GENERATION Y PHYSICAL ACTIVITY:
THE PHYSIOLOGIC EFFECTS OF EXERGAMING

A Thesis by

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GENERATION Y PHYSICAL ACTIVITY:
THE PHYSIOLOGIC EFFECTS OF EXERGAMING

The following faculty members have examined the final copy of this thesis for form and content, and recommend that it be accepted in partial fulfillment of the requirement for the degree of Master of Science, with a major in Exercise Science

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DEDICATION

This is dedicated to all those who strive to end childhood obesity
ACKNOWLEDGEMENTS

There are many people who have supported me through this journey, and I owe my gratitude to them.

Thank you to the students of Cooper Elementary School. You are truly more than just my inspiration for this study. Thank you to Dr. Patterson for your guidance and support through my graduate studies and helping me become a better teacher for my students. Thank you to Mr. Craig Wilford and USD 260, Mr. Vince Evans and Paul B. Cooper Elementary School, and to Mrs. Andi Icenhour and Prime Time for allowing me to conduct my study with the children. Thank you to my thesis committee members for their time, and a special thanks to Dr. Parham for helping me understand all the data I collected during my exergaming sessions. Lastly, thank you to my family and friends, especially my dad, mom, and sister, for their love and support during this process.
ABSTRACT

Childhood obesity is on the rise, and many critics claim that environmental factors, such as screen-based media, are a contributing factor to this epidemic. Video games have gained popularity among this age group, especially exergames, which have researchers pondering the physiological effects of playing exergames. The purpose of this study is to examine the differences in heart rate achieved and maximum heart rate achieved between three exergaming systems, and to analyze the intensity level achieved while playing exergames. Twenty males and females ages 8-12 were in this study. Participants were allowed three sessions to become familiarized with equipment and were allowed to play three game systems: (1) Nintendo Wii, (2) Dance Dance Revolution (DDR), (3) Xbox Kinect. Heart rate monitors were worn on the wrist by each participant and were used to record heart rates during six exergaming sessions. Participants played one type of exergaming system for 30 minutes each session, collecting heart rate seven times. Heart rate data were compared to baseline measures, between the three-exergaming systems, and to heart rate thresholds of 50 percent and 70 percent of maximum heart rate. Repeated Measures ANOVA did not show significance for heart rate achieved and heart rate ranges achieved ($p=0.563$, $p=0.738$ respectively). Sixty-four percent of participants achieved heart rates that ranged between set thresholds of 50 percent and 75 percent on all three exergaming systems. Thus, exergaming can be used as physical activity to supplement other forms of physical activity.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHAPTER ONE</strong></td>
<td></td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>1</td>
</tr>
<tr>
<td>1.1 Purpose</td>
<td>2</td>
</tr>
<tr>
<td>1.2 Significance of Study</td>
<td>2</td>
</tr>
<tr>
<td>1.3 Variables</td>
<td>3</td>
</tr>
<tr>
<td>1.3.1 Independent Variable</td>
<td>3</td>
</tr>
<tr>
<td>1.3.2 Dependent Variable</td>
<td>3</td>
</tr>
<tr>
<td>1.4 Hypothesis</td>
<td>3</td>
</tr>
<tr>
<td>1.5 Definitions</td>
<td>3</td>
</tr>
<tr>
<td>1.6 Assumptions</td>
<td>4</td>
</tr>
<tr>
<td>1.7 Limitations</td>
<td>4</td>
</tr>
<tr>
<td>1.8 Delimitations</td>
<td>6</td>
</tr>
<tr>
<td><strong>CHAPTER TWO</strong></td>
<td></td>
</tr>
<tr>
<td>REVIEW OF LITERATURE</td>
<td>7</td>
</tr>
<tr>
<td>2.1.1 What is obesity?</td>
<td>7</td>
</tr>
<tr>
<td>2.1.2 Incidence and Prevalence of Obesity</td>
<td>7</td>
</tr>
<tr>
<td>2.1.3 Childhood Obesity</td>
<td>8</td>
</tr>
<tr>
<td>2.1.4 Determinants and Risk Factors of Childhood Obesity</td>
<td>9</td>
</tr>
<tr>
<td>2.2.1 Definition of Physical Activity</td>
<td>10</td>
</tr>
<tr>
<td>2.2.2 Benefits of Physical Activity</td>
<td>11</td>
</tr>
<tr>
<td>2.2.3 Risk Factors of Physical Inactivity</td>
<td>11</td>
</tr>
<tr>
<td>2.2.4 Physical Activity in Public Schools</td>
<td>11</td>
</tr>
<tr>
<td>2.2.5 National Recommendations and Guidelines for Children</td>
<td>13</td>
</tr>
<tr>
<td>2.2.6 Exercise Programming for Children</td>
<td>13</td>
</tr>
<tr>
<td>2.3.1 Screen Based Media</td>
<td>14</td>
</tr>
<tr>
<td>2.3.2 Evolution of Exergaming</td>
<td>15</td>
</tr>
<tr>
<td>2.3.3 Physiological Affects of Exergaming</td>
<td>15</td>
</tr>
<tr>
<td><strong>CHAPTER THREE</strong></td>
<td></td>
</tr>
<tr>
<td>METHODS</td>
<td>17</td>
</tr>
<tr>
<td>3.1 Participants</td>
<td>17</td>
</tr>
<tr>
<td>3.2 Procedures</td>
<td>18</td>
</tr>
<tr>
<td>3.2.1 Instrumental Measures</td>
<td>18</td>
</tr>
<tr>
<td>3.2.2 Exergaming Sessions</td>
<td>19</td>
</tr>
<tr>
<td>3.2.3 Setting</td>
<td>21</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS (continued)

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3 Data Analysis</td>
<td>21</td>
</tr>
<tr>
<td>3.4 Summary of Variables</td>
<td>22</td>
</tr>
<tr>
<td>CHAPTER FOUR</td>
<td></td>
</tr>
<tr>
<td>RESULTS</td>
<td></td>
</tr>
<tr>
<td>4.1 Overview</td>
<td>23</td>
</tr>
<tr>
<td>4.2 Research Question</td>
<td>24</td>
</tr>
<tr>
<td>4.2.1 Heart Rate Achieved Playing Three Exergaming Systems</td>
<td>24</td>
</tr>
<tr>
<td>4.2.2 Intensity Level of Exergaming Systems</td>
<td>25</td>
</tr>
<tr>
<td>CHAPTER FIVE</td>
<td></td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>29</td>
</tr>
<tr>
<td>5.1 Overview</td>
<td>29</td>
</tr>
<tr>
<td>5.1.1 Exergaming Systems</td>
<td>33</td>
</tr>
<tr>
<td>5.1.2 Physical Activity Intensity Levels of Exergaming System</td>
<td>34</td>
</tr>
<tr>
<td>5.1.3 Practical Implications</td>
<td>35</td>
</tr>
<tr>
<td>5.1.4 Limitations</td>
<td>37</td>
</tr>
<tr>
<td>5.2 Future research</td>
<td>38</td>
</tr>
<tr>
<td>5.3 Conclusion</td>
<td>39</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>40</td>
</tr>
<tr>
<td>APPENDIXES</td>
<td>48</td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Participants Descriptive Data</td>
<td>17</td>
</tr>
<tr>
<td>2 Heart Rate Achieved Playing Exergames</td>
<td>25</td>
</tr>
<tr>
<td>3 Mean Heart Rates Achieved Reflective of Heart Rate Thresholds of 50 and 75 percent</td>
<td>27</td>
</tr>
<tr>
<td>4 Percentage of Participants’ Mean Heart Rate Achieved in Moderate-Intensity Zone</td>
<td>27</td>
</tr>
<tr>
<td>5 Maximum Heart Rates Achieved Reflecting Heart Rate Thresholds of 50 and 75 percent</td>
<td>28</td>
</tr>
<tr>
<td>6 Percentage of Participants’ Max Heart Rate Achieved in Moderate-Intensity Zone</td>
<td>28</td>
</tr>
<tr>
<td>7 Exergaming With Children Literature Review</td>
<td>30</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Summary of Methods</td>
<td>22</td>
</tr>
</tbody>
</table>

x
CHAPTER 1
INTRODUCTION

Obesity's rise to epidemic status began in the early twentieth century. Over the last ten years, obesity has doubled for US adults. According to the National Health and Nutrition Examination Survey (NHANES), 33.8% of survey participants had a body mass index (BMI) greater than or equal to 30 kg/m\(^2\), 14.3 percent of participants had a BMI of 35 kg/m\(^2\), and 5.7 percent of participants had a BMI of 40 kg/m\(^2\) or more (Flegal, Carroll, Ogden, & Curtin, 2010). Early studies looking at adding sugar and fat to the usual diets of poor children became an important approach to reduce malnutrition challenges that faced the United States during the 1900s (Caballero, 2007). The ramifications of this practice were being seen within the first half this century.

