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The Effects of Playing Exergames on Energy Expenditure

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THE EFFECTS OF PLAYING EXERGAMES ON ENERGY EXPENDITURE

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THE EFFECTS OF PLAYING EXERGAMES ON ENERGY EXPENDITURE

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Directed by: James Navalta, Scott Lyons, and Mark Schafer

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The purpose of this study was to assess the performance, ratings of perceived exertion, metabolic responses, and energy expenditure as individuals participated in interactive video game play. There were 14 participants that participated in the study, whose age was 20.1 ± 1.64 years of age. Participants completed a maximal aerobic test to exhaustion (VO_{2max} test), and then 30 minute testing session on both the Kinect Adventures (K) and Wii Fit Plus game. Data were analyzed using a dependent t-test and one-way ANOVA. Significance was accepted at $P \leq 0.05$. Energy expenditure and RPE were significant in both exergames interactive game play P=0.044 and $P < 0.05$, respectively. In addition, heart rate (P=0.001) and performance during exergame play P=0.00015 were of significance in the Xbox Kinect and Wii Fit Plus. In conclusion, we found that individuals participating on the exergame Xbox Kinect expends more calories and work at a higher intensity than the Wii Fit Plus, thus justifying an alternative way to participate in physical activity via exergames. As an alternative way to exercise, individuals can meet the daily requirements of energy expenditure of moderate intensity, which is 150-400 kcals.

Chapter I

Introduction

Regular physical activity throughout life is important for maintaining a healthy body, enhancing psychological well-being, and preventing premature death (Healthy People 2010). It can increase muscle and bone strength, lean muscle, aid in weight control and is a key part of any weight loss effort (Healthy People 2010). Yet, in today's society, there has been an increase in technology, which is intended to improve our way of life. Some of these devices help us yet hinder us at the same time; these can range from Global Positioning System (GPS), IPod's, video games, and many more. While technology seems to be taking over increasingly each day, physical activity seems to be dwindling. With this increase in video games, physical activity is pushed aside while the top video game becomes the new "physical activity". Also, with a decrease in physical activity resting heart rate increases due to the lack of exercise, therefore affecting cardiovascular responses and the prevalence of obesity Today, with release of interactive games video games such as Wii Fit Plus, individuals may increase their physical activity level, along with a possible decrease in the current overweight and obese population, who may rid of the traditional sedentary video game (Kautianen et al., 2005). This concept is called exergaming, which is the use of video games as an exercise activity (Sinclair et. al., 2007). With such games, little is known of the energy expenditure between the lower and upper extremities. Studies have shown that there is a correlation between experienced active game players and energy expenditure (Sell, 2008).

With the Dance Dance Revolution game, it was implied by the researchers that the experienced player, met the ACSM guidelines of meeting daily energy expenditure requirement of 15-400 kcals a day, by achieving a maximal oxygen uptake (R) equivalent to moderate intensity (Sell, 2008). Research has shown that while playing activity-promoting games that the energy expenditure is increased in the individual with prolonged activity (Lanningham-Foster et al. 2009). This reflects the physiological response of the cardiovascular system to satisfy the rising needs of muscles involved by an increase in cardiac output, which causes an imbalance between metabolic needs and energy production that can lead to cardiovascular risk in children and young adults (Borusiak et al., 2008). Playing video games was inversely correlated with physical activity and playing these games lead to a more sedentary lifestyle. Video games are considered a low-energy activity, yet interactive video games results in greater improvements in health-related physical fitness than traditional cycling (Warburton, 2007).

While the literature on video games and their effects continues to grow, the primary focus has been on heart rate, blood pressure and energy expenditure primarily in young males or children. Few compare interactive video games and their effects in the upper extremities versus the lower extremities. Interactive games require less work than actual physical activity, yet they are becoming popular due to fact that they are fun. While individuals are having fun, they are becoming physically active for a longer period of time. It is unknown what the responses will be with interactive video games and the correlation between the entire human body along with metabolic responses and energy expenditure.

Statement of Purpose

Based on previous literature, traditional sedentary video games have been shown to affect the cardiovascular system and energy expenditure in a negative manner. This is a major risk to the body, which may lead to diabetes, hypertension, and obesity just to name a few. In addition, active video games, such as Wii games, were found to move the body more in the trunk, back and thighs. To date there has not been a study on whole-body active video games. Studies have evaluated the addiction, engagement, scholastic achievement and cardiovascular effects in adolescents (Skoric et al., 2009), yet there has not been a study involving two exergame systems that focus on the entire body, such as Wii Fit and Xbox Kinect. This study will assess the energy expenditure, VO_2, and heart rate of these young adults who are untrained.

