). Yang et al. (2002) proposed that “surrogate feedback providers” (pedometer and website) encouraged students using individually referenced norms that may have contributed to the increase in steps. A recent study found that exercising with a virtual partner improved performance on an aerobic exercise task (Irwin, Scorniaenchi, Kerr, Eisenmann, Feltz, 2012). Participants that exercised with a virtual avatar that was superior to them exercised longer than those that exercised with an independent partner.

The degrees to which these needs are met specify a specific motivational state. In SDT, there are three motivational states, amotivation, extrinsic, and intrinsic. Intrinsically motivated behaviors occur while doing an activity for its enjoyment and not for a tangible reward (Deci & Ryan, 1985). The opposite of intrinsic motivation is amotivation, or the complete lack of motivation. Amotivation occurs when the person believes their efforts would not affect their feelings of competence, autonomy or relatedness. Between the two previously mentioned forms of motivation are four forms of extrinsic motivation (See Figure 2-3). The first form of extrinsic motivation is external regulation. If the person is being forced to do it or because she/he will get a reward, then they are externally regulated. Introjected regulation is when the person will do
something to avoid guilt, show off, or improve their feelings of worth. A more self-determined form of extrinsic motivation is identified regulation. An example of identification is a person who consciously values a behavioral goal like going for a run. Integrated regulation is the most autonomous form of extrinsic motivation. The integration of values and reasons for doing something is the most autonomous form of extrinsic motivation; however, actions are still done to attain separate outcomes.

<table>
<thead>
<tr>
<th>Motivation Level</th>
<th>Amotivation</th>
<th>Extrinsic Motivation</th>
<th>Intrinsic Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDT Self-determination Theory</td>
<td>Self-determined</td>
<td></td>
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<tr>
<td></td>
<td>Highly self-determined</td>
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<tr>
<td></td>
<td>Low self-determined</td>
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</tr>
<tr>
<td></td>
<td>Non self-determined</td>
<td></td>
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</tr>
</tbody>
</table>

**Reasons for behavior**

1. uncertain
2. disorganized

- rewards
- pressure
- fear
- ego

- health aspects
- physical fitness
- special aspects
- relaxation

- enjoyment
- stimulation
- mastery

Figure 2-3. Adapted self-determination theory model (Deci & Ryan, 1985)

SDT is a theory that is used to explain why people behave the way they do, and is a comprehensive theory. It is used to explain all types of human behavior including how physical activity affects motivation. For example, a self-determined child is engaged and agentic when she joins her friends in jumping rope, or an intrinsically motivated boy rushes home to join his friends in playing pickup basketball. Besides these anecdotal examples, there is a great deal of research on intrinsic motivation in physical activity settings. Motivation is a consistent theme of
much of the research in youth-centered physical activity. Deci & Ryan created SDT to measure the many influences that guide youth behaviors and personality development (1985).

**Measuring self-determination**

A measurement tool that assesses motives for being physically active is the Motives for Physical Activities Measure – Revised (MPAM-R). The MPAM-R has been used to assess the reasons why people engage in physical activities, sports, and exercise (Ryan, Frederick, Lepes, Rubio, & Sheldon, 1997). Based on SDT, the MPAM-R measures an individual’s level of competence, autonomy, and relatedness while doing a given activity. The measure consists of five subscales that measure enjoyment (seven items), competence (seven items), appearance (six items), relatedness (five items), and fitness (five items). Likert-type scale (1 = not at all true for me, 7 = very true for me) will be used to rate the importance of each of the 30 items. Previous research has found the MPAM-R to be valid and reliable (Frederick, Morrison, & Manning, 1996; Frederick & Ryan, 1993; Ryan et al., 1997), while other studies have used MPAM-R have assessed motives for physical activity in children and adolescents (Corban, Gee, & Taylor, 2003; Koivula, 1999; Taylor, Coen, & Corban, 2005; Wilson, Rodgers, & Fraser, 2002).

**SDT in physical activity settings**

The U.S. Department of Health and Human Services established Healthy People 2020 goals for children and adolescents - to increase physical activity levels and decrease sedentary behaviors (2010). Since many schools do not require daily physical education, it is important to find settings where adolescents can voluntarily be physically active. Guidelines were established for communities to ensure that activities and games were fun in order to promote active lifestyles
(Centers for Disease Control and Prevention, 2000). These government guidelines are comparable to self-determination’s tenets of human motivation. That is, if adolescents enjoy an activity, have fun with their peers, and feel confident, they will likely continue with that activity. In the past, interventions often prescribed a standard set of games, fitness routines, or walking plan for all participants. According to SDT, having little say in the choices of activities is likely to lower feelings of autonomy and competence thus lowering intrinsic motivation.

New research is warranted and should focus on what adolescents like to do. Researchers should investigate games and activities which adolescents are already intrinsically motivated to play. The foundations for self-determination theory can help parents and educators foster environments that develop self-determined motivation. To examine adolescents’ motives for participating in games they enjoy, the following framework (Figure 2-4) was adapted. This framework best represents the intended research and is adapted from previous research on SDT and social-cognitive theory (Bandura, 1997; Li, 1999; Vallerand & Losier, 1999).

Figure 2-4. Relationships between SDT mediators, motivation, outcomes and motives

This model suggests that individuals may have motives to participate in an activity, which may include enjoyment or appearance. An example would be a girl who enjoys playing Dance Dance Revolution (DDR), a dance simulation video game. The motives to play DDR feed into the mediators of the activity which include competence, autonomy, and relatedness. If the girl thinks that by playing DDR she will feel competent, she will likely continue playing.
Continued feelings of competence would likely lead to self-determined (intrinsically motivated) behavior. Some of the outcomes from playing DDR might include physical activity, enjoyment, and adherence. Most of the available literature on SDT does not use a representational model like the one adapted above. From a practical viewpoint, there should be some form of feedback from the experience of playing a game. In Figure 2-4, the feedback (arrows) from the outcomes, flow back into the motives and mediators. It makes more sense for the relationships to be cyclical as opposed to linear.

Parents, educators, and community leaders need to foster socially supportive and fun environments for positive youth development. Research has shown that that young people learn best when they are interested, engaged and freely choose to participate. Certain conditions appear to influence youth development. Firstly, adolescents feel motivated when they are with their peers in voluntary settings such as sports and hobbies. Adolescents have a “window of opportunity” to engage in activities in which they freely chose to participate. By empowering adolescents to choose for themselves, sports and physical activity can provide unique environments that help build competence, autonomy, and relatedness.

Studies indicate that participation in voluntary structured activities during non-school time is associated with the development if positive identity, increase initiative and positive relationships with diverse peers and adults, better school achievement, reduced rates of dropping out of school, reduced delinquency, and more positive outcomes in adulthood. (pg.30)

-(National Research Council and Institute of Medicine, 2002)

The numerous theoretical models and studies on human motivation present challenges in understanding physical activity behavior. In recent years, some researchers have called for research methodologies that are more comprehensive when determining mediators of physical activity (Bauman, Sallis, Dzewaltowski & Owen, 2002). To date, individual dispositions have only accounted for 20-40% of variance in physical activity (Spence & Lee, 2003). Although that figure explains some of the variance, other theorists believe that we should be looking at the
environmental influences as well. Bronfenbrenner believed that events and behaviors do not occur in isolation without influences (1979). No matter how much variables are “controlled for”, a person’s experiences, backgrounds, and beliefs have an affect on the results. In the past twenty years, research using personal-level approaches to physical activity has been fruitful (D. S. Downs & Hausenblas, 2005; Marshall & Biddle, 2001). Theories and models that look at cognitive, social, and affective influences include Self-Determination Theory (SDT)(Deci & Ryan, 1985), Theory of Planned Behavior (TPB) (Ajzen, 1985), Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975), and Transtheoretical Model (TTM) (Prochaska, & DiClemente, 1983). However, these theories have explained at best only 20 to 40% of the variance in physical activity. Clearly, more holistic approaches are required to better understand what influences people. A theory that seeks to explain how family and community environments influence a child’s behavior is the Ecological Systems Theory (EST).

Ecological Systems Theory

Many research studies in youth physical activity settings display a lack of ecological and holistic perspective. Bronfenbrenner’s EST (1979) defined human development as “a lasting change in the way in which a person perceives and deals with his environment” (pg. 3). Bronfenbrenner categorized the systems that can influence an individual into four parts, micro-system, meso-system, exo-system, and macro-system. He distinguished direct influences on behavior as being part of a micro-system. As detailed in Figure 2-5 (Retrieved from: http://geopolicricatus.wordpress.com/2011/01/12/integral-ecology/), both meso-system and exo-system are settings that are linked to the individual’s micro-system. A person is affected by his/her meso-system but an exo-system is not directly linked to the person’s micro-system, yet it still affects what happens to that person. The final system that encompasses the three smaller
systems is the macro-system and it includes the overarching social institutions and constraints, specific to one’s culture. Bronfenbrenner strongly believed that “social policy should be based on scientific knowledge” (p. 9), however; scientific researchers take a reductionistic approach and do not incorporate how the environment influences behavior.

As described earlier, Epstein (1998) has been researching how behavioral choice theory (Behavioral Economics) might be part of the solution to our dwindling physical activity levels. Although on the surface behavioral economics may seem like an individual approach, it does integrate different theories and multiple environments to try to explain behavior. Much of Epstein’s work involves obese children and finding successful ways to reduce sedentary activities. Here are some of the successful methods that have helped the obese youth but also

Figure 2-5. Bronfenbrenner’s Ecological Systems Theory
their entire family: a) reducing accessibility of sedentary behaviors, b) increasing the cost of being sedentary, c) delaying reinforcers that are more valuable causes subjects to switch to the less valuable, but more available reinforcers, d) children dramatically increased PA levels to obtain sedentary rewards, and e) children were more likely to be active if activity was a nearby option. Epstein’s strategies are solid starting points to begin a more thorough understanding of behaviors in physical activity. As indicated by several researchers (Salmon, 2010) (Zenzen & Kridli, 2009) including King et al. (2002), Sallis (1998), and Spence & Lee (2003) long-term, interdisciplinary environmental approaches are needed for physical activity research. Behavior occurs in all types of environments, therefore, interventions should be designed to 1) emphasize intrapersonal, interpersonal, physical environment and sociocultural variables; 2) be synergistic and address multiple environment conditions; and 3) develop websites and other electronic communication channels where professionals can develop collaborations.

The Institute of Medicine’s (IOM) new model (See Figure 2-6) of the influences on children’s health is multifaceted and incorporates biological, behavioral, environmental and societal components is similar to Bronfenbrenner’s EST (National Research Council and Institute of Medicine, 2004). Recently, there seems to be more research focused on the environmental influences of physical activity (Dowda et al., 2001; Hume et al., 2005; Jago et al., 2005; Sallis et al., 2003; Timperio et al., 2005) and there seems to be growing support that physical environments can impact children’s activity levels.
Epstein found when parents (or monitoring devices) reduced the amount of time watching television, physical activity levels increased in obese children (Epstein, Saelens, Myers, & Vito, 1997). Increases in physical activity were strongest when the ability to watch television was taken away or when adults suggested watching less television. These types of conditions are very good starting points for investigators because the focus is on behavior change through self-regulation and environmental supports. The byproduct of Epstein’s research is affirmation that children often do activities they enjoy and find inherently fun.

In summary, activities, sports, and games that provides feelings of fun, competence, autonomy, and relatedness will likely increase a youngster’s motivation to continue with that activity (Wang et al., 2002). Future research should also include investigations of activities that adolescents enjoy doing at home, in school and in the community. As explained by EST, an investigation into youth development must take into account the influences of the surrounding environments and people. Finally, researchers must develop more powerful and lasting interventions by incorporating qualitative research methods. Qualitative methods will allow adolescents to explain in their own words why they chose play certain games and activities. This
is especially relevant when investigating a new class of video games called exergames. In exergames the player must move parts of the body or the entire body in order to play the game.

The topic of children’s use of electronics, video games, and exergames will be discussed in the following section of this literature review.

**Children’s use of media and technology**

People have been worried about children’s use of television, computers, and video games for a long time. Numerous studies have linked the amount of television children watch (Dietz & Gortmaker, 1985; Giammattei, Blix, Marshak, Wollitzer, & Pettitt, 2003; Gortmaker et al., 1996; Kaur, Choi, Mayo, & Jo Harris, 2003; Motl, McAuley, Birnbaum, & Lytle, 2006; Tremblay & Willms, 2003; Wake, Hesketh, & Waters, 2003) or video games played (Stettler, Signer, & Suter, 2004; Vandewater, Shim, & Caplovitz, 2004) to being overweight. There have also been studies that did not find a relationship between television time and overweight (Biddle, Gorely, Marshall, Murdey, & Cameron, 2004; Feldman, Barnett, Shrier, Rossignol, & Abenhaim, 2003; Katzmarzyk, Malina, Song, & Bouchard, 1998; Robinson et al., 1993). In fact, the amount of television adolescents watch has not changed that much in the past four decades (Biddle et al., 2004). The Kids & Media at the New Millennium study was one of the largest comprehensive media studies conducted on youth (Roberts, Foehr, Rideout, & Brodie, 1999). Supported by the Henry J. Kaiser Family Foundation, this study surveyed over 3000 children age two to 18. On average children watched two to three hours of television each night. Including radio, newspaper, video games, and computers, children spend 5.5 – 6.5 hours a day with media (Roberts et al., 1999; Woodard & Gridina, 2000). The majority of their time they (56%) watch television, followed by listening to music (22%), and playing video games (5%). Similarly, Jupiter Research ranked television, computer/internet, listening to music, and playing video game in order of their
popularity with adolescents 13-17. Watching television came easy to many of the adolescents because 88% of the home had more than two televisions while 12% had more than five televisions (Roberts et al., 1999). According to an international study of teen habits (U.S. Department of Health & Human Services. Health Resources and Services Administration, 2003), approximately 34% and 36% respectively of 11 year old girls and boys watch more than 4 hours of television a day. In another national sample of children (n=2902), researchers had the volunteers keep 24-hour time use diaries (Wright et al., 2001). They discovered that the oldest boys spent more time watching sports programs and playing electronic sports games while the oldest girls spent watching mostly television dramas. In a more recent report about 8-18 year olds, they averaged: 33 minutes talking on the phone; 17 minutes listening to music; 17 minutes playing games, and; and 15 minutes watching television, and text 118 messages (Rideout, 2010).

Another highly popular form of digital media is the home computer.

The use of computers at home and school has risen dramatically in the past decade, due in large part to the drop in prices of computer hardware. The U.S. Department of Education surveyed more than 50,000 children and found that about 90% of adolescents five to 17 use computers, 59% use the Internet, and the most popular activity at home to do on the computer is to play computer games for children age five to 14 (59%) (U.S. Department of Education, 2003). Nearly all (91%) young children and adolescents (age five to 17) who use computers at home use them to play computer games.

Although the percentage of time spent playing video games has not increased substantially, the percentage of adolescents who have played video games increased from 77% in 1995 games (Phillips, Rolls, Rouse, & Griffiths, 1995) to 92% in 2000 (Woodward, Hales, Litidamu, Phillips, & Martin, 2000). The video game industry was a respectable niche market but is now a powerful industry all by itself. According to the consulting firm NPD, the electronic game industry surpassed movie box office receipts in 2001 and had revenues in excess of $24
billion (NPD, 2011). Moore’s Law states that processor power will double every two years but like everything about it, the video game industry is surpassing expectations. In 2006, the new PlayStation 3 was 1000% faster than PlayStation 2 (6 year span) and 100 times the power of a 2.6 GHz Pentium 4 PC, far exceeding Moore’s Law. A number of things have pushed this innovation wave, including faster and cheaper processors, cheaper storage, more access to broadband for wireless devices, and online gaming. According to the Entertainment Software Association, the consortium of the leading interactive entertainment software manufacturers, in 2009, 275 million computer and video games sold compared to 85 million games in 1996, which is a 350% increase (ESA, 2010). Two areas that will continue to push video game popularity to new levels are games for mobile devices and social games. Children and adolescents under 18 years old make up 25% of computer and video game players. Forty-three percent of game players play online games compared to 31% only two years ago.

Demographically, Generation Y (those born after 1976) makes up 26% of the population and by 2010, they will be 41% of the population (Geraci, Silsbee, Fauth, & Campbell, 2000). The video game industry depends on this “Kid-fluence” group because they grew up with video games are technically proficient in various technologies and have a large amount of money to spend online. Geraci calculated all eight to 24 year olds in the United States combined will spend $164 billion annually online. Often dubbed as a family’s “Chief Technology Officers” most (75%) adolescents have influence on purchasing computer or computer equipment for the home.

One of the difficulties in measuring children’s use of media is no standard set of questions are used. For example the YRBS presents data in the following format “32.8% reported watching television three or more hours per day (Centers for Disease Control and Prevention, 2004b; Ogden et al., 2010) whereas, other surveys ask you how long you spent watching television (Roberts et al., 1999), or to write in a 24 hour log (Wright et al., 2001). To compare results of media use, researchers should agree on a set of standardized questions. We
are fighting the same battle in the physical activity measurement world. Figure 2-7 represents an overview of studies that collected the amount of time children used the various forms of media.

![Bar chart showing media use by children](chart.png)

Figure 2-7. Time children and adolescents spend with media per day (hours/day)

Another difficulty in measuring absolute values of media use is that children often use more than one form of media simultaneously. In the Knowledge Networks study on how children use media technology (2003) 72% of children (n=245) age eight to 17 do other things while watching television chiefly homework (18%) and eating (20%). Children watching television in their own bedroom is quickly becoming a common site. Knowledge Networks found 61% of children had a television in their bedroom and one third of them had cable, DVD/VCR, or a video game (Knowledge Networks & SRI, 2003). Figure 2-8 shows the percentage of children and
adolescents with a TV in the bedroom. Gentile (2002) reported a similar amount of children with televisions in bedrooms (56%), while Rideout reported 36% of children age zero to six had televisions in their bedrooms (2003), and in 2010, they found 71% of kids 8-18 also reported having TVs in their bedrooms (Rideout, 2010).

The American Academy of Pediatrics recommends that children under two years not watch any television, and that all children over two be limited to one to two hours of educational screen media a day (American Academy of Pediatrics. Committee on Public Education, 2001). Despite these recommendations, Rideout discovered that in a typical day, 68% of all children under two years old have average about two hours of screen-time a day (Rideout et al., 2003). In a larger study (n=22,322), children spent about ten hours a day with many forms of media including television, cable, radio, internet, newspapers, magazines, and mail (Feldman et al., 2003). Thirty-three percent of males and 36% of females watch TV when they go online and 24% males and 29% females go online when watching television. Multitasking although sometimes convenient, if started at a young age it might affect attention span (Christakis, Zimmerman, DiGiuseppe, & McCarty, 2004), muscle soreness (Tazawa & Okada, 2001), and perhaps even sleep (Van den Bulck, 2003).
Can video games foster positive youth development?

Children and adolescents love to play video games; in fact they make up 25% of all computer and video game players (Entertainment Software Association, 2004). There is a growing niche of video games that goes beyond sitting in front of a screen to push buttons. This new genre of video games and game controllers (*exergames*) requires the player to move their body or body parts in order to play the game (Yang, Smith, Graham, 2008)

Video games are pervasive in American homes as most adolescents eight to 18 years old have a video game console at home (87%), while 50% have a video game console in their bedroom (Rideout, 2010). The most popular video game consoles are the Sony PlayStation 3,
Microsoft Xbox360, and Nintendo Wii. According to a recent study of youth media habits, the average home has two video game consoles, two computers, 59% of youth own a handheld gaming system and 66% own a cell phone (Rideout, 2010). The number of devices on which to play games has also increased especially in the hand-held and mobile phone categories, in fact over the past few years, as these categories increased, little change occurred in console or pc based gaming (Entertainment Software Association, 2004). In 2009, 273 million computer and video games sold compared to 85 million games in 1996 (Entertainment Software Association, 2010) which represents a three-fold increase. The amount of time adolescents spend playing video games also increased nearly five-fold to 119 minutes in 2009 from 26 minutes in 1999 (Rideout, 2010).

**Side-effects from playing video games**

There are both positive and negative side effects of playing video games. Research shows that playing video or computer games can be a foundation to computer literacy because it helps children to picture images in three-dimensional space (Subrahmanyam, Kraut, Greenfield, & Gross, 2000). Action video game playing can also improve visual attention (Dye, Bevelier, 2010; (Green & Bavelier, 2003) and is used extensively in military combat flight simulators, police training scenarios, and professional sports training (Sawyer, Smith 2008).

There are other reports that say playing video games does not displace health habits such as exercising (Feldman et al., 2003) but does increase levels of aggression and reports of getting into fights after playing violent video games are played (Gentile, Lynch, Linder, & Walsh, 2004). Playing traditional video games (seated with a hand controller) can illicit many physical effects including increased heart rate, blood pressure, and oxygen consumption (Segal & Dietz, 1991),
Behaviors associated with video games

Many experts believe that increasing amounts of sedentary activity, including video game playing, is one of the reasons obesity is increasing in the United States today. As mentioned above, the most recent findings from the NHAMES data set, indicate that 31.7% of adolescents were overweight or obese (Ogden et al., 2010). According to the most recent national poll, young people watch four and a half hours of television a night (Rideout, 2010) which is an hour more than just five years ago (Centers for Disease Control and Prevention, 2004b); but, they are typically simultaneously using other forms of media like surfing the net, and talking on the phone. On average they spend 7:38 hours with various forms of media and are exposed to 10:45 hours each day (Rideout, 2010). It also appears that many of these sedentary behaviors track over time through adolescence and should be monitored for negative health effects (Biddle, Pearson, Ross, Braithwaite, 2010)

Media use and exposure cannot be the sole culprit in the overweight crisis, poor eating habits and environmental factors also contribute. Only 22% of adolescents eat the daily recommended five or more fruits and vegetables (Centers for Disease Control and Prevention, 2004b). Not eating the good foods is one of the issues; eating food with poor nutritional value is another. Not surprisingly, adolescents who eat more fast-food take in more calories and fat than those who eat less frequently at fast-food outlets (French, Story, Neumark-Sztainer, Fulkerson, & Hannan, 2001). Another negative aspect of the high amounts of time spent in sedentary behaviors (watching television, using the computer and playing video games) is snacking on junk food (Miller, Taveras, Rifas-Shiman, Gillman, 2008). Although some posit that there is insufficient
evidence to point to any negative impact on health from playing video games and using the computer (Rey-López, Rodríguez, Bioscacr, Moreno, 2008).

At the same time video games and computer usage have been increasing, physical education programs in schools have been decreasing. The state of Illinois is the only state with daily physical education requirements for students in kindergarten through 12th grade (NASAPE, 2011).

Current state of physical education

Currently, most states do not require daily physical education; in fact, 33.3% of adolescents do not attend physical education in an average week and only 18.4% of them participated in sufficient daily moderate physical activity (Ogden et al., 2010). One of the challenges for educators, parents and health care providers alike, is to find ways to increase the amount and quality of physical activity for adolescents. While it may seem contradictory to suggest that video games may be one way to increase physical activity, there is a new genre of video games, called exergames, which require game players to use their entire bodies rather than only their fingers.

The role of physical activity in addressing the inactivity problem

Many people blame electronic media such as television, computer, and video games for the “slowing down” of today’s youth. Some studies report that television is positively associated with overweight adolescents (Kaur et al., 2003; Tremblay & Willms, 2003; Wake et al., 2003) while others report that television watching does not take time away from physical activities or increase obesity (Feldman et al., 2003; Robinson et al., 1993). Considering the popularity of
computer and video games, parents and educators should capitalize on their love for video games (National Institute on Media and the Family, 2001). One way to make sure that time spent playing video games is active instead of sedentary, is to play the new genre of video games, exergames.

Traditional video games are played with a handheld controller, but exergames require the player to move parts of the body or the entire body to play a game. In essence, the player becomes the character in the video game. In this augmented reality the player must now interact with the game on screen (Matysczok, Radkowski, & Berssenbruegge, 2004; Ohshima, Satoh, Yamamoto, & Tamura, 1998). Dance Dance Revolution (DDR) is probably the most well-known exergame. It requires players to step to the beat and rhythm of various types of music. Arrows flash on the TV screen cue the players when to step on the arrows on a plastic dance pad. Players receive points and cheers when they step in time (in sync) with the flashing arrows. It appears to be a physical workout for the player, although no research has been completed to date that documents the intensity of the workout obtained when individuals play DDR for an extended period of time. If, in fact, individuals who play an exergame like DDR are moderately to vigorously physically active then DDR, and similar exergames, may be one way to increase the amount of physical activity obtained by those who play exergames.

**Motivation for video games**

There are a number of things that make video games enjoyable. First, video games are a form of play and children are intrinsically motivated to play them (Prensky, 2001a). Besides intrinsic motivation, there are many other motivating properties of video games that are consistent with the three tenets of self-determination theory (SDT) as discussed in the previous section; namely competence, autonomy, and relatedness.
The first SDT tenet refers to competence and refers to a youngster’s ability to feel effective and be in control of one’s environment. Video games are designed to be challenging and have many levels to explore and master. In order to play the “higher” levels, players must first master certain moves, accomplish a specific goal (defeat all enemies), learn new skills, or collect a specific object (key) to advance to the next level. Prensky states in his book *Digital Game-Based Learning*, that solving problems “is what gets your adrenaline and creative juices flowing, and makes you feel excited about playing the game” (pg. 05-14) (Prensky, 2001a). Positive feedback and challenging situations facilitate feelings of competence (Deci & Ryan, 1985). A youngster will likely play a video game that fulfills his need for competence.

The second tenet is autonomy and it refers to the need to feel ownership of one’s actions. Adolescents who freely choose to play video games will be more likely to be intrinsically motivated towards playing video games. In school and at home, adolescents feel their lives are structured and they have no-decision making power (Crawford, 1982). Video games give adolescents the freedom to control their activities and transport themselves into another world that which they can also control. Crawford stated that video games are potentially superior to books and movies because the player is actively playing the game as opposed to just watching (pg. 18). Dreaming and fantasizing are integral components of human play and video games provide ample opportunities to get away. Exploring new worlds can be fun by oneself, but oftentimes playing with others can just as or more exciting.

The third tenet of SDT is relatedness and it is characterized by the meaningful connections with others and social groups. From playing video games with computers/game consoles connected together in one room (LAN parties) to playing in multi-player mode online with people from all over the world (MMOGs), video games are socially engaging. Besides the games and events themselves, video game players also communicate online while playing the game and or through discussion forums on websites, blogs (web-logs). Spending time and
communicating with potentially millions of other gamers (video game players) likely increases one’s sense of connectedness to a larger socially accepting group. Examples of the social nature of playing video games can be seen in Figure 9 below. SDT posits that the intrinsically motivated who feel the need to be related, autonomous, and competent, will likely participate in activities that fulfills these needs. For some, playing video games can lead to fulfillment of all three SDT needs. What follows is an analysis of three current popular exergames and makes them appealing to adolescents.

![Figure 2-9. Children playing Dance Dance Revolution (DDR)](image)

**Game analysis**

The objective of the game is to step to the beat and rhythm of the song while being cued by arrows that scroll up the screen to tell you which arrow to step on. A player develops stronger beliefs about her stepping skills as she learns to step in time to the music cued by the scrolling arrows. Optimal challenges and supportive feedback enhance feelings of competence (Deci & Ryan, 1985). DDR allows players to self-select difficult levels (beginner, intermediate,
advanced), songs (song speed), and provides instantaneous feedback (See Figure 2-10) on each step taken as well as a summary of successful and successful attempts at the end of the game. All of these factors contribute to a player’s feelings of competence and the likelihood of being intrinsically motivated to play the game. As players earn higher scores, new songs become available to play. That challenging strategy is no different from a Zelda game where you first have to defeat an enemy before getting a key to open a gate to the next level.

Choosing which songs to play, the level of difficulty, or even how long to play (set time limit or even number of calories) increases feeling of autonomy. Players with the ability to choose are likely to boost their feelings of agency and responsibility of action. As Bandura states, “the capacity to exercise control over the nature and quality of one's life is the essence of humanness” (Bandura, 2001). Adolescents learn that they can choose fast, medium, or slow songs. From preliminary studies, most adolescents alternated between the fast and slow songs. DDR players also have the option of playing alone or side-by-side with a partner.

Playing games with friends at home or a DDR tournament are frequently used as “social lubricants” (Crawford, 1982). Sometimes the social interaction is just as important, or maybe less to some, as the games themselves. Players can learn vicariously from watching others struggle.

Figure 2-10: Beginner level DDR feedback and level of difficulty
or succeed, thus fostering feelings of relatedness. Adolescents can also learn how to move and often practice while waiting for their turn (See Figure 2-9). Motivating aspects like competence, autonomy and relatedness certainly feed into whether or not adolescents play any video game; however, the number one reason most gamers play video games is to have fun (Entertainment Software Association, 2001).

DDR is a fun exergame first because it is unique and players must step with their feet. Secondly, the gameplay (how the game is played) is all about thinking, acting, and decision making (Prensky, 2001b), which is perceived as fun to adolescents. Adolescents love music, and DDR Max, DDR Max II, and DDR Max Extreme are loaded with a certain number of unlocked tracks. When players get higher scores, previously locked songs become available to play. The musical styles of the songs range from pop, rock, techno, to disco and with the newer games, the artist’s music video plays in the background instead of an animated character.