Approximately 17 percent of the children and teenage population in the United States are affected by obesity (Ogden, Carroll, Curtin, Lamb, & Flegal, 2010). The prevalence of obesity has increased since the 1970s (Flegal, et al., 2010). From 1980 to 2008, the percentage of obese children aged 6-19 had tripled, and an increase in preschool aged children (2-5 years) has been observed over the last 20 years (Centers for Disease Control, 2011b).

Cardiovascular risk factors develop as a result of obesity in children, as well as adults. These risks include hypertension and high cholesterol (Serdula, Ivery, Coats, Freedman, Williamson, & Byers, 1993). Freedman (2007) and colleagues found that 70 percent of obese children had at least one additional cardiovascular risk factor. This study also found that 30 percent of obese children had two or more cardiovascular risks. Additionally, children with high BMIs are likely to become obese adults (Wright, Pepe, Seidel, & Dietz, 1997). Along with this
comes the increased risk for diabetes (Bell, Mayer, Beyer, D’Agostino, Lawrence, & Linder, 2009) and heart disease (Odgen, et al., 2010b).

Studies have shown that when children are involved with daily physical activity, performed repetitively, improve cardiovascular function and reduce body fat (US Department of Health and Human Services, 2005). In recent years pervasive solutions for weight management and tailored physical activity for children are gaining relevance in both the scientific and in the public education community. One new approach has been due to technology advancements in electronics and computer sciences. In particular, new gaming technology and devices with active motion sensors have presented innovative methods to encourage physical activity among tech-savvy children that are typically sedentary. These systems have been referred to as ‘exergaming’.

Recently these exergaming systems have been proposed for use in wellness and physical activity centers to promote exercise. In the present study, exergaming systems are described and used with young children as part of an after school program to determine if this is a viable method of promoting physical activity.

**Statement of the Problem**

**1.1 Purpose**

The purpose of this study was to observe differences in heart rate between three exergaming systems, and to also compare maximum heart rate achieved to activity intensity levels.

**1.2 Significance of the Study**

This is the first study to assess heart rate using Nintendo Wii, DDR, and Xbox Kinect in children 8-12 years of age. This study is also one of the few to examine activity intensity
levels of exergaming. This study is also unique because it was conducted in the field setting rather than a laboratory setting.

1.3 Variables

1.3.1 INDEPENDENT VARIABLES

The independent variables in this study were exergaming systems.

1.3.2 DEPENDENT VARIABLES

The dependent variable in this study was heart rate.

1.4 Hypothesis

Hypothesis 1:

It was hypothesized that exergaming will increase heart rate above resting values.

Hypothesis 2:

It was hypothesized that exergaming will increase heart rate above 50 percent of the participants’ predicted maximum heart rate.

1.5 Definitions

1. **Physical activity**: any bodily movement produced by the contraction of skeletal muscles that results in a substantial increase over resting energy expenditure (American College, 2010; Caspersen, Powell, & Christenson, 1985; President’s Council, 2000; World Health Organization, 2012)

2. **Rest**: Five minutes of rest (Graves, Stratton, Ridgers, Cable, 2007), sitting with their back at a 90-degree angle.

3. **Moderate intensity**: 50 percent to 70 percent of maximal heart rate (Duncan & Staples, 2010) (Ridgers, Stratton, Clark, Fairclough, & Richardson, 2006)
4. **Exergaming**: A type of video gaming system that allows the players to control their character on the screen. Another name for exergaming is active video gaming.

5. **Nintendo Wii**: Exergaming system using a hand held remote controller.

6. **DDR**: Exergaming system using a remote controlled by the players feet.

7. **Xbox Kinect**: Exergaming system that is controlled using a combination of arms and legs using a motion sensor.

1.6 Assumptions

In order for the experimental design to be valid the author accepted the following assumptions.

1. It was assumed that subjects had prior experience with video games.

2. It was assumed that subjects and guardians were truthful regarding the participants’ health, and the participants were healthy to participate in physical activity.

3. It was assumed that the Accusplit EAGLE 920HRM Heart Rate Monitors were correctly and accurately in working order, per the manufacturer instructions.

4. It was assumed that each individual participated to the best of his or her ability giving an accurate reading of heart rate.

1.7 Limitations

The author recognizes the limitations to this study design and will briefly discuss them in this section.

1. The participants were limited to children participating in the after school program at Cooper Elementary School. This may not be a representation of other populations.
2. The time for each session was the last 45 minutes of the after school program. This presented the problem of participants exiting the session early and not completing the data collection.

3. Although similar to several studies, the sample size was still small. This limited the statistical analysis.

4. Physiologically, children respond differently to exercise than adults. The guidelines for moderate-intensity heart rate ranges used in this study were developed for everyone. It has been suggested that higher intensity is required for the development of cardiorespiratory fitness in children (Wolfe, 2005).

5. Three different dance-themed games were chosen for participants to play on each system. It is difficult to compare the heart rates of three different types of games, which may question the validity of the findings.

6. Participants were allowed to choose songs from the list included with each game. The beats per minute and intensity of each song will vary, which may impact the validity of results.

7. Heart rate was compared between three different types of exergaming systems. Results from similar studies comparing different type of exergaming system may not yield like findings.

8. Although heart rate monitors are an accepted method for reporting energy expenditure, the participants self-measured and self-reported their heart rates for each session. This could impact the validity of the results.

9. Participants may or may not play Nintendo Wii, DDR, and/or Xbox Kinect at home. This may impact the validity of results.
1.8 Delimitations

This study design includes four delimitations, which may impact the validity of results.

1. The individuals involved in this study are between the ages of 8 and 12 years.
2. The exergames played in this study are dance themed games
3. No more than twenty participants were included in this study
4. Heart rate was the chosen method to report energy expenditure.
CHAPTER 2
REVIEW OF LITERATURE

2.1.1 WHAT IS OBESITY?

Life insurance companies observed the association between excess body weight and premature deaths when they began using body weight to determine premiums in the 1930s (Caballero, 2007). Shortly thereafter, President Eisenhower created the Council on Fitness and Health in the 1950s to promote physical activity in the American population (Cabellero, 2007). The end of the first half of the twentieth century brought the first definition of obesity: "excess of body adiposity" (Cabellero, 2007). During the 1980s, obesity was further defined, for both men and women, as having a body mass index (BMI) greater than 30 (Cabellero, 2007). BMI is calculated as a person’s weight divided by the square of a person’s height, using the metric units kg/m² (American College, 2010). The World Health Organization recognized obesity as a disease in 1997 (World Health Organization, 2000) and Medicare formally recognized obesity as a disease in 2004 (Roehr, 2004).