Statement of Hypothesis

H_{O1}: While playing active video games there will be no effect in metabolic rates.

H_{A1}: During interactive game play metabolic rates will increase significantly above will increase in the Kinect than Wii games in young adults.

H_{O2}: Playing interactive games will have no effect on ratings of perceived exertion on the body in young adults.

H_{A2}: Xbox Kinect will have a greater effect on the body than Wii Fit for ratings of perceived exertion on young adults

Definition of Terms

Energy expenditure: refers to the amount of energy that a person uses to breathe, circulate blood, digest food, and be physically active.

Physical inactivity: any bodily activity that enhances or maintains physical fitness and overall health.

Metabolic responses: any reaction by the body to a specific influence or impact.

Exergame: a gaming system used as a form of exercise.

Limitations

- Participants will have different experience in playing XBox Kinect and Wii Fit Plus, as Xbox Kinect is fairly new and more popular than Wii Fit Plus.
- Equipment may not be efficient in assessing exact movements.
- Participants' physical fitness will vary.
- May have more males than females.

Delimitations

- Participants will be familiar with playing video games in general.
- Metabolic responses of VO_2 will be measured with open circuit spirometry throughout the exercise bout.

- HR will be measured using a telemetry unit.
- Energy expenditure will be measured using measurements of VO_2.
- The protocol will be playing XBox Kinect and Wii Fit Plus.
- VO_2max test will be completed on a treadmill which will increase every 3-min at a .6mph increase.
- Active games will be played with shoes and a Wii remote.
- There will be a practice session of 5 minutes to familiarize participants with games.
- Participants will have a10-minute resting period between practice session and actual play.

Chapter II

Review of Literature

Interactive video games are a form of physical activity. They allow the body to move freely while imitating or free styling movement. Recently, they have become more and more popular for physical activity rather than actual exercise. They have become more and more popular in recent years. Many studies have looked at energy expenditure and activity promoting games in children and young adults. Others have evaluated the relationship between video games and individuals who are obese and overweight, while some have looked at the psychological and physiological aspects of individuals who play. No known studies have compared two exergames whom demand the use of the entire body, while looking at energy expenditure.   The primary focuses of this study will be energy expenditure, metabolic responses, such as heart rate (HR), and maximal oxygen uptake (VO_2). This review of literature will look at energy expenditure, active video games, and physical fitness.

Energy Expenditure

Energy expenditure refers to the amount of energy that a person uses to breathe, circulate blood, digest food, and be physically active. In the following articles, it is discussed that physical activity is a major part of energy expenditure. Some studies used cycle ergometers or active video games to obtain data to determine energy expenditure.

The purpose of this study was to determine whether playing experience influences energy expenditure during a single Dance Dance Revolution (DDR) exercise bout (Sell,

2008) . To determine whether experienced and inexperienced DDR players were able to meet the minimal recommendations of daily physical activity and energy expenditure through playing DDR was observed. There were 19 college-aged students, 12 experienced (level 4) and 7 inexperienced (level 1 or 2). A treadmill was used to test VO_2max and for the DDR game, participants completed 30 minutes of continuous play while barefoot on a 3-foot-square plastic pad facing the television. They found that experienced players exhibited higher average exercise values on all cardiovascular values, greater DDR playing experience was associated with greater relative energy expenditure (4.6 ± 0.5 and 3.9 ± 1.1). They concluded that DDR game play at a higher level appears to elicit greater energy expenditure, suggesting that increasing an individual's proficiency through practice will promote increases in energy expenditure and potentially generate greater long-term health benefits.