Playing DDR can be a physical workout of low, moderate and even moderate to vigorous intensity, according to the many studies that have documented the intensity while playing DDR for short periods of time, i.e. 15 minutes or less (Barney & Mauch, 2007; Chin A Paw, Jacobs, Vaessen, Titzel, & Mechelen, 2008; Hester et al., 2007; Johnson, Alsac, & Swan, 2007; Lanningham-Foster et al., 2006; Marks et al., 2005; McGraw, Burdette, & Chadwick, 2005; Olmstead, 2007; Savoye et al., 2007; Steiner, 2007; Tan, Aziz, Chua, & Teh, 2002; Unnithan, Houser, & Fernhall, 2006; White, Lehmann, & Trent, 2007). Only two studies have analyzed participants DDR playing longer than 15 minutes (Yang & Foley, 2008; Yang & Graham, 2005) and both of these studies allowed the players to play as long as they wanted for up to 45 minutes. No study has allowed teenagers to play for 60 minutes to see if they could obtain most of the recommended amount of moderate to vigorous physical activity.
EyeToy™ is a Sony PlayStation 2™ video game that requires the player to move the entire body or body parts to play any of the games. It consists of a small video camera (See Figure 2-11) that sits on top of the TV and is sensitive to the players’ movements. The movements of the player, in response to the video game, result in a score for each game played. The more the player succeeds in completing their tasks (bouncing a ball, karate chopping, cleaning windows) the more points they will receive. In EyeToy, players must move their entire body or body parts to bounce a soccer ball on their head, karate chop, clean windows with circular arm movements, and/or box with their fists.

Currently there are 11 titles for games that use the EyeToy camera. There are games with a personal trainer (Kinetic), karaoke singing and dancing (SingStar), and hover board riding (Antigrav). DDR Extreme is a new game that combines all the foot pounding of DDR with the crazy arm movements of EyeToy. In the original game, EyeToy Play, there are 12 different games of various challenges. With the nature of this game, hand-eye coordination skills are learned as well as reaction time. The objective of most of the EyeToy games have players move their bodies and extremities to touch certain spots on the screen or avoid other virtual objects.
One EyeToy Kinetic game that was chosen was Breakspeed (See Figure 2-12). The objective of the game is to play for three minutes and try to keep the four punching pads from coming in contact with the translucent circle in the middle of the screen. There are no rules as to which body parts you can use, so some choose to use hands for the upper pads and feet for the lower pads, but others will kick the upper pads or use their head and shoulders. The pads fall down in random sequences and more than one falls as the round progresses. Every time a punching pad is hit there is visual (pad glows momentarily) and auditory (punching bag sound) feedback.

EyeToy is a fun game to play because the players are on screen and not represented by a computerized action figure or avatar. In the truest sense, the player is in of the game as they can fully see their entire body as part of the action. One particular element of EyeToy that is different from DDR is the number of games that can be played. DDR is one game, whereas EyeToy Kinetic has several different games ranging from yoga/stretching to cardio and kickboxing type games. This ability to choose games, as well as difficulty level increases one’s
sense of competence and autonomy. Goals and objectives of the different games can be motivating because people love to set goals and attempt to accomplish them. A player, who wants to get to a high level or score will be motivated to play if he or she feels competent. Overcoming obstacles in previous games likely enhanced her feelings competence.

To date there have been three studies that have investigated EyeToy Kinetic’s impact on energy expenditure (Alsac, Johnson, & Swan, 2007; Böhm, Hartmann, & Böhm, 2008; Thin, Howey, Murdoch, & Crozier, 2007). All three studies found that people who played EyeToy Kinetic engaged in moderate to vigorous intensity physical activity; however, each study was conducted on college undergraduate populations. Furthermore, no study has investigated the amount time teenagers would play if given an hour and if the time they accumulate while playing would meet the daily recommendation of moderate to vigorous physical activity.

Another exergame system that does not use a traditional video game console is the XaviXPORT (SSD Company Limited). In 2005, the Japanese company XaviX released its “new generation” game system in the United States. XaviX is being marketed as a way to interact with onscreen video game action. XaviX games require a XaviXPORT game console which plugs into the video input on a television or VCR and a XaviX game cartridge that comes with a specially modified sports accessory. In XaviX® Tennis, participants will swing a small 12” racquet in attempt to hit a moving tennis ball on the TV screen. The speed, angle, and, trajectory of the virtual ball will be determined by the player’s swing. On the racquet, there are small infra-red sensors that interact with the XaviXPORT motion sensing technology. These sensors detect players’ actions and respond with appropriate onscreen action (See Figure 2-13).

The field of exergames is relatively new and to date, over 30 research studies involving exergames have been completed. Only four studies have compared more than one type of exergame interaction (Bausch, Beran, Cahanes, & King, 2008; Böhm, Hartmann, & Böhm, 2008; Lanningham-Foster et al., 2006; Yang & Foley, 2008) and no studies have compared three or
more different exergames. Despite not knowing all the effects of playing exergames, the State of West Virginia recently implemented DDR in all middle schools.

Figure 2-13. Preparing to hit a virtual tennis ball in XaviX Tennis

Positive performance feedback (computer-generated) gives the player information to help play the game better and enhances feelings of competence. As Prensky notes that “it is from feedback that learning takes place” (pg. 05-13) (Prensky, 2001a). In XaviX® Tennis, the instantaneous feedback can help the player time their swing and hit the ball accurately. In some games, feedback is delivered through the game controller. A new online fitness bike, MOG provides force feedback (vibrations) in the handles, seat and pedals. This type feedback can be useful for game play and also better imitates the real-life experience.

Socially engaging events foster feelings of fun, relatedness, and allow players to learn by watching one another. As in all video games, choosing to play is autonomy enhancing. Adolescents have to abide by family, school, and societal restrictions. By playing video games, they are in control and can “escape” to a fantasy world where they can forget their problems (Crawford, 1982). Becoming a dancing diva, ninja fighter, or tennis swinging sensation definitely constitutes a fantasy world, but one nonetheless chosen by the youngster.
Given today’s overweight epidemic in youth, video game designers should be aware of specific motivational guidelines that may increase the likelihood of adolescents enjoying the game. As discussed in the previous sections, Self-Determination Theory (SDT) can be a useful theory upon which to design interventions that include exergames. SDT incorporates having fun, playing with peers, and building skills in order to master the game. Based on SDT motivation principles, the following four guidelines can inform exergame design.

This final section outlines possible solutions to increasing children’s levels of physical activity especially in reference to out-of-school physical activity.

**Solutions to increase voluntary physical activity levels**

Researchers have addressed the overweight epidemic in various settings including community centers, health-care providers, and research centers; however, schools are ideal settings because of the children spend a large portion of time in school (U.S. Department of Health and Human Services, 2001). School-based interventions that targeted an increase in physical activity were based on different theoretical frameworks, methodologies, and assessment tools; therefore, a more detailed analysis of interventions and their effectiveness was reviewed (Dobbins, De Corby, Robeson, Husson, Tirilis, 2009).

School-based physical activity interventions from 1981 to 2004 were identified through electronic database searches and by reviewing previous published articles, reviews, dissertations, and research briefs. In total, there were 26 interventions identified and included in this review. The duration of the majority of interventions was short (five to 16 weeks) but there were 17 interventions that lasted two or more years. Despite increased physical activity levels within the intervention setting or period, there was no impact on leisure-time physical activity or BMI outside of the intervention environment. Despite the mixed findings from this review, more
research using qualitative methods and an ecological perspective is warranted (A. C. King et al., 2002).

Qualitative measures have a definite advantage over purely quantitative measures as they allow the subject to respond in their own voice, using their own words (Locke, 1989). For the participant there is less ambiguity in trying to understand what the question is asking. Subjects are not limited by pre-determined responses and are free to respond with whatever language, phrasing or expression. For example, Hassandra et al. (2003) qualitatively investigated the factors associated with intrinsic motivation in a physical education class. They wanted to see how students linked their perceived competence to intrinsic motivation. After participants completed the Intrinsic Motivation Inventory (IMI), researchers selected students from each of the categories so that all opinions and gender were equally balances. In the second phase of their study, they used semi-structured in-depth interviews. Similar to previous studies, students in this study used concepts such as effort, willingness, interest, and ability to define competence and motivation.

A semi-structured interview with open-ended questions with prompts for elaborations can be useful in physical activity settings (Parker, 1984; Rogers, 1987). Typically researchers will start off with a general comment about the study and how the participant perceived or enjoyed the entire experience. Guiding questions might include: “Did you like being a part of the study?”; “Did you have fun?”, and “Do you think you improved from the start of the study?” Common elaboration prompts include; “Why do you think we did this study?”, Why did you like/not like this study”, “How do you think you did?”, and “Why do you think you improved?” The semi-structured interview format has been used in previous research studies and interviews are often recorded with a recording device to ensure accurate transcriptions (Anderson, 1998; Hassandra et al., 2003; Manross, 1994; Yang, Vasil, et al., 2004). Although qualitative data has some methodological advantages over quantitative data, there are researchers who feel that there are
ecological influences that need addressing. Besides data collection, environmental influences can greatly impact any program’s success.

Environmental interventions that include school, family, and community components should be pursued to maximize impact (Dishman et al., 2004; King et al., 2002; Sallis et al., 2001). For many years, research was only at the school level, usually trying to modify in-school behaviors. These stimulus-response type interventions did not show maintenance effects after the intervention or between sessions. In other words, once the child went home they did the same things; there was no carryover into the other areas of their life. There needs to be supportive environmental changes at home (Wrotniak, Epstein, Paluch, & Roemmich, 2004) and in the community (Jago & Baranowski, 2004) to reinforce the effects of the interventions in schools (Epstein, 1998; Kahn et al., 2002). Besides a collaborative effort, researchers must find activities that adolescents enjoy.

Researchers often presume that adolescents will enjoy the activities or exercises they use in their intervention; however, this is not always true. Despite the many school-based physical activity interventions, only a few studies assessed student enjoyment and many of the results were not favorable (Jamner, Spruit-Metz, Bassin, & Cooper, 2004; McKenzie et al., 2004). Adolescents need to have fun while playing, feel competent, and be with their peers to increase the likelihood of them staying physically active (Sallis et al., 2000). Highly motivated adolescents usually have high levels of competence in physical activity settings (Ferrer-Caja & Weiss, 2000; Fredenburg et al., 2001; Goudas et al., 2001; Miller et al., 2002; Ntoumanis, 2001; Wang et al., 2002) and interested in the activities (Centers for Disease Control and Prevention, 2000; Hassandra et al., 2003). Adolescents who feel competent while doing activities are also more motivated to continue doing that activity. Specifically, Ntoumanis (2001) and Digeldis (2003) found students who felt encouraged to participate in physical education had higher levels of skill competence, enjoyed class because it was inherently fun, and deliberately attempted more
challenging tasks. Other findings show that students are intrinsically motivated when evaluations (feedback) focus on their abilities and not based on other students’ performances (Pellett et al., 1994; Shea & Wulf, 1999).

Henderlong & Lepper (2002) support the positive effects of correctly applied positive performance feedback (PPF) on children’s intrinsic motivation. The use of genuine praise is effective so long as it is congruent with a specific performance and not “overly general” (p. 778). This implication is also suggested in the physical education pedagogy literature which emphasizes the use of “specific congruent feedback” when teaching (Graham, 2001; Silverman, Tyson, & Krampitz, 1992; Viitasalo et al., 2001). PPF enhances intrinsic motivation because it informs the learner about her performance but is not a controlling factor. It does not dictate future actions however; a student who perceives negative or incongruent feedback is less likely to repeat that action. As in any discipline, student motivation is a very important moderator of behavior and physical education is no exception.

The National Association for Sport and Physical Education (NASPE) advocates quality physical education programs that encourage healthy and physically active lifestyles by developing “health-related fitness, physical competence, cognitive understanding, and positive attitudes about physical activity” (2004a). If a physical education program can foster adolescents’ competence in and intrinsic motivation for physical activity settings, we might be one step closer to reversing the overweight epidemic. Michelle Obama’s Let’s Move campaign has certainly put more focus on finding opportunities for everyone to be more active and eat healthier. “The physical and emotional health of an entire generation and the economic health and security of our nation is at stake. This isn’t the kind of problem that can be solved overnight, but with everyone working together, it can be solved. So, let’s move!” (2010)

Many people blame electronic media such as television, computer, and video games for the “slowing down” of today’s youth. Some studies report that television is positively associated
with overweight adolescents but, considering the popularity of computer and video games (92% of children age two to 17 play video games), researchers and educators should capitalize on their love for video games (National Institute on Media and the Family, 2001). One way to make sure that time spent playing video games is active instead of sedentary, is to play exergames. Traditionally an enemy, the line between video games and physical activity is now less defined. It is important not to ignore exergames because one of them might be a gateway to a lifetime of physical activity. For someone who does not like lifting weights or playing team sports, one of these games might inspire them to dance an hour each day, do yoga three times a week or even kick box for half an hour. Given the choice of playing video games with your fingers or your entire body, exergames might be a healthier alternative.
Chapter 3

Methodology

According to the U.S. Department of Health and Human Services, children and adolescents should accumulate at least 60 minutes of moderate to vigorous intensity physical activity (MVPA) daily for improved cardiovascular fitness, muscular strength, bone health and favorable body composition (2008). Vigorous intensity activities should also be done at least three times a week. Despite these recommendations, nationally only 35% of high school students accumulate 60 minutes of physical activity a week and 25% do not participate in 60 minutes of physical activity on any day of the week (Centers for Disease Control and Prevention, 2008). Some experts feel that the increase in time playing computer and video games is displacing time spent being physically active and is also responsible for the increased rates of overweight and obesity (Stettler et al., 2004; Vandewater et al., 2004). A typical American adolescent plays video games 73 minutes a day and the many of these games are played while seated using a hand-held controller (Rideout, 2010). Newer video games called exergames are different in that they require the player to move their body in order to play the game. Three popular commercially available exergames are Dance Dance Revolution (primarily legs), XaviX® Tennis (arms only), and EyeToy Kinetic™ (legs and arms). Currently, exergames are being marketed as fitness games and being used in interventions with very little knowledge about their effects on MVPA in teenagers and reasons for playing. Recently, four studies (Bausch et al., 2008; Böhm et al., 2008; Lanningham-Foster et al., 2006; Yang & Foley, 2008) compared two exergames but no studies have compared three or more exergames in adolescents. Only one of the above-mentioned studies (Yang & Foley, 2008) reported the percentage of time participants were engaged in MVPA for DDR and EyeToy Play.
The primary purpose of this study was to determine the differences in minutes and percentage of time spent in MVPA as well as ratings of perceived exertion while playing three commercially available exergames. The secondary purpose was to compare energy expenditure (calories, calories per minute) measured by a heart rate monitor and SenseWear Armband. The final purpose was to determine which reasons they chose to play as long as they did.

Experimental Design

This study used a quasi-experimental within-subjects design to compare heart rate and SenseWear Armband responses of participants playing three different exergames. Using self-report methods (Motives for Physical Activity Measures – Revised), it also compared differences between games on why one exergame appears to lead to more MVPA than another.

Setting

The study was conducted at a community fitness center (CFC) located in a small city in the Northeastern United States. The membership base was approximately 400 families with approximately 100 adolescents associated with the facility, including clubs and teams. Data was collected in a 150 square foot multi-purpose room equipped with a projector and a sound system hooked up to all three exergames. The participant and the researcher were the only ones in the room during data collection, but the door was always open to the reception area and attendant.
Participants

Recruitment

The researcher obtained permission from the CEO of the community fitness center (CFC) to conduct the study (See Appendix). The researcher also contacted the youth program coordinator, community groups, and teams that use the CFC to recruit participants. The researcher posted flyers and information packets in the lobby to attract attention to the study. The CFC staff also publicized the study in the monthly newsletter and provided the researcher’s contact information. All interested adolescents or their parents were invited to call or e-mail (contact information was listed on the flyers and posters) the researcher to learn more about the details of the study and to arrange a time to participate. Prior to each experimental visit, participants were asked to abstain from food and caffeine intake for two hours, and vigorous exercise for 24 hours. All participants were asked to wear typical workout clothing (short sleeve cotton t-shirt and shorts and appropriate footwear) for each visit.

Screening

Participants were 27 healthy adolescents between 14 and 18 years of (Females =10, Males = 17). This number is consistent with other studies that have measured the differences between more than one exergame (Bausch et al., 2008; Böhm et al., 2008; Graves, Ridgers, & Stratton, 2008; Yang & Foley, 2008). The researcher obtained informed written consent from their parent/guardian in order to participate if they were less than 18 years old. Each youth was a CFC member and was permitted to participate in physical activities within the facility. All participants signed an informed assent form prior to starting the study. Participation in this study
was voluntary and for those who completed the first two sessions received a $10 gift card to Subway and for those who completed all parts of the study (surveys, 4 days of playing exergames, and answering all questions) there was a free three-month membership extension to the CFC.

**Sample Size**

In determining the appropriate sample size at the CFC during the time period of the research project, it was estimated that approximately 100 adolescents might be available to participate. Using data from a previous study (Yang & Graham, 2005), the heart rate confidence interval of 19.55 was applied to a confidence level of 95% to a population of 100, yielding a required sample size of 20 participants (Creative Research Systems, 2006).

**Procedures**

Visits occurred after school or on weekends as the participants’ schedule permitted. On visit one, each participant submitted the following forms completed and signed: 1) parental consent, 2) teen assent, and 3) Physical Activity Readiness-Questionnaire (PAR-Q). The participant then completed the Personal History Questionnaire (PHQ), which asked about their typical sedentary and physical activities during a typical school day and weekend (Appendix). The researcher measured each participant’s weight and height using a calibrated digital scale and a portable stadiometer, and from those measurements body mass index was calculated (BMI = mass(kg)/height(m²)). The participant then received instructions on how to wear a heart rate monitor (Polar E600) (snug across the sternum) and SenseWear Armband (on the back of the
upper right arm) and was directed to the bathroom to put them on. A female CFC staff member was available to assist the females if needed.

A randomized counter-balanced design was used to ensure equal treatments across all three exergames and to prevent an ordered-effect, (Campbell, Stanley, & Gage, 1972; J. T. Thomas, Nelson, & Silverman, 2005). On Visit 1, the researcher introduced and gave instructions on how to play the first randomly assigned exergame. The participant had five minutes to play and was able to ask any question to the researcher about how to play the game. Once the participant was ready, the record modes on the heart-rate monitor and SenseWear Armband were started, and participants were asked to play the first game for 15 minutes, after which, participants were verbally asked four questions about their enjoyment from playing each game on a 7-point Likert-type scale, anchored from 1 (not at all true) to 7 (very true) and the OMNI-RPE scale for perceived exertion (0-10 scale of perceived exertion). The researcher then recorded their responses on a data collection form (See Appendix) and gave participants a ten-minute rest period. During their rest period, participants were allowed to leave the room to get a drink or go to the bathroom. This procedure continued until all three exergames were played and all answers recorded. The total amount of time spent being physically active on visit one was up to 60 minutes (5 minutes + 15 minutes = 20 minutes x 3 = 60 minutes). This protocol was consistent with pervious studies that assessed adolescents’ energy expenditure across multiple exergames (Epstein, Beecher, Graf, & Roemmich, 2007; Lanningham-Foster et al., 2006; Maddison et al., 2007). At the end of the each visit, participants removed the monitors and data was downloaded to a portable computer. Heart-rate data was imported to Polar PE Manager software (Oy, Finland) and the ArmBand data was imported to InnerView Professional software versions 6.1 (SWA 6.1). Prior to leaving, the participants scheduled the remaining visits over a two-week span with at least 2 days between sessions.
On visits two, three and four the participants were randomly assigned one exergame to play. Similar to the first session, participants wore a heart rate monitor and SenseWear Armband for the entire session. They were informed that they had up to 60 minutes to play and they could stop whenever they no longer want to play. After playing, they gave their rating (0-10 scale) of perceived exertion (OMNI-RPE) to the researcher, completed the paper-based MPAM-R survey, and then removed the monitors. Following a brief cool down and drink period, the researcher interviewed participants (approximately five minutes) and recorded the conversations on a digital voice recorder. The researcher asked participants about their experiences including the following series of questions:

“You played the game for ?? minutes. (number of minutes they played up to 60 minutes), Why do you think you played the game for this long? (Probe—fun? Why was it fun? Would you like to play this game again on another day? What did you like about the game? Why? What didn’t you like about the game? Why? Would you take these games home to play if you were allowed? Which one? Why? Would your parent/guardian want you to play these types of games?)

On the last day the researcher asked each participant to rank the games in their order of preference.

**Retention of participants**

In order to retain as many participants and to avoid withdrawals, the researcher was sure to ask participants if they have any questions about the study or protocols. The researcher was also in contact with the CFC staff to ensure the testing room was available when the participant was scheduled. Reminder cards with the date and time of the next testing session were given to the participant prior to leaving for the day. The researcher also called each participant to remind them of their appointment a day or two prior to the scheduled appointment.
Measures

*Physical Activity Readiness Questionnaire*

The Physical Activity Readiness Questionnaire (PAR-Q) is a paper-based screening tool used to determine if a participant is able to be physically active (Shephard, 1994; Thomas, Reading, & Shephard, 1992). There are seven questions that ask if there are any medical reasons or symptoms that would prevent participation in physical activities. The participant must answer (on paper) all seven questions, all with NO responses, in order to be eligible to participate in the study and if they are below the age of majority, it must be signed by their parent/guardian. This questionnaire is a commonly used self-assessment tool used to see if you should check with your doctor before becoming much more physically active (Canadian Society for Exercise Physiology, 2002).

*Personal History Questionnaire*

The Personal History Questionnaire (PHQ) is a paper-based 23-item questionnaire (See Appendix) that asks general personal information (e.g., age, height, weight, date of birth). There are several questions that ask participants to report the time they spend doing sedentary activities such as watching television, using the computer and talking on the phone. This data was helped to describe the participants and their behaviors and supported the analyses and discussions. The questions related to time spent in sedentary behaviors are drawn from a large sample of children’s media habits (Roberts, Foehr, & Rideout, 2005; Roberts et al., 1999). Participants were asked to write approximately how many minutes they spend with a variety of media including computers, video games, and music. The PHQ has been used to assess these variables in previous research studies (Downs, Graham, Yang, Bargainnier, & Vasil, 2006; Yang, Downs, Graham, Vasil, &
Bargainnier, 2004) and when reviewed for internal consistency, the combined sedentary scores yielded a Chronbach’s alpha of 0.52 (Yang, Treece, Miklas, Graham, 2009) (See Appendix).

**MVPA - Heart rate**

The Polar heart rate monitor E600 (Polar Electro Oy, Finland) is a system that consists of a chest strap transmitter worn across the sternum and a wristwatch display. The wristwatch-like unit displays the heart rate of the participant and once the participant is finished, the researcher downloaded the data to a computer using an infra-red receiver attached via USB cable. Data was imported to Polar’s PE Manager software (Lake Success, NY) was used to view data and to export to Microsoft Excel for subsequent analysis. Heart rate was analyzed to determine the percentage of time each participant was engaged at moderate and vigorous intensity (MVPA) levels. The American College of Sports Medicine (ACSM) defines MVPA as 50-85% of age predicted maximum heart rate (220 – age). The duration of total time spent playing the exergame was also captured on the heart rate monitor and was reported as total minutes. The E600 Polar heart rate monitor collected data in beats per minute at five-second epochs and by using the PE Manager software calibrated to each participant’s age predicted maximum heart rate. The total minutes spent at MVPA and the percentage of total time spent at MVPA was calculated.

**MVPA – SenseWear Armband**

The SenseWear Armband PRO2 is a small device that is worn on the back of the upper right arm held by a stretchy band with Velcro strap. It continuously recorded movement, skin temperature and Galvanic skin response, when combined generates a measure of total energy expenditure (calories, calories per minute) and minute-by-minute metabolic equivalent values
(METs) (1 MET = 3.5 mL O2/min/kg or 1 MET = 1 kcal). Once calibrated to the participant’s age, height, and weight the device and software can output the number of minutes and the percentage of time the participant was above 3.0 MET (moderate intensity) and 6.0 MET (vigorous intensity). The ArmBand has been validated to use with children and adolescents (Arvidsoon, 2007; Backlund, 2010; Calabro, 2009; Crawford, 2005).

**Intrinsic Motivation Inventory (IMI)**

A four question shortened version of the IMI was used to gauge the participants level of enjoyment after playing each exergame (Ryan, Mims, & Koestner, 1983).

**Motives for Physical Activities Measure – Revised**

The MPAM-R has been used to assess the reasons why people engage in physical activities, sports, and exercise (Ryan et al., 1997). Previous research has found the MPAM-R to be valid and reliable (Frederick et al., 1996; Frederick & Ryan, 1993; Ryan et al., 1997), while other studies have used MPAM-R to assess motives in children and adolescents (Corban et al., 2003; Koivula, 1999; Taylor et al., 2005; Wilson et al., 2002).

The Motives for Physical Activities Measure – Revised (MPAM-R) is a paper–based 35-item questionnaire used to assess the strength of five motives (fitness, appearance, competence, social or enjoyment) for playing the exergame as long as they did (See Appendix). After playing each of the exergames on visits two, three and four by, participants wrote their answers to the questions on the MPAM-R survey. The seven point Likert-type response scale ranged from 1 (not at all true for me) to 7 (very true for me) on questions like “Because its fun” and “Because I want to improve existing skills.”
Response Variables

The primary outcome measures was heart rates and percentage of time spent in moderate to vigorous intensity physical activity while playing the exergames. The secondary outcome assessed the reasons for playing the exergames for as long as they do by completing a short questionnaire. The response variables for the study are summarized as follows:

Duration (time): duration of playing the video game in minutes (continuous variable);

Percent MVPA (%MVPA): percent of time participant played at a moderate to vigorous intensity (continuous variable);

MPAM-enj, MPAM-com, MPAM-app, MPAM-fit, MPAM-soc: these five variables represent the combined scores from the MPAM-R survey for reasons of enjoyment, competence, appearance, fitness, and social (continuous variables) specific to each game.

<table>
<thead>
<tr>
<th>Study 1</th>
<th>Hypothesis</th>
<th>Measures</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: %MVPA</td>
<td>EyeToy Kinetic &gt; DDR &gt; XaviX Tennis</td>
<td>Heart Rate Monitor IMI - Enjoyment</td>
<td>RM-ANOVA</td>
</tr>
<tr>
<td>Study 2</td>
<td>H2: Time</td>
<td>EyeToy Kinetic &gt; DDR &gt; XaviX Tennis</td>
<td>Time</td>
</tr>
<tr>
<td>H3: Percent Time in MVPA</td>
<td>EyeToy Kinetic &gt; DDR &gt; XaviX Tennis</td>
<td>Heart Rate Monitor</td>
<td>RM-ANOVA</td>
</tr>
<tr>
<td>H5: Moderation</td>
<td>Gender/BMI—Time/%MVPA</td>
<td>Heart Rate Monitor</td>
<td>Pearson r Regression</td>
</tr>
<tr>
<td>H6a: Enjoyment</td>
<td>EyeToy Kinetic &gt; DDR &gt; XaviX Tennis</td>
<td>MPAM-R</td>
<td>RM-ANOVA</td>
</tr>
<tr>
<td>H6b: Moderation</td>
<td>Enjoyment – Time/%MVPA</td>
<td>MPAM-R</td>
<td>Pearson r Regression</td>
</tr>
<tr>
<td>Study 3</td>
<td>H4.1a: Phase 1</td>
<td>Calories—15 mins: AB &gt; HRM</td>
<td>Heart Armband Heart Rate Monitor</td>
</tr>
<tr>
<td>H4.1b: Phase 2</td>
<td>Calories—15 mins: AB &gt; HRM</td>
<td>Armband Heart Armband</td>
<td>Pearson r Bland-Altman</td>
</tr>
<tr>
<td>H4.2a: Phase 1</td>
<td>Calories per Minute—60 mins: AB &gt; HRM</td>
<td>Armband Heart Armband</td>
<td>Pearson r Bland-Altman</td>
</tr>
<tr>
<td>H4.2b: Phase 2</td>
<td>Calories per Minute—60 mins: AB &gt; HRM</td>
<td>Armband Heart Armband</td>
<td>Pearson r Bland-Altman</td>
</tr>
</tbody>
</table>
**Exergames**

Three different exergames (Dance Dance Revolution, EyeToy Kinetic, XaviX Tennis) were chosen, as they are three popular exergames. They were also selected because they represent three distinctly different modes of user interactions. Dance Dance Revolution involves primarily the legs, XaviX Tennis is primarily an arm-based game, and the EyeToy Kinetic requires moving the whole body including arms and legs.