2.1.2 INCIDENCE AND PREVALENCE OF OBESITY

Approximately 73 million American adults are obese, and six percent of these adults have a BMI of 40 kg/m² or higher (Flegal, et al., 2010). The literature states that 3.2 million deaths are attributed to obesity each year (World Health Organization, 2012), and the medical costs associated with obesity were estimated at 147 billion dollars; this attributes to nine percent of all medical costs (Finkelstein, Trogdon, Cohen, & Dietz, 2009). The prevalence of obesity for adult men and women increased from 13.4 percent in 1980 to 34.3 percent in 2008 (Flegal, et al., 2010; Ogden, et al., 2010b). The NHANES also found that non-Hispanic blacks had the highest rate of obesity (Flegal, et al., 2010).
Several researchers have found that the increase in prevalence in the United States is similar to those in other countries (Stamatakis, Primatesta, Chinn, Rona, & Falascheti, 2005). Popkin et al (2004) found that an increase in obesity is occurring in developing countries such as Mexico, China, and Thailand. Sixty-five percent of the world’s population lives in countries where obesity or overweight kills more people than underweight (World Health Organization, 2011).

2.1.3 CHILDHOOD OBESITY

Obesity is not just a disease that impacts adults. In that last twenty years, obesity has tripled in children (Ogden & Carroll, 2010a) and affects approximately 12.5 million children and teens in the United States (Ogden, et al., 2010b). Obesity impacts all children, especially minority children. In 2009, 29 percent of African American teenagers were obese, 17.5 percent Hispanics were obese, and 14.5 percent of white teenagers were obese (Differences, 2009). Greater disparities have been observed in black girls and Hispanic boys; black girls are significantly more likely to be obese than white girls, and Hispanic boys had a higher prevalence of obesity than white boys. Regardless of ethnicity or sex, there has been an increase in obesity among children and adolescents (Ogden & Carroll, 2010a).

Body mass index (BMI) is also used to define childhood obesity. BMI is a number calculated using a person’s height and weight, and can be a fairly reliable tool for measuring body fat. BMI does not measure fat directly, but research has shown that it correlates directly to direct measures of body fat, such as underwater weighing (CDC 2011e). For children, the Center for Disease Control and Prevention (CDC) 2000 Growth Charts are used to determine BMI-for-age. BMI in children is calculated using their height and weight. A child’s BMI is then graphed, reflecting the child’s age and gender. A child whose BMI is in the 85th percentile is considered
overweight; a child whose BMI is in the 95th percentile is considered obese (Kuczmarski, Ogden, Guo, Gummer-Strawn, Flegal, Mei, Wei, Curtin, Roche, & Johnson, 2002). The primary difference in BMI values in adults versus children is that in adults the results are used as a diagnostic tool to categorize obesity and in children it is used for screening purposes and determining potential risks. In children, BMI is used as a screening tool to identify possible weight problems and can be used as early as two years old (Kuczmarski, et al., 2002).

2.1.4 DETERMINANTS AND RISK FACTORS OF OBESITY

There are several determinants of obesity. Some researchers have linked the pathology of obesity to genetics and/or metabolism (Moll, Burns, & Laure, 1991; West, Goudey-Lefevre, York, & Truett, 1994; Stunkard, Foch, & Hrubec, 1986). Other researchers have shown connections to modifiable behaviors, including consuming excess calories, physical inactivity, environment (US Department of Health and Human Services, 2010), and culture (Ritenbaugh, 1982).

The role the environment plays in today’s youth has increased the interests of many researchers. Van der Horst, et al. reviewed 58 papers that focused on sociocultural and economical-environmental factors at the household level associated with obesity-related dietary behaviors among youth. These behaviors included energy, fat, fruit/vegetable, snack/fast food, and soft drink intake. The most consistent associations were found between parental intake and children’s fat, fruit/vegetable intakes, parent and sibling intake with adolescent’s energy and fat intakes, and parental education with adolescent’s fruit/vegetable intake. A positive association was found for availability and accessibility on children’s fruit/vegetable intake (2007). Another review by Campbell and Crawford also examined the family food environmental determinates and preschool-aged children. This review showed that children’s eating behaviors are influenced
by parental food preferences and beliefs, children’s food exposure, role modeling, media exposure, and child-parent interactions around food (2001).

Socioeconomic status (SES) has also been found to play a role in obesity. Sobal and Stunkard reviewed 144 studies regarding the relationship between SES and obesity. Their review found that a strong direct relationship exists between SES and obesity among men, women, and children (1989). A more recent review conducted by Monteio et al. looked at studies conducted in adult populations from developing countries. The researchers concluded that obesity affects groups with a low SES, and that the shift of obesity toward women of low SES occurs earlier than it does for men (2004).

The risk factors associated with obesity include high blood pressure, high cholesterol, type II diabetes, coronary heart disease, stroke, gallbladder disease, osteoarthritis, sleep apnea, respiratory problems, and several types of cancers including endometrial, breast, prostate, and colon (World Health Organization, 2000). Obese children are also at risk for insulin resistance, abnormal glucose tolerance, and diabetes (Nathan & Moran 2008). One study reported that three-fourths of obese children have type-2 diabetes (Bell, et al., 2009), and the National Diabetes Fact Sheet found that rates for type-2 diabetes is greater in youth aged 10-19 (Centers for Disease Control, 2011d).

2.2.1 DEFINITION OF PHYSICAL ACTIVITY

Physical activity is defined as any bodily movement produced by the contraction of skeletal muscles that result in a substantial increase over resting energy expenditure (ACSM, 2010; Caspersen, Powell, & Christenson, 1985; President’s Council, 2000; World Health Organization, 2012). Moderate-intensity physical activities are activities that noticeably increase breathing, sweating, and heart rate. Vigorous-intensity physical activities are those that
substantially increase breathing, sweating, and heart rate (CDC, 2011a). The Centers for Disease Control and Prevention (2011a) also define moderate-intensity activity as heart rate ranging 50 percent to 70 percent of a person’s maximum heart rate, and a vigorous-intensity activity as heart rate ranging 71 percent to 85 percent of a person’s maximum heart rate.

2.2.2. BENEFITS OF PHYSICAL ACTIVITY

Many benefits are associated with physical activity. Overall, physical activity (PA) increases a person’s chances of living longer (Paffenbarger, Hyde, Wing, Lee, Jung, & Kampert, 1993; Lee & Skerrett, 2001). More specifically, PA can help control weight and strengthen bones and muscles. It can also reduce the risk for many diseases, including heart disease and certain types of cancer (Serdula, et al., 1993; Taylor, Brow, Ebrahim, 2004; Thune & Furger, 2001). PA can improve mental health, including relieving symptoms of depression and anxiety (US Department of Health, 1996). Even some researchers have also found that PA has a positive influence on academics (Centers for Disease Control and Prevention, 2010). Clearly, the benefits of physical activity can produce vast improvements for a person’s overall health.

2.2.3 RISK FACTORS OF PHYSICAL INACTIVITY

Physical inactivity has been identified as the 4th leading risk factor for global mortality (World Health Organization, 2012). The World Health Organization reported in 2002 that 60 to 85 percent of people in the world lead a sedentary lifestyle. This lack of physical activity increases all mortality (Lee & Paffenbarger, 2001) and it increases a person’s risk of cardiovascular diseases, diabetes, and obesity (Raitakan, Porkka, Taimela, Telama, Rasanen, Vilkari, 1994). Physical inactivity also increases the risks of colon cancer, high blood pressure, osteoporosis, lipid disorders, depression, and anxiety (World Health Organization, 2002).

2.2.4 PHYSICAL ACTIVITY IN THE PUBLIC SCHOOLS
National Association for Sport and Physical Education (NASPE) recommends that school-age children accumulate at least 60 minutes of PA every day and should avoid prolonged periods of inactivity (NASPE, 2012b). NASPE also recommends that schools provide 150 minutes of instructional PE for elementary-age students, and 225 minutes for middle school/high school students (NASPE, 2012a). In addition to this, the Surgeon General has also recommended that recess be offered at least once a day, for at least 20 minutes, for all elementary students (US Department of Health and Human Services, 2010). No federal law requires physical education to be provided to students in American schools, and many school districts are responsible for implementing the state-defined guidelines and set requirements for physical education and physical activity in schools (NASPE, American Heart Association, 2010). Currently, 43 states have set mandates for elementary physical education, 40 for middle school, and 46 in high school. This is an increase from 2006 data (NASPE, American Heart Association, 2010).