Playing sedentary video games can lead to obese and overweight in children and adults giving Lanningham-Foster reason to examine energy expenditure and physical movement while lean, overweight or obese children and adults play sedentary video games and the activity-promoting game system Nintendo Wii (2009). There were 22 children, 11 male and 11 female and 20 adults, 10 male and 10 female. BMI was used to separate participants into obese and overweight groups. Physical activity measurement system (PAMS) was used to measure physical activity, which included 6 sensors, 4 inclinometers, and 2 accelerometers. Energy expenditure was measured every 10 minutes while sitting and then standing, in children resting energy expenditure (REE) was traditional game values: 1.67 ± 0.37 [kcal/hr]/kg bodyweight; Nintendo Wii 5.14 ±

1.71 [kcal/hr]/kg bodyweight, $P < .001$; the adults 1.03 ± 0.20 [kcal/hr]/kg bodyweight; Nintendo Wii 2.67 ± 0.95 [kcal/hr]/kg bodyweight, $P < .001$. Also, energy expenditure was taken while the participant was playing the sedentary game while sitting and during the activity-promoting games while standing. Energy expenditure at rest and during the various activities was significantly higher in children than in adults. Also, that energy expenditure increased significantly greater than all other activities when adults played Nintendo Wii. The back, trunk, and thighs were examined during movement; back movement children moved significantly more than adults. Children moved more at the trunk and thighs compared to adults sitting and watching television and playing the sedentary game. Energy expenditure more than doubled compared with the sedentary equivalent when children or adults played activity-promoting games. It was found that for weekly video game expenditure 652 calories could be burned playing a sedentary game and 1990 calories playing the activity-promoting Nintendo Wii Boxing. At the current level of weekly video gaming, activity promoting video games have the potential to substantially increase daily energy expenditure

According to Graf et al. activity-promoting video games increase energy expenditure equivalent to moderate intensity walking and the games have the potential to attract children to become more physically active (2009). Indirect calorimetry was used to compare the rate of energy expenditure in children playing 2 popular physically active video games, DDR and Wii sports in relation to walking. There were 23 children, 14 boys and 9 girls aged 10 to 13 from the local community. Each child completed 2 visit to the lab within 4 weeks either DDR performed on visit 1 and Wii play and treadmill walking on visit 2. Each visit was initialized with a 20 minutes rest phase followed by 30 minutes of either DDR or Wii. Results showed that the highest rate of energy expenditure was recorded for DDR2 and walking 5.7 km/hour elevated energy expenditure 3-fold on average. For VO_2, the highest value was recorded during DDR2 with lower values during boxing and walking at 5.7 km/hour. HR was higher during boxing than all other activities energy expenditure was 19% to 33% higher for boys when playing DDR1, DDR2, and bowling. Also, it can be of extreme value for sedentary individuals and for those who shun traditional forms of exercise.

Siegel et al. investigated the participation of playing interactive video/arcade games increase energy expenditure and heart rate of young adults (2009). There were 13 (6 male and 7 female) that participated in this study. There were 3 active games that participants had to play, one with moving and lighting lighted pads, boxing and bicycle game. Participants played any of the three games for 30 minutes each, while metabolic and HR data were collected. The results show that the boxing game provided the highest VO_2 (17.47 ± 4.79 ml/kg/$^{-1}$min^{-1}). Participants achieved 60% or better of their HR reserve (162.82 ± 10.78 beats/min and Caloric expenditure during the 30-minute exercise session (226. 07 ± 48.68). Overall energy expenditure increases in all interactive game play. it is concluded that interactive video game/exergame type exercise is effective in requiring sufficient energy expenditure to meet ACSM recommendations for intensity of exercise bouts and can be utilized as part of an overall aerobic exercise programs.

Determining whether overweight children who played video games would play them at an intensity that will increase energy expenditure was the purpose of this study by Haddock et al.(2008). There were 23 children between the ages of 7 and 14 who played Jackie Chan Studio Fitness for 30 minutes, whom had a familiarization session before the testing session. VO_2 was measured at resting and during game play. The results from this study were that energy expenditure increased significantly from baseline, 1.1.5 ± 0.32 to 4.08 ± 1.18 for the 30 minutes of play. They concluded that that energy expenditure playing this game that allowed these children to utilize their entire body was similar to other studies. Also, that with children being overweight and borderline obese, playing these games can improve physical fitness.

Physiological cost and enjoyment of adolescents, young and older adults while playing the Wii Fit compared to walking on a treadmill and sedentary game play was evaluated in this study (Graves et al, 2010). There were 14 adolescents, 15 young adults and 13 older adults whose ages were 11-17, 21-38, and 45-70 respectively. Each participant familiarized themselves with the handheld game of Tetris, Wii Fit: 7 exercises in the training category and walking on the treadmill. They played 7 activities from the Wii for 10 minutes each, treadmill walking for 10 minutes and the handheld games for 10 minutes as well. The results were that all variables, VO_2, EE, HR for Wii fit sessions were greater than the handheld games, yet lower than walking on the treadmill. Most participants enjoyed the Wii fit sessions more than the handheld game. In conclusion, the physiological costs of the Wii Fit were greater than handheld games and the intensities from the Wii fit are a daily health-benefit of physical activity recommendation for all age groups.