*Dance Dance Revolution™ Supernova 2*

Dance Dance Revolution™ (DDR) Supernova 2 is a video game played on the Playstation 2 game system. DDR is a video game that requires the player to move to the beat and rhythm of varying types of music by stepping on arrows on a touch-sensitive dance pad. During visit one, each participant was assigned to the “Game” and “Single” player modes and to the “Beginner” level of difficulty and then the participants played the pre-selected set of seven songs (Say Goodbye, Rock Your Body, Angellus, Got To Be Real, Le Freak, Temperature, Take on Me). During visits two through four, participants were assigned to the “Game” and “Single” player modes and to the “Standard” level of difficulty and then participants were able to choose any of the 15 pre-selected songs in any order (ANSELUS, Beginning of the End, Can't Stop the Rain, EternuS, Every Little Step, daGot To Be Real, LE FREAK, Rock Your Body, Say Goodbye, Take On Me, Temperature, The Rockafeller Skank, The World Around Me, Until Forever, volcano.)
**EyeToy Kinetic™**

In most EyeToy Kinetic games, the objective is to touch (with any body part) certain colored objects and avoids others. During visit one, each participant was assigned to the “Single” player mode and to the “Easy” level of difficulty, then played the five pre-selected games (Wildfire, Reflex, Backlash, Breakspeed, Sidewinder). During visits two through four, each participant was assigned to the “Single” player mode and to the “Medium” level of difficulty, and then they could play any of the 12 pre-selected games in any order (Cascade, Pulsate, Ricochet, Arcburst, Wildfire, Trespass, Backlash, Reflex Breakspeed, Sidewinder, Precision, and Protector).

**XaviX® Tennis**

In XaviX® Tennis, small tennis racquets equipped with motion sensing reflectors relay the speed, direction and angle of a player’s swing to the XaviX® PORT™. Players were required to follow the ball and adjust to hitting it at the appropriate time and with sufficient force in order to keep it in play. On the first visit, each participant was assigned to: “One Player”, “Exhibition” “6 Game Set” play modes, given the B.Lovely character to play and compete against B.Lovely at the US Open court option, and were instructed to playing for 15 minutes. During visits two through four, each participant was assigned to the “the “One Player”, “Exhibition” and “6 Game Set” play modes, but were free to select any game player, opponent (from a selection of four male and four female tennis players), and tennis venue (four locations). Once done a “6 Game Set” they could continue playing by starting a new game.
Data Analysis

SPSS™ (SPSS, Inc. Chicago, IL) version 19.0 was used for analyzing all test score data and alpha levels were set at 0.05.

1. H1: There will be significant differences in percentage of total time spent at MVPA between DDR, EyeToy Kinetic, and XaviX Tennis during a 15 minute session (EyeToy Kinetic > DDR > XaviX Tennis). To test this hypothesis, a one-way repeated-measures ANOVA was used to assess any differences between games.

2. H2: There will be significant differences in time spent in minutes playing DDR, EyeToy Kinetic, and XaviX Tennis. (EyeToy Kinetic > DDR > XaviX Tennis). To test this hypothesis, a one-way repeated-measures ANOVA was used to assess any differences between games.

3. H3: There will be significant differences in percentage of total time spent in MVPA between DDR, EyeToy Kinetic, and XaviX Tennis if given up to 60 minutes to play. (EyeToy Kinetic > DDR > XaviX Tennis). To test this hypothesis, a one-way repeated-measures ANOVA was used to assess any differences between games.

4. H4: There will be significant difference in percentage of time spent in MVPA recorded by two separate devices (heart-rate monitor vs. SenseWear Armband) while playing three exergames for up to 60 minutes (EyeToy Kinetic > DDR > XaviX Tennis). To test this hypothesis, separate t—tests were used to assess any differences between devices for each game.

5. H5: There will be moderating effects of gender, weight-status or reasons for playing on MVPA. To test this hypothesis, a series of regression equations were conducted to determine any moderating effects on MVPA.
6. H6: There will be significant differences in MPAM-R sub-scale scores between DDR, EyeToy Kinetic, and XaviX Tennis. (MPAM-R enjoyment, competence, fitness, appareness, social: EyeToy Kinetic > DDR > XaviX Tennis). To test this hypothesis, separate one-way repeated-measures ANOVA were used to assess differences between games.
Citations


Centers for Disease Control and Prevention. (2000). Promoting better health for young people through physical activity and sports. A report to the President from the Secretary of Health and Human Services and the Secretary of Education.


*Research Quarterly for Exercise and Sport, 79* (1 Supplement), A-17.


*Research Quarterly for Exercise and Sport, 76* (1 Supplemental), A-96.


Chapter 4

Results

The current chapter will include 3 separate articles that report on the findings separately and in manuscript format. The research hypotheses are separated into three separate papers and are outlined below to give readers a better framework with which to follow the results.

Paper 1

- H1: Over 15 minutes, EyeToy Kinetic was played for a higher percentage of time in MVPA than Dance Dance Revolution, and XaviX Tennis

Paper 2

- H2: EyeToy Kinetic was played longer than Dance Dance Revolution, and XaviX Tennis when given up to 60 minutes to play
- H3: EyeToy Kinetic was played for a higher percentage of time in MVPA than Dance Dance Revolution, and XaviX Tennis when given up to 60 minutes to play
- H5a: Gender did not have a moderating effect on percentage time spent in MVPA
- H5b: BMI did not have a moderating effect on percentage time spent in MVPA.
- H6a: No differences were found in enjoyment scores between games.
- H6b: MPAM-R enjoyment scores did not have a moderating effect on the percentage time spent in MVPA.

Paper 3

- H4.1a Armband did not record higher calories than Heart Rate Monitor over 15 minutes
- H4.1b Armband did not record higher calories than Heart Rate Monitor over 60 minutes
• H4.2a Armband did not record higher calories per minute than Heart Rate Monitor over 15 minutes
• H4.2b Armband did not record higher calories per minute than Heart Rate Monitor over 60 minutes
Paper 1: Comparison of Adolescent MVPA, RPE, and Enjoyment Playing Three Exergames
Abstract

There is growing acceptance of exergaming as a potentially safe outlet for accumulating adequate physical activity. The purpose of this study was to examine the differences between XaviX Tennis (XVT), EyeToy Kinetic (ETK), and Dance Dance Revolution (DDR) for percentage of time spent in moderate to vigorous physical activity (MVPA) and ratings of perceived exertion (RPE). The percent time spent in moderate to vigorous physical activity (%MVPA) was measured via heart rate monitors, rating of perceived exertion (RPE) was measured via OMNI-RPE scale, and enjoyment level was measured via Intrinsic Motivation Inventory (IMI), were obtained from 27 adolescents (female = 10, males = 17) age 14-18 years, during 10 minutes of rest between three 15-minute bouts of XVT, ETK, and DDR. Results for the dependent variables (%MVPA, RPE, and enjoyment) were analyzed using separate repeated measures ANOVA. ETK elicited a significantly higher ($p < .001$) heart rate (bpm; $M = 137.22$, $SD = 23.41$) than XVT ($M = 118.41$, $SD = 22.05$) and DDR ($M = 112.44$, $SD = 21.60$). Analyses examining the percentage of time spent at MVPA revealed that participants spent a higher percentage ($p < .001$) of game play time in MVPA while playing ETK (percentage time, $M = 89.02$, $SD = 16.72\%$) compared to DDR ($M = 74.50$, $SD = 32.92\%$) and XVT ($M = 67.17$, $SD = 37.28\%$). Participants rated ETK ($M = 4.39$, $SD = 2.13$, $p < .001$) and DDR ($M = 3.87$, $SD = 2.07$, $p < .001$) significantly higher on perceived exertion compared to XVT ($M = 2.30$, $SD = 1.79$). The present study indicates that participants engaged in MVPA across all three exergames at a minimum of 67% of the time. If exergames becomes more popular and prevalent in homes, they may be a partial solution to increasing physical activity and improving health.
INTRODUCTION

The recent rise in childhood obesity rates has prompted action from the U.S. Department of Health and Human Services. The Healthy People 2020 addresses physical activity goals for children and adolescents to target declining physical activity and increasing childhood obesity rates (2000). Physical activity recommendations suggest that adolescents accumulate 60 minutes or more of moderate-to-vigorous-intensity physical activity (MVPA) daily (Physical Activity Guidelines Advisory Committee, 2008). Despite these recommendations and the diseases related to sedentary behavior, less than 20% of adolescents meet these recommendations based on self-report data (Centers for Disease Control, 2010).

It is generally considered that exercise and physical activity are beneficial to maintaining optimal mental and physical health (Penedo & Dahn, 2005). Childhood obesity is likely to track into adulthood and may be a precursor for chronic disease later in life (Goran, 2001). Activities that encourage adolescents to be active and maintain an active lifestyle are desirable and greatly needed. Since many schools do not require daily physical education, finding innovative solutions to promote physical activity and creating settings where youth can be active is crucial to meeting the Healthy People 2020 goals and addressing the childhood obesity crisis.

On average, American children and adolescents watch four and a half (4:29) hours of television daily and spend three additional hours using computers and playing video games (Rideout, 2010). These media usage rates tend to increase with age and recent reports suggest that adolescents play video games an average of 50 -73 minutes a day (Entertainment Software Association, 2010; Rideout, 2010). There is conflicting evidence on the role video games play in promoting sedentary behavior and displacing physical activity. (Anderson, Economos, Must, 2008; Biddle, Gorely, Marshall, Murdey, & Cameron, 2004; Goldfield, 2011; Hardy, 2010, Marshall, Biddle, Gorely, Cameron, & Murdey, 2004; Mendoza, Zimmerman, Christakis, 2007; Rey-Lopez, 2008, Wong, Cerin, Ho, Mak, Lo, Lam, 2010).
Exergames (active video games) is a growing niche of video game technology that require the player to perform bodily movements whilst playing a video game (Yang, Smith, & Graham, 2008). In essence, the player is the character in the game (Matysczok, Radkowski, & Berssenbruegge, 2004; Ohshima, Satoh, Yamamoto, & Tamura, 1998) and as a result interaction between video game and player is more intense when compared with traditional video games. Approximately 40% of US high school students (n = 9,125) play exergames (Fulton, 2012), with teenage girls and boys playing nine to 30 minutes, respectively (n = 1,465) each day (Yang, Treece, Miklas, 2009). Emerging evidence has provided support for the use of active video games to increase energy expenditure. However, few investigations have compared the energy cost of various types of exergames and data describing preference for a particular active gaming system or the amount of time children play when given the choice is nonexistent. (Bailey, 2011; Bausch, Beran, Cahanes, & King, 2008; Böhm, Hartmann, & Böhm, 2008; Lanningham-Foster et al., 2006; Yang & Foley, 2008). Furthermore, there are no studies that describe adolescents’ percentage of time spent in MVPA during an exergame session, or examined differences in MVPA across several exergames. If in fact adolescents who are playing exergames are engaging in sufficient amounts of moderate to vigorous physical activity, then exergames may be an option to accumulate the recommended amounts of daily physical activity and health benefits (Healthy People 2020, the U.S. National Physical Activity Plan, (2010); U.S. Department of Agriculture and U.S. Department of Health and Human Services, (2010).

It seems evident that the games industry is embracing activity-based video gaming. In 2008, the exergame market was estimated to have generated $6.4 billion in revenue (Donner, 2008), with more fitness-based software titles being launched each year. Based on sales figures from www.vgchartz.com, three affordable commercial exergames are Dance Dance Revolution (21 million copies sold), EyeToy Kinetic™ (5 million EyeToy sales), XaviX® Tennis (successful in Japan), are being marketed as fitness games. These active gaming systems are being used in
interventions with very little knowledge about their effects on MVPA in teenagers and reasons for playing.

Dance Dance Revolution (DDR), the most established exergame, is a dance simulation game and is available on all game platforms and arcade machines. DDR is played on a touch sensitive dance pad. Players receive points and cheers when they step in time (in sync) to music and with flashing arrows illuminated on a screen. Previous research has shown DDR can be a physical workout of low or moderate intensity (B. Bailey, Marcelus, Lujares, Kennard, & McInnis, 2008; Chin A Paw, Jacobs, Vaessen, Titzeb, & van Mechelen, 2008; Graf, Pratt, Hester, & Short, 2009; Lanningham-Foster et al., 2006; Marks et al., 2005; Olmstead, 2007; Tan et al., 2002; Unnithan et al., 2006; White et al., 2007). It can also be a source of the more moderate to vigorous intensity levels, when children and adolescents are given no time limits and freedom to play at higher game levels (Weaver, Yang, & Foley, 2009; Yang & Foley, 2008; Yang & Graham, 2005).

Sony PlayStation 2 EyeToy™ Kinetic (ETK) uses a small web camera pointed at the player. All player movements are depicted on-screen interacting with the game and moving objects. Players move their body or specific body parts to play any of the games. The movements of the player, in response to the video game, result in a score for each game played. The more players succeed in completing their tasks (breaking bricks, punching or kicking moving objects, etc.) the more points they receive. Research using the more fitness-based EyeToy Kinetic games has shown that the games result in moderate to vigorous intensity activity (Alsac et al., 2007; Böhm et al., 2008; Gasperetti, Milford, Blanchard, Yang, & Foley, 2009 (In Press); Thin et al., 2007; Weaver et al., 2009). Some researchers have hypothesized that because ETK requires you to move your whole body and use both your arms and legs to play the games there is potential to accumulate MVPA.
XaviX is an exergame system that does not use a traditional video game console is XaviX (SSD Company Limited). XaviX games require a XaviXPORT game console plugs into the video input on a television and a XaviX game cartridge. Specially modified sports accessories that serve as the game controller include a number of traditional exercise equipment. For example, in XaviX® Tennis, players must swing a small 12” racquet to hit a moving tennis ball seen on screen. The speed, angle, and trajectory of the virtual ball was determined by the player’s swing. On the racquet are small infrared sensors that interact with the XaviXPORT motion sensing technology. These sensors detect players’ actions and respond with appropriate onscreen action.

Few studies have reviewed XaviX effects on MVPA but from the four identified research studies; it appears that some XaviX games can elicit moderate to vigorous intensity physical activity (B. Bailey et al., 2008; Brandt, Haddock, Wilkin, & So, 2006; Mellecker & McManus, 2008; Weaver et al., 2009).

If some of the time spent playing sedentary video games is being replaced by active play video games, it is important to determine which games are able to illicit MVPA (55-85% of heart rate maximum [220 - age x .55 to .85]) and positively contribute to health-related fitness (ACSM, 2010). The American Heart Association’s recent initiative: The Power of Play: Innovations in Getting Active Summit, summarized the possible health impact of exergames (Lieberman, et al. 2011). Guidelines and strategies for future technology and health games to improve the health and healthcare of Americans were proposed. The psychological and social effects as well as reasons for playing exergames were also highlighted at the Summit. The authors stated that although further research is needed to better understand how to use exergames for positive behavior change, these emerging technologies might be particularly attractive and useful to specific populations. This plea for active video game play research was focused on enjoyable, affordable, in-home exergames. Activities that are enjoyed are more likely to be repeated and it’s important to determine which games are more enjoyable and more effective at increasing MVPA.
The three commercial exergames that were the focus of this study, Dance Dance Revolution, EyeToy Kinetic, and XaviX Tennis, required the player to use three different muscle groups (primarily legs, legs and, arms, primarily arms respectively). The gaming consoles were chosen for this investigation because the consoles are affordable, representative of three well known exergames, and can be played at home. The energy cost whilst playing exergames has been documented yet there is limited information on percentage of time spent in MVPA, perceived rate of exertion, and enjoyment when playing exergames.

The purpose of this study was two-fold. Our first aim was to examine the differences between XaviX Tennis (XVT), EyeToy Kinetic (ETK), and Dance Dance Revolution (DDR) on percentage of time spent in moderate to vigorous physical activity (MVPA). For the second aim, we investigated differences in perceived exertion and enjoyment when playing the three exergaming systems. Based on previous research (Yang & Foley, 2008) and the premise that ETK requires more engaging more muscle groups (arms and legs) than the other games, we hypothesized that participants would spend more time in MVPA playing ETK, then DDR and XVT. We also hypothesized that there would differences in enjoyment and perceived exertion between the three gaming systems.

METHODS

Study design

This study used a quasi-experimental within-subjects design to compare heart rate MVPA of participants playing three different exergames. A randomized counter-balanced design was used to ensure equal treatments across exergames and to prevent an ordered-effect (Campbell et al., 1972; Thomas et al., 2005).

Participants

Participants were recruited from a community fitness center located in a small city in the Northeastern United States through flyers posted in the lobby and monthly newsletters. Prior to
commencement of the study the participants also completed the Physical Activity Readiness-Questionnaire (PAR-Q) to ensure that all participants presented with no physical limitations or risk factors contraindicated by exercise/physical activity. As noted in the PAR-Q results, all participants were healthy, non-smokers, free from any cardiovascular or musculoskeletal condition that would prevent them from being physically active. Informed written consent was obtained from the parents for children under the age of 18 and from the participants over the age of 18. A total of 27 participants, 10 females and 17 males were recruited and completed all portions of the protocol approved by a University’s Institutional Review Board. Three individuals signed up but failed to report to the Community Center and when contacted indicated their desire to withdraw from the study.

Procedure

Data was collected in a 150 square foot multi-purpose room equipped with a projector and a sound machine hooked up to the three exergames. Participants were asked to abstain from food and caffeine intake for two hours, and vigorous exercise for 24 hours prior to data collection. The participants reported to the fitness center in workout clothing (short sleeve t-shirt and shorts and appropriate footwear) at a time convenient for the community center and the participant.

The protocol used in this study is consistent with other studies that assessed adolescents’ energy expenditure across multiple exergames (Epstein, Beecher, Graf, & Roemmich, 2007; Lanningham-Foster, et al., 2006; Maddison et al., 2007). The researcher introduced and gave instructions on how to play the first exergame; after which, participants were given five minutes to habituate to the video game and the gaming console. Following habituation, participants were given an opportunity to ask questions about the game and/or gaming console. Heart rate monitoring was started when the participants were habituated to the gaming console and confident playing the game. The participants played each game for 15 minutes and after each game they were verbally asked to rate how much they enjoyed playing each game on a seven-
point Likert-type scale (derived from the Intrinsic Motivation Inventory – IMI – Ryan, 2000) and to rate their perceived exertion using the OMNI-RPE (Utter, 2002) walk/run scale (0-10 scale).

The participants were given 10 minutes rest period between each game, at which time they could drink water. This procedure was continued until participants completed all three exergames and answered all questions. At the end of the study, the participants removed the heart rate monitor and data was downloaded to a portable computer via Polar PE Manager software (Lake Success, NY).

Exergames

The participants were given pre-selected games and music and were asked to play on each of the following three gaming systems for 15-minutes. A summary of each game setup can be found in Table 1.

Insert Table 2 here

Dance Dance Revolution™ (DDR) Supernova 2, played on the Playstation 2 game system, is a video game that requires the player to move to the beat and rhythm of varying types of music by stepping on arrows on a touch-sensitive dance pad. During the study each participant was assigned to the “Game” and “Single” player modes and to the “Beginner” level of difficulty and then the participants played the pre-selected set of seven songs (Say Goodbye, Rock Your Body, Angellus, Got To Be Real, Le Freak, Temperature, Take on Me). Participants were instructed to play all the songs, which took approximately 15 minutes.

In an EyeToy Kinetic™ (ETK) game, typically the object was to “touch” (by moving any body part) certain colored objects that were moving on the display and avoid others. For the study each participant was assigned the “Single” player mode and the “Easy” level of difficulty, then played the five pre-selected games (Wildfire, Reflex, Backlash, Breakspeed, Sidewinder), which took approximately 15 minutes.
In XaviX® Tennis (XVT), a small tennis racquet equipped with motion sensing reflectors relayed the speed, direction and angle of a player’s swing to the XaviX® PORT™. Participants had to follow the ball and adjust to hitting it at the appropriate time and with sufficient force in order to keep it in play. Each participant was assigned the “One Player”, “Exhibition” and “6 Game Set” play modes, and given the B.Lovely character to play and were instructed to continue playing for 15 minutes.

Anthropometric Measures

Weight and height was measured using a calibrated digital scale and a portable stadiometer. Body mass index was calculated using the formula mass(kg)/height(m²).

Physical Activity, Motivation and Enjoyment Measures

The participants completed the Personal History Questionnaire (PHQ), which assessed typical sedentary and physical activities during a school day and weekend. The participants were given instructions on proper placement of the Polar Heart Rate Monitor E600 and asked to wear the heart rate monitor whilst exergaming. Once finished playing each game, a shortened version (four items) of the Intrinsic Motivation Inventory (IMI) was administered to assess enjoyment levels of the participants. The IMI used a seven-point Likert-type scale (anchored from 1 = not at all true, to 7 = very true), with anchors appropriate to each type of question (Ryan, Mims, & Koestner, 1983). Negatively rated responses were recoded to match the positive responses and the four items were combined and averaged for a composite “enjoyment” score for each game. Two of the items included “I enjoyed doing this activity very much” and “This activity was fun”. Individually the responses were found to have excellent to acceptable internal consistency (Chronbach’s alpha; XVT α = 0.944, ETK α = 0.650, DDR α = 0.908).

Insert Figure 1 here

The total amount of time spent being physically active during the entire study was approximately 60 minutes (5 minutes + 15 minutes = 20 minutes x 3 = 60 minutes).
Heart rate was assessed using the Polar E600 heart rate monitor, downloaded through a Polar IR interface connected to a laptop (via USB), into the PE Manager software. The recording interval for the heart rate monitors was set at five second and heart rate zones were calculated individually based on the Max Heart Rate (MHR) formula (220 – age). The intensity zones come from ACSM’s Guidelines for Exercise Testing and Prescription (2010); low = less than 55% of MHR, moderate = 55-70% of MHR, and vigorous 70-85% MHR. Percent of time spent in MVPA was calculated by totaling the number of seconds each participant’s heart rate (beats per minute) spent above 55% of MHR divided by 900 seconds (15 minutes).

Perceived exertion was assessed by asking participants to rate how tired they felt immediately after playing each exergame by using the OMNI-RPE (Roberston, 2005; Utter, 2002) walk/run scale. The scale ranges from 0 (not hard at all) to 10 (very very hard) with small representative cartoon figures depicting exertion, and in this study yielded acceptable to good internal consistency (Cronbach’s alpha = 0.726).

Data Analysis

SPSS™ (SPSS, Inc. Chicago, IL) version 19.0 was used for analyzing all test score data and alpha levels were set at 0.05. To test the hypotheses that there would be differences between exergames (DDR, ETK, XVT) for game, a series of one-way repeated-measures ANOVA was performed. Dependent variables include overall mean heart rate, percentage of time spent in moderate to vigorous physical activity, ratings of perceived exertion, and level of enjoyment.

RESULTS

Participants

The physical characteristics of the 27 children are presented in Table 2. Of the 27 participants that completed the study, 82.5% Non-Hispanic White, 14.9% Non-Hispanic Black, and 3.7% Hispanic of any race. In total a total of 27 participants, ten females and 17 males were
recruited and completed all portions of the protocol that was approved by the university’s Institutional Review Board.

Self-report results of previous exergame experience and time spent playing the three games indicated that 18 participants had some experience playing Dance Dance Revolution (DDR), three participants played EyeToy previously but none of the participants reported playing EyeToy Kinetic (ETK) or XaviX Tennis. On average, participants previously played DDR for less than two hours (minutes; \( M = 104.44, SD = 148.17 \)) and EyeToy (\( M = 12.22, SD = 42.64 \)) minutes respectively.

On an average school night (Monday-Friday), participants reported over seven hours (minutes; \( M = 443.70, SD = 293.02 \)) in sedentary activities and very few minutes (\( M = 13.33, SD = 23.70 \)) engaging in exergames. On weekends (Saturday & Sunday), participants engaged in more than 13 hours of sedentary activities (minutes; \( M = 788.70, SD = 568.90 \)) compared to less than an hour of exergaming activities (minutes, \( M = 42.67 \) minutes, \( SD = 49.13 \)).

**Exergaming mean and percentage time spent in MVPA via heart rate monitoring**

A repeated-measures ANOVA (RM-ANOVA) revealed mean heart rates between exergames differed significantly \( F(2, 52) = 34.24, p < .001 \). Post hoc tests using the Bonferroni correction revealed that EyeToy Kinetic elicited a significantly higher heart rate (bpm; \( M = 137.22, SD = 23.41 \)) than XaviX Tennis (\( M =118.41, SD = 22.05, p < .001 \)) and DDR (\( M =112.44, SD = 21.60, p < .001 \)). No differences were found between DDR and XVT. A secondary analysis using another RM-ANOVA on time spent in vigorous (> 70% MHR) physical activity intensity (VPA) levels revealed participants spent more in time in VPA playing ETK (minutes; \( M = 2.50, SD = 3.06 \)) compared to DDR (\( M = 0.29, SD = 0.79, p = .002 \)) and XVT (\( M = 0.62, SD = 2.91, p = .005 \)) with no differences between XVT and DDR.
To provide a more detailed analysis of the differences in intensity of play and the three exergames, we analyzed the percentage of time spent in moderate to vigorous physical activity (MVPA) intensity as determined by heart rate (55-85% MHR). A separate RM-ANOVA was used to determine any differences between games and MVPA and determined that the percentage of time spent in MVPA was statistically significant between games $F(2, 52) = 10.23, p < .001$. Post hoc tests using the Bonferroni correction revealed that participants spent a higher percentage of time ($p < .001$) in MVPA while playing ETK (percentage time; $M = 89.02, SD = 16.72$) compared to DDR ($M = 74.50, SD = 32.92$) and XVT ($M = 67.17, SD = 37.28$). However, no significant difference was found between DDR and XVT ($p = .433$).

**Enjoyment**

A repeated-measures ANOVA with Huynh-Feldt correction determined a significant main effect for enjoyment $F(1.67, 43.47) = 5.57, p = .001$. Post hoc tests with Bonferroni correction factors (See figure 4) revealed significantly higher rates of enjoyment for ETK (enjoyment; $M = 6.66, SD = 0.47$) when compared to XVT ($M = 5.70, SD = 1.57, p = .012$) and DDR ($M = 6.00, SD = 1.18, p = .014$). No differences were found between DDR and XVT ($p = 1.00$).

**OMNI Ratings of Perceived Exertion (OMNI-RPE)**

To determine any differences in ratings of perceived exertion (RPE), a repeated-measure ANOVA with Huynh-Feldt correction revealed significant main effect for RPE $F(1.63, 42.53) = 19.77, p < .001$. Using post hoc tests with Bonferroni correction revealed significantly higher rates of exertion for ETK (OMNI-RPE; $M = 4.74, SD = 2.68, p < .001$) when compared to DDR ($M = 2.81, SD = 1.59$) and XVT ($M = 2.26, SD = 1.83$), but no differences were detected between XVT and DDR ($p = .275$).

**DISCUSSION**
The present study was designed to compare the effects of playing three exergames on moderate to vigorous physical activity (MVPA) and levels of enjoyment. Playing EyeToy Kinetic (ETK) elicited the highest mean percentage of time spent in moderate to vigorous physical activity (%MVPA) and was enjoyed the most of the three exergames. When heart-rate data was further analyzed as a percentage of total time spent in MVPA, participants played ETK in MVPA more than DDR and XVT. It should also be noted that participants spent more than half of their time playing at the MVPA intensities for all exergames. Using perceived exertion as an indicator of level of intensity, participants rated ETK more strenuous than DDR ad XVT. The results of this study support previous research, which show that exergames can illicit levels of MVPA and produce healthy benefits (Graf et al., 2009). Being able to accumulate MVPA while playing an enjoyable exergame (for more than half of the playing period) is encouraging considering several review studies that have demonstrated an overall weak effect on MVPA (Barnett, 2011; Biddiss 2011; Foley 2010; Peng, 2011).

In a recent review of exergaming Biddiss & Irwin (Biddiss & Irwin, 2010), concluded that games that involve primarily upper-body motions were not as effective in eliciting MVPA as lower-body exergames; which contrasts the findings from this study. We found no differences for percentage of time spent at MVPA and overall mean heart rate between the gaming systems with different body movements, XaviX Tennis (upper-body) and DDR (lower-body). One possible explanation for this discrepancy in intensity is the difference in gaming systems and the controllers. Previous studies included in the review, concentrated investigations on upper body motions using the Wii system, which includes the Wiimote, a motion sensitive device that resembles a remote control. (Nintendo, 2006). This study is unique in that it included the XVT racquet, which looks and feels like a small tennis racquet. The Wiimote is is 14.8 cm long, and weighs 133 grams whereas the XVT racquet measurements are 35.8 cm long and it weighs 230 grams (XaviX, 2006). The added length and weight of the XVT racquet in the current study may
have contributed to the higher-than-expected observed values and to the heightened sense of realism and intuitiveness of game play (Johnsone, 2002).

Using the rating of perceived exertion measure, participants rated playing ETK as the most strenuous followed by DDR and XVT. The values from the current study seem somewhat lower than the values found by Graf et al. (2009). Research has also shown that rate of perceived exertion does not change even though energy costs are higher when cycling and exergaming than when cycling alone (Haddock, Siegel, & Wikin, 2009). The previous investigation by Graf and colleagues (2009) assessed RPE during DDR1, DDR2, Wii Boxing and Bowling and treadmill walking. These authors focused on gender differences in RPE and the reported overall results indicated that DDR 2 (stepping rate is higher than DDR1) elicits the highest RPE score (boys 5, girls 7) followed by Wii Boxing (boys 5, girls 7) and treadmill walking at 5.7km/hr (boys 5, girls 7). More recently, Abbott et al (2009) examined perceived rate of exertion differences for college-aged participants when performing a five-stage treadmill fitness test and running at the same cadence while playing Wii Fit Free Run (FFR). The results of this study indicated non-significant differences in mean heart rate and energy expenditure; however, a significant difference in perceived levels of exertion was notable. The authors of this study postulated although treadmill running and running playing the Wii Fit Free Run produced similar physiological strain for the individuals, the relative perceived effort was blunted when running due to the distraction from playing Wii. This explanation has been well documented in the extant literature (Masters, Ogles, 1998, Szmedra, Bacharach, 1998, Boutcher, Trenske, 1990).