The No Child Left Behind Act of 2001 placed higher demands on public schools. Many of these provisions required schools to ensure that all students had the opportunity to a high, quality education, and that these students become proficient in the areas of math and reading. To meet these demands, many public schools had to reduce or cut programs, and many of the nation’s schools cut or eliminate recess and physical education programs (Public Law 107-110, 2002).

In 2007, 29.4 percent of Kansas’s residents were considered obese. This number has risen steadily since 1992. Thirty-one percent of Kansas’s children are overweight or obese; this is similar to the US percentage. The prevalence of childhood obesity in Kansas has risen since 2003 (2007 National Survey).
2.2.5 NATIONAL RECOMMENDATIONS AND GUIDELINES FOR CHILDREN

The American Academy of Pediatrics, NASPE, American Heart Association, U.S. Department of Health and Human Services, President’s Council of Physical Fitness and Sport, and the Centers for Disease Control and Prevention all support the need for PA for youth (Patrick, Spear, Holt, & Sofka, 2001; NASPE, American Heart Association, 2010; US Department of Health and Human Services, 2005; US Department of Health and Human Services, 2010; Presidents Council; Centers for Disease Control, 2011c). Sixty minutes of moderate-intensity to vigorous-intensity physical activity is recommended for children (Center for Disease Control, 2011c; US Department of Health and Human Services, 2010; NASPE, American Heart Association, 2010; US Department of Health and Human Services, 2005; Presidents Council). The Centers for Disease Control and Prevention (CDC) also recommends children participate in muscular and bone strengthening activities three days per week (Centers for Disease Control and Prevention, 2011c).

2.2.6 EXERCISE PROGRAMING FOR CHILDREN

Special consideration needs to be given when developing an exercise program for children as a result of growth and immaturity of their physiologic regulatory systems at rest and during exercise. Physiologically, children respond to exercise differently when compared to adults. Children will have a higher heart rate and respiratory rate, but a lower cardiac output during exercise. The commonly used indicator of cardiorespiratory capacity is maximal oxygen uptake (VO₂ max), but peak oxygen uptake is the recommended indicator to measure endurance capacity in children (Saltareeli, 2009).

FITNESSGRAM is recommended to assess the components of health-related fitness in youth (Saltareeli, 2009). The components assessed include aerobic capacity, muscular strength,
endurance, and flexibility, and body composition. Aerobic capacity assessments for
FITNESSGRAM include the PACER, one-mile run/walk, and walk test (13 or older). The
PACER test is the recommended assessment by FITNESSGRAM. Muscular strength,
endurance, and flexibility assessments include abdominal strength and endurance (i.e. curl-up),
trunk extensor strength and endurance (i.e. trunk lift), upper body strength and endurance (i.e.
push-ups, and flexibility (i.e. back saver sit and reach). Body composition is assessed by percent
body fat (tricep and calf skinfolds), or by body mass index (calculated from height and weight)
(FITNESGRAM 2010).

To establish the minimal amount of physical activity needed to achieve the various
components of health-related fitness, the following are guidelines for children and adolescents
(ACSM, 2010):

- **Frequency**: at least 3-4 days per week, preferably daily
- **Intensity**: Moderate to vigorous intensity
- **Time**: 30 minutes per day of moderate-and 30 minutes of vigorous-intensity activities: 60
  minutes of accumulated physical activity
- **Type**: a variety of activities that is developmentally appropriate and enjoyable

2.3.1 SCREEN BASED MEDIA

Screen-based media is considered to be one contributing factor to a sedentary lifestyle.
According to a study conducted by the Kaiser Family Foundation (Rideout, Foehr, & Roberts,
2010), media use among 8- to 18- year-olds has steadily increased since 1999. This age group
spends 7 ½ hours using media each day. On average, participants had 3.8 TVs, 2.3 console
video games players, and 2 computers.
Participants in this study reported playing video games for one hour and thirteen minutes per day. African American participants reported the greatest amount of time spent playing video games in a typical day (0:45 minutes), and participants of parents with an education level of high school or less reported the greatest amount of time spent playing in a typical day (0:36 minutes). Eighty-seven percent of participants have a video game console in the home, and 49 percent of all video game playing takes place on consoles hooked-up to a T.V. Thirty-six percent of participants own an exergaming system (Nintendo Wii, Xbox, Sony PlayStation, etc.), and 64 percent of participants play exergaming games.

2.3.2 EVOLUTION OF EXERGAMING

Video gaming has, over the last 10 years, developed into what is called exergaming. Many systems are available on the market today, and several have managed to gain popularity in a less active society. Exergaming has changed the way many look at video games in today’s society, and this type of gaming is sparking a new wave of PA in all generations. Many studies have found and support the physiological benefits of active video games, and several studies have examined the results in children/adolescents and adults.

2.3.3 PHYSIOLOGIC IMPACT OF EXERGAMING

Several studies have shown exergaming increase energy expenditure [EE] and HR when compared to resting values (Graves, et al., 2007; Lanningham-Foster, Jensen, Foster, Redmond, Walker, & Heinz, 2006; Barkley & Penko, 2009; Graves, Ridgers, & Stratton, 2008; Haddock, et al., 2008; White, Schofield, Kildding, 2011; Perron, Graham, Feldman, Moffett, Hall, & 2011) and other studies have also found that there was an increase when compared to other types of media [i.e. sedentary video games] (Maddison, Mhurchu, Jull, Jiang, Prapavessis, & Rodgers, 2007; Graves, et.al., 2007; Straker, & Abbott, 2007; Graves, Ridgers, Stratton, 2008; Graves,
When compared to traditional forms of exercise, exergaming is comparable to walking on a treadmill (Barkley & Penko, 2009; Graf, et al., 2008), and exergaming activities fall within the recommended intensity levels (Siegel, et al., 2009; Sell, Lillie, & Taylor, 2008; Tan, Aziz, Chue, & Teh, 2002; Unnithan, Houser, & Fernhall, 2006; Perron, et al., 2011). Contrary, some studies have found that energy expenditure is lower than walking (Graves, et al., 2010; Graves, et al., 2007; Duncan, Birch, Woodfield, & Hankey, 2011) and that exergaming falls below the recommended intensity (Graves, et al., 2007; Graves et al, 2010; Duncan & Staples, 2010; White, Schofield, & Kilding, 2011).
CHAPTER 3

METHODS

3.1. PARTICIPANTS

Participants were recruited from an after school program held at Paul B. Cooper Elementary School in Wichita, KS. The participants included males and females of varying ethnicities. English consent forms (appendix A) were issued to the students 7-14 days prior to testing. No participant was allowed to participate without a signed consent and waivers were not accepted in lieu of a signed consent form. Once a parent or guardian gave consent, the researcher explained procedures and risks with the participants, and then participants signed an assent form (appendix B). Twenty-one participants were recruited for this study. Eleven participants were female, 10 were male. The mean age for participants was 8.9 years. Mean height for participants was 53.4 inches, weight was 86.8 pounds, and body mass index was 21 lb/in². Table 1 summarizes participant descriptive data. Body mass index (BMI) was calculated using the following formula: Weight (lbs.) / Height (in)² * 703. This formula was used for both boys and girls (CDC, 2011e)

TABLE 1

PARTICIPANTS DESCRIPTIVE DATA

<table>
<thead>
<tr>
<th>Code</th>
<th>Age</th>
<th>Ethnicity</th>
<th>M/F</th>
<th>Height (in)</th>
<th>Weight (lbs.)</th>
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<td>F</td>
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<td>Hispanic</td>
<td>M</td>
<td>47</td>
<td>57</td>
<td></td>
</tr>
</tbody>
</table>

3.2 PROCEDURES

3.2.1 INSTRUMENTAL MEASURES

Heart rate was calculated using an Accusplit EAGLE 920HRM Heart Rate Monitor (Accusplit, Inc). This heart rate monitor is designed to measure heart rate through a sensor in the watch. The heart rate, in beats per minute, is displayed on the receiver/watch face. To measure heart rate, the individual places two fingers on the sensors located on the face of the watch, and the heart rate displays in the digital window within seconds.