The purpose of the study by Sell et al. was compare physical demands of climbing compared to Wii boxing and a brisk walk. There were 24 college age students who participated. Each participant completed a VO_2 max test and came in 4 different days to walk, play the Wii and climb, which each activity was completed for 30 minutes. The results of this study were that the climbing exerted more energy than walking and boxing, which was 265 ± 58.3 kcal/min. They concluded that the greater physical demand was with the climbing due to the more adventurous type of activity it is, which all met the physical activity recommended daily.

Physical Activity

In the below summarized articles, active video games are looked at to determine one's physical fitness and to determine what cardiovascular effects they have on the human body. Physical activity is an important aspect in a healthy lifestyle. It helps to maintain acceptable values in blood pressure, heart rate, and even provides prevention from becoming overweight and obese, if practiced regularly.

Warburton evaluated the effectiveness of interactive video games on health-related physical fitness and exercise adherence in comparison with traditional aerobic training (2007). It was conducted over a 6 week period, 14 stratified college-aged males were the participants, who were randomly assigned to an experimental condition (interactive video games) or control condition (stationary cycling). Participants were screened for physical activity inclusion by self-report. The results were that participants in the interactive game attended 30% more frequently than the traditional group. There was a significant change between VO_2 max and interactive video games and resting systolic blood pressure in both training groups, which was conducted over a period of 6-weeks. There was no significant difference in body composition, cardiorespiratory response to exercise or musculoskeletal fitness in either group. They revealed that interactive video game training leads to significant improvements in several markers of health status. This study is the first to reveal that interactive video games results in greater improvements in health-related physical fitness than traditional cycling.

The purpose of this study was to address whether playing modern video games was associated with an increase in blood pressure (BP) and heart rate (HR) of more than 2 standard deviation *(SD)*, if BP and HR level differ during the course of extended video game playing, either within one playing session or comparing sessions 1 and 2 (Borusiak, 2008). Also, it addressed if the energy consumption, in relation to HR and BP, during playing of video games was the same compared with exercise testing. There were 17 German nonsmoking adolescents boys between 12 and 14 years of age. The games used were "Need for Speed" on PlayStation 2, the participants were escorted in and placed on a chair 3m for the screen and were instructed to play as normal. They found that during the video game an increase for mean HR of 13.1 bpm. All participants reached a maximum strain of 1.7 to 2.2 W/kg. The mean maximum HR of all participants was 152.2 bpm at a mean exercise strain of 1.94W/kg. The authors concluded that these indicated some habituation in response to video game playing. There was a permanent rise in measured parameters throughout the whole two-game sessions without any significant change in comparing Sessions 1 and 2.

The contribution of upper limb and total body movement to adolescents EE whilst playing active video games on Nintendo Wii was examined by Graves et al. (2008). There were 6 girls and 7 boys that participated in this study. On separate days participants practiced playing the active game and inactive game for 10 minutes each. Participants played for 15 min on each game with 5 min rest in between each. Overall, the playing time was 60 minutes for each participant. This study found that upper limb and total body activity movement was greater in active compared to sedentary games with upper limb movement being greater than total body in all games. Energy expenditure and HR were greater in all active video games compared to rest and sedentary gaming and during boxing compared to tennis and bowling. Active gaming on the Wii significantly increased total body and upper limb movement in adolescent boys and girls compared to sedentary games. It is concluded that increased upper limb and total body movement during active gaming on Wii sports increased EE and HR compared to sedentary gaming. The physiological cost for upper-body orientated active video games increases movement of both upper limbs was encourage.

Kang examined whether and how contraction frequency affects energy expenditure and substrate utilization during exercise and to examine whether the relation between contraction frequency and energy metabolism is affected by exercise modality or relative exercise intensity (2004). There were 24 college-aged individuals, 12 men and 12 women as participants. Twelve were tested on a cycle ergometer and twelve were tested on an arm ergometer. Each group completed a VO_2 peak test and three submaximal exercise trials on four separate laboratory visits. The peak tests were preceded by a 10 minute warm up and the initial power output was 25W for the arm test and 50 W for the leg test. For both tests, power output was increased by 25W every two minutes and the pedal rate was 50 rev/min. For the submax test, participants performed a 10 minute steady state exercise at 40, 60, or 80 rev/min. It was found that the total energy expenditure was higher at 80 rev/min than at 40 rev/min, whereas there was no difference found between 40 and 60 rev/min and between 60 and 80 rev/min in upper and lower body exercise. It was concluded that pedaling at a greater frequency helped to maximize energy expenditure during either upper body exercise (UE) or lower body exercise (LE) despite unchanging power output and a concomitant reduction in brake resistance.