According to some authors external stimuli may be more motivating than internal motivators (Fillingim, Fine, 1986) and recent investigations with obese children suggest that distraction may be an avenue into initiating and adhering to physical activity interventions (De Bourdeaudhuij, Crombez’, Deforche, Vinaimont, Debode, Bouckaert 2002). Emerging evidence suggest that
exergames may provide a distraction and increase physical activity levels and adherence (Warburton et al., 2007)

The participants from the current study reported high levels of enjoyment when playing the exergames. ETK was enjoyed more than DDR and XVT. It is interesting to note that ETK was enjoyed more than DDR and XVT, despite the higher mean heart rate, percentage time spent in MVPA and perceived exertion while playing ETK. However, it would seem that a game that requires a high level of exertion may be less attractive and enjoyable for adolescents. It is possible that Csikszentmihalyi’s (1990) flow theory could be used to explain the reported level of enjoyment when playing ETK. According to Csikszentmihalyi (1990), when individuals are highly intrinsically motivated to complete a task they become absorbed in the activity or game. Sinclair et al (2007) outlined exergaming gameflow as a balance between a deep sense of immersion/challenge vs. skill development and fitness vs. intensity.

Limitations

Participants in this study played three separate exergames at MVPA intensities; however, it was only a short period of time (15 minutes) and most of that time was spent at the moderate intensity level. Future studies should investigate longer periods of time and allow for some autonomy in choosing game options or level of difficulty.

This study was limited by the measurement methods and procedures selected for this study. Given participants played all of these games by themselves without peer support or competition, the results can only reflect these conditions. Other factors not specifically measured may have contributed to participants enjoying the exergames. Since most adolescents play video games at home with their friends or online, future studies should investigate the impact of playing collaboratively or simultaneously as suggested by Lieberman et al. (2011) and Staiano, Abraham & Calvert (2012). Given the small sample size and that participants were volunteers who self-selected to participate in the study; no assumptions of randomization can be made. A larger
Current guidelines suggest that children and adolescents should acquire at least one hour of moderate to vigorous physical activity (MVPA) every day. Unfortunately, the prevalence of obese children and adolescents is 16.9% obese and the majority of these youngsters are not getting their recommended dose of physical activity daily (Ogden, Carroll, Kit, & Flegal, 2012). Furthermore, research shows that American teenagers are also spending a lot more time in front of televisions, computers, and other forms of screen devices than being physically active and 87% of eight to 17-year-olds play video games at home (Rideout, Foehr, & Roberts, 2010). The public health problem is, other than organized sports, physical education classes and occasional after school programs; there are not many alternative and enjoyable opportunities for children (or youth- to include teens) to obtain the recommended daily 60 minutes of MVPA. Besides the lack of opportunities, unsafe neighborhoods and distance to facilities negatively impact adiposity (Carver et al. 2010, Carver et al, 2011; Molnar, Gortmaker, Bull, & Buka, 2004; Timperio et al. 2010). Despite the high prevalence and use of technology, some forms require physical activity in order to use. Alternatives such as interactive video fitness games (exergames) are gaining popularity, and have the potential to increase physical activity levels if properly implemented at home, in the schools and/or in the community.

CONCLUSION

This study adds to the existing literature that has shown that some exergames can be enjoyable and help youth accumulate moderate to vigorous physical activity. The growth of exergaming has provided an opportunity for many (including typically sedentary adolescents) to be more active. These non-traditional games are attractive to many adolescents because technology and games are already a big part of their daily routine and they’re fun to play. The challenge is to make these active games more engaging for longer periods of time so that
youngsters will want to play them and understand the benefits of choosing a more active lifestyle.

As exergaming becomes more popular and widely accepted, one day they might serve as a “Gateway Game” to other physical activities away from the screen.
Figure 1

Procedural Flow Chart for Exergame Study

<table>
<thead>
<tr>
<th>Procedural Flow Chart Exergame Study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Participants</strong></td>
</tr>
<tr>
<td>- Age 14-18 years old (n=27)</td>
</tr>
<tr>
<td>- Boys (n=17), Girls (n=10)</td>
</tr>
<tr>
<td><strong>Inclusion</strong></td>
</tr>
<tr>
<td>- Provide informed consent and give appropriate assent</td>
</tr>
<tr>
<td>- Complete PAR-Q and PHQ</td>
</tr>
<tr>
<td>- &lt; 10 total hours experience with each exergame</td>
</tr>
</tbody>
</table>

- Random Exergame 1
  - Practice (5 min)
  - Trial (15 min)
  - Rest & Questions (5 min)

- Random Exergame 2
  - Practice (5 min)
  - Trial (15 min)
  - Rest & Questions (5 min)

- Random Exergame 3
  - Practice (5 min)
  - Trial (15 min)
  - Rest & Questions (5 min)
Figure 2

Mean Heart Rate for Three Separate Exergames (n=27)

Exergaming Mean Heart Rate

* $p < .05$
Figure 3

Mean Percentage of Time in Moderate-Vigorous Physical Activity for Three Separate Exergames (n=27)

Exergaming Percent Time in MVPA

* p < .05
Table 1

Single Player Setup

<table>
<thead>
<tr>
<th></th>
<th>Level</th>
<th>Songs/game, and order (if necessary)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day 1 (15 minutes each game)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xavix Tennis</td>
<td>Exhibition</td>
<td>6 Game Set, B.Lovely (player)</td>
</tr>
<tr>
<td>EyeToy Kinetic™</td>
<td>Easy</td>
<td>1. Wildfire, 2. Reflex, 3. Backlash,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Breakspeed, 5. Sidewinder</td>
</tr>
<tr>
<td>Dance Dance Revolution</td>
<td>Beginner</td>
<td>1. Say Goodbye, 2. Rock Your Body,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Temperature, 7. Take on Me</td>
</tr>
</tbody>
</table>
### Table 2
**Mean (SD) Values For Participant Demographics, Self-Reported Data**

<table>
<thead>
<tr>
<th>Variable</th>
<th>All participants</th>
<th>Females</th>
<th>Males</th>
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</thead>
<tbody>
<tr>
<td><strong>Descriptive and Anthropometric</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>15.44 (1.55)</td>
<td>15.80 (1.69)</td>
<td>15.24 (1.48)</td>
</tr>
<tr>
<td>Grade</td>
<td>10.07 (1.33)</td>
<td>10.30 (1.49)</td>
<td>9.94 (1.25)</td>
</tr>
<tr>
<td>Height (meters)</td>
<td>1.69 (0.73)</td>
<td>1.64 (0.04)</td>
<td>1.71 (0.08)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>67.31 (13.41)</td>
<td>64.08 (9.80)</td>
<td>69.22 (15.10)</td>
</tr>
<tr>
<td>Body mass index (kg/m$^2$)</td>
<td>23.63 (3.84)</td>
<td>23.83 (3.49)</td>
<td>23.52 (4.14)</td>
</tr>
<tr>
<td><strong>Self-report data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate to Vigorous PA - days</td>
<td>4.19 (2.10)</td>
<td>3.10 (1.37)</td>
<td>4.82 (2.22)</td>
</tr>
<tr>
<td>Moderate PA - days</td>
<td>3.89 (2.46)</td>
<td>3.40 (2.07)</td>
<td>4.18 (2.68)</td>
</tr>
<tr>
<td>Strength PA - days</td>
<td>3.15 (2.23)</td>
<td>3.00 (1.83)</td>
<td>3.24 (2.49)</td>
</tr>
<tr>
<td>XVT - minutes</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>EyeToy - minutes</td>
<td>12.22 (42.64)</td>
<td>21.00 (66.41)</td>
<td>7.06 (19.93)</td>
</tr>
<tr>
<td>DDR - minutes</td>
<td>104.44 (148.17)</td>
<td>192.00 (172.16)</td>
<td>52.94 (106.74)</td>
</tr>
<tr>
<td><strong>Experiment data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting HR (bpm)</td>
<td>74.33 (8.08)</td>
<td>76.30 (5.23)</td>
<td>73.18 (9.32)</td>
</tr>
<tr>
<td>XVT HR (bpm)</td>
<td>112.44 (21.60)</td>
<td>121.70 (19.18)</td>
<td>107.00 (21.60)</td>
</tr>
<tr>
<td>ETK HR (bpm)</td>
<td>137.22 (23.41) *</td>
<td>145.40 (11.04)</td>
<td>132.41 (23.47)</td>
</tr>
<tr>
<td>DDR HR (bpm)</td>
<td>118.41 (22.05)</td>
<td>132.00 (20.81) †</td>
<td>110.41 (19.06)</td>
</tr>
<tr>
<td>XVT range HR (bpm)</td>
<td>70.00 - 170.00</td>
<td>96.00 - 145.00</td>
<td>70.00 - 170.00</td>
</tr>
<tr>
<td>ETK range HR (bpm)</td>
<td>83.00 - 184.00</td>
<td>109.00 - 184.00</td>
<td>83.00 - 169.00</td>
</tr>
<tr>
<td>DDR Range HR (bpm)</td>
<td>73.00 - 163.00</td>
<td>102.00 - 163.00</td>
<td>73.00 - 146.00</td>
</tr>
<tr>
<td>XVT OMNI-RPE</td>
<td>2.26 (1.93)</td>
<td>1.90 (1.66)</td>
<td>2.47 (1.94)</td>
</tr>
<tr>
<td>ETK OMNI-RPE</td>
<td>4.74 (2.68) *</td>
<td>4.40 (2.46)</td>
<td>4.94 (2.86)</td>
</tr>
<tr>
<td>DDR OMNI-RPE</td>
<td>2.81 (1.59)</td>
<td>2.80 (1.93)</td>
<td>2.82 (1.42)</td>
</tr>
<tr>
<td>XVT Enjoyment</td>
<td>5.70 (1.57)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ETK Enjoyment</td>
<td>6.66 (0.47) *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DDR Enjoyment</td>
<td>6.00 (1.18)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. N = 27; Females n = 10, Males n = 17; SD = Standard Deviation; XVT=XaviX Tennis; ETK=EyeToy Kinetic; DDR=Dance Dance Revolution; XVT/ETK/DDR minutes=self-reported number of minutes of prior exergaming experience; resting HR=heart rate prior to beginning testing performed while seated; HR=heart rate; OMNI-RPE=the average ratings of perceived exertion immediately following each exergaming session. * Significantly different from other games p < 0.05. † Significantly different from other gender.*
Figure 4

*Mean Enjoyment Levels of Exergames (n=27)*

Exergaming Enjoyment Levels

![Exergaming Enjoyment Levels](image-url)


International Conference on Physical Activity and Obesity in Children, Toronto, Ontario, Canada.


Paper 2: Self-Selected Duration, MVPA, RPE, and Enjoyment of Three Exergames in Adolescents
Abstract

Introduction:

There is growing body of evidence to suggest that exergaming (video games that require physical movements to play) might be a way to engage in moderate to vigorous physical activity (MVPA). The purpose of this study was to determine if three popular exergames, XaviX Tennis (XVT), EyeToy Kinetic (ETK), and Dance Dance Revolution (DDR) help adolescents achieve an intensity consistent with current physical activity guidelines.

Methods:

Twenty-three adolescents (females = nine, males = 14) participated in this study by playing each game (separate sessions) for as long as they wanted up to an hour (years; $M = 15.39, SD = 1.5$). During each session, participants wore a heart rate monitor and reported their rating of perceived exertion (RPE) using the run/walk OMNI-RPE (0-10) scale. All three measures of exercise intensity; mean heart rate, percentage of time in MVPA (seconds above 55% of maximum heart rate divided by total seconds, and RPE) found that ETK elicited higher exercise intensities than DDR and XVT.

Results:

Across all games participants averaged playing at 119 bpm, for 45 minutes, with 75% of the time spent in MVPA, and RPE of 3.5. ETK and DDR had significantly higher heart rate (128, 120 bpm) and percent time in MVPA (77.8, 76.9 %), and time spent in VPA (15.9, 11.0 minutes) than XVT. When using heart rate as an indicator of exercise intensity it appears that all three exergames can be played at levels sufficiently high enough to attain MVPA. Participants
perceived ETK (4.4) and DDR (3.9) higher than XVT (2.3) and enjoyed playing ETK more than the other two games.

Conclusion:

Future studies should continue to examine long-term impacts on adolescent physical activities and sports taken up as a result of first experiencing success in an exergame.
Self-Selected Duration, MVPA, RPE, and Enjoyment of Three Exergames in Adolescents

Introduction

The physical health status of children and adolescents continues to present a public health challenge in the U.S.; in fact, the rates of adolescent obesity have increased seven-fold in the past forty years (Ogden, 2010). Spending more time in sedentary activities and eating poorly have contributed to an increased risk of obesity, diabetes, and cardiovascular disease among youth (Leatherdale & Wong, 2008; Pearce et al. 2012; Van Der Horst et al. 2007). Finding different ways and modalities to increase physical activity is a promising approach to improving physical and health indicators. Although the importance of improving dietary habits cannot be overstated, this study focused on unique ways to engage adolescents in voluntary physical activities.

Adolescents need to accumulate 60 or more minutes of moderate to vigorous intensity physical activity (MVPA) daily (Physical Activity Guidelines Advisory Committee, 2008). Despite these recommendations, current YRBSS self-report data less than 20% of adolescents achieve these levels of daily physical activity (Centers for Disease Control, 2010). Adding to this lack of physical activity, the average American child and adolescent spends over seven and a half (7:38) hours a day with different forms of media including video game playing 50 -73 minutes a day (Rideout, 2010). The current literature on the role of video games in the current situation with the health of adolescents is conflicted. Some research has indicated that playing video games is directly associated with being overweight and increased blood pressure in adolescents (Anderson, Economos, Must, 2008; Goldfield, 2011; Mendoza, Zimmerman, Christakis, 2007). However, other studies have found no such relationship and reported that video game playing does not necessarily displace physical activity (Marshall, Biddle, Gorely, Cameron, & Murdey, 2004; Wong, Ceerin, Ho, Mak, Lo, Lam, 2010). There is a new genre of video games and game controllers known as “exergames” that require the game player to move their body or body parts in order to play the game (Yang et al., 2008).
Using exergames has been proposed as a means to engage youth in accumulating more physical activity and impacting behavior change (Baranowski et al. 2008; Baranowski et al. 2012; Graf et al. 2009). Given the current sales figures (number of units produced) of the newest generation of camera-based controllers including Xbox Kinect and Playstation Move are 19 and 10.5 millions units respectively (Matthews, 2012; Moriarty, 2012) it seems evident that the games industry has embraced activity-based video games.

In order to play exergames, players must move on a touch sensitive device, point or shake a motion sensitive controller, or move within view of a web camera. Three affordable exergames are Dance Dance Revolution™ (DDR), XaviX® Tennis (XVT), and EyeToy Kinetic™ (ETK). Many of these types of games are being marketed to improve fitness levels and being used in interventions with very little knowledge about their use and effects in adolescents. As noted in Paper 1, when given 15 minutes to play a specific game or set of songs, adolescents are able to accumulate MVPA for 67-89% of the time spent playing. What is still unknown, is how choice and autonomy impact how long players decide to play. Of the few studies that provided choice, youth were more likely to choose a sedentary game over an exergame (Mellecker et al. 2012), but tended to play longer than traditional games when given more than one option (Roemmich et al., 2012). Besides providing choice, there is evidence to suggest that enjoyment is helpful for adherence when introducing children to physical activities (Dishman et al. 2005; Van Der Horst, Paw, Twisk, & Van Mechelen, 2007) and exergames (Bailey, & McInnis, 2011; Peng, Lin, Pfeiffer, & Winn,. 2012).

According to Self-Determination Theory (SDT), there are three factors that positively influence intrinsic motivation: competence, autonomy and relatedness (Deci & Ryan, 1985). Competence is the feeling of being self-confident in actions within a particular environment. Autonomy refers to the perception of being the source of one’s actions. Relatedness is the sense of belonging to a group or community. The more needs a person satisfies while doing an activity,
the more likely she/he will be motivated to repeat it. The most influential mediator of intrinsic motivation is competence (Deci & Ryan, 2002); however more recently, Osorio, Moffatt and Sykes (2012) contrasted those findings by listing competence as the lowest mediator for exergames. In light of the contrasting findings, a more thorough exploration of which SDT factors impact exergame play and how long adolescents choose to play is warranted.

According to two large studies, approximately 40% of nationwide high school students \((n = 9,125)\) play exergames (Fulton, 2012), with teenage girls and boys (from Northeastern USA) playing 21 to 30 minutes respectively \((n = 1,465)\) each day (Yang, Treece, Miklas, 2009). Previous research has shown DDR can be a physical workout of low intensity (Graf, Pratt, Hester, & Short, 2009; Lanningham-Foster et al., 2006; Unnithan, Houser, & Fernhall, 2006;), moderate intensity Bailey 2011, Maddison 2007 (Bailey, Marcelus, Lujares, Kennard, & McInnis, 2008; Tan, Aziz, Chua, & Teh, 2002) and even vigorous intensity levels (Gasperetti et al., 2011, Haddock et al., 2012; Noah et al., 2011; Yang & Foley, 2008). According to five studies that used EyeToy Kinetic, participants were able to accumulate not only moderate but also some vigorous intensities (Alsac, Johnson, & Swan, 2007; Böhm, Hartmann, & Böhm, 2008; Gasperetti, Milford, Blanchard, Yang, & Foley, 2009; Thin, Howey, Murdoch, & Crozier, 2007; Weaver, et al., 2009). Very few studies have reviewed XaviX’s effects on MVPA but from the four identified research studies; it appears that some XaviX games can elicit moderate intensity physical activity (Bailey, et al., 2011; Brandt, Haddock, Wilkin, & So, 2006; Mellecker & McManus, 2008; Weaver, et al., 2009). If these active video games can be as entertaining to play as traditional video games, but with additional health benefits, research should explore how they might be a stimulus for those not attaining the recommended levels of physical activity.

Dance Dance Revolution (DDR) is a rhythm game that is the oldest and most well-known exergame and is available on all game platforms as well as arcade machines. DDR is played on a touch sensitive dance pad where the goal is to step in sync with the music and arrows scrolling
upwards on a display screen. Players received points and cheers when they stepped in time with the arrows. Sony PlayStation 2 EyeToy™ Kinetic (ETK) is an exergame that uses a small web camera pointed at the player to display all of their movements on-screen as the game character. Players had to move their entire body or specific body parts to interact with elements projected on the wall, and when done correctly resulted in accumulating points for each game. The more players succeeded in completing their tasks (breaking bricks, punching or kicking moving objects, etc.) the more points they received. XaviX (SSD Company Limited) is an exergame system that is being marketed as a way to interact with onscreen video game action through motion detection devices. XaviX games require a XaviXPORT game console which plugs into the video input on a television or VCR and a XaviX game cartridge that comes with a specially modified sports accessory that serves as the game controller. For example, in XaviX® Tennis, players swung a small 12” racquet to hit a moving tennis ball seen on screen. The speed, angle, and trajectory of the virtual ball was determined by the player’s swing. On the racquet are small infrared sensors that interacted with the XaviXPORT motion sensing technology. These sensors detected the players’ actions and responded with appropriate onscreen action.

These three commercially available exergames required to players to use three different motions (primarily arms, primarily legs, arms and legs). They were chosen because of: a) the different motions required to play, b) the different technology (dance pad vs. USB webcam vs. infrared motion sensors), c) they represented three well known exergames, d) they were affordable, and e) could all be played at home. While studies have been completed on the energy expenditure associated with playing two of these games, none of them have been used to examine if they help individuals meet the daily MVPA recommendations.

The field of exergames is relatively new but very few studies have compared exercise intensity across more than one type of exergame interaction (Bausch, Beran, Cahanes, & King, 2008; Böhm, Hartmann, & Böhm, 2008; Graf et al. 2009; Kraft et al. 2011; Lanningham-Foster et
(al., 2006; Yang & Foley, 2008) while only one study (Bailey & McInnis, 2011) compared three or more different exergame interactions. Additionally, although several studies have investigated some of the physiological outcomes associated with participating in exergames, there are no studies that describe adolescents’ percentage of time spent in MVPA. In order for more people to understand the research findings, it is important to translate the details for the general public into a format that more generally understood and accepted. If in fact adolescents who are playing exergames are engaging in sufficient amounts of moderate to vigorous physical activity, then exergames may be an option to accumulate the recommended amounts of daily physical activity and health benefits set out by Healthy People 2020, the National Physical Activity Plan, and the USDA Dietary Guidelines. Therefore the purpose of this study was to examine the duration and intensity of exergame play across three separate exergame systems. Additionally differences in levels of motivation (enjoyment, competence, appearance, fitness, and social) were determined between gaming conditions.

Methods

Participants

Participants were recruited from a community fitness center (CFC) located in a small city in the Northeastern United States through posted flyers and information included on the monthly newsletter. Each youth was a member of the CFC and was permitted to participate in physical activities within its facilities. Data was collected in a 150 square foot multi-purpose, air-conditioned room equipped with all the game systems, an LCD projector and a music machine. Prior to each experimental visit, participants were asked to abstain from food and caffeine intake for two hours, and vigorous exercise for 24 hours. All participants were asked to wear standard exercise clothing (short sleeve t-shirt and shorts and athletic footwear) during each visit. This protocol was approved by a university’s Institutional Review Board and participation in this study was completely voluntary.
Design

This study used a quasi-experimental within-subjects design to compare heart rate MVPA of participants playing three different exergames. A randomized counter-balanced design was used to ensure equal treatments across exergames and to prevent an ordered-effect (Campbell, Stanley, & Gage, 1972; Thomas, Nelson, & Silverman, 2005). On three separate days, participants were randomly assigned one exergame to play while wearing a heart rate monitor. They were given up to 60 minutes to play and could stop whenever they wanted. After participants had decided they were done playing, time was noted and measurements were completed.

XaviX Tennis

Participants were free to select any on-screen tennis player from a selection of four male and four female tennis players, an opponent, and a tennis venue (four locations). Once done a “Best of 3 Match - 6 Game Set” they were able to continue playing by starting a new match.

EyeToy

Each participant was assigned to the “Single” player mode and to the “Medium” level of difficulty, and then they were able to play any of the 12 pre-selected games in any order for any length of time (Cascade, Pulsate, Ricochet, Arcburst, Wildfire, Trespass, Backlash, Reflex Breakspeed, Sidewinder, Precision, and Protector).

DDR

Participants were assigned to the “Game” and “Single” player modes and to the “Standard” level of difficulty and then participants were able to play any of the 15 pre-selected songs in any order (ANGELUS, Beginning of the End, Can't Stop the Rain, EternuS, Every Little Step, Got To Be Real, LE FREAK, Rock Your Body, Say Goodbye, Take On Me, Temperature, The Rockafeller Skank, The World Around Me, Until Forever, volcano). Once a song was selected, participants were able to select any of the four levels of song intensity (Beginner, Basic,
Advances, Expert) which made the game more difficult by increasing the number of arrows or changing the sequencing of step patterns.

Measures

Participants completed the Personal History Questionnaire (PHQ), which assessed typical sedentary and physical activities during a typical school night and weekend period. Heart rate was assessed with the Polar E600 heart rate monitor (Kempele, Finland) downloaded through a Polar IR interface connected to a laptop (via USB), into the PE Manager software. The recording interval was set at five seconds and heart rate zones were calculated individually based on the Maximal Heart Rate (MHR) formula (220 – age). The intensity zones come from ACSM’s Guidelines for Exercise Testing and Prescription (2010); low = less than 55% of MHR, moderate (MPA) = 55-70% of MHR, and vigorous (VPA) 70-85% MHR.

Motives for physical activities was assessed by using the 30-item questionnaire Motives for Physical Activity – Revised (MPAM-R) which determined the strength of five general motives for participation (Ryan et al., 1997). Participants responded to the items on a seven-point Likert-Type scale (1-7) ranging from 1, not at all true for me, to 7, very true for me. The average Cronbach’s alpha (internal reliability) of each subset of questions was very strong; enjoyment (α = 0.873), competence (α = 0.825), appearance (α = 0.912), fitness (α = 0.943), and social (α = 0.709).

Perceived exertion was assessed by asking participants to rate how tired they felt immediately after playing each exergame by using the OMNI-RPE (Roberston, 2005; Utter, 2002) walk/run scale. The scale ranges from 0 (not hard at all) to 10 (very very hard) with small representative cartoon figures depicting exertion, and in this study yielded good internal consistency (α = 0.790).

Data Analysis
Chi-square tests were performed to determine differences between genders on each game and results can be found in Table 2 AND Table 3. Separate within-subjects repeated measures analyses of variance (RM-ANOVA) were performed to determine differences between games on playing time, mean heart rate (HR), percentage of time in moderate to vigorous physical activity (MVPA), calories, calories per minute (CPM), metabolic equivalents (MET), and steps per minute (SPM), and all measures of the MPAM-R (enjoyment, competence, appearance, fitness, and social). When differences were found, separate pairwise comparisons using post-hoc tests with Bonferroni correction factors determined which pairs were significantly different from one another. Bland-Altman plots were also developed to visually judge the 95% limits of agreement for how well two methods (HRM & AB) of calories per minute (CPM) measurements agree. According to Bland & Altman, (1986), the smaller the range between these two limits the better the agreement is. SPSS™ (SPSS, Inc. Chicago, IL) version 19.0 was used for analyzing all data and alpha levels were set at 0.05.

Results

Demographic

A total of 23 participants, nine females and 14 males completed the three sessions each lasting up to one hour from the original pool of 30 interested and eligible teenagers. Three youth signed up but did not show up, while four participants completed the initial familiarization protocol (described elsewhere) but did not complete the remaining three days of testing. Participants were healthy, non-smokers, free from any cardiovascular or musculoskeletal condition that would prevent them from being physically active as indicated on the completed PAR-Q screening tool. All participants under 18 years old obtained written parental consent and gave their assent in writing while participants who were 18 years old gave their written consent. Among the participants 86.36% were Caucasian, 18.18% were African-American, and 4.5% were Hispanic of any race.
Level of self-reported physical activity

On average, in the seven days prior to beginning the study, the participants reported doing moderate to vigorous intensity physical activities 4.26 days ($SD = 2.07$), moderate intensity physical activities 3.61 days ($SD = 2.31$), and muscle strengthening activities 3.04 days ($SD = 2.16$).

Insert Table 1 here

Previous experience playing exergames

Sixteen participants had some experience playing Dance Dance Revolution (DDR), three had played EyeToy previously but none had played EyeToy Kinetic (ETK) or XaviX Tennis. On average, participants previously had played DDR for less than two hours (minutes; $M = 104.35$, $SD = 152.33$) and EyeToy ($M = 14.35$, $SD = 46.00$) and no participants had experience playing XaviX Tennis (XVT).

Self-reported sedentary and exergaming time

On an average school night, participants reported over seven hours (minutes; $M = 437.61$, $SD = 288.77$) of sedentary activities on an average school night and very little time ($M = 13.04$, $SD = 23.25$) engaging in exergames. On weekends, participants engaged in more than 13 hours of sedentary activities (minutes; $M = 807.83$, $SD = 608.78$) compared to less than an hour of exergaming activities (minutes; $M = 34.57$, $SD = 51.68$).

Time spent playing exergames during the experiment

No effects for gender was found on time spent playing, therefore subsequent analyses collapse across gender. A repeated-measure ANOVA (RM-ANOVA) with Bonferroni correction revealed that participants played the exergames for different lengths of time $F(2, 42) = 11.68, p < 0.001$. Both ETK (minutes; $M = 50.98$, $SD = 11.83$, $p = .002$) and DDR ($M = 50.03$, $SD = 13.71$, $p = 0.01$) were played significantly longer than XVT ($M = 36.47$, $SD = 14.91$); however, there was no differences between ETK and DDR ($p = 1.00$).
Average heart-rate and percentage time spent in MVPA

A RM-ANOVA revealed mean heart rates between exergames differed significantly $F(2, 44) = 10.54, p = 0.014$. Post hoc tests (See Figure 2) using Bonferroni correction revealed ETK (bpm; $M = 128.04, SD = 27.51, p = 0.003$) and DDR ($M = 120.83, SD = 20.86, p = .002$) with significantly higher heart rates than XaviX Tennis ($M = 109.35, SD = 19.14$). However, differences between ETK and DDR were not significantly different from one another ($p = 0.29$). These findings are reinforced by a secondary RM-ANOVA on time spent at vigorous (> 70% MHR) physical activity intensity (VPA) levels. Overall, participants spent more in time in VPA playing ETK (minutes; $M = 15.92, SD = 17.00, p = .001$) and DDR ($M = 11.04, SD = 15.35, p = .02$) compared to XVT with no differences between ETK and DDR.