One exergaming system used in the present study is the Nintendo Wii. This type of exergame uses a wireless remote control that has a sensor located at the top end of the remote. The remote detects movement and then sends a signal to the sensor bar that is located by the television. This signal then is computed to move the character on the screen, simulating the player’s movement.

Another exergaming system used in the present study is DDR. This type of exergame uses a platform or mat to control the game. Up, down, right and left arrows are on the mat and
used to control the game. The player steps on the arrow the mat that corresponds with the arrow on the screen. The more accurate the player is with matching the arrows, the more points he or she scores.

The third exergaming system used is the Xbox Kinect. This exergame uses a motion sensor, which sits near the television. The motion sensor has a camera placed in the middle of the bar to sense movement from the player. The system then computes the movement to allow the character on the screen to mimic the movements of the player.

The type of game played on each system was a dance themed game. Just Dance for Kids was played on the Nintendo Wii, Dance Dance Revolution Extreme was played on the DDR, and Dance Central was played on the Xbox Kinect. All three games were played using the easiest game mode, and the beats per minute for songs varied within the game and also between gaming systems.

3.2.2 EXERGAMING SESSIONS

Participants completed three sessions of orientation and six sessions of exergaming. Each participant was randomly assigned, using the random function from Microsoft Excel, to an exergaming group. Each group was assigned an exergaming system, and the groups rotated between the three systems. Each group was able to use each system twice. The game played on each exergaming system was a dance themed game. Nintendo Wii had four controllers, the DDR had two controllers, and the Xbox Kinect allowed one participant to control the game.

The first orientation session was designed to give participants an opportunity to familiarize themselves with the exergaming systems. The researcher explained each system to participants, including procedures for playing each system (appendix C). Participants were placed in groups and were given 10 minutes to play each gaming systems. The second
orientation session was designed to give participants an opportunity to continue play with the exergaming systems and to familiarize themselves with the heart rate monitors. Prior to playing the games, the researcher demonstrated to participants how to use the heart rate monitor. This included how to wear the monitor, how to take resting heart rate, and how to check for heart rate. Participants were then fitted for a heart monitor to ensure correct fit, encouraged to take a resting heart rate, and then were allowed to use the monitor while playing the games. Participants were instructed to check heart rate after each round of play, and were reminded to check heart rate by the researcher throughout the session. The third orientation session was designed to give participants an opportunity to continue using the exergaming systems and the heart rate monitors. This session was also designed to familiarize participants with the heart rate logs. The heart rate logs (appendix D) were used to record heart rates taken during play. Participants were instructed to record heart rate seven times during play, and they were to record after each song. The researcher demonstrated to participants how to record data, and the participants were given the rest of the session to practice using the logs.

Prior to each session, the researcher set up the gaming systems according to manufactures instructions and safety guidelines. These gaming systems were in separate locations in the facility. Participants began each session by collecting a heart rate monitor, heart rate log, and a pencil. Participants were instructed to sit as a group and place heart rate monitors on their wrist and to write in the necessary information on their heart rate log. The researcher assisted students with this part of the session. Once all participants completed these tasks, they were then asked to sit, limiting their movements as much as possible, for a five-minute rest period. At the completion of the period, students recorded their resting heart rate and then their groups were assigned an exergaming station. During the exergaming portion of the sessions, participants
played their assigned system. Participants were allowed to choose songs from a game generated list. Participants also rotated within their group so that everyone had an opportunity to control the game. The researcher monitored each group and assisted when necessary. The researcher also used words to encourage participants to do their best and reminded participants to record heart rate. Figure 1 summarizes the methods used in the present study.

3.2.3 SETTING

The current study was conducted in the field setting. The assessment facility was the gymnasium of the elementary school. The researcher utilized a ceiling mounted projector and screen for one exergaming system, and two televisions for the other two gaming systems. Each system was set up approximately 10 feet from the other to ensure safety and space between the groups. The gaming systems were set up according the manufacturing guidelines, and the researcher also added numbered spots on the floor for participants.

3.3 DATA ANALYSIS

The seven hearts used from each exergaming session were averaged to find a mean heart rate achieved. Maximum heart rate achieved was determined by determining the maximum heart rates for each exergaming system. The statistical package IBM® SPSS® Statistic version 19 was used for all analysis. A Repeated Measures ANOVA and Paired Sample T-tests used to compute differences in heart rate to find significance between heart rate achieved, heart rate ranges achieved exergaming systems.
3.4 SUMMARY OF METHODS

FIGURE 1

Week 1:
Parental Consent

Week 2
Introduction and
Participant Assent

Week 3
Orientation session
1/exergaming
systems

Week 4
Orientation
Session 2/Heart
Rate Monitors

Week 5
Orientation Session
3/ Heart Rate Log
and Group
Assignments

1 subject
Drop out

Group 1
6 Participants

Group 2
7 Participants

Group 3
7 Participants

6 weeks of exergaming,
switching systems each
week

End of 6-
weeks/data
collections
CHAPTER 4
RESULTS

4.1 OVERVIEW

The present study recruited 21 participants. One participant dropped out of the study due to attendance. From the 20 remaining participants, 11 collected data for all three systems. The remaining nine participants collected data for one or two different systems. These nine participants were unable to collect data due to absence from sessions, leaving the session early, or the heart rate monitors. The heart rate monitors posed a problem with data collection. The batteries of the heart rate monitors stopped working, and many participants were unable to collect data during the sessions. Participant compliance with procedures also posed problems with collecting data. Participants were explained procedures at the beginning of the study and reinforced throughout the sessions. However, with one researcher and three separate groups it became a challenge to monitor each group equally during the 30-minute session.

Predicted age maximum heart rate was calculated by subtracting the participants’ age from 220. Mean heart rate achieved was calculated by averaging the heart rates recorded during the two sessions (a maximum of 14 heart rates) for each exergaming system. Maximum heart rate achieved was determined by using the maximum heart rate achieved during the 2 sessions (greatest HR achieved out of a maximum of 14 HR) for each exergaming system. Mean Heart Rate ranges were calculated by using the mean heart rate achieved for each system, divided by the participant’s maximum heart rate, then multiplied by 100 to express the number as a percent.
4.2  RESEARCH QUESTION

4.2.1 HEART RATE ACHIEVED WHILE PLAYING THREE EXERGAMING SYSTEMS

Hypothesis 1:

It is hypothesized that exergaming will increase heart rate above resting values.

Tables 2 shows the differences in resting heart rate, mean heart rate achieved during the 30 minutes session, and the maximum heart rate achieved for Nintendo Wii, DDR, and Xbox Kinect. The Nintendo Wii had a 29 percent increase from resting heart rate to mean heart rate achieved, and a 79 percent increase from resting to maximum heart rate achieved. The DDR system had a 20 percent increase from resting heart rate to mean heart rate achieved, and a 69 percent increase from resting to maximum heart rate achieved. Lastly, the Xbox Kinect had a 28 percent increase from resting heart rate to mean heart rate achieved, and a 70 percent increase from resting to maximum heart rate achieved. These results support hypothesis one; there was an increase above resting values.

A Repeated Measures ANOVA was used to determine significance in heart rate between the three-exergaming systems, and the analysis showed that there was not a significant difference in mean heart rates between the three systems ($p=0.563$). When comparing two systems at a time, (Nintendo Wii vs. DDR, DDR vs. Xbox Kinect, Nintendo Wii vs. Xbox Kinect) the analysis did not indicate a significant difference in mean heart rate achieved ($p=0.018$, $p=0.330$, $p=0.072$, respectively). However, when comparing the Nintendo Wii to the DDR, the analysis showed that the DDR produced a mean heart rate that was approximately 9 more beats per minute than the Nintendo Wii. Gender, weight, and age did not significantly affect heart rate.
4.2.2 INTENSITY LEVEL OF EXERGAMING SYSTEMS

Hypothesis 2:

It is hypothesized that exergaming will increase heart rate above 50 percent of the participants’ predicted maximum heart rate.