Insert Figure 2 here

Given, that participants all did not play the same amount of time, we analyzed each participants’ heart rate and calculated the percentage of time spent in MVPA (See Figure 3). A RM-ANOVA determined a significant effect of exergames $F(2, 44) = 6.45, p = 0.05$. Using a Bonferroni correction factor for multiple comparisons, post hoc tests revealed that participants spent a greater percentage of their time in MVPA while playing ETK ($M = 77.81, SD = 31.23, p = 0.04$) and DDR ($M = 76.93, SD = 32.92, p = 0.03$) compared to and XVT ($M = 62.21, SD = 39.26$). However, no significant difference was found between DDR and XVT ($p = 1.00$).

Insert Figure 3 here

Rating of Perceived Exertion (RPE)

A RM-ANOVA revealed significant group effect of exergames $F(2, 44) = 15.23, p < 0.001$ on RPE. Post hoc tests using the Bonferroni correction revealed that participants rated ETK ($M = 4.39, SD = 2.13, p < 0.001$) and DDR ($M = 3.87, SD = 2.07, p < 0.001$) significantly higher (i.e. more intense) than XVT ($M = 2.30, SD = 1.79$). However, between ETK and DDR no statistical differences were found ($p = 0.700$).
Motives for physical activity

Figure 4 shows the average scores for the five different motives for each exergame. As is evident, the analysis indicated that motives for enjoyment, competence, and fitness were consistently higher than the other two motives across all games. Participants rated reasons of enjoyment (5.50), competence (4.66) and fitness (4.18) higher than reasons of appearance (2.75) and social (2.15). Further analyses were only conducted on the three highest rated elements (enjoyment, competence, and fitness) by using separate RM-ANOVAs.

There was a significant main effect of exergames $F(2, 42) = 4.47, p = 0.017$ on enjoyment. Using post hoc tests with Bonferroni correction only revealed marginally significantly higher rates of enjoyment for ETK ($M = 5.68, SD = 0.92, p = 0.051$) compared to XVT ($M = 5.09, SD = 1.54$); however, no differences were found between ETK and DDR ($p = \text{report}$) or between XVT and DDR ($p = 0.097$). Conducting a RM-ANOVA with a Huynh-Feldt correction determined no main effect for competency ratings between games $F(1.61, 35.33) = 1.34, p = 1.00$. Thirdly, there was a significant main effect for playing exergames, $F(2, 44) = 3.71, p = 0.033$ on reasons of fitness. Participants reported fitness as a motivator for playing ETK ($M = 4.64, SD = 2.14, p = 0.012$) significantly higher than a motivator for XVT ($M = 3.66, SD = 2.20$). No differences were found between ETK and DDR ($p = .927$) or between XVT and DDR ($p = .453$).

Moderating Effect on Percentage of Time Spent in MVPA

None of the MPAM-R subscales were highly correlated with MVPA; however, there was a high correlation of enjoyment scores to total time $r = .493, p = 0.014$ and enjoyment was highly correlated with competence $r = 0.579, p = 0.003$. A multiple regression of enjoyment scores moderated by competence on total time played revealed $R^2 = 0.253, b = 0.565, p = 0.024$. 
Insert Figures 5 & 6 here

Discussion

The present study was designed to compare self-selected amount of playing time and determine levels of moderate to vigorous physical activity (MVPA), perceived exertion, for the three exergame systems; EyeToy Kinetic (ETK), Dance Dance Revolution (DDR), XaviX Tennis (XVT). Our second aim was to determine differences in Motives for Physical Activity Measures – Revised (MPAM-R) across exergaming systems. In examining both physiological and psychological motives for self-selected durations of exergame play, the researchers wanted to extend the research base on which games are effective at eliciting health-enhancing levels of physical activity.

Exergames have the potential to provide a novel physical activity choice for adolescents that increases energy expenditure and elicit cardiovascular responses related to health (Graf, Pratt, Hester, Short, 2009, Lanningham-Foster, Jensen, Foster, Redmond et al, 2009, Mellecker, McManus, 2008, Murphy et al. 2009). The choice of “time”, a mediating factor for play and adherence has not been previously considered and the results of this study show that XVT, ETK and DDR can illicit health-enhancing levels of MVPA and are enjoyable to play. These findings are particularly relevant given that most studies restrict gameplay options and offer little in terms of ecological validity. Adolescents spend a great deal of time at home and most play video games each day and much of that activity is autonomous. In allowing the participants to choose which games, songs, characters, levels, and duration, the researchers sought to provide as naturalistic an environment as possible. Besides means heart rates, we also chose to report the total time and percentage of time spent in MVPA so that the general public would clearly understand the intensity levels of physical activity and compare them to the current national recommendations.
In fact, most exergame research provides physiological data but fail to express the relevance and validity of their findings in ways that are easily interpretable.

When given up to sixty minutes to play, participants averaged more than half an hour on each game with ETK producing the highest: mean heart rate, number of minutes spent in vigorous physical activity (VPA), percentage of time in MVPA, and perceived exertion. Despite these higher intensity levels, ETK was also the most enjoyed of the three exergames. In particular, the higher enjoyment levels contrasts Lyons and colleagues’ findings (2011) that players enjoyed lower intensity games (band simulation) over dance and fitness games; however, both intensity levels were performed at levels lower (3.10 and 2.91 MET respectively) than the present study. Given the short time frame of the current study, future research to determine if these intensities and enjoyment levels can be sustained over time is warranted.

When given an hour to play three exergames (on three separate occasions), participants averaged playing each game for approximately 75% of the allotted time. This study is unique in that it is one of the first to investigate differences in self-selected duration of play. Recent research suggests that when given free choice between seated and active games, children choose to sit (Mellecker, Lanningham-Foster, Levine, & McManus, 2012); however, the aforementioned investigation included only one gaming console and did not investigate self-selected duration. Roemmich et al., (2012) found that by providing autonomy (choice of several exergames) girls were as active as boys. The ability to choose from three exergames almost doubled the amount of activity time (90% increase) when compared to only one exergame; although the overall intensity was 83% less than the traditional indoor versions of the same games. Interestingly, the exergame choices were all Wii console-based and each game was played for only three minutes. The authors concluded that autonomy and mastery were important mediators for increasing the amount of time children chose to be active when playing exergames.
The results from this study indicate that exergames can elicit MVPA in a free play scenario (duration of play is unrestricted), at levels commensurate with current physical activity recommendations (Baranowski, Abdelsamad, Baranowski, O’Connor, Thompson, 2012). Mean heart rate values for each game, ETK, DDR, or XVT, are similar to a recent study investigating self-selected intensity across several exergames (Haddock et al. 2012). The authors allowed each participant to choose their own difficulty level but limited duration to 30 minutes of game play. The heart rate response (adults) under these conditions ranged between 117 and 131 bpm suggesting that some level of direction or supervision does not affect intensity of play. More recent examinations of choice and autonomy of exergame play have shown that children should be given some form of instruction and follow specific goals if exergaming is going to be effective as a physical activity intervention (Baranowski et al., 2012).

A trend is apparent when comparing the results of this study with studies using other gaming systems that offer similar modes of activity. Examples of this phenomenon are noted in studies undertaken to determine intensity of play for dance and workout exergames. DDR results from the current study and “Just Dance” (Haddock et al. 2012) revealed similar mean heart rates (121 and 117 bpm respectively). In an earlier study, playing DDR at two different levels, girls averaged 106-124 bpm while boys averaged 111-121 bpm over 15 minute intervals (Graf et al., 2009). Finally, when asking adolescent girls to play DDR for 10 minutes at each of three increasing levels of difficulty, Fawkner (2012) observed mean heart rates of 117, 124, 134 bpm.

In the “workout” exergame genre we also see similarities in outcomes with ETK from this study and “Gold’s Gym/Biggest Loser/Your Shape” by Haddock et al., which resulted in mean heart rates of 128 and 126, 126, 131 bpm, respectively (2012). The similarities of these results are encouraging as they demonstrate that various exergame systems result in comparable levels of MVPA despite being different age groups (adolescents vs. adults respectively) and game platforms. Another important factor to consider when reviewing physical activity intensity is to
examine the amount of time spent in vigorous physical activity (VPA), as it is known to decrease through adolescence (Pate, Dowda, O’Neill, & Ward, 2007).

Using accelerometer data from 10-minute sessions of playing Wii Fit Basic Run, college students spent 50% of the time in VPA (Garn, Baker, Beasley, & Solmon, 2012). To investigate if playing DDR could be a vigorous workout, Noah, Spierer, Tachibana, & Bronner (2011) asked experienced DDR adults to play a pre-selected routine of songs. Over the 30 minutes of play, average heart rate was 157 bpm which is considered VPA. These findings are not surprising given the type of games they are and the ways in which the game player is required to move. Results from the current study also reveal that some of the time (minutes) spent playing was vigorous, including ETK (16) and DDR (11). When compared to the average amount of time spent playing each game; these figures include VPA approximately 30% and 22% of the time respectively. Future research that measures physical activity intensity with sensors other than heart rate monitors (accelerometers and multiple body array sensors) will allow for more discrete comparisons. Besides the intensity of the activity, how participants rate their overall physical effort can help guide researchers and practitioners in implementing exergame programs.

In the current study, participants rated ETK and DDR more tiring than XVT and these values seem to parallel the observed heart rate values; however, this is not always the case. The RPE values for DDR from the current study seem slightly lower (3.87) than those found in adolescent girls completing a 10-minute stage (level 3) of DDR (Fawkner et al. 2010). Playing DDR at a similar level of heart rate intensity (124 bpm), the average RPE was 11.6, which roughly converts to 5.8 on a 10-point scale. One study that reported similar levels of RPE while playing 30 minutes of self-selected intensity Wii boxing (Sell, Clocksinn, Spierer, & Ghigiarelli, 2011), participants averaged 123 bpm and an RPE of 3.9. Given the discrepancies in levels of reported exertion and the possibility of under-reporting (Abbott, McElroy, & Ruocco, 2009; Haddock, Siegel, & Wikin, 2009; Warburton et al., 2009) future studies should continue to
explore the relationship between exertion and enjoyment. Given the short exposure to the exergames in the current study, there could have been a novelty effect. It is unknown if participants would play the games at their own homes at the same intensities over time. Another important factor to consider is competence, in that does playing this exergame build your perceived level of competence to do that game (exercise) again.

In a ten-week dance-exergaming study involving obese adolescents, participants had higher levels of perceived-competence to exercise than a control group (Wagener et al., 2012). Besides better perceived competence, maternal reporting discovered lower overall stress levels after the 10 weeks despite no changes to BMI. Although the current study did not reveal differences between games in terms of competence, it is important to note that competence was the second highest reason participants played as long as they did on each game. Also discovered through multiple regression, competence moderated the relationship between enjoyment and total time spent playing XaviX Tennis. Besides enjoyment, participants liked engaging in activities which physically challenged them and caused them to want to learn skills. As expressed earlier, in order to impact duration and intensity, we must allow adolescents to choose: from a variety of exergames; levels of difficulty; exergames that provide enough feedback that is informative and provides knowledge of performance. As Bailey & McInnis (2011) explains: “that game choice and level selection, as well as the gaming environment, can influence how much energy is expended while playing exergames.” (p. E5). Although beyond the scope of this study, future research is warranted on examining levels of interactivity or sense of immersion while playing different exergames.

The recommendations for adolescents to get at least 60 minutes of moderate to vigorous physical activity (MVPA) each day comes from years of evidenced-based research and is important in maintaining overall health. Numerous organizations and government agencies have established this threshold level; however, the majority of adolescents are not getting their
recommended dose of physical activity either in school or at home. However, this study demonstrated the efficacy of adolescents using exergames to obtain MVPA all while enjoying the experience. Educators, parents and other health professionals should consider incorporating exergames into school or after-school programs, as they may be a stimulus or “Gateway Game” for other activities with peers.

Limitations

This study was limited by the measurement methods and procedures selected for this study. Participants in this study played three separate exergames for only a short period of time (up to 60 minutes) in a community fitness center, but most of that time was spent at the moderate to vigorous intensity levels. Future studies should investigate longitudinal changes to play frequency and intensities in home playing routines. Future studies should examine differences when played with friends as opposed to solo-play. Given the small sample size and that participants were volunteers who self-selected to participate in the study; no assumptions of randomization can be made. A larger sample population would allow for randomization across different games and/or for participants to self-select games. Given the large range afforded by the two standard deviations used in the Bland Altman plots, a less liberal treatment might yield different findings. Another limitation to this study is that no “gold standard” was used to compare the ArmBand results thus limiting the overall power of the findings.

Conclusion

A growing body of work including the current study has demonstrated the potential for adolescents to play exergames at levels that can improve and maintain cardiovascular and muscular health. Using technology and games that are already in the home and community has its advantages. Given the ubiquity and availability of games on numerous platforms and mobile devices, playing them for more minutes beyond entertainment and more for health should be pursued.
Figure 1

Procedural Flow Chart for Exergame Study

Participants
- Age 14-18 years old (n=23)
- Girls (n=9), Boys (n=14)

Inclusion
- Provide informed consent and give appropriate assent
- Complete PAR-Q and PHQ
- < 10 total hours experience with each exergame

Day 1 - Random Exergame 1
- Practice (5 min)
- Trial (60 min)
- Rest & Questions (5 min)

Day 2 - Random Exergame 2
- Practice (5 min)
- Trial (60 min)
- Rest & Questions (5 min)

Day 3 - Random Exergame 3
- Practice (5 min)
- Trial (60 min)
- Rest & Questions (5 min)
Figure 2

*Mean Heart Rate for Three Separate Exergames (n=23)*

Exergaming Mean Heart Rate

![Bar Chart]

- **XaviX Tenis**
- **EyeToy Kinetic**
- **Dance Dance Revolution**

*Error bars: 95% CI*
Figure 3

Mean Percentage of Time in Moderate-Vigorous Physical Activity for Three Separate Exergames (n=23)

Exergaming Percent Time in MVPA

Error bars: 95% CI
Table 1
Mean (SD) Values For Participant Demographics, Self-Reported And Exergaming Activities

<table>
<thead>
<tr>
<th>Variable</th>
<th>All participants</th>
<th>Females</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Descriptive and Anthropometric</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>15.39 (1.50)</td>
<td>15.80 (1.69)</td>
<td>15.24 (1.48)</td>
</tr>
<tr>
<td>Grade</td>
<td>10.00 (1.28)</td>
<td>10.30 (1.49)</td>
<td>9.94 (1.25)</td>
</tr>
<tr>
<td>Height (meters)</td>
<td>1.68 (0.07)</td>
<td>1.64 (0.04)</td>
<td>1.71 (0.08)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>65.97 (11.32)</td>
<td>64.08 (9.80)</td>
<td>69.22 (15.10)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>23.48 (3.52)</td>
<td>24.06 (3.63)</td>
<td>23.10 (3.54)</td>
</tr>
<tr>
<td><strong>Self-report data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate to Vigorous PA - days</td>
<td>4.26 (2.07)</td>
<td>3.10 (1.37)</td>
<td>4.82 (2.22)</td>
</tr>
<tr>
<td>Moderate PA - days</td>
<td>3.61 (2.31)</td>
<td>3.40 (2.07)</td>
<td>4.18 (2.68)</td>
</tr>
<tr>
<td>Strength PA - days</td>
<td>3.04 (2.16)</td>
<td>3.00 (1.83)</td>
<td>3.24 (2.49)</td>
</tr>
<tr>
<td>XVT - minutes</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>ETK - minutes</td>
<td>14.35 (46.01)</td>
<td>21.00 (66.41)</td>
<td>7.06 (19.93)</td>
</tr>
<tr>
<td>DDR - minutes</td>
<td>104.35 (152.33)</td>
<td>192.00 (172.16)</td>
<td>52.94 (106.74)</td>
</tr>
<tr>
<td><strong>Experiment data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting HR (bpm)</td>
<td>73.78 (8.32)</td>
<td>75.89 (5.37)</td>
<td>72.43 (9.72)</td>
</tr>
<tr>
<td>XVT time (minutes)</td>
<td>36.47 (14.91)*</td>
<td>35.11 (17.90)</td>
<td>37.34 (13.31)</td>
</tr>
<tr>
<td>ETK time (minutes)</td>
<td>50.98 (11.83)</td>
<td>53.78 (6.94)</td>
<td>49.19 (14.09)</td>
</tr>
<tr>
<td>DDR time (minutes)</td>
<td>50.13 (13.71)</td>
<td>52.81 (11.24)</td>
<td>48.25 (15.22)</td>
</tr>
<tr>
<td>XVT range time (minutes)</td>
<td>11.00 – 60.00</td>
<td>11.00 – 60.00</td>
<td>17.00 – 60.00</td>
</tr>
<tr>
<td>ETK range time (minutes)</td>
<td>27.00 - 60.00</td>
<td>43.00 – 60.00</td>
<td>27.00 – 60.00</td>
</tr>
<tr>
<td>DDR range time (minutes)</td>
<td>12.00 – 60.00</td>
<td>26.00 – 60.00</td>
<td>12.00 – 60.00</td>
</tr>
<tr>
<td>XVT HR (bpm)</td>
<td>109.35 (19.14)*</td>
<td>112.89 (10.08)</td>
<td>107.07 (23.31)</td>
</tr>
<tr>
<td>ETK HR (bpm)</td>
<td>128.04 (27.51)</td>
<td>144.89 (20.69)</td>
<td>117.21 (26.35)</td>
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<tr>
<td>DDR HR (bpm)</td>
<td>120.83 (20.86)</td>
<td>132.00 (13.93)</td>
<td>113.60 (21.79)</td>
</tr>
<tr>
<td>XVT range HR (bpm)</td>
<td>70.00 – 170.00</td>
<td>96.00 - 145.00</td>
<td>72.00 - 152.00</td>
</tr>
<tr>
<td>ETK range HR (bpm)</td>
<td>74.00 – 177.00</td>
<td>108.00 - 177.00</td>
<td>74.00 - 167.00</td>
</tr>
<tr>
<td>DDR Range HR (bpm)</td>
<td>73.00 – 153.00</td>
<td>107.00 - 150.00</td>
<td>73.00 - 153.00</td>
</tr>
<tr>
<td>XVT MVPA (% time)</td>
<td>62.21 (39.26)*</td>
<td>71.34 (37.51)</td>
<td>56.33 (40.58)</td>
</tr>
<tr>
<td>ETK MVPA (% time)</td>
<td>77.81 (31.23)</td>
<td>95.08 (07.59)</td>
<td>66.71 (35.71)</td>
</tr>
<tr>
<td>DDR MVPA (% time)</td>
<td>76.93 (32.10)</td>
<td>89.70 (19.96)</td>
<td>68.72 (36.25)</td>
</tr>
<tr>
<td>XVT RPE</td>
<td>2.30 (1.79)*</td>
<td>1.89 (1.69)</td>
<td>2.57 (1.87)</td>
</tr>
<tr>
<td>Game</td>
<td>ETK RPE</td>
<td>DDR RPE</td>
<td>XVT Competence</td>
</tr>
<tr>
<td>--------</td>
<td>---------</td>
<td>---------</td>
<td>----------------</td>
</tr>
<tr>
<td></td>
<td>4.39 (2.13)</td>
<td>4.56 (2.19)</td>
<td>4.29 (2.16)</td>
</tr>
<tr>
<td></td>
<td>4.43 (1.31)</td>
<td>4.21 (1.27)</td>
<td>4.58 (1.37)</td>
</tr>
<tr>
<td></td>
<td>4.56 (1.33)</td>
<td>4.21 (1.27)</td>
<td>4.58 (1.37)</td>
</tr>
</tbody>
</table>

**Note.** N = 23; Females n = 9, Males n = 14; SD = Standard Deviation; XVT=XaviX Tennis; ETK=EyeToy Kinetic; DDR=Dance Dance Revolution; XVT/ETK/DDR minutes=self-reported number of minutes of prior exergaming experience; resting HR=heart rate prior to beginning, testing performed while seated; HR=heart rate; OMNI-RPE=the average ratings of perceived exertion immediately following each exergaming session. *Significantly different from other game p < 0.05
Figure 4

Mean Motives for Physical Activity of Exergames (n=23)

Note. * Significantly different from other game $p < 0.05$
Figure 5

Pearson Correlation of MPAM Enjoyment and Time

Pearson $r = 0.493$
Figure 5
Pearson Correlation of MPAM Enjoyment and MPAM Competence
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Yang, S. P., Smith, B. K., & Graham, G. M. (2008). Healthy video gaming: oxymoron or
Paper 3: Comparing Exercise Intensity Between Heart Rate and SenseWear ArmBand For Three Exergames
Abstract

Exercise video games (exergames) are widely used in homes and are seen as a safe and enjoyable way to accumulate physical activity, though there is limited information on the intensity of activity from these games. The purpose of this study was to examine the differences between four measurements of exercise intensity while playing XaviX Tennis (XVT), EyeToy Kinetic (ETK), and Dance Dance Revolution (DDR) for 15 minutes (Phase 1) and up to 60 minutes (Phase 2). This study was conducted with 23-27 adolescents aged 14-18 years and used data collected via heart rate monitor (HRM) and SenseWear ArmBand (AB). Dependent measures included beats per minute (measured via HRM), calories (CAL), calories per minute (CPM), steps per minute (SPM), and metabolic equivalents (MET) (measured via AB). Pearson correlation coefficients were used to examine associations between measures; Bland Altman plots assessed the amount of agreement between the methods of assessment. Correlation analyses found low to medium associations between CPM from HRM and AB, for DDR \( r = 0.354, p = 0.07 \), ETK \( r = 0.249; p = 0.211 \) and XVT \( r = -0.048; p = 0.814 \). The Bland Altman method showed good agreement in the assessment of calories per minute between data obtained by HRM and AB in prescribed duration of play. Pearson correlation coefficients determined moderate to strong associations for all three games measured with HRM and AB; XVT \( r = 0.839; p < .001 \), ETK \( r = 0.703; p < .001 \) and DDR \( r = 0.650; p < .001 \). Bland Altman plots showed good agreement in the assessment of calories per minute in Phase 2. When compared with HRM, the AB typically reported higher values for calories. Across all games, conditions (phase 1 vs. phase 2), and measurement methods, ETK was consistently played the highest levels of intensities (HR, CAL, CPM, MET). These findings suggest that the AB may be a useful tool, especially in addition to heart rate monitoring, to measure exercise intensity while playing exergames.
INTRODUCTION

The recommendations for adolescents to accumulate daily physical activity are well described. Adolescents should do one hour (60 minutes) or more of either moderate- or vigorous physical activity every day and as part of their daily physical activity, adolescents should do vigorous-intensity activity on at least three days per week (Physical Activity Guidelines Advisory Committee, 2008). Despite these recommendations and the actions by the newly released National Physical Activity Plan (2010) less than 20% of adolescents participated in physical activities for at least 60 minutes daily (Centers for Disease Control, 2010). The more time spent in sedentary behaviors, coupled with poor dietary habits contribute to an increased risk of obesity, diabetes and cardiovascular disease among youth (Andersen, Crespo, Bartlett, Cheskin, & Pratt, 1998; Goran, Reynolds, & Lindquist, 1999; Molnar & Livingstone, 2000). In fact, the rates of childhood and adolescent obesity have increased seven-fold in the past forty years (Ogden, 2010). Although the importance of improving dietary habits cannot be overstated, this study will focus on examining out-of-school voluntary physical activity levels in adolescents.

On average, American children and adolescents watch four and a half (4:29) hours of television daily and combined with video games and computers, spend over seven and a half (7:38) hours a day interacting with media (Rideout, 2010). Clearly technology is appealing and playing video games seems to be one of the more enjoyable activities. Adolescents play video games an average of 50-73 minutes a day (Entertainment Software Association, 2010; Rideout, 2010). Some research has indicated that playing video games is directly associated with being overweight (Anderson, Economos, Must, 2008; Mendoza, Zimmerman, Christakis, 2007; Stettler, Signer, & Suter, 2004; Vandewater, Shim, & Caplovitz, 2004); however, others found no such relationship and reported that video game playing does not necessarily displace physical activity (Biddle, Gorely, Marshall, Murdey, & Cameron, 2004; Marshall, Biddle, Sallis, McKenzie,
Exergames (active video games) is a growing niche of video games and controllers that require the player to move their body or body parts in order to play (Yang et al., 2008). In essence, the player becomes the character in the video game in a form of augmented reality (Matysczok, Radkowski, & Berssenbruegge, 2004; Ohshima, Satoh, Yamamoto, & Tamura, 1998). In order to play these games, players must be physically active and moving compared with traditional video games which require little exertion. A recent study found that each day high school students spend nine to 30 minutes playing exergames (Yang, Treece, Miklas, 2009). If these games can be as motivating to play as traditional video games, but with additional physical benefits, we should continue to explore which games are suitable to improve health-related fitness. This study is focused on the differences between exercise intensities between XaviX Tennis (XVT), EyeToy Kinetic (ETK), and Dance Dance Revolution (DDR).

A device that has multiple sensors is the BodyMedia SenseWear ArmBand (AB). It consists of an array of sensors that approximates energy expenditure (EE) without a cumbersome setup as in traditional indirect calorimetry. The device is worn on the back of the arm and measures movement via a dual-axis accelerometer, galvanic skin response via skin conductivity, skin temperature, and metabolic equivalents (METS). The Armband has been validated with college age subjects (Fruin & Rankin, 2004; King, Torres, Potter, Brooks & Coleman, 2004) and in children and adolescents (Arvidsson, 2007; Backlund, 2010; Calabro, 2009; Crawford, 2005). Although originally designed and calibrated for adults, BodyMedia adjusted its original algorithms to be a valid instrument with children and adolescents. Backlund (2010) compared EE using the SenseWear Pro2 Armband to doubly labeled water method, and found that when using InnerView Professional software versions 5.1 (SWA 5.1) in free-living overweight and obese children, it was a valid assessment. When used in healthy children (n=21) across multiple
sedentary (sitting, coloring) and physical activities (treadmill walking, stationary biking), Calabro only found 1.7% measurement error across 41-minute testing bouts (2009) using InnerView Professional software versions 6.1 (SWA 6.1).

The purpose of this study was to compare exercise intensities (calories, calories per minute-CPM, MET, and steps minute-SPM) measured from a heart rate monitor (HRM) and SenseWear Armband (AB) while playing exergames over separate fifteen-minute periods (phase 1) and for up to 60 minutes on three other occasions (phase 2). Based on previous research (Yang & Foley, 2008) we hypothesized that participants would participate at higher intensities playing ETK, than DDR and XVT. We also hypothesized that there would be differences in CAL and CPM in measurements from HRM and AB.

METHODS

Participants

Participants were recruited from a local community fitness center (CFC) located in a small city in the Northeastern United States through flyers and newsletters. Participants were healthy, non-smokers, free from any cardiovascular or musculoskeletal condition that would prevent them from being physically active as indicated on the completed PAR-Q screening tool. All participants under 18 years old obtained written parental consent and gave their assent in writing while participants who were 18 years old gave their written consent.

Each participant was a CFC member and was permitted to engage in physical activities within the facility. Data was collected in a 150 square foot multi-purpose room equipped with a data projector and a sound machine hooked up to the three exergames. Prior to each experimental visit, participants were asked to abstain from food and caffeine intake for two hours, and vigorous exercise for 24 hours. All participants were asked to wear typical workout clothing (short sleeve t-shirt and shorts and appropriate footwear).
Prior to the start of study, participants submitted the following forms completed and signed: 1) parental consent, 2) teen assent, and 3) Physical Activity Readiness-Questionnaire (PAR-Q). The researcher measured each participant’s weight and height using a digital scale (LifeSource UC-321, Milpitas, CA-USA) and a portable stadiometer (Seca 214, Birmingham, UK), and from those measurements body mass index was calculated (BMI = mass(kg)/height(m²)). The participants received instructions on how to wear a Polar Heart Rate Monitor E600 (snug across the sternum) and SenseWear® PRO2 Armband (on the back of the upper right arm).

Measures

Heart rate was assessed with the Polar E600 heart rate monitor (HRM - Kempele, Finland) downloaded through a Polar IR interface connected to a laptop (via USB), into the PE Manager software (Lake Success, NY, http://education.polarusa.com/education/products/pemanager/pemanager.asp). The recording interval was set at five seconds and heart rate zones were calculated individually based on the maximum heart rate (MHR) formula (220 – age). Intensity zones from ACSM’s Guidelines for Exercise Testing and Prescription (2010) were used; low = less than 55% of MHR, moderate (MPA) = 55-70% of MHR, and vigorous (VPA) 70-85% MHR. Since PE Manager did not calculate EE and VO2 max was also unknown, each participant’s age, height, weight, time exercising, and mean heart rate data was entered into a formula suggested by Keytal et al. (2005): Males: ((-55.0969 + (0.6309 x HR) + (0.1988 x W) + (0.2017 x A))/4.184) x 60 x T; Females: ((-20.4022 + (0.4472 x HR) - (0.1263 x W) + (0.074 x A))/4.184) x 60 x T. For the above formulas: A = Age (in years), HR = Heart rate (in beats/minute), T = Exercise duration time (in hours), W = Weight (in kilograms).

MET and steps per minute values were calculated using the SenseWear® PRO2 Armband (AB) monitor that records physiological responses including acceleration, step counts, galvanic
skin response, and skin temperature. Data was downloaded to a laptop computer (via USB) into InnerView® Professional software version 6.1 (Pittsburgh, PA, www.bodymedia.com), where minute-by-minute metabolic equivalent values (MET; 1 MET = 3.5 mL O2/min/kg or 1 MET = 1 kcal) and EE (kcals) were calculated using SenseWear®’s proprietary formulas. Established MET zone intensities include light (< 3 MET), moderate (3.0–6.0 MET), vigorous (6.0–9.0 MET), and very vigorous (>9.0).

Phase 1 Procedure

A randomized counter-balanced design was used to ensure equal treatments across all three exergames (XVT, ETK, DDR) and to prevent an ordered-effect, (Campbell et al., 1972; J. T. Thomas et al., 2005). The researcher introduced and gave instructions on how to play the first exergame (randomly selected by the researcher). The participant was given five minutes to play and orient him or herself with the game and was able to ask questions (to the researcher) about how to play the game. See Table 1 for more details on the games that were played and in which order. After starting the record mode on the HRM and AB, participants were asked to play the first game for 15 minutes, followed by a 10-minute rest period with access to a water fountain. This procedure was continued until participants finished playing all three exergames. The total amount of time spent being physically active was approximately 60 minutes (5 minutes + 15 minutes = 20 minutes x 3 games = 60 minutes). This protocol is consistent with other studies that assessed adolescents’ EE across multiple exergames (Epstein et al., 2007; Lanningham-Foster et al., 2006; Maddison et al., 2007). At the end of the session, participants removed the monitors and data was downloaded to a portable computer.

Insert Table 1 here

Phase 2 Procedures

As in Phase 1, a randomized counter-balanced design was used to ensure equal treatments across all three exergames (XVT, ETK, DDR) and to prevent an ordered-effect, (Campbell,
Stanley, & Gage, 1972; Thomas, Nelson, & Silverman, 2005). Participants wore the same activity monitors (heart-rate monitor - Polar E600 and SenseWear® Armband PRO2) from the first phase. Given all participants already knew how to play the games no familiarization period was required; however, some autonomy was given in terms of game play options (duration of play, mini-game selection, order, song, characters, and/or opponent – See Table 1), and participants were given up to 60 minutes to play. Once participants indicated they were finished playing the game, the monitors were removed and data was downloaded to a portable computer. The amount of time they spent playing each game was noted. Following a brief cool-down period an appointment was made to complete the other two games over the following two weeks and not sooner than 48 hours after the current session.

Data Analysis

Phase 1 analyses consisted of Chi-square tests performed to determine differences between genders on the 15 minutes of play for each game (Table 2). Separate within-subjects repeated measures analyses of variance (RM-ANOVA) were performed to determine differences between games on mean heart rate (HR), calories, calories per minute (CPM), metabolic equivalents (MET), and steps per minute (SPM). When differences were found, separate pairwise comparisons using post-hoc tests with Bonferroni correction factors determined which pairs were significantly different from one another. Bland-Altman plots were also developed to visually judge the 95% limits of agreement for how well two methods (HRM & AB) of calories per minute (CPM) measurements agreed. According to Bland & Altman, (1986), the smaller the range between these two limits the better the agreement is. Phase 2 analyses entailed a Chi-Square tests performed to determine differences between genders on the minutes of play for each game (Table 3). Separate within-subjects repeated measures analyses of variance (RM-ANOVA) were performed to determine differences between games on mean heart rate (HR), calories, calories per minute (CPM), metabolic equivalents (MET), and steps per minute (SPM). When
differences were found, separate pairwise comparisons using post-hoc tests with Bonferroni correction factors determined which pairs were significantly different from one another. Bland-Altman plots were also developed to visually judge the 95% limits of agreement for how well two methods (HRM & AB) of calories (CAL) measurements agreed. SPSS™ (SPSS, Inc. Chicago, IL) version 19.0 was used for analyzing all data and alpha levels were set at 0.05.

RESULTS

Participants

A total of 27 participants, 10 females and 17 males were recruited and completed all portions of the protocol that was approved by the university’s Institutional Review Board. Four adolescents completed the initial familiarization protocol (phase 1) but did not complete the remaining three days of testing (phase 2), one participant completed two of the sessions, and three participants originally signed up signed up but did not show up for their appointments despite repeated attempts to contact them. The mean age of the group was 15.44 ± 1.55 years (range 14-18 years), mean body mass index (BMI) was 23.63 ± 3.84 kg/m² and racially the group was made of 81.5% Non-Hispanic White, 14.85% Non-Hispanic Black, and 3.7% Hispanic of any race.

Phase 1

Heart rate (via HRM): A repeated-measures ANOVA (RM-ANOVA) revealed significant differences in mean heart rates between exergames ($F(2, 52) = 34.244, p < .001$). Post hoc tests using Bonferroni correction revealed that ETK elicited a significantly higher heart rate ($137.22 \pm 23.41$ bpm, $p < .001$) than DDR ($118.41 \pm 22.05$ bpm) and XVT ($112.44 \pm 21.60$ bpm). However, no significant differences were found between XVT and DDR ($p = .084$).

Calories (via HRM): Individual heart rate data was transformed to calories using formulas developed by Keytal et al. (2005). A RM-ANOVA revealed significant differences between games in total calories expended ($F(2, 52) = 34.549, p < .001$). Post hoc tests revealed
participants burned more calories ($p < .001$) playing ETK ($152.25 \pm 47.09$) compared to DDR ($112.97 \pm 39.08$) and XVT ($101.99 \pm 41.48$). No differences were found between XVT and DDR ($p = 0.104$). Using HR derived CPM data and cross-referenced from the Compendium of Physical Activities (Ainsworth, 2011), ETK and DDR were played at vigorous intensities ($> 7.0$ CPM) while XVT was played at moderate levels (3.5-7.0 CPM).

*Calories (via AB):* A RM-ANOVA revealed significant differences by game in total calories expended ($F(2, 52) = 16.646, p < .001$). Participants burned more calories ($p < .001$) playing ETK ($133.85 \pm 31.96$) and XVT ($117.25 \pm 43.65$) than DDR ($91.04 \pm 30.97$). Pearson correlation coefficients between total calories expended measured via HRM and AB revealed a medium association ($0.3 - 0.5$) for DDR ($r = 0.354, p = 0.07$), a small association ($0.1 - 0.3$) for ETK ($r = 0.249; p = 0.211$) and no association for XVT ($r = -0.048; p = 0.814$).

*Calories per minute (via AB):* Paired sample t-tests on calories per minute (CPM) for each game revealed no significant difference in XVT scores for HRM ($6.80 \pm 2.76$) and AB ($7.82 \pm 2.91$) conditions; $t(26) = -1.287, p = 0.209$. No significant difference was also found for ETK between HRM ($10.15 \pm 3.14$) and AB ($8.92 \pm 2.13$) conditions; $t(26) = 1.916, p = 0.066$. There was a significant difference for DDR scores of HRM ($7.53 \pm 2.61$) and AB ($6.07 \pm 2.06$) conditions; $t(26) = 2.823, p = 0.009$. Using AB derived CPM data and cross-referenced with the Compendium of Physical Activities (Ainsworth, 2011), XVT and ETK were played at vigorous intensities ($> 7.0$ CPM) while DDR was played at moderate intensity (3.5-7.0 CPM).

Insert Figures 1, 2 and 3 here

Bland Altman plots illustrating agreement between calories per minute (CPM) measured via AB and HRM are shown in Figure 1, Figure 2, and Figure 3. The mean difference in CPM was small ($1.02 \pm 8.06$) and all values fell within the ($95\%$ CI range -6.08 to 2.64) between CPM estimates for XVT. The differences in CPM for ETK was also small ($-1.46 \pm 5.27$) and all values fell within the ($95\%$ CI range -2.54 to 0.09). There was a small difference in CPM for DDR (-
2.53 ± 5.27) and all values except one fell within the (95% CI range -2.53 to -0.40). There was an apparent trend showing small differences between the two measures across all three exergames.

**Metabolic equivalent (MET):** A RM-ANOVA was conducted on mean metabolic equivalents (MET) revealed significantly different MET levels $F(2, 52) = 17.337, p < .001$. Using post hoc tests with Bonferroni correction revealed higher MET values playing ETK (8.07 ± 1.71, $p < 0.005$) and XVT (7.06 ± 2.08, $p = 0.006$) were played at higher levels when compared to DDR (5.56 ± 1.35). However, no significant difference was found between ETK and XVT ($p = 0.143$). Both ETK and XVT were played at vigorous intensities (6.0-9.0 MET) for the 15-minute protocol, while DDR was played at a moderate intensity (3.0-5.9 MET).

**Steps per minute (SPM):** A RM-ANOVA determined that mean steps per minute (SPM) differed significantly ($F(2, 52) = 20.924, p < .001$) between games. Post hoc tests using Bonferroni correction revealed that participants stepped more ($p < .001$) playing ETK (45.11 ± 17.27) and DDR (45.41 ± 18.10) than XVT (24.37 ± 17.72).

**Phase 2**

**Time spent playing game:** A repeated measure ANOVA indicated a difference in the amount of time participants played ($F(2, 44) = 9.746, p < .001$). Post hoc tests show participants played ETK (51.48 ± 12.96 minutes, $p = .004$) and DDR (50.13 ± 13.70 minutes, $p = .011$) longer than XVT (37.35 ± 14.86 minutes). No differences were found between ETK and DDR.

**Heart rate (via HRM):** As in Phase 1, differences in mean heart rates was found between exergames ($F(2, 52) = 34.244, p < .001$). Post hoc tests revealed ETK (128.04 ± 27.51 bpm, $p = 0.003$) and DDR (120.83 ± 21.43 bpm, $p = 0.002$) elicited significantly higher heart rates than XaviX Tennis (109.35 ± 19.23 bpm). No differences were found between XVT and DDR ($p = .292$).
**Calories (via HRM):** Using heart rate data, there were significant differences \((F(2, 44) = 16.148, p < 0.005)\) in the amount of calories burned between exergames. Post hoc tests revealed participants burned more calories \((p < .001)\) playing ETK \((335.81 \pm 114.16)\) and DDR \((324.32 \pm 139.95)\) than XVT \((283.82 \pm 171.77)\). There was no difference between ETK and DDR \((p = .413)\). Pearson correlation coefficients between total calories expended measured via heart rate and ArmBand revealed strong \((0.5 – 1.0)\) associations for XVT \((r = 0.839)\), ETK \((r = 0.703)\) and DDR \((r = 0.650)\). Paired sample t-tests on calories for each game revealed a significant difference in XVT \(t(23)=-2.198, p = 0.038\) scores for HRM \((243.18 \pm 181.03)\) and AB \((287.71 \pm 164.84)\), ETK with HRM \((466.53 \pm 228.16)\) and AB \((338.91 \pm 112.51)\); \(t(23)=3.617, p = 0.002\); and DDR of HRM \((419.00 \pm 213.92)\) and AB \((325.61 \pm 136.87)\); \(t(23)=2.744, p = 0.012\).

Given the strong correlations between devices on total calories, Bland Altman plots were developed to illustrate agreement between calories measured via AB and HRM as seen in Figure 7, Figure 8, and Figure 9. The mean difference in calories XVT burned is moderate \((44.52 \pm 99.23)\) and all values but one fell within the 95% CI range \((2.65 to 86.42)\). The difference in calories for ETK was much larger \((-127.62 \pm 169.22)\) yet all values except one fell within the 95% CI range \((-200.79 to -54.45)\). There was a large difference in calories for DDR \((-93.39 \pm 163.23)\) and all values except one fell within the 95% CI range \((-163.98 to -22.80)\). Overall, there was an apparent trend showing small differences between the two measures across all exergames.

**Calories per minute (CPM (via HRM):** Since each participant played varying amounts of time, a RM-ANOVA with Greenhouse-Geisser correction was conducted and found differences in CPM expended \((F(1.511, 33.247) = 8.680, p = 0.002)\). Post hoc paired comparisons revealed participants expended more calories playing ETK \((8.62 \pm 3.28, p = 0.007)\) and DDR \((7.75 \pm 2.73, p = 0.003)\) when compared to XVT \((6.35 \pm 2.92)\). No significant differences were found between
ETK and DDR ($p = .443$). Paired sample t-tests on CPM for each game revealed significant differences between HRM and AB for XVT $t(23) = -2.172, p = 0.04$, ETK $t(22) = 2.903, p = 0.008$ and DDR $t(22) = 2.446, p = 0.023$. According to heart rate derived data and cross-referenced CPM from Ainsworth et al’s 2011 update of the Compendium of Physical Activities, ETK and DDR were played at vigorous intensities (> 7.0 CPM) while XVT was played at moderate intensity (3.5-7.0 CPM).

*Calories per minute (CPM)(via AB):* No significant differences in ArmBand calories per minute in total calories expended was found ($F(2, 40) = 16.646, p < .001$; but a RM-ANOVA on calories per minute (CPM) was performed in light of the varying amounts of playing time. Despite finding differences between games ($F(2, 40) = 4.470, p = .017$), post-hoc tests revealed no significant differences in pairwise comparisons of games (XVT–ETK, $p = 0.149$; XVT–DDR, $p = 0.069$; ETK-DDR, $p = 1.00$). In contrast to findings from Study 1, XVT was played at vigorous intensity (> 7.0 CPM) while both ETK and DDR were played at moderate intensities (3.5-7.0 CPM) while.

*Metabolic equivalent (MET)(via AB):* A RM-ANOVA on metabolic equivalents (MET) revealed significantly different MET levels by game $F(2, 42) = 7.086, p = 0.002$. Post hoc tests revealed higher MET values playing XVT ($7.20 \pm 2.17, p = 0.048$) and ETK ($6.09 \pm 0.93, p = 0.014$) compared to DDR ($5.91 \pm 1.28$). No difference was found between ETK and DDR ($p = 1.00$). Both XVT and ETK were played at vigorous (6.0-9.0 MET) intensities while DDR was played at moderate (3.0-6.0 MET) but nearly vigorous intensity.

*Steps per minute (SPM)(via AB):* A RM-ANOVA determined that mean steps per minute (SPM) differed significantly by game ($F(2, 42) = 44.440, p < .001$). Post hoc tests revealed that participants stepped at a faster rate while playing DDR ($54.70 \pm 17.67, p < .001$) and ETK ($46.94 \pm 11.89, p < .001$) compared to XVT ($21.11 \pm 11.85$). No differences were found between ETK and DDR ($p = 0.232$).
DISCUSSION

The present study was designed to compare exercise intensities measured from heart rate monitors (HRM) and SenseWear Armbands (AB) while playing exergames for fifteen-minute periods of time and a self-selected period of time not longer than 60 minutes. As both are popular tools used in exercise interventions, it’s important to determine their reliability and consistency when used in an exergaming scenario. Both devices have been used and validated in adolescents in regular exercises and activities, but in terms of exergaming, only one published study evaluated the validity of the AB to assess exercise intensity with HRM (Leatherdale, Woodruff, & Manske, 2010); however, the authors did not assess calories per minute from each device.

Using heart rate data, which is highly accessible at home and in schools, slight differences in expected outcomes were revealed. As predicted, playing ETK (upper and lower body movements) elicited a significantly higher mean heart rate compared to XVT (upper body) and DDR (lower body). Our study confirms other studies that list dance exergames at higher intensities compared to tennis exergames (Brown et al., 2008; Hennig et al., 2009; Lyons et al., 2009). In the current study, although HR values were not statistically different, DDR was played at higher levels than XVT; however, AB calories revealed XVT being significantly higher than DDR. This could possibly be explained by the extra weight and tactile nature of the XVT racquet that may have contributed to the higher-than-expected caloric AB values. The XVT racquet weighs 230 grams and measures 35.8 cm long (XaviX, 2006) almost twice as long and heavy compared to the Wiimote (Nintendo, 2006). As suggested by Johnsone (2002), these factors may have heightened the sense of realism and intuitiveness of game play and as a result, players may have swung the racquet more like a traditional tennis racquet as opposed to simply flicking their wrist (Biddiss & Irwin, 2010).

In evaluating CPM via HRM for both Phase 1 and 2, both ETK and DDR were played at vigorous intensities while XVT was played at moderate, but nearly vigorous intensity. Previous
research has shown dance exergames can be vigorous in nature (Bailey & McInnis, 2011; Johnson, Alsac, & Swan, 2007; Noah et al. 2011) however the majority of studies typically yield low to moderate levels (Barnett, Cerin, & Baranowski 2011; Biddiss & Irwin, 2010; Peng, Lin, & Crouse, 2011). Data from the AB mirrored HR, where ETK and XVT produced significantly higher calories and MET values; however, this relationship did not exist for SPM where ETK and DDR were both higher than XVT. Through general observations, playing XVT did not require much lower limb movement; however combined with the swinging of the arm while holding a small racquet required overall more energy to produce these movements. These higher levels for XVT contrasts a literature review which concluded that games that require upper-limb movements were not as vigorous as lower-limb movements (Biddiss & Irwin 2010). Previous research has shown Tennis exergames to yield low MET values (Bausch, Beran, Cahanes, & King (2008); Haddock, Siegel, & Wikin 2010; Miyachi, Yamamoto, Ohkawara, & Tanaka, 2009; O’Donovan & Hussey, 2012; Willems & Bond, 2009 respectively) and HR values (Graves, Ridgers, & Stratton, 2008; Haddock, Siegel, & Wikin 2010; O’Donovan & Hussey, 2012 respectively) though many of these studies involved older participants and a different exergame. For example a study with college students (mean age 24 years, females 21, males 30) conducted by Leatherdale, Woodruff, & Manske (2010). Playing a sedentary tennis video game HRM overestimated EE (64.7 vs. 42.3); while playing Wii Tennis HRM underestimated EE (97.4 vs. 192.4). Results from the active gaming option mirrors the current study (XVT) where HRM calories overestimated AB; however when factoring the actual amount of time participants played each game, XVT was played at higher MET and CPM than the other games. This study is believed to be the first to assess XaviX Tennis in terms of exercise intensity.

Low to medium correlations were found between CPM data of the HRM and AB and only DDR was significantly lower than XVT and ETK in Phase 1. Given that both devices have been validated for assessing physical activity intensity in previous studies, the present study
suggests that the AB is a valid instrument for measuring physical activity in adolescents playing exergames. Using CPM cut-points (Ainsworth, 2011) revealed parallel intensities to MET; whereby, ETK and XVT were significantly higher than DDR. Additionally, using Bland & Altman plots show good agreement in the assessment of CPM between heart rate and AB data. Across all games, the mean CPM range in differences was (-2.53 - 1.02).

In phase 2 significantly higher mean heart rates and calories via HR and AB were found in ETK compared to XVT but not for DDR. Strong correlation coefficients (0.65 – 0.839) were found between calories from HRM and AB, and Bland Altman plots further explored their relationships. The results indicate good agreements in the assessment of calories between devices because the mean differences (58.83 ± 143.89) were within the limits of agreement and most data points were within the limits of agreement of bias (−200.79 to 86.42). The mean difference was, and the limits of agreement ranged from. On average, despite HRM’s higher EE (calories) compared to AB, measures between devices demonstrated strong agreements and as well as the direction of the results.

Besides daily goals to accumulate at least 60 minutes of MVPA, the Physical Activity Guidelines for Americans (2008) recommends people to accumulate 500-1000 MET-minutes each day for health benefits. On average in the Phase 1 with fifteen minutes of play for XVT, ETK, and DDR participants accumulated 105.9, 121.05, and 83.4 MET-minutes respectively, representing approximately 20% of the minimum recommendation. During Phase 2, participants playing XVT, ETK, and DDR for self-selected durations accumulated 268.92, 313.51, and 296.27 MET-minutes respectively. These values represent approximately 54-63% of the daily minimum of 500 MET-minutes. Accomplishing over half of the daily minimum MET-minutes in a fun and engaging virtual environment bodes well for those looking to find novel ways to be more physically active. One advantage to exergames, or any video game, have is that they can be easily adapted to suit the needs and the abilities of the players and there are many titles and platforms
from which to choose (Yang & Foley, 2011). Many are console-based with peripherals (Taylor et al., 2011); however all the major platforms have camera based systems that do not require controllers and this particular area of exergaming shows a lot promise with engaging the entire body as in ETK. Some exergaming options, when played to the levels discovered in this study, is are a promising option that can counter some of the high amounts of sedentary time adolescents typically accumulate each day.

The results of this study show that AB and HRM estimated EE of adolescents who played a variety of exergames over short periods of time. The majority of exergaming studies have been very restrictive in terms of autonomy and choice in game options. Research has shown that when players are given more opportunities to customize their own game experience, they perceive higher levels of autonomy and tend to enjoy the experience more (Peng et al 2012; Roemmich et al. 2012). One of this study’s contributions to the literature is from Phase 2, where participants were allowed to self-select duration as well as numerous game-play options such as game character (XVT, ETK), songs (ETK, DDR), levels of song difficulty (DDR), and virtual location/playing surfaces (XVT).

The findings of this study are promising when considering the low levels of adolescent physical activity and the pervasiveness of gaming technology in homes and schools. Based on our findings, participants were able to achieve moderate and vigorous intensities in each of the three exergaming systems (XVT, ETK, DDR). New research is also shows the health benefits of exergaming showed that it can be useful in also be useful in improving balance (Vernadakis et al. 2012), coordination (Deutsch et al. 2001) and cognitive functioning (Anderson-Hanley et al, 2012; Best, 2011; O’Leary, 2011; Staiano, Abraham, & Calvert, 2012). Other research has shown that playing games that can elicit higher levels of intensity can improve endothelial function (Murphy et al., 2009) and higher math scores (Gao & Mandryk, 2012). Exergames are gaining popularity and clearly have the potential to increase physical activity in youth and
perhaps overtime can be useful tool in attenuating low fitness levels. However, further research is needed to better define the elements, situations, and technology that improve health.

**Limitations**

This study provides useful information on the ability to use the SenseWear Armband for assessing and detecting different activity levels. However, the study has some limitations. Firstly, the population was very homogeneous in age and physical fitness may have been a threat to external validity. Given the small sample size and high inter-individual differences, data cannot be interpreted as representative for all adolescents. Future work on larger samples and longer durations is warranted to assess the accuracy of caloric expenditure in different race groups, across a diverse range of body mass index and in larger groups such as fitness classes.

**CONCLUSION**

The growth of exergaming in schools and at home has provided opportunities for many typically sedentary adolescents to accumulate more physical activity. These non-traditional games are attractive to many adolescents because video games and technology are a big part of their lives. As exergaming becomes more popular and prevalent in homes, the barriers to provide quality opportunities to be physically active decrease.
Table 1

*Single Player Setup*

<table>
<thead>
<tr>
<th></th>
<th>Level</th>
<th>Songs/game, and order (if necessary)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day 1 (15 minutes each game)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xavix Tennis</td>
<td>Exhibition</td>
<td>6 Game Set, B.Lovely (player)</td>
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<tr>
<td>EyeToy Kinetic™</td>
<td>Easy</td>
<td>1. Wildfire, 2. Reflex, 3. Backlash,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Breakspeed, 5. Sidewinder</td>
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<tr>
<td>Dance Dance Revolution</td>
<td>Beginner</td>
<td>1. Say Goodbye, 2. Rock Your Body,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Angellus, 4. Got To Be Real, 5. Le</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Freak, 6. Temperature, 7. Take on Me</td>
</tr>
<tr>
<td><strong>Days 2-4 (up to 60 minutes each game)</strong></td>
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<td></td>
</tr>
<tr>
<td>Xavix Tennis</td>
<td>Exhibition</td>
<td>6 Game Set, any player</td>
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<td>EyeToy Kinetic™</td>
<td>Medium</td>
<td>Cascade, Pulsate, Ricochet, Arcburst,</td>
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<td></td>
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<td></td>
<td></td>
<td>Breakspeed, Sidewinder, Precision,</td>
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<tr>
<td></td>
<td></td>
<td>and Protector (any order or length)</td>
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<td>Dance Dance Revolution</td>
<td>Standard</td>
<td>ANGELUS, Beginning of the End, Can't</td>
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<td>Step, Got To Be Real, LE FREAK, Rock</td>
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<td>Your Body, Say Goodbye, Take On Me,</td>
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<td>Temperature, The Rockafeller Skank,</td>
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<td>The World Around Me, Until Forever,</td>
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<td>Variable</td>
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<td><strong>Descriptive and Anthropometric</strong></td>
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<td>Age (years)</td>
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<td>15.80 (1.69)</td>
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<td>10.30 (1.49)</td>
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<td>Resting</td>
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<td>XVT</td>
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<td>DDR</td>
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<td>113.66 (32.52)</td>
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<td><strong>Calories per minute (CPM) (via HRM)</strong></td>
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<td>XVT</td>
<td>6.80 (2.76)</td>
<td>6.48 (2.15)</td>
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<tr>
<td>ETK</td>
<td>10.15 (3.14)*</td>
<td>9.01 (2.41)</td>
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<tr>
<td>DDR</td>
<td>7.53 (2.61)</td>
<td>7.58 (2.17)</td>
</tr>
<tr>
<td><strong>Calories (via AB)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XVT</td>
<td>117.26 (43.65)</td>
<td>115.50 (46.17)</td>
</tr>
<tr>
<td>ETK</td>
<td>133.85 (31.96)</td>
<td>130.40 (37.75)</td>
</tr>
<tr>
<td>DDR</td>
<td>91.04 (30.97)*</td>
<td>74.00 (14.52)</td>
</tr>
<tr>
<td><strong>Calories per minute (CPM) (via AB)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XVT</td>
<td>7.81 (2.91)</td>
<td>7.70 (3.08)</td>
</tr>
<tr>
<td>ETK</td>
<td>8.92 (2.13)</td>
<td>8.69 (2.52)</td>
</tr>
<tr>
<td>DDR</td>
<td>6.07 (2.07)*</td>
<td>4.93 (0.97)</td>
</tr>
<tr>
<td><strong>Metabolic equivalent (MET) (via AB)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XVT</td>
<td>7.06 (2.08)</td>
<td>7.22 (2.47)</td>
</tr>
<tr>
<td>ETK</td>
<td>8.07 (1.72)*</td>
<td>8.15 (2.14)</td>
</tr>
<tr>
<td></td>
<td>DDR</td>
<td>4.82 (0.66)$^\dagger$</td>
</tr>
<tr>
<td>----------</td>
<td>-------</td>
<td>-----------------------</td>
</tr>
</tbody>
</table>

**Steps per minute (SPM)(via AB)**

<table>
<thead>
<tr>
<th></th>
<th>XVT</th>
<th>ETK</th>
<th>DDR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>24.37 (17.73)*</td>
<td>18.00 (14.07)</td>
<td>28.12 (18.95)</td>
</tr>
<tr>
<td>ETK</td>
<td>45.11 (17.27)</td>
<td>38.50 (8.48)</td>
<td>49.00 (20.02)</td>
</tr>
<tr>
<td>DDR</td>
<td>45.40 (18.10)</td>
<td>49.80 (17.15)</td>
<td>42.82 (18.65)</td>
</tr>
</tbody>
</table>

*Note. AB= SenseWear PRO Arm band, HRM= heart rate monitor, SD = Standard Deviation; XVT=XaviX Tennis; ETK=EyeToy Kinetic; DDR=Dance Dance Revolution; resting HR=heart rate prior to beginning testing, performed while seated; HR=heart rate. * Significantly different from other games $p < 0.05$. $^\dagger$ Significantly different from other gender $p < 0.05$. 
Figure 1

Phase 1: Mean difference between SenseWear PRO2 ArmBand and heart rate monitor for calories per minute (CPM) during XaviX Tennis
Figure 2

Phase 1: Mean difference between SenseWear PRO2 ArmBand and heart rate monitor for calories per minute (CPM) during EyeToy Kinetic
Figure 3
Phase 1: Mean difference between SenseWear PRO2 ArmBand and heart rate monitor for calories per minute (CPM) during Dance Dance Revolution
Table 3  
**Phase 2: Mean (SD) Values For Exercise Intensity (n=23)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>All participants</th>
<th>Females (n=9)</th>
<th>Males (n=14)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time spent playing game (minutes)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XVT</td>
<td>37.35 (14.86)*</td>
<td>35.67 (18.40)</td>
<td>38.43 (12.74)</td>
</tr>
<tr>
<td>ETK</td>
<td>51.48 (12.96)</td>
<td>55.78 (5.72)</td>
<td>48.71 (15.59)</td>
</tr>
<tr>
<td>DDR</td>
<td>50.13 (13.70)</td>
<td>55.79 (5.72)</td>
<td>48.29 (15.19)</td>
</tr>
<tr>
<td><strong>Heart rate (bpm via HRM)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting</td>
<td>73.78 (8.32)</td>
<td>75.89 (5.37)</td>
<td>72.43 (9.72)</td>
</tr>
<tr>
<td>XVT</td>
<td>109.35 (19.23)*</td>
<td>112.89 (10.08)</td>
<td>107.07 (23.31)</td>
</tr>
<tr>
<td>ETK</td>
<td>128.04 (27.51)</td>
<td>144.89 (20.69)</td>
<td>117.21 (26.35)</td>
</tr>
<tr>
<td>DDR</td>
<td>120.83 (21.43)</td>
<td>132.00 (13.93)</td>
<td>113.64 (21.79)</td>
</tr>
<tr>
<td><strong>Calories (via HRM)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XVT</td>
<td>242.11 (185.02)*</td>
<td>194.32 (116.98)</td>
<td>272.84 (216.59)</td>
</tr>
<tr>
<td>ETK</td>
<td>466.53 (228.16)</td>
<td>486.80 (152.88)</td>
<td>453.50 (270.63)</td>
</tr>
<tr>
<td>DDR</td>
<td>406.02 (211.48)</td>
<td>408.07 (142.47)</td>
<td>404.70 (251.37)</td>
</tr>
<tr>
<td><strong>Calories per minute (CPM)(via HRM)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XVT</td>
<td>6.35 (2.92)</td>
<td>5.51 (1.14)†</td>
<td>6.89 (3.59)</td>
</tr>
<tr>
<td>ETK</td>
<td>8.62 (3.28)*</td>
<td>8.94 (2.14)</td>
<td>8.42 (3.90)</td>
</tr>
<tr>
<td>DDR</td>
<td>7.75 (2.73)</td>
<td>7.56 (1.51)</td>
<td>7.88 (3.33)</td>
</tr>
<tr>
<td><strong>Calories (via AB)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XVT</td>
<td>283.82 (171.77)</td>
<td>223.56 (134.58)</td>
<td>325.54 (186.95)</td>
</tr>
<tr>
<td>ETK</td>
<td>335.81 (114.16)</td>
<td>317.00 (58.26)</td>
<td>348.85 (141.75)</td>
</tr>
<tr>
<td>DDR</td>
<td>324.32 (139.95)</td>
<td>305.33 (101.72)</td>
<td>337.46 (164.07)</td>
</tr>
<tr>
<td><strong>Calories per minute (CPM)(via AB)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XVT</td>
<td>7.77 (3.18)</td>
<td>6.51 (1.72)†</td>
<td>8.65 (3.70)</td>
</tr>
<tr>
<td>ETK</td>
<td>6.53 (1.32)</td>
<td>5.70 (0.95)</td>
<td>7.10 (1.26)</td>
</tr>
<tr>
<td>DDR</td>
<td>6.45 (1.81)</td>
<td>5.81 (1.46)</td>
<td>6.89 (1.96)</td>
</tr>
<tr>
<td><strong>Metabolic equivalent (MET)(via AB)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XVT</td>
<td>7.20 (2.17)*</td>
<td>6.33 (1.51)</td>
<td>7.81 (2.40)</td>
</tr>
<tr>
<td>ETK</td>
<td>6.09 (0.93)</td>
<td>5.44 (0.72)</td>
<td>6.53 (0.81)</td>
</tr>
<tr>
<td>DDR</td>
<td>5.91 (1.28)</td>
<td>5.51 (1.26)</td>
<td>6.18 (1.26)</td>
</tr>
<tr>
<td><strong>Steps per minute (SPM)(via AB)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>XVT</td>
<td>ETK</td>
<td>DDR</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>HR</td>
<td>21.11(11.85)*</td>
<td>16.89(7.42)</td>
<td>24.02(13.65)</td>
</tr>
<tr>
<td>HRM</td>
<td>46.94(11.89)</td>
<td>41.52(8.88)</td>
<td>50.68(12.55)</td>
</tr>
<tr>
<td>SD</td>
<td>54.70(17.67)</td>
<td>51.06(18.40)</td>
<td>57.23(17.44)</td>
</tr>
</tbody>
</table>

*Note. AB = SenseWear PRO₂ Armband, HRM = heart rate monitor; SD = Standard Deviation;
XVT=XaviX Tennis; ETK=EyeToy Kinetic; DDR=Dance Dance Revolution; resting HR=heart rate prior to beginning testing performed while seated; HR=heart rate; * Significantly different from other games $p < 0.05$; † Significant difference between genders.*
Phase 2: Measurements of total calories from the SenseWear PRO2 ArmBand (AB) vs. heart rate monitor (HRM) for XaviX Tennis. Note: Dotted line is from linear regression. $p < .001$ for all correlations.
Figure 5

Phase 2: Measurements of total calories from the SenseWear PRO2 ArmBand (AB) vs. heart rate monitor (HRM) for EyeToy Kinetic. Note: Dotted line is from linear regression. $p < .001$ for all correlations.