Mean heart rate achieved during the 30 minutes of play and maximum heart rate achieved during the 30 minutes of play were both used to analyze the intensity level for each participant. Table 5 shows that the mean heart rates for participants using all three systems. Almost all participants’ heart rates fall within the heart rate thresholds of 50 percent and 70 percent. Table 7 for maximum heart rate shows similar results. These results support hypothesis 3; heart rates achieved playing exergaming increased above 50 percent of participants predicted maximum heart rate.
Table 6 and 8 reflects the percent of participants that fell within these two thresholds. Eighty-seven percent participants achieved the moderate-intensity threshold playing Xbox Kinect, 84 percent of participants achieved the moderate-intensity threshold playing DDR, and 64 percent of participants achieved the moderate-intensity threshold playing Nintendo Wii using heart rate means. Eighty-threess percent of participants achieved the moderate-intensity threshold playing Xbox Kinect, 75 percent achieved the moderate-intensity threshold playing Nintendo Wii, and 68 percent of participants achieved the moderate-intensity threshold playing DDR using heart rate max. These results support hypothesis two.

A Repeated Measures ANOVA was used to determine significance in heart rate ranges achieved by each participant, and the analysis did not indicate a significant difference in mean heart rate ranges achieved by group interaction ($p = 0.738$). When comparing two systems at a time, (Nintendo Wii vs. DDR, DDR vs. Xbox Kinect, Nintendo Wii vs. Xbox Kinect) the analysis did not indicate a significant difference in mean heart rate ranges achieved ($p = 0.073$, $p = 0.484$, $p = 0.676$, respectively). Gender, weight, and age did not significantly affect heart rate ranges.
TABLE 3

Mean Heart Rate Achieved Reflective of Heart Rate Thresholds of 50 and 70 percent

![Graph showing heart rate data for various game platforms.]

TABLE 4

Percentage of Participants' Mean Heart Rate Achieved in Moderate-Intensity Zone

![Bar chart showing percentage of participants in moderate-intensity game zones.]

- Percent of Participants in Moderate-Intensity Zone
TABLE 5

Maximum Heart Rate Achieved Reflective of Heart Rate Thresholds of 50 and 70 Percent

TABLE 6

Percentage of Participants' Maximum Heart Rate Achieved in Moderate Intensity Zone

<table>
<thead>
<tr>
<th></th>
<th>Percent %</th>
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<tbody>
<tr>
<td>Nintendo Wii</td>
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<td>DDR</td>
<td>68.42</td>
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<tr>
<td>Xbox Kinect</td>
<td>83.33</td>
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</table>

Percent of Participants in Moderate Intensity Zone
CHAPTER 5

DISCUSSION

5.1 OVERVIEW

The purpose of this study was to observe differences in heart rate between three exergaming systems, and to also compare heart rate achieved to activity intensity levels. Numerous studies have shown the effects or influences exergaming has on physical activity and/or inactivity. A search through PubMed showed that there are 878 previous studies using exergaming, active video games, and the two popular gaming systems. Of those 878 exergaming studies, 90 discussed its relevance to physical activity or physical inactivity. Many different populations have been studied using the exergaming systems. The present study used children ages 8-12. Of the 878 exergaming studies, only 88 studies used children as their population. Many different methods of assessment were used to obtain physiologic effects of exergaming. The present study used HR. Of the 878 exergaming studies, 157 studies observed exergaming, children, and heart rate. Thirteen studies used Nintendo Wii only, eight used DDR only, and 104 used a combination of both Nintendo Wii and DDR. To the author’s knowledge, this is the only study to use the Xbox Kinect. This is also one of the few studies that were conducted in the field setting versus a laboratory setting.

This discussion will look at the two hypotheses formed: increase above resting values and the physical activity intensity level while playing the gaming. Fourteen studies were reviewed, and table 7 summarizes the methods and results of each study.
<table>
<thead>
<tr>
<th>Year</th>
<th>Author</th>
<th>Population</th>
<th>Game Type</th>
<th>Measures</th>
<th>Results</th>
</tr>
</thead>
<tbody>
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<td>2001</td>
<td>Ridley, et al.</td>
<td>10 males/females Mean age=12.5 years</td>
<td>Arcade games</td>
<td>VO2 Heart Rate</td>
<td>↑ Increase above RH?</td>
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<tr>
<td></td>
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<td>Accelerometer counts</td>
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<td>Heart rate=112-169 bpm</td>
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<td>Accelerometer counts= 0-1.3 counts.min</td>
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<td>2002</td>
<td>Tan, et al.</td>
<td>40 males/females Mean age= 17.5 years</td>
<td>DDR</td>
<td>VO2 Heart Rate</td>
<td>↑ Increase above RH?</td>
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<td>EE 480 watts</td>
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<td>2006</td>
<td>Lanningham-Foster, et al</td>
<td>25 children, ages 8-12</td>
<td>Sony EyeToy DDR</td>
<td>VO2</td>
<td>↑ Increase above RH</td>
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<td>EE=13.6-17.26 kJ.h⁻¹.kg⁻¹</td>
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<td>Unnithan, et al.</td>
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<td>DDR</td>
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<td>↑ Increase above RH</td>
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<td>EE=2.9-4.6 kcal.min⁻¹</td>
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<td></td>
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<td></td>
<td>Heart Rate=126-127 bpm</td>
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<td>2007</td>
<td>Graves, et al.</td>
<td>11 (5 girls 6 boys) Age 13-15</td>
<td>Nintendo Wii</td>
<td>IDEEA Counts</td>
<td>↑ Increase above RH</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>EE= 190.6-202.5 kJ.kg⁻¹.min⁻¹</td>
</tr>
<tr>
<td>2007</td>
<td>Maddison, et al.</td>
<td>21 males/females Age 10-14</td>
<td>Sony EyeToy</td>
<td>VO2 Heart Rate</td>
<td>↑ Increase above RH</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>Accelerometer</td>
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<td>HR= 110-142 bpm</td>
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<td></td>
<td></td>
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<td>Accelerometer counts= 122.9-2,132 steps.min⁻¹</td>
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<tr>
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<td>Authors, et al.</td>
<td>Participants</td>
<td>Devices</td>
<td>Variables</td>
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<td>---------</td>
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<tr>
<td>2007</td>
<td>Straker, et al.</td>
<td>20 males/females, Age 10-14 years</td>
<td>Sony EyeToy</td>
<td>VO₂, Heart Rate</td>
<td>EE= 0.127 kcal.min⁻¹.kg⁻¹, Heart Rate=130</td>
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<td>Graves, et al.</td>
<td>13 males/females, Age 11-17 years</td>
<td>Nintendo Wii</td>
<td>VO₂ EE, Heart Rate</td>
<td>↑ Increase above RH, VO₂= 0.55-0.82 l.min⁻¹, EE= 182.1-267.2 J.kg⁻¹.min⁻¹, HR= 103.2-136.7 bpm</td>
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<td>2008</td>
<td>Haddock, et al.</td>
<td>23 males/females, Age 7-14 BMI 85th percentile or above</td>
<td>Jackie Chan Studio Fitness</td>
<td>EE</td>
<td>↑ Increase above RH, EE= 14.03± 3.54 ml.kg⁻¹.min⁻¹</td>
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<tr>
<td>2008</td>
<td>Mellecker, et al. (9)</td>
<td>18 males/females, Age 6-12 years</td>
<td>XaviX</td>
<td>VO₂, Heart Rate</td>
<td>↑ Significant Increase above RH, EE=1.89-5.23 kcal.min⁻¹, HR=102-160 bpm</td>
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<tr>
<td>2009</td>
<td>Graf, et al.</td>
<td>23 males/females, Ages 10-13</td>
<td>DDR Nintendo Wii</td>
<td>EE, HR</td>
<td>↑ Increase above RH, EE= 7.7-15.8 mL.kg.min, HR= 98-140 bpm</td>
</tr>
<tr>
<td>2011</td>
<td>Perron, et al.</td>
<td>30 males/females, Age 9.4 ± 1.8 years</td>
<td>Nintendo Wii Fit, Nintendo Wii EA Sports Active</td>
<td>HR Monitor and Nintendo Wii Fit</td>
<td>↑ Increase above RH, HR= 118.0-162.4, Nintendo Wii EA Sports Active, ↑ Increase above RH, HR= 130.4-170.8</td>
</tr>
</tbody>
</table>
## TABLE 7 (CONTINUED)