![EyeToy Kinetic (Phase 2)](image-url)
Figure 6

Phase 2: Measurements of total calories from the SenseWear PRO2 ArmBand (AB) vs. heart rate monitor (HRM) for Dance Dance Revolution. Note: Dotted line is from linear regression. $p < .001$ for all correlations.
Figure 7

Phase 2: Mean difference between SenseWear PRO2 ArmBand and heart rate monitor for calories during XaviX Tennis
Phase 2: Mean difference between SenseWear PRO² ArmBand and heart rate monitor for calories during EyeToy Kinetic
Figure 9

Phase 2: Mean difference between SenseWear PRO2 ArmBand and heart rate monitor for calories during Dance Dance Revolution.


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*Statistical Methods in Medical Research,* 8(2), 135-160.


The motivation of children to play an active video game. *Journal of Science and Medicine in Sport* 11(2), 163-166.


Marks, J., Maloney, A., Bethea, T., Kelsey, K., Rosenberg, A., Paez, S., & Sikich, L. (2005, June...


Chapter 5
Discussion

Given the many studies in the existing literature that cited an overall weak effect (Barnett, Cerin, & Baranowski, 2011; Biddiss & Irwin, 2010; Foley & Maddison, 2010; Peng, Lin, & Crouse, 2011) on moderate to vigorous physical activity (MVPA), this dissertation sought to determine which commercial exergame could elicit high levels of MVPA. In a series of three studies with adolescents playing EyeToy Kinetic (ETK), Dance Dance Revolution (DDR) and XaviX Tennis (XVT), I identified the following: Study 1 – Differences in mean heart rate, percentage of time spent in MVPA, ratings of perceived exertion (RPE), and enjoyment while playing 15 minutes at pre-scripted games options and levels; Study 2 - Differences in mean heart rate, RPE, Motives for Physical Activity – Revised (MPAM-R) (sub-scales: enjoyment, competence, appearance, fitness, social) while playing up to 60 minutes at self-selected game options and levels; and Study 3 – Differences in exercise intensities (calories, calories per minute) measured from heart rate monitors (HRM) and SenseWear Armbands (AB) across the previous two studies.

Study 1 compared the effects of playing three exergames on MVPA, RPE and levels of enjoyment. Using heart rate, ETK elicited the highest mean MVPA and RPE. When heart-rate data was analyzed as a percentage of total time spent in MVPA, participants spent more time in MVPA playing ETK than DDR and XVT. Furthermore, adolescents rated all three exergames; ETK, DDR and XVT, as enjoyable activities. Based on these results, it is possible to conclude that ETK may be a more enticing exergaming alternative and that adolescents may choose certain exergames according to their interest and skill level. These findings are of importance due to the
recent suggestion (Baranowski et al, 2012) that some exergames do not increase physical activity when children are simply provided a Wii console and games without prescribing times or intensities of play. Knowing which games are effective and enjoyable may be the first step when suggesting an exergame to play. The preliminary findings in this study provide evidence that some exergaming systems may be used to meet physical activity levels commensurate with current recommendations and that adolescents enjoy the time spent exergaming. Future studies are warranted to determine if these findings would hold up in experiments with a longer duration of play as well as determining the mediators (game choice and effects of autonomy) of active game play.

Study 2 compared self-selected amount of playing time and levels of moderate to vigorous physical activity (MVPA), perceived exertion, for ETK, DDR, and XVT. Using Self-Determination Theory constructs, the second aim was to determine differences in Motives for Physical Activity Measures – Revised (MPAM-R) across all games. When given up to sixty minutes to play, participants played an average of 36 minutes for each game but played ETK and DDR longer than XVT. ETK produced the highest: mean heart rate, number of minutes spent in vigorous physical activity (VPA), percentage of time in MVPA, and perceived exertion. Despite these higher intensity levels, participants also enjoyed ETK more than the other exergames. The results of this study show that exergames can illicit health-enhancing levels of MVPA and that at higher intensities exergames can still be enjoyable. Given the potential distractionary effects (Abbott et al., 2011; Warburton et al., 2009) of playing exergames at high intensities, we should be careful not to only use RPE to prescribe intensity levels.

Study 3 compared the exercise intensities measured (calories, calories per minute, MET, steps per minute) from heart rate monitors (HRM) and SenseWear Armbands (AB) while playing XVT, ETK, and DDR for fifteen minutes (Phase 1) and then a self-selected period of time not
longer than 60 minutes (Phase 2). For Phase 1, participants burned more calories (HRM) playing ETK than XVT and DDR; however, for calories via AB, participants burned more playing XVT and ETK than DDR. Data from the AB mirrored HRM, where ETK and XVT produced significantly higher MET values than DDR; however, this relationship did not exist for SPM where ETK and DDR were both higher than XVT. In evaluating calories per minute (CPM) via HRM for both Phases, ETK and DDR were played at vigorous intensities while XVT was played at moderate, but nearly vigorous intensity. Low to medium correlations were found between CPM data and only DDR was significantly lower than XVT and ETK in Phase 1. Additionally, Bland and Altman plots show good agreement in the assessment of CPM between HRM and AB. In phase 2 significantly higher mean heart rates and calories via HR and AB were found in ETK compared to XVT but not for DDR. Bland Altman plots indicate good agreements in the assessment of calories between devices. On average, despite higher EE (calories) from HRM compared to AB, measures between devices demonstrated strong agreements as well as a similar direction of the results. The CDC (2008) recommends adolescents to accumulate 500-1000 MET-minutes each day, and Phase 1 participants accumulated approximately 20% of the minimum; and Phase 2 participants accumulated 54-63% of the minimum. Accomplishing these levels in a fun and engaging virtual environment is encouraging as we continue to expose youngsters to novel ways to be more physically active.

To assess effects on overall exertion, some experts recommend using multiple devices to minimize any potential confounders (Freedson & Miller, 2000; Saris, 1985). In schools where using Armbands might be cost prohibitive, combining lower cost devices such as a pedometer and heart-rate monitors or accelerometers has been suggested (Welk, 2002). Besides simply assessing exercise intensity, Physical Education teachers can develop interdisciplinary lesson plans that integrate Common Core Standards for Math, English, and Science using fitness data
from their class. In this manner, Physical Educators could “teach through the physical” and not just the physical skills and concepts (Williams, 1930). Using this holistic approach to learning has been suggested (Kretchmar, 2005) but few programs have truly adopted a “lived-experience” approach to physical education

**Design recommendations and Implications for Practice**

The National Association for Sport and Physical Education (NASPE) advocates quality physical education and physical activity programs that encourage healthy and active lifestyles (2004a). In fact, First Lady Michelle Obama “Let’s Move” campaign draws attention to this same relationship between lifestyle choices and health (2010). According to Self-Determination Theory, if a program or teacher can help foster skill competence/development as well as intrinsic motivation for certain activities, we might be one step closer to improving health and activity levels in youth. To better understand exergaming, and its potential for impact, we must understand as much of the ecosystem, its strengths, weaknesses, and relationships, as possible. One of the critical issues in looking at this ecosystem is the difference between exergaming’s market success and its true overall health impact. An encouraging sign are the many therapists, cognitive scientists, educators that are using or adapting exergaming equipment to suit the needs and abilities of their population (Yang & Foley, 2011). What remains to be seen is whether or not exergaming can be a sustainable force in health, education, wellness, and exercise. That exergaming is a product attached to the “21st century’s fastest growing media form” (Entertainment Software Association, 2010) does not hurt its chances either. Yet despite its rise in popularity, there is much work to be done to see it play a deeper, sustained, and more meaningful role in day-to-day health.

Given today’s overweight epidemic in youth, video game designers should be aware of specific motivational guidelines that may increase the likelihood of youngsters enjoying the
game. As discussed in the previous sections, Self-Determination Theory (SDT) can be a useful theory upon which to design or improve exergames. SDT incorporates having fun, playing with peers, and building skills in order to master the game. Based on SDT motivation principles, the first four guidelines can inform future exergame design while the remaining three recommendations come were generated form user experiences and future development of the genre and health impacts.

Recommendation #1: Since games are a form of play, they should be inherently fun to play.

The game has to be fun, challenging, and different from all the other games to entice someone to buy it. If it is enjoyable to play, people will be intrinsically motivated to continue playing the game. Interactions with industry professionals (EA Sports manager, Nintendo Canada PR executive) have revealed that neither company used children or adolescents to run focus groups or test their games prior to distribution. If youngsters are the target audience, they should be included in the design, development, or evaluation processes. A recent addition to iDANCE version 2 (Positive Gaming - Hillegom, The Netherlands), a multi-player dance platform (explained further in Recommendation 2) is in the teacher/class setting. At the end of a class, each player is required to provide feedback on how they felt (smiley face, neutral face, or sad face) by tapping on their dance pad. By gathering more data on the players (besides game scores), the designers understood how enjoyment influences overall game and exercise experiences. Results from Studies 1 and 2 revealed high levels of enjoyment for both conditions: 15 minutes of pre-scripted game play and up to sixty minutes despite the moderate to vigorous intensity levels.

Recommendation #2: Design challenging game objectives and provide more than one type of feedback to develop player competency.
Exergames should have clear objectives and goals that allow the player to develop confidence-building skills and strategies. As Gee suggests, game objectives should be obtainable and challenging but not impossible (2003). Participants from Study 2 rated competence from EyeToy Kinetic higher than the other games, although the levels were not statistically significant. Despite playing EyeToy Kinetic longer and at a higher intensity, participants received a great deal of feedback from the game (visual and auditory) as well as the immediate and summative point scoring feedback a reason they played as long as they did (more time playing EyeToy Kinetic and Dance Dance Revolution than Xavix Tennis) while 2 indicate slightly. The i

Exergames that allow players to advance incrementally to more difficult levels enhance competence. To further develop feelings of competence, designers should include as much positive performance feedback as possible. Physiological feedback like heart rate might also enhance a player’s level of fun and competence. Exergames should incorporate heart rate monitor support and display player’s heart rates on screen; currently only EA SPORTS (Redwood City, California) Active 2 and EA SPORTS NFL Training Camp have those features. It would be great way to track a player’s exercise profile over time or for specific goals. Two examples of providing immediate feedback to a player’s performance include Positive Gaming’s iDANCE multiplayer dance gaming system. Using a PC to power the company’s own software, the iDANCE system can accommodate up to 32 players simultaneously on wireless pads that provide instantaneous feedback while playing and summative feedback at the end of each song. As pictured in (Figure 5-1), each player receives the percentage of steps accurately performed as well as a histogram of how well timed each step was performed (i.e. early, on-time, late) and overall ranking among those playing at the same song difficulty level.

All games in the current group of studies provided feedback in the form of game summary scores on how well participants did; however, in some EyeToy Kinetic games, if you
get hit by a red ball, your score decreased. All other games accumulated points in the positive direction without penalties. One alteration to the DDR game not mentioned previously, was that negative audio feedback (in the form of “Boos”) which was removed for all participants; however, if a step was missed the negative visual feedback word “Boo” flashed on screen. All positive feedback (audio and visual) was activated for Dance Dance Revolution and was given frequently but not for each step. Several participants mentioned the lack of feedback for XaviX Tennis and knowing if they swung too early or too late while first learning how to play. Those comments did not persist into Phase 2 of the study where they played for extended periods of time. The game that presented the most amount of feedback was EyeToy Kinetic as the entire body can be seen on screen interacting with the game elements. When targets are hit at the right time the game provides visual (bright flashes of colored light) and auditory (exploding objects) feedback and throughout the games there is a virtual personal trainer providing verbal prompts such as “Great job” and “Keep your feet moving”. If the game detects several wrong moves in a row, an on-screen avatar will appear in shadow to lead you through the correct motion or patterns to score well. Once a player’s success rate increases, the virtual trainer disappears. Only EyeToy Kinetic and Dance Dance Revolution had features that allowed a player, with a saved gamer profile, to accumulate fitness data (minutes of play and calories burned) as long as the profile is not deleted on the system of memory card.
Another type of system that is currently available and provides instantaneous feedback while playing is the Activio (Stockholm, Sweden) heart rate monitoring systems. Activio is one of the pioneers in real-time multi-person feedback coupled with online access to your data. Using a chest strap heart rate monitor, each person’s data is wirelessly sent to a USB receiver attached to a computer (See Figure 5-2). Once received on the computer, heart rate data can be projected on the wall, TV screen or monitor so that it can be seen by all participants or just the fitness professional. This data can be tracked online by you and/or your trainer and can only help to provide more information and feedback in regards to performance, training loads, and goal setting.

In the Physical Education setting, managing fitness data over long periods of time - let alone a semester - is frequently not done; however, a monitoring system like Activio’s has great potential to fill that void. If students, teachers, parents, and administrators had long-term fitness and wellness data they would be able to assess curricular changes across those measures. It’s ironic that most school districts rigorously track attendance and grades from Kindergarten
through Grade 12, but few incorporate regular physical activity/fitness/health test scores along with regular subject grades. Unfortunately, only 14 states require fitness testing (National Association for Sport and Physical Education, 2012).

Figure 5-2. Activio real-time heart-rate monitoring system connected to online account

Recommendation #3: Build social networking into the gameplay to foster relatedness.
A game played by one player in isolation will not foster feelings of relatedness to other game players. However, exergames can foster positive social connectedness if games are done together either in person or online. An exergame that fulfills feelings of competence, relatedness, and autonomy will more likely be played for intrinsic reasons. The high levels of competence and enjoyment experienced by participants in Study 2 is encouraging as supported by Staiano, Abraham, & Calvert’s findings that competitive exergame play yielded better executive function scores than cooperative play (2012). Playing games with friends at home or at a LAN party can be a “social lubricant”, an opportunity to get together (Crawford, 1982). A recent addition to video games is the ability to collaborate online with friends and even strangers from anywhere in the world. Collaborating and competing with peers online to workout, play sports, or conquer new kingdoms is a current trend in gaming. In the game Just Dance (Ubisoft, Paris) there is a feature called AutoDance (Figure 5-3) where over a million videos have been uploaded to the web via a mobile phone application (app). Once a dance is recorded and sent to the website, it goes through a series of stop animation sequences which makes the videos very amusing to watch online where they can be viewed and voted upon. In Dance Central 2 (Harmonix Music – Viacom, New York) for Kinect and PS3, the sensors take snapshots of your dancing and these photos can then be shared online. With millions of online gamers, sharing experiences online is definitely a driving force behind the video game industry (Entertainment Software Association, 2010). The need to feel connected to others is an important principle to include into new exergames. Bogost even suggests in order “to incite real, motivated physical activity, exergames will have to do more than just demanding physical gestures that produce latent exercise. In addition, they will have to simulate and create the social rituals that make us want to be physically active, whether alone or with others.” (2006). In the current studies, only ETK allowed you to take a small photograph of yourself that was saved to the memory card if you beat a high score.
Launched in July 2012 on Xbox Live is a free downloadable dashboard application for Xbox LIVE members. Kinect PlayFit will track the time and calories you burn while playing certain exergames like Dance Central 2 and Your Shape Fitness Evolved 2012. It is the first time a major console has integrated fitness tracking across games as previously it only existed within each specific game (e.g. DDR, EA SPORTS Active, and EyeToy Kinetic). Fitness data such as time played and calories burned stayed on the system console and was not automatically logged to a central data location. In Studies 1-3, fitness data could have been tracked on ETK and DDR if each player took time to create separate player profiles; however, this was not done to save time and because ETK could only hold 8 profiles at a time. Soon to be released in conjunction with PlayFit is a heart rate monitor (Joule) that will function with Xbox Kinect’s sensor and gather in game heart rate data, display it on screen, and calculate calories burned for specific games. Using Microsoft’s data sharing platform Xbox Live, fitness and game information (achievements, challenges) will produce leaderboards that will all be visible to all your friends (See Figure 5-4 )
If more developers make fitness data trackable and available to the dashboard - we might be witnessing the start of something incredible as a health application, research tool, and social engagement tracker. Some might say that the gamification of this data is not enough, but it might once they pair the soon to be released Joule Heart rate monitor, mobile phone, and other motion trackers to the Gamer Health Record as predicted by Ben Sawyer at the Games for Health (www.gamesforhealth.org) project. Although this is a step in the right direction, there is limited use of standardized caloric expenditure guidelines, making tracking less reliable and inconsistent. Cuurently, there are two other online exergaming options: 1) Use a CATEYE GameBike (Hudson Fitness, Forney, TX) to play a racing game over Xbox Live (XBL) or the Playstation Network (PSN); 2) Gamerize® (Southampton, UK) is another device that enables players to play any type of game so long as they are moving on a mini-stepper, mini-cycle equipped with a Gamereize® unit. It can be used on any console network (XBL, PSN, Wii) or even PC. This is a new class of
exergaming products that is movement-mediated gaming (MMG) explained further in Recommendation #6.

**Recommendation #4: Allow autonomous decision making by youngsters. Allow them to choose from more than one game and select their own level of difficulty.**

Adolescents love to explore and that theme is central to the constructs of video games (Crawford, 1982). Adventurously exploring different worlds but always coming back home is seen in countless video games. One aspect that is appealing to them is the attainment of power, which adolescence may not have in real life. In Study 2, although autonomy was not part of the Motives for Physical Activity – Revised (MPAM-R), there was a significant difference in self-selected time played when given up to 60 minutes. Players chose to play ETK and DDR longer than XVT; however there were no differences in their levels of enjoyment. Normally they have to listen to their parents, teachers, and older siblings, but in video games, they are in control. An example of self-selected difficulty in a PE setting is best seen in iDANCE as up to three levels of difficulty can be selected. Prior to starting the song, players simply need to press up or down on their own pad to select their desired difficulty level (See Figure 5-5). The education literature cites this feature as teaching by invitation or challenge by choice (Graham, 2008) and is generally recognized as good practice. In the past, games could only be played one way; however, now teams and players can be drafted, traded, or even created and previously impossible match-ups are now commonplace. In *Dance Central 3* (Harmonix Music – Viacom, New York) for Kinect and PS3, the sensors allow users to record their own dance routines so that others can play the way you designed the dance.

A new feature in Microsoft (Redmond, WA) Kinect is the ability to customize your own avatar and with the motion sensors, players are able to have a real-time animated avatar interact with game elements or friends on the Xbox Live network. Besides the motion tracking
capabilities, Microsoft has a Kinect Education division (http://www.microsoft.com/education/en-us/products/Pages/kinect.aspx) that highlights ways in which teachers can harness the technology for their students for both exercise and learning. One particular video highlighted how special education students with autism are using Kinect to improve social and communication skills, and learn to work better in teams through their personalized avatars. Today’s games and controllers can enhance a player’s level of autonomy by allowing them to customize the game environments, characters, or even “be the controller”. A youngster who feels in control has stronger feelings of competence and intrinsic motivation (Deci & Ryan, 1985).

Figure 5-4. Positive Gaming’s three levels of song difficulty to increase autonomy

**Recommendation #5: Monitor exertion levels and build in a feedback loop to game play for extended periods of high intensities**

From the studies that reviewed ratings of perceived exertion (RPE) while exergaming, it seems that people playing exergames either accurately reported or under-reported their levels. In Studies 1 and 2, reports of perceived exertion appear to be lower than expected. For example, the average time spent playing ETK was over 50 minutes at a vigorous intensity levels (8 METs) yet
participants only reported a 4.4 for RPE. Similarly XVT was played for over 30 minutes at 7 METs, and RPE was even lower (2.4). As exergames continue to be more immersive and require true 1:1 movement it would seem reasonable for game designers to monitor exertion from time to time to avoid overexertion. Most current exergames provide reminder prompts to: take a break after 15-20 minutes of continuous play, drink water to replenish fluid loss, or messages to stretch from time to time. Although no known commercial exergames exist that connect either perceived or real exertion levels, several projects have been developed are show strong promise at effectively integrating heart rate data and altering intensity levels (Stach & Graham, 2011; Stach, Graham, Yim, & Rhodes, 2009)

**Recommendation #6: Investigate Movement-Mediated Gaming (MMG)**

Movement-Mediated Gaming (MMG) requires a minimum threshold of physical activity in order to play the game; however, game-play is not related to how fast the players step or pedal. Gamerize® is device that enables players to play any type of game so long as they are moving on a mini-stepper, mini-cycle (See Figure 5-6). This enables gamers to play any software title on any game console or PC, so long as they are moving. Instead of just playing a dance game, any game (along with a traditional game controller) can be used with Gamercize®, which opens up thousands of possible games instead of only a few titles. Once the player stops moving, the game is paused and will not resume until the unit detects movement. Although Gamercize® was not part of these studies; its adoption can impact a player’s sense of autonomy (Self-Determination Theory) as described in Recommendation 4. The biggest weakness of exergames is that typically they’re either based on dancing and rhythm or are similar to full body workouts like cardio kickboxing. In the current studies, up to one third of the time spent playing ETK, was vigorous intensity and those levels cannot be sustained. The high levels of energy expenditure seen in studies 1 and 2 are beneficial to those who play, however, males recorded lower mean heart rates
than females and they often don’t like to dance in front of their peers. Despite the benefits of higher MVPA activities, it is also important to explore activities and exergames that might be of a lighter intensity and can be played for a longer period of time (Lyons, 2011). If a youngster does not enjoy those experiences it would be very hard to convince them to play a game. In contrast, by allowing adolescents to bring their own game (which they already know how to play using a traditional game controller) they would have the opportunity to play as long as they wanted. This is in fact that the reason why the CEO invented it; he wanted a way to get his teenagers more fit while allowing them to play the games they enjoyed playing with their friends. The literature base for this type of gaming is small but children who used Gamercize® during recess accumulated as much physical activity as those who had a typical free-play recess (Michael Duncan & Staples, 2010) and lunch period (M Duncan, Birch, Woodfield, & Hankey, 2012) These findings are encouraging as they help to shed light on different motivational components impacting adoption and retention of a physically active lifestyle.

Figure 5-5. Gamercize® on Family 3-1 Recumbent Cycle
Chapter 6

Conclusion

Participation in physical education on a regular basis for all children has been linked to multiple positive outcomes; therefore it may be an effective strategy in reducing the onset of obesity in elementary school-aged children (Datar, Sturm, & Magnabosco, 2004). In addition, the CDC confirmed that these benefits carry over to academic achievement as well (2010). Time spent in quality physical activity (at moderate to vigorous intensities) is correlated with higher academic achievement in youth. Further, this report supported the notion that regular physical activity through physical education classes or recess is associated with increased concentration and on-tasked behavior. Unfortunately, if there are state mandates for number of minutes of physical education and recess, many schools are substituting one form of physical activity for another rather than providing the recommended amount of both recess and physical education (Slater, Nicholson, Chriqui, Turner, & Chaloupka, 2012). Providing adolescents opportunities to play exergames may engage typically sedentary adolescents in attaining some of the daily-recommended physical activity.

Supporting this new field of game research, the results from these studies demonstrate that exergames can engage adolescents in MVPA that helps maintain cardiovascular health. Recently the President’s Council on Fitness, Sports & Nutrition (2012) recognized exergames as a way to collect physical activity that can go towards their Physical Activity Lifestyle Award (PALA+). In its recent announcement the President’s Council announced that certain companies “will incorporate PALA+ promotional features into some of their most popular active video games to educate video gamers on how they can use technology to get physically active and earn PALA+." This is the biggest endorsement since the 2010-2011 partnership between the AHA and Nintendo which resulted in the Power Of Play Summit in January 2011 (Lieberman et al., 2011).
Given the prevalence and use of computer games in general, and even more recently the levels of regular exergame play (Kari, Makkonen, Moilanen, & Frank, 2012; O’Loughlin, Dugas, Sabiston, & O’Loughlin, 2012; Osorio, Moffat, & Sykes, 2012; Yang, Treece, Miklas, & Graham, 2009), we have a way to leverage video games’ appeal beyond entertainment and more for health and wellness benefits. Exergames can increase physical activity levels and decrease sedentary time, and can be part of the long-term solution of preventing morbidity and mortality from chronic disease. With more opportunities at home, in schools and the community we can lower the barriers to quality opportunities to be physically active in positive and safe environments for youth development.
Citations


Swedish adolescents in whom energy intake was underestimated by 7-d diet records. *American Journal of Clinical Nutrition*, 67(5), 905-911.


Centers for Disease Control and Prevention. (2000). Promoting better health for young people through physical activity and sports. A report to the President from the Secretary of Health and Human Services and the Secretary of Education.


Appendix

IRB Forms, Authorizations, Recruitment Flyers, Consent, Assent, PAR-Q, PHQ, OMNI-RPE, MPAM-R
February 25, 2008

To Whom it May Concern:

I am writing this letter on behalf of Stephen Yang - Assistant Professor of Physical Education at SUNY Cortland. As the Executive Director of the Cortland YMCA, I am supporting his research project "Video GAME" by providing access to our YMCA members and a place to collect data. I look forward to working with Stephen on this very interesting and worthwhile project.

If you have any questions please let me know.

Don Kline
Executive Director
Cortland County Family YMCA
APPLICATION FOR THE USE OF HUMAN PARTICIPANTS

Project Title: Video GAME (Games for Activity and Movement Enjoyment)

1. Purpose and location of this project
The primary purpose of this study is to establish objective physical activity measures of youngsters playing physical activity video games. This study seeks additional data to add to the pilot study conducted for Project GAME (Perm State IRB# 19132 and #23064). The data collection will take place at the Cortland YMCA.