<table>
<thead>
<tr>
<th>Year</th>
<th>Authors</th>
<th>Participants</th>
<th>Activities</th>
<th>Heart Rate</th>
<th>Energy Expenditure</th>
<th>Increase above RH</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>White, et al</td>
<td>26 males age 11.4 ± 0.8 years</td>
<td>Nintendo Wii Spots Nintendo Wii Fit</td>
<td>Heart Rate Energy Expenditure VO₂</td>
<td>♦ Increase above RH</td>
<td>HR=106-140 b.min⁻¹ EE= 230-411 J.kg⁻¹.min⁻¹ VO₂= 11.3-20.2 ml.kg⁻¹.min⁻¹</td>
</tr>
</tbody>
</table>

Abbreviations Key: EE= Energy Expenditure, HR= Heart Rate, DDR=Dance Dance Revolution
5.1.1 EXERGAMING SYSTEMS

This study has focused on the effects exergaming has on a child’s heart rate. We have found that all three systems increased heart rate above rest. The results of this study support the results of previous studies.

Supporting published research has observed this same increase in heart rate above resting values when playing exergames. (Ridley & Olds, 2001; Maddison, et al., 2007; Straker & Abbot, 2007; Mellecker, et al., 2008). Ridley & Olds used arcade exergames to assess heart rate (2001). Maddison, et al. (2007) and Straker et al. (2007) used the Sony EyeToy to assess HR. Lastly, Mellecker et al. (2008) used XaviX to assess HR. Although these are different exergaming systems than the systems used in the present study, the results of these studies are consistent to the results of the present study.

The results of the current study are also comparable to many other recent studies using specifically the Nintendo Wii and/or DDR exergame systems (Tan, et al., 2002; Unnithan, et al., 2006; Graves, et al., 2008; Graf et al., 2009; Graves, et al., 2010). Tan, et al. (2002) and Unnithan et al. (2006) found that HR increased above resting values using the DDR exergaming system. Graves, et al. (2008; 2010) and White, et al. (2011), also found that HR increased above resting values using the Nintendo Wii exergaming system. Graf, et al. used both the DDR and the Nintendo Wii to assess HR achieved and found that both systems increased HR above resting values (2010).

Perron, et al. studied a population similar to the population used in this study. Participants in this study were 9.4 years of age, and included both males and females. Participants in this study played two different types of Nintendo Wii games, Nintendo Wii Fit and Nintendo EA Sports. For both games played, heart rate was increased above resting values
The results of this study are parallel to the findings of the current study. However, this study was conducted in a laboratory setting, and the current study was conducted in the field setting.

5.1.2 PHYSICAL ACTIVITY INTENSITY LEVELS OF EXERGAMING SYSTEM

This study has focused on the physical intensity of exergaming. The current study has found that exergaming does produce HR that is 50 percent of the participants’ age predicted maximum heart rate, and that exergaming produces HR that fall within the moderate-intensity level. When playing all three systems, more than 50 percent of the participants’ mean and maximum HR achieved fell within the moderate intensity level. This supports the results of previous studies (Tan, et al., 2002) (Unnithan, et al., 2006) (Perron, et al., 2011).

Tan et al. defined moderate intensity as 60 percent of maximum HR. When playing DDR, participants’ heart rate was 70 percent of maximum heart rate (2002). The result of this study meets the guidelines suggested and are similar to the results in the current study. However, the mean age of participants in this study was 17.5 years, which are not comparable to the participants in the present study.

Unnithan et al. used 55 percent to 65 percent of maximum HR to define moderate intensity. The average HR maintained while playing DDR was 65 percent, which falls within the range defined for moderate intensity (2006). These results are similar to the results of the current. However, the participants in this study were 11-17 years of age, which is not parallel to the participants in the current study.

Perron, et al., also used 50 percent to 70 percent of maximum HR to define moderate-intensity. The researchers found that both exergames increased HR into the moderate-intensity level, and that these games meet the requirements for children (2011). The participants and the
results of this study are similar to the current study. Again, the setting for Perron, et al. study was in a laboratory, and the current study was conducted in the field setting.

Duncan & Staples conducted a study that looked at the time spent in moderate-vigorous intensity levels. Moderate-intensity was defined as 50 percent to 70 percent of heart rate reserve. Participants in this study included children ages 10-11 years, both males and females. The participants were then assigned to the intervention or control groups. The intervention group played Nintendo Wii Sports during their school lunch break for six weeks, and the control group participated in regular recess. The analysis found that children in the exergaming intervention group spent a significantly lower percentage of time in moderate-vigorous intensity levels when compared to the control group. The findings of this field study are supported by the findings of another study (Duncan, et al., 2011). Nevertheless, exergaming in this study produced HR that did increase into the moderate-intensity levels, but the HR achieved playing exergames was not sustained over a period of time. The current study also found that HR achieved playing exergames did increase into the moderate-intensity level, and these results support the findings in Duncan & Staples. However, the current study did not assess time spent in the moderate-intensity level nor use heart rate reserve.

5.1.3 PRACTICAL IMPLICATIONS

The results of this study support the use of exergaming with children. The results show that exergaming does increase heart rate above rest and in most cases into the moderate-intensity level, which is the minimum requirement to achieve health benefits (Lee & Skerrett, 2001; Paffenbarger, et al., 1993). Exergaming is enjoyable and is an appropriate game for children (Graves, et al., 2010).
The protocol used in this study is also suitable in children this age. Several studies have used heart rate monitors (Ridley & Olds, 2001; Tan, et al., 2002; Unnithan, et al., 2006; Maddison, et al., 2007; Straker, et al., 2007; Graves et al., 2008; Mellecker, et al., 2008; Graf, et al., 2009; Perron, et al., 2011; White, et al., 2011), and have proved to be an appropriate way to measure heart rate in children. This is especially useful in the field settings.

Exergaming is also appropriate for young adults. Adults are recommended to engage in 30 minutes of at least moderate intensity physical activity everyday (Graves et al., 2010). As with children, enjoyment of activities is a major determinant influencing the time a person devotes to activity (Graves, Ridgers, Williams, Stratton, Atkinson, & Cable, 2010), and repetitive activities can lead to boredom (Geiwitz, 1966). Many games supported by each of the systems offer sport and dance, and Graves et al. found that young adults enjoyed playing exergames when compared to walking on a treadmill and handheld inactive gaming (Graves, et al., 2010). Many studies have found that exergaming does increase energy expenditure in young adults (Sell, Lillie, & Taylor, 2008; Barkley & Penko, 2009; Siegle, Haddock, Dubois, & Wilkin, 2009).

Exergaming is a beneficial tool for the aging population. Research has shown that light-to-moderate intensity activity provides health benefits in older adults (Graves, et al., 2010). Graves (2010) found that exergaming was a moderate intensity activity for older adults. The study also cited that exergaming (Wii Fit) will reduce their risk for all-cause mortality, cardiovascular disease, and type-2 diabetes. Graves also found that older adults enjoyed the balance exergames the most. Exergaming can be an enjoyable tool that could help improve balance and minimize age related impairments in balance.
5.1.4 LIMITATIONS

This study is not without limitations. One limitation was that is present in this study includes dance song selection. Participants were allowed to choose songs from the game generated list. These songs may differ from the other gaming systems, especially in beats per minute. The duration of the song may also differ from system to system.

The hardware used to measure heart rate was also a limitation in this study. Heart rate had to be taken by the participant on his or her watch. This created several problems associated with participant compliance with procedures. There were several times when participants forgot to record HR and would simply wait for the next dong to fix the error. In addition, five participants struggled to obtain a HR reading on the watch. These participants were having to redo heart rate checks, or leave that HR check blank. This could be due to participant compliance or the HR monitor.