Measured variables will include: (a) minutes of moderate to vigorous physical activity, heart rate, step counts, and energy expenditure as determined by metabolic equivalents; (b) the “stickiness”, which is the length of time youth choose to voluntarily play these video games; and (c) interest, motivation, and attitudes towards playing the video games that require physical activity.

2. Description of project objectives, methods and procedures:
Essentially, we want to describe the type, intensity, and duration of adolescent physical activity while playing video games. These video games require players to use their entire body (or body parts) as the primary game controller instead of a handheld game controller. Many of the games also incorporate music and sports themes, which are appealing to youngsters. We are also interested in exploring the use of video games as a stimulus for voluntary physical activity and to determine if these games fulfill competency, autonomy or relatedness needs based on the self-determination theory (SDT).

Researchers will obtain informed written consent from the youngster’s parents or legal guardians and ask that the Physical Activity Readiness Questionnaire (PAR-Q) (attached) also be signed and returned. As part of the assent process, students will be asked to complete the Personal History Questionnaire (attached) and have their height and weight measured by a researcher.

Then the following steps will occur:
1. Participants will put on heart rate monitor, a SenseWear Armband, and an accelerometer. The researcher will ask the child to put the strap on himself/herself in the locker room. If they are unable to put the monitor on themselves, a same sex researcher or YMCA employee of the same sex will assist the child with putting the strap on.
2. On Day 1, participants will be asked to play three video game (DDR, EyeToy Play or XaviX Tennis) each for 20 minutes to familiarize themselves with the games. On Days 2-4, participants will return and play one of the three games (randomly selected) for up to a sixty (60) minutes. Each day when the participants are finished playing the game(s) all monitors will be removed.
3. Participants will be asked to complete the OMNI Ratings of Perceived Exertion (OMNI-RPE) and the Motives for Physical Activities Measure – Revised (MPAM-R) after playing on Days 2-4.
4. The researcher will then verbally ask the following questions and use a tape recorder to record their responses:
   i. Why did you play the video game as long as you did?
   ii. Why did you stop?
   iii. Which games were your favorites? Why?
   iv. Would take these games home to play if you were allowed? Why?
   v. Would your parents/guardians allow you to play these games? Why?
vi. Do you have any questions or comments for us about the games you played?

3. Number and characteristics of participants:
   
a. List criteria for inclusion of participants:
      • Youth age (13-18)
      • A member of the Cortland YMCA
      • Willingness to participate
      • Availability to participate
   
b. List criteria for exclusion of participants:
      • Answering YES on any items on the PAR-Q.

4. Status & Qualifications of researchers and assistants:
The main researcher is Stephen Yang. All other faculty members and student researchers will only assist in data collection.

Assistant Professors in SUNY Cortland’s Physical Education Department, Stephen Yang (PhD-ABD – Penn State), John Foley, (Ph.D – Oregon State) and Luis Columbia (Texas Women’s) have considerable experience with teaching and research projects and in particular, collection data with children and adolescents. All have experience with physical activity measurement (i.e., pedometers, accelerometers, heart rate monitors), and website applications (i.e., website design and implementation). All undergraduate and graduate students will be trained on CITI, video game and computer equipment.

5. Expected starting date: February 18, 2008 or upon IRB approval
   Expected completion date: February 18, 2009

6. Confidentiality: The participants data will be kept confidential by: (a) excluding their name from the address label, data, and any other identifying information, (b) keeping their data secure and locked in the Physical Activity Research Laboratory at E221 Park Center, and (c) not reporting any information that can personally identify the participants. Names of the participants will be used to track students over the span of the study, and only researchers will have access to them. No names will ever be reported. The data will be kept in a locked file cabinet in the Physical Activity Research Laboratory and conforming to the American Psychological Association guidelines, the data will be kept for at least five years. After five years, the data will be destroyed.

7. Description of potential risks.

   a) What are the potential risks to the participants? Describe all procedures that will cause any degree of discomfort, embarrassment, possible injury, stress, invasion of privacy, harassment, threat to the dignity of participants, or be otherwise potentially harmful to participants.
   Participants will be physically active while playing these games and as a result, heart rates will increase with physical exertion. Participants will play video games instead of participating in other activities such as playing basketball, exercising on the cardiovascular equipment, or weight lifting. At the YMCA, they routinely use cardio, weight equipment, and play various organized sports so our research will not differ largely from their normal activities.

   The monitoring devices that we will use are relatively unobtrusive and all activities will be performed at the Cortland YMCA with employees nearby. In their physical education classes, they routinely wear heart rate monitors and use cardio and weight equipment so our research will not
differ to a great extent from their normal physical activities in physical education. All youth members have gone through a facility orientation and have permission to engage in various physical activities throughout the YMCA.

Because some of the questions will pertain to adolescents’ exercise behaviors, some of the students may be uncomfortable with answering these questions. However, this discomfort is not expected to be any greater than the participants would experience in daily life. In addition, it is clearly stated in the consent and assent forms that the participants are free to DECLINE from answering any of the study questions or stop playing the games at any time.

b) What is the likelihood and seriousness of these risks?
The likelihood and seriousness of these risks are no greater than a typical physical education class; however, it is possible that any of the participants could succumb to any of the risks associated with vigorous activities.

c) Describe how you will minimize or protect participants throughout the project against potential risks.
1) The participants will be recruited from the Cortland YMCA. The YMCA Directors or members of the research team will be available to answer any questions.
2) No identifying information will ever be reported.
3) The participants’ data will be stored in a locked cabinet in Physical Activity Research Laboratory in E221 Park Center and only the research team will have access to the data.
4) Participants can stop at any time while playing the video games.
5) Participants can choose not to answer any question.
6) Pre-screening (PAR-Q)
7) YMCA physical fitness/clearance forms

8. Description of potential benefits
   a. What are the potential benefits to the individual participants and/or society of the proposed research? (If none, state “None.”)
Motivating youth to be physically active is a main concern for parents and educators alike, and given the obesity epidemic, finding alternate strategies that can be done at home are a priority. Participants may be physically active for up to 240 (4 bouts of 60) minutes and will benefit similarly to other physical activities/exercise. More specifically, participants’ heart rates will increase while playing video games they find interesting and enjoyable. Other anticipated benefits are that some adolescents may become aware of their positive health and exercise behaviors, which may positively influence their self-esteem and exercise adherence.

b. If applicable, explain how the benefits outweigh the risks.
Since the risks of participation are no greater than a typical physical education class, it is expected that more adolescents will become aware of the positive benefits of their exercise participation, which may influence them to continue exercising on their own at home.

9. Informed Consent is attached
10. Permission from YMCA is attached
11. Special populations (minors) – assent form is attached
12. Deception is not used in this study
MEMORANDUM

To: Steven Yang
From: Amy Henderson-Harr, IRB Interim Chair
Institutional Review Board
Date: October 16, 2009
RE: Institutional Review Board Approval for Continuation

In accordance with SUNY Cortland’s procedures for human research participant protections, the protocol referenced below has been approved for continuation for an additional year.

Title of the study: Video GAME: Gaming Activities for Movement Enjoyment

<table>
<thead>
<tr>
<th>Level of review: Full</th>
<th>Protocol number: 0708-F22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project start date: Upon IRB approval</td>
<td>Approval expiration date*: 5/16/2010</td>
</tr>
</tbody>
</table>

* Notes: Please include the protocol expiration date to the bottom of your consent form. Yearly continuation information is requested to maintain the protocol among those that are current or in progress.

For information about continuation policies and procedures, visit [http://www.cortland.edu/irb/applications/continuations.html](http://www.cortland.edu/irb/applications/continuations.html)

The federal Office for Research Protections (ORHP) emphasizes that investigators play a crucial role in protecting the rights and welfare of human subjects and are responsible for carrying out sound ethical research consistent with research plans approved by an IRB. Along with meeting the specific requirements of a particular research study, investigators are responsible for ongoing requirements in the conduct of approved research that include, in summary:

- obtaining and documenting informed consent from the participants and/or from a legally authorized representative prior to the individuals’ participation in the research, unless these requirements have been waived by the IRB;
- obtaining prior approval from the IRB for any modifications of (or additions to) the previously approved research; this includes modifications to advertisements and other recruitment materials, changes to the informed consent or child assent, the study design and procedures, addition of research staff or student assistants, etc. (except those alterations necessary to eliminate apparent immediate hazards to subjects, which are then to be reported by email to irb@cortland.edu within three days);
- providing to the IRB prompt reports of any unanticipated problems involving risks to subjects or others;
- applying for continuation requests, consistent with SUNY Cortland Policies and Procedures and federal guidelines, prior to the expiration of this approval, and;
- maintaining records as required by the HHS regulations and NYS State law, for at least three years after completion of the study.

Given the topics and methods of research conducted at SUNY Cortland, investigators frequently possess multiple and possibly conflicting role responsibilities. A principle investigators primary duty is to ensure the protection of research participants during recruitment, participation, and after the study has concluded. In the event that questions or concerns arise about multiple roles or the conduct of research at SUNY Cortland, contact the IRB by email irb@cortland.edu or by telephone at (607) 753-2511. You may also contact a member of the IRB who possesses expertise in your discipline or methodology, visit [http://www.cortland.edu/irb/members.html](http://www.cortland.edu/irb/members.html) to obtain a current list of IRB members.

Sincerely,

Amy Henderson-Harr
Interim IRB Chair

For more information about SUNY Cortland’s Human Participant Protection Program, visit us on the web:
[http://www.cortland.edu/irb](http://www.cortland.edu/irb)

Old Main, Room 134-B ● P.O. Box 2000 ● Cortland, NY 13045
Phone: (607) 753-2079 ● Fax: (607) 753-5437 ● email: irb@cortland.edu
IRB Authorization Agreement
The Pennsylvania State University

Name of Institution providing IRB review (Institution A): State University of New York College at Cortland (SUNY Cortland)

OHRP Federal-wide Assurance (FWA) Number: 00009541

IRB Registration Number: 00004790 SUNY Cortland IRB #1

Name of Institution relying upon IRB review above (Institution B):
The Pennsylvania State University

OHRP Federal-wide Assurance (FWA) Number:
FWA00001534

The Officials signing below agree that Institution B may rely on the designated IRB for review and continuing oversight of its human participant research described below:

Name of Research Project: Video GAME (Games for Activity and Movement Enjoyment)
Principal Investigator(s): Stephen Yang
IRB Protocol Number: 0708F22
Sponsor or Funding Agency: N/A
Award Number, if any: N/A

The review performed by the designated IRB will meet the human participant protection requirements of Institution B’s OHRP-approved FWA. The IRB at Institution A will follow written procedures for reporting its findings and actions to appropriate officials at Institution B. Relevant minutes of IRB meetings will be made available to Institution B upon request. Institution B remains responsible for ensuring compliance with the IRB’s determinations and with the Terms of its OHRP-approved FWA. This document should be kept on file at both institutions and must be provided to OHRP upon request.

Signature of Signatory Official (Institution A): __________________________ Date: October 16, 2009
Print Full Name: Amy Henderson-Harr Institutional Title: Assistant Vice President for Research and Sponsored Programs, Interim IRB Chair

Signature of Signatory Official (Institution B): __________________________ Date: ______________
Print Full Name: Candice A. Yekel, MS, CIM
Institutional Title: Director, Office for Research Protections

Signatory authority granted by Dr. Eva J. Pell, Senior Vice President for Research & Institutional Official, to Ms. Yekel to sign as proxy – via memo dated September 14, 2007.
Volunteers Needed for Video GAME Study

Games for Activity and Movement Enjoyment

Do you want to play

DDR, Eye Toy

&

XaviX Tennis?

If you are interested in learning more about this study, please take an information sheet and a consent form home to be signed and returned.

Please contact Stephen Yang

yangs@cornell.edu or 753-5700
PARENTAL INFORMATION SHEET

RESEARCH STUDY ON VIDEO GAMES & EXERCISE

Dear Parent:

Researchers at SUNY Cortland are asking permission for your child to be in a research study on how much exercise your child does while playing a new type of video game.

During the next month, researchers from SUNY Cortland will be conducting a research study at the Cortland YMCA. The study will measure your child’s heart rate and level of enjoyment while playing video games that require moving instead of just sitting.

With your permission, your child will work on a one-to-one basis with a professor or trained research assistant from the College on four occasions for approximately 90 minutes each time (up to sixty minutes of physical activity). During each session, your child will play fun video games that are not difficult and in most instances the children find them quite enjoyable. The video games are Dance Dance Revolution, EyeToy Play 2, and Xavi Tennis.

Your child’s responses will remain confidential (or anonymous depending on the data collection procedures).

No reports about the study will contain your child’s name. We will not release any information about your child without your permission.

Taking part is voluntary.

Taking part in this research project is voluntary. We will first ask you for your consent and then we will also ask your child to participate. Only children who want to will take part in the study. Your child may choose to stop at any time, without penalty. Deciding not to participate will never affect any services you are receiving at the YMCA.

Participation is voluntary. Refusal to participate will involve no penalty or loss of benefits to which the subject is otherwise entitled, and the subject may discontinue participation at any time without penalty or loss of benefits to which the subject is otherwise entitled.

If you have questions about the study, please contact (Stephen Yang) at SUNY Cortland, phone 753-5700. If you have questions about your rights as a parent or your child’s rights as a volunteer, please contact Leslie Eaton (Phone 753-2079) or E-mail ateaton@cortland.edu, IRB Administrator, SUNY Cortland IRB.

Title of Project: Video GAME (Games for Activity and Movement Enjoyment)

Principal Investigator: Stephen Yang (yangs@cortland.edu)
E253 Park Center – PE Department
SUNY Cortland
753-5700

Video GAME info, consent, assent, PARQ 2006-02-20.doc
PARENTAL CONSENT

Child’s Name __________________________

RESEARCH STUDY ON VIDEO GAMES & EXERCISE

Dear Parent:

Researchers at SUNY Cortland are asking permission for your child to be in a research study on how much exercise your child does while playing a new type of video game. The study will measure your child’s heart rate and level of enjoyment while playing video games that require moving instead of just sitting.

This study has the approval and support of the Cortland YMCA. Your child is eligible to be part of this study because s/he is a member of the Cortland YMCA.

With your permission, your child will work on a one-to-one basis with a professor or trained research assistant from the College on four occasions for approximately 90 minutes each time (up to sixty minutes of physical activity each session). During each session, your child will play fun video games that are not difficult and in most instances the children find them quite enjoyable. The video games are Dance Dance Revolution, EyeToy Play 2, and Xavix Tennis. During all sessions besides the trained researcher, there will also be a YMCA staff member in the main reception area and the door to the reception area will always be open.

While your child is engaged in playing these active video games, they will wear three non-invasive devices that measure their physical activity intensity. The three devices are a heart rate monitor (chest strap worn across the chest), an accelerometer (clipped on to belt or shorts like a pedometer), and an Armband (strap worn across the upper arm like an MP3 music player).

Your child’s responses will remain confidential. The participants data will be kept confidential by: (a) excluding their name from the address label, data, and any other identifying information, (b) keeping their data secure and locked in the Physical Activity Research Laboratory at E221 Park Center, and (c) not reporting any information that can personally identify the participants. Names of the participants will be used to track students over the span of the study, and only researchers will have access to them. No names will ever be reported. The data will be kept in a locked file cabinet in the Physical Activity Research Laboratory and conforming to the American Psychological Association guidelines, the data will be kept for at least five years. After five years, the data will be destroyed.
No reports about the study will contain your child’s name. Information will be reported at the group (all children) level. We will not release any information about your child without your permission.

**Taking part is voluntary.**

Taking part in this research project is voluntary. We will first ask you for your consent and then we will also ask your child to participate. Only children who want to will take part in the study. Your child may choose to stop at any time, without penalty. Deciding not to participate will never affect any services you are receiving at the YMCA.

*Participation is voluntary, refusal to participate will involve no penalty or loss of benefits to which the subject is otherwise entitled, and the subject may discontinue participation at any time without penalty or loss of benefits to which the subject is otherwise entitled.*

If you have questions about the study, please contact (Stephen Yang) at SUNY Cortland, phone 753-5700. If you have questions about your rights as a parent or your child’s rights as a volunteer, please contact Leslie Eaton (Phone 753-2079) or E-mail eatonl@cortland.edu, IRB Administrator, SUNY Cortland IRB.

Below you will find a place to indicate whether or not you agree to have your child be in the study and have him/her return the form to the YMCA. We would greatly appreciate your cooperation in this research.

---

I have read and understand the information provided to me about the research study on active video games by researchers from SUNY Cortland.

---

**For Parent or Legal Guardian – Consent**

This is to certify that I consent to and give permission for my (my child’s) participation as a volunteer in this study. I understand that I will receive a signed copy of this consent form. I have read this form and understand the content of this consent form.

**Parent/Legal Guardian Signature**

**Date**

**Principal Investigator’s Signature**

**Date**

**Title of Project:** Video GAME (Games for Activity and Movement Enjoyment)

**Principal Investigator:**

Stephen Yang (yangs@cortland.edu)

E253 Park Center – PE Department

SUNY Cortland - Phone: 753-5700

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*Video GAME info, consent, assent, PARQ 2009-02-20.doc*
MINOR ASSENT

Child’s Name ____________________________

RESEARCH STUDY ON VIDEO GAMES & EXERCISE

Do you remember the permission slip you took home for your parents to sign a few days ago?

The people with whom I work and I are interested in learning about how much exercise children get while playing active video games (DDR and EyeToy). We are asking you and a lot of other kids to work with us to find out about it. If you agree to do this, I will ask you to wear a heart rate monitor and answer some questions about the games.

This is not a fitness test like you may have in school. All we ask is that you try as hard as you can. At any time you can ask me to stop and you do not have to continue to take the test.

Your parents and the other children will not know how you do. It will be just between you and me and the people with whom I work.

Of course, you don’t have to do this if you don’t want to, even if your parents gave their permission. If you do not want to do this or your parents asked you not to do this, just tell me. It is OK with me if you don’t want to be in the study and no one else will know.

Do you have any questions?

If you agree to do this, I would like you to sign this paper.
For Children Age 13 Years or YOUNGER – Verbal & Written Assent (To be filled out at YMCA)

- I want to participate and my parent/guardian has given me permission to be a part of this study.
- I can stop at any time and nothing will happen to me and I may refuse to answer any question.
- When the researchers are finished with this study they will write a report about what was learned. This report will not include my name or that I was in the study. I can ask any questions about the study at any time or call Stephen Yang (753-5700).

Your Child’s Signature ___________________________ Date ____________
Witness (Not parent or researcher) ___________________________

My signature indicates that the informed consent procedure has been followed.

For Children Age 14 Years or OLDER - Written Assent (To be filled out at YMCA)

- I want to participate and my parent/guardian has given me permission to be a part of this study.
- I can stop at any time and nothing will happen to me and I may refuse to answer any question.
- When the researchers are finished with this study they will write a report about what was learned. This report will not include my name or that I was in the study. I can ask any questions about the study at any time or call Stephen Yang (753-5700).

Your Child’s Signature ___________________________ Date ____________

My signature indicates that the informed consent procedure has been followed.

Principal Investigator’s Signature ___________________________ Date ____________

Title of Project: Video GAME (Games for Activity and Movement Enjoyment)
Principal Investigator: Stephen Yang (yangs@cornell.edu)
E253 Park Center – PE Department
SUNY Cortland
753-5700

Video GAME info, consent, assent, PARQ 2009-02-20.doc
PAR – Q & YOU

Physical Activity Readiness Questionnaire

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active everyday.
Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. The PAR-Q will tell you if you should check with your doctor before you start.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly; check YES or NO.

YES NO

1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?

2. Do you feel pain in your chest when you do physical activity?

3. In the past month, have you had chest pain when you were not doing physical activity?

4. Do you lose your balance because of dizziness or do you ever lose consciousness?

5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?

6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

7. Do you know of any other reason why you should not do physical activity?

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want - as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.

- Find out which community programs are safe and helpful for you.

If you answered

I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

NAME: ____________________________

(please print name)

SIGNATURE: ____________________________ DATE: ____________________________

SIGNATURE OF PARENT or GUARDIAN: ____________________________

Note: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

Video GAME info, consent, assent, PARQ 2006-02-20.doc
# Video GAME Personal History Questionnaire

Thank you for participating in Video GAME (Games for Activity and Movement Enjoyment). Some of the questions may ask about your background. We are asking these questions so that we can describe the type of students involved in this study. We will not use your names when we report the results.

This study is completely voluntary. You can skip any question that you do not wish to answer and you may stop at any time. If you have any questions, please ask me or a member of our research team.

First name (Please print): _______________________________

## Personal History Questionnaire

<table>
<thead>
<tr>
<th>Instructions. Please circle or write the answer that best matches your response to each statement below.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How old are you? 8 9 10 11 12 13 14 15 16 17 18</td>
</tr>
<tr>
<td>2. Are you: MALE FEMALE</td>
</tr>
<tr>
<td>3. What grade are you in? 2nd 3rd 4th 5th 6th 7th 8th 9th 10th 11th 12th</td>
</tr>
<tr>
<td>4. How tall are you? 0 1 2 3 4 5 6 feet 7 8 9 10 11 inches</td>
</tr>
<tr>
<td>5. How much do you weigh? ________ pounds</td>
</tr>
<tr>
<td>6. What is your race/ethnicity? African American Asian Caucasian/White Hispanic/Latino Indian Other</td>
</tr>
<tr>
<td>7. On how many of the past 7 days did you exercise or participate in physical activity for at least 20 minutes that made you sweat and breathe hard, such as basketball, soccer, running, swimming laps, fast bicycling, fast dancing, or similar aerobic activities? 0 1 2 3 4 5 6 7 days</td>
</tr>
<tr>
<td>8. On how many of the past 7 days did you participate in physical activity for at least 30 minutes that did not make you sweat or breathe hard, such as fast walking, slow bicycling, skating, pushing a lawn mower, or mopping floors? 0 1 2 3 4 5 6 7 days</td>
</tr>
<tr>
<td>9. On how many of the past 7 days did you do exercises to strengthen or tone your muscles, such as push-ups, sit-ups, weight lifting? 0 1 2 3 4 5 6 7 days</td>
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<tr>
<td>10) a) Have you ever played Eye Toy before?</td>
</tr>
<tr>
<td>b) If yes, for how long?</td>
</tr>
<tr>
<td>c) If yes, what level would you rate yourself?</td>
</tr>
<tr>
<td>11) a) Have you ever played Eye Toy before?</td>
</tr>
<tr>
<td>b) If yes, for how long?</td>
</tr>
<tr>
<td>c) If yes, what level would you rate yourself?</td>
</tr>
<tr>
<td>12) a) Have you ever played XaviX Tennis before?</td>
</tr>
<tr>
<td>b) If yes, for how long?</td>
</tr>
<tr>
<td>c) If yes, what level would you rate yourself?</td>
</tr>
</tbody>
</table>

For questions 13-24 please use these time guidelines to help you report approximately how many minutes you are engaged in each of the following activities.

**Note:** 60 minutes = 1 hour; 120 minutes = 2 hours; 180 minutes = 3 hours; 240 minutes = 4 hours; 300 minutes = 5 hours; 360 minutes = 6 hours

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<tr>
<td>13) On an average school day, how many minutes do you watch TV (including DVDs, videos, and prerecorded television)?</td>
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<td>14) On an average weekend, how many minutes do you watch TV (including DVDs, videos, and prerecorded television)?</td>
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<td>15) On an average school day, how many minutes do you spend reading books, magazines, or newspapers?</td>
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<tr>
<td>16) On an average weekend, how many minutes do you spend reading books, magazines, or newspapers?</td>
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<tr>
<td>17) On an average school day, how many minutes do you spend using the computer to do things other than play games (surfing the net, IMing, doing homework, etc.)?</td>
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<tr>
<td>18) On an average weekend, how many minutes do you spend using the computer to do things other than play games (surfing the net, IMing, doing homework, etc.)?</td>
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<tr>
<td>19) On an average school day, how many minutes do you spend playing exergames (video and computer games that require you to move) like Dance Dance Revolution, EyeToy, XaviX, Donkey Konga, Wii, or KiloWatt?</td>
<td></td>
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<tr>
<td>20) On an average weekend, how many minutes do you spend playing exergames (video and computer games that require you to move) like Dance Dance Revolution, EyeToy, XaviX, Donkey Konga, Wii, or KiloWatt?</td>
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<tr>
<td>21) On an average school day, how many minutes do you spend playing regular video and computer games (PC games, Xbox/360, PS2/3, GameCube or other game consoles), handheld games, and cell phone games?</td>
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<tr>
<td>22) On an average weekend, how many minutes do you spend playing regular video and computer games (PC games, Xbox/360, PS2/3, GameCube or other game consoles), handheld games, and cell phone games?</td>
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</tbody>
</table>
23) On an average school day, how many minutes do you spend **talking on the phone** (including home phone, cell phone, and text messaging)?

24) On an average **weekend**, how many minutes do you spend **talking on the phone** (including home phone, cell phone, and text messaging)?

<table>
<thead>
<tr>
<th>Please circle Yes or No for the following questions.</th>
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<tbody>
<tr>
<td>25) Are there family rules about how many hours you spend doing the following:</td>
</tr>
<tr>
<td>a. Watching TV</td>
</tr>
<tr>
<td>b. Reading</td>
</tr>
<tr>
<td>c. Using the computer</td>
</tr>
<tr>
<td>d. Playing exergames</td>
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<tr>
<td>e. Playing video games</td>
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<tr>
<td>f. Talking on phone</td>
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</tbody>
</table>

*Personal History Questionnaire - 01/2008*
Video GAME
Games for Activity and Movement Enjoyment OMNI RPE
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</thead>
<tbody>
<tr>
<td>1</td>
<td>not at all true for me</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7 very true for me</td>
</tr>
</tbody>
</table>

__1. Because I want to be physically fit.____

__2. Because it’s fun.____

__3. Because I like engaging in activities which physically challenge me.____

__4. Because I want to obtain new skills.____

__5. Because I want to look or maintain weight so I look better.____

__6. Because I want to be with my friends.____

__7. Because I like to do this activity.____

__8. Because I want to improve existing skills.____

__9. Because I like the challenge.____

__10. Because I want to define my muscles so I look better.____

__11. Because it makes me happy.____

__12. Because I want to keep up my current skill level.____

__13. Because I want to have more energy____

__14. Because I like activities which are physically challenging.____
<table>
<thead>
<tr>
<th></th>
<th>not at all true for me</th>
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<th>very true for me</th>
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<tbody>
<tr>
<td>15.</td>
<td>Because I like to be with others who are interested in this activity.</td>
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<td>16.</td>
<td>Because I want to improve my cardiovascular fitness.</td>
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<td>17.</td>
<td>Because I want to improve my appearance.</td>
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<td>18.</td>
<td>Because I think it’s interesting.</td>
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<td>19.</td>
<td>Because I want to maintain my physical strength to live a healthy life.</td>
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<td>20.</td>
<td>Because I want to be attractive to others.</td>
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<td>22.</td>
<td>Because I enjoy this activity.</td>
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<td>23.</td>
<td>Because I want to maintain my physical health and well-being.</td>
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<td>24.</td>
<td>Because I want to improve my body shape.</td>
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<td>25.</td>
<td>Because I want to get better at my activity.</td>
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<td>26.</td>
<td>Because I find this activity stimulating.</td>
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<td>27.</td>
<td>Because I will feel physically unattractive if I don’t.</td>
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<td>28.</td>
<td>Because my friends want me to.</td>
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<td>29.</td>
<td>Because I like the excitement of participation.</td>
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<tr>
<td>30.</td>
<td>Because I enjoy spending time with others doing this activity.</td>
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</table>
VITA
Stephen Peter Yang

Stephen P. Yang is an adjunct faculty at the State University of New York College at Cortland (SUNY Cortland) and he researches the effectiveness of using exergames/active games for healthy benefits. The state of exergaming is a relatively new area of interest for researchers; however, Yang has been active in the field since its infancy and has published several papers and abstracts and presented posters and workshops both internationally and nationally. He’s been invited to speak at the: Game Developers Conference, Journal of Health Promotion Conference, NCTI Technology Innovators Conference, Indiana University, American Heart Association/Nintendo Summit (The Power of Play: Innovations in Getting Active), two events in Seoul, South Korea for the Korean Serious Games Festival and Continua Alliance Fall Meeting and was invited to speak at the World Health Care Congress Middle East in Abu Dhabi. Another group he works closely with is the Games for Health (GFH) Project (www.gamesforhealth.org) which is part of the Serious Games Initiative and is sponsored by the Robert Wood Johnson Foundation. He also consults with video game developers, toy companies, and exergame companies on products and services for several populations. In recognition of his knowledge and expertise, he was recently appointed to the Board of Advisors of Exergame Fitness, is a founding member of the ExerGame Network (TEN), and has been interviewed on for: national television news network (Good Morning America Health), national online news (Reuters and U.S. News & World Report), morning television (Fox 45 Baltimore), internet radio (Into Tomorrow with Dave Graveline), national newspaper (USA Today), online magazine (Chicago Tribune), print magazine (Oprah Magazine and Today’s Dietician), and video. Throughout all his research and collaborations, Yang wishes to see how exergames and technology can be used to inspire people of all ages and abilities to be active and healthy for a lifetime. As he investigates how to best use the latest exergames and gaming technologies and he keeps the exergaming world up to date on http://www.exergamelab.org.