Over the course of the exergaming sessions, several of the heart rate monitors lost battery power, which meant some participants were unable to complete data collection during their sessions. When this current study started collecting data, there were 20 heart rate monitors. Eleven heart rate monitors were only working at the end of the session, and those eleven were beginning to show signs of battery weakness. All participants were able to collect HR data during the first three data collection sessions. Eleven participants were able to collect data for all six exergaming sessions, and nine participants were unable to collect during the last three session. During session four, three participants were not able to collect HR. Five participants were not able to collect data during session five. During the last session, nine participants were not able to collect data.
5.2 FUTURE RESEARCH

Future research needs to begin by looking at heart rate intensity ranges in children. As noted in chapter 1, it is believed more research is needed to determine if a higher intensity is required for the development of cardio-respiratory fitness in children when compared to adults (Wolfe, 2005). By determining this factor, researchers can truly measure the effects of exergaming and determine if it is an appropriate physical activity based on intensity levels.

In this study, participants were given flexibility within their session group. Future research should be designed to eliminate this flexibility and replace it with more structured procedures. An example to accomplish this would include altering the procedures so that all participants play the same system during the 30-minute time period. Another example would be for the researcher to select songs from each system that were similar if not same beats/minute and allowed the participants to choose from that selection.

This study compared dance games across three systems. Future research should incorporate comparing games within one system. For example, researchers could compare a dance game versus a sports game that is played on the same exergaming system.

This study compared heart rate achieved using three different types of systems. Future research should focus on comparing systems that use the same type of controlling mechanism. For example, the researcher can compare two gaming systems have hand-held motion sensor controllers to control the computerized player.

This study used mean heart rate and maximum heart rate achieved for each participant. The limitation that exists is participants recorded heart rate seven times during their session. Future research should assess heart rate over a sustained period of active video game time. In order to accomplish this, a heart rate monitor that comes with software capable of collecting this
data would be recommended. By doing so, this will give the researcher a better representation of data, especially when looking to see the duration participants stay within an activity intensity level. It is also recommended that a second form of measurement be used to supplement and support the data collected using heart rate monitors.

Lastly, future research should focus on exergaming as an intervention to decrease childhood obesity. Interventions should not just focus on increasing activity levels in children. Research should also focus on how it compares to a control group, whether a participant enjoys the activities, how difficult the participant perceives activities, and if a participant becomes uninterested with activities.

5.3 CONCLUSIONS

At the conclusion of this study, the researcher has developed the following conclusions:

1. Heart rate achieved on all three systems is greater than resting values.
2. Heart rate achieved on all three systems is above 50 percent of a child’s maximum heart rate.
3. Exergaming can be used to replace regular physical activity. It increases heart rate above into the moderate-intensity level, which meets physical activity recommendations for children.
REFERENCES
REFERENCES


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REFERENCES (Continued)


REFERENCES (Continued)


REFERENCES (Continued)


APPENDICES
APPENDIX A

CONSENT FORM

August 2011

Parental Consent Form

**Purpose:**
Your son or daughter is invited to participate in a study evaluating the affects of active video games, such as Nintendo Wii, have on the body. There is a growing base of scientific research that suggest active video games do have greater affects on the body when compared to sedentary activities. I hope that my study supports these findings and also find which type of games have the greatest effect on the body.

**Participant Selection:**
Your son or daughter is invited to participant in this study to compare average heart rate when playing different types of video games. Thirty 3rd, 4th, and 5th grade students in Prime Time at Paul B. Cooper Elementary School are invited to participate.

**Explanation of Procedures:**
If you, as the parent, consent to your son or daughter’s participation, your son or daughter will participate in a set of activities that include inactive video games and active video games during Prime Time. Heart rate will be recorded during each type of activity and compared to each other. Your son or daughter will meet with me during their recreation session of Prime Time, and each activity session will last 30 minutes.

**Discomfort/Risks:**
The discomforts or risks for your son or daughter involve possible injury or fatigue while participating in any kind of physical activity. These will be minimized by asking your son or daughter about their health before conducting the activities. If your son or daughter has an existing injury, illness, or fatigue, or one of these develop during an activity, they will not be allowed to participate and will assessed at a later date.

**Benefits:**
Your son or daughter will benefit from this study by understanding how physical activity can have a positive affect on their heart rate. Your son or daughter can gain knowledge about the importance of maintaining physical fitness level of aerobic endurance, muscular strength, flexibility, and body composition. For you as a parent, you will gain knowledge about the types of video games available and which will produce greater benefits. This study has the potential to report an outcome that would be beneficial to the general public and have a significant contribution to the scientific body of knowledge.
Confidentiality:
Any information obtained in this study in which you can be identified will remain confidential and will be disclosed only with your permission. Heart rate data will be kept confidential and not released to the students, staff, or faculty of Paul B. Cooper Elementary School.

Compensation or treatment:
Wichita State University does not provide medical treatment or other forms of reimbursement to persons injured as a result of or in connection with participation in research activities conducted by Wichita State University or its faculty, staff, or students. If you believe that your son or daughter has been injured as a result of participating in the research covered by this consent form, you can contact the Office of Research Administration, Wichita State University, Wichita, KS 67260-0007, and telephone (316) 978-3285.

Refusal/Withdrawal:
Participation in this study is entirely voluntary. Your decision whether or not to allow your son or daughter to participate will not affect your future relations with Wichita State University, Derby Public School USD 260, or Paul B. Cooper Elementary School. If you agree and allow your son or daughter to participate in this study, your son or daughter may withdraw from the study at any time without penalty.

Contact:
I will answer any questions you have about this study at your convenience. Please feel free to contact my principle investigator or me if you have questions or comments at:

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Wichita, KS 67216
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e-mail: aday@usd260.com

If you have questions pertaining to your son/daughter’s rights as a research subject, or about research-related injury, you can contact the Office of Research Administration at Wichita State University, Wichita, KS 67260-0007, and telephone (316) 978-3285. Your son/daughter is under no obligation to participate in this study. Your signature indicates that you have read the information provided above and have voluntarily decided to participate. You will be given a copy of this consent form to keep.

Signature of Subject __________________________ Date __________________________

Signature of Parent or Legal Guardian __________________________ Date __________________________
Student Assent Form

I have been informed that my parent(s) have given permission for me to participate in a study concerning active video games. My participation in this project is voluntary and I have been told that I may stop my participation any time during the activities. I have been given instructions about the procedures. Also, I can ask any questions about the instructions or procedures before I begin my activities. If I choose not to participate, it will not affect my grade or participation in Prime Time in any way.

Name of Student ___________________________ Date ____________
APPENDIX C

PARTICIPANT PROCEDURES

Nintendo Wii
- Participants will be assigned a number. This will determine who is player one through four. Each participant will use a wireless remote control.
- Player one will choose the song and wait until all participants are ready to play
- Each participant will mimic the character on screen.
- At the conclusion of the song, the participants will rotate by moving forward to the next spot (four goes to three, three to two, two to one, one to four)

Xbox Kinect
- Participants will be assigned a number. This will determine who is player one through four
- Player one will stand in front of the sensor and will choose the song. Player one will wait until all participants are ready to play.
- Each participant will mimic the character on screen.
- At the conclusion of the song, the participants will rotate by moving forward to the next spot (four goes to three, three to two, two to one, one to four)

DDR
- Participants will be assigned a number. This will determine who is player one through four. Players one and two will be using the remote control dance mats.
- Player one will choose the song and wait until all participants are ready to play
- Each participant will mimic the character on screen.
- At the conclusion of the song, the participants will rotate by moving forward to the next spot (four goes to three, three to two, two to one, one to four)
APPENDIX D

HEART RATE LOG

Session:__________________________________________

Name:__________________________________________

RH:     _____  Check 4 _____
Check 1   _____  Check 5 _____
Check 2   _____  Check 6 _____
Check 3   _____  Check 7 _____