Exergaming

Exergaming is the new terminology for physically active video game, which has increased activity levels in children and young adults. The below articles describe and compare different active games that have become popular in the past years. Most look at the fact that the American society has become increasingly physically inactive over the years, thus the increase in obesity, especially in children with a few considering young adults.

Participating in exergames was an effective way to be physically active for youth ages 9-12 years of age (Wittman, 2010). Twenty-five youth, aged 9-12, participated in two of three Wii activities: Tennis, Boxing and Dance Dance Revolution (DDR) and played for 20 minutes. Then the youth participated in two traditional activities: capture the flag, kick ball, for 20 minutes, and wore pedometers with all activities. The perceived exertion scale from the OMNI system was used; also, an enjoyment scale 1 to 4, with 4 being like and 1 being dislike. Results show that for the perceived exertion 5 or above for DDR: 80%, Tennis/Boxing: 84%, Capture the flag: 68%, Kick ball: 63%; 8 or above: DDR: 36%, Tennis/Boxing: 60%, Capture the flag: 64%, Kick ball: 32%. Capture the flag had the highest percentage of enjoyment with 79%, tennis/boxing: 76%, DDR: 72%, and last kick ball with 26%. The average steps taken during DDR was 802, Tennis/Boxing: 746, kick ball: 789 and capture the flag was an average of 1171. In conclusion, exergames are a way to stimulate the child's mind as well as their body, which is an avenue health professionals want to incorporate to stimulate activity physically and mentally.

Sinclair et. al. attempted to identify success factors to guide designers of exergaming systems, which have been evaluating the physical and health characteristics of these games (2007). In light of the obesity epidemic in children, these researchers looked into the correlation between obesity and children between 8 and 18 years of age who watch television. It was shown that children have become less active over the more recent years and this attempt to develop exergames was developed. Exergaming is the use of video games in an exercise activity. Previous interactive games were reviewed such as exercise bikes, foot operated pads, motion sensors, and other hand held devices. This study did not necessarily involve participants but compared other studies that observed active games and considered an exercise program that would be beneficial for children who are inactive, yet are interested in playing video games. Effectiveness and attractiveness were compared as well to look at the psychological and physiological components.   It was concluded that these exergames have to be made attractive to players and at the same time be effective enough to count for exercise.

Jin answered the following questions in this study, What are the effects of priming the actual self-versus the ideal self on users' perceived interactivity and immersion in avatar-based exergame playing? and What are important moderators that play a role in exergame users' self-concept perception? To answer these question, she looked at leveraged the Wii's avatar-creating function (Mii Channel) and exergame feature (Wii Fit) in a controlled, randomized experimental design (2009). There were 126 undergraduate students (84 females, 42 males) who participated and a 2x2 factorial design experiment demonstrated the significant main effect of self-priming on interactivity and the moderating role of the actual-ideal self-concept discrepancy in influencing immersion during exergame playing. Game players wanted to create an avatar reflecting the ideal self-reported greater perceived interactivity than those who created a replica avatar mirroring the actual self. The results used a two-way ANOVA demonstrated the moderating role of the actual–ideal self-concept discrepancy in determining the effects of the primed regulatory focus on immersion in the exergame play and there were managerial and practical implications for video game designers and the general interactive media industry. It is concluded that game developers are leveraging the exergame trend and that stimulate provocative discussions about the social-psychological impact of avatar-based exergames in the current cultural environment where the obesity epidemic and the pressure to maintain a perfectly fit body coexist.

Determine whether VO_2, heart rate (HR), RPE and liking of playing Nintendo Wii Sports Boxing was greater than sedentary video game play and treadmill walking in adults was the purpose of this study (Barley, 2009). No study has compared Wii play to a bout of physical activity, assessed ratings of perceived exertion (RPE) or hedonics (liking) of Wii play until this one by Barkely. Twelve healthy males (N=6) and females (N=6) had their HR and VO_2 assessed during four, 10-minute conditions: rest, walking on a treadmill at 2.5 miles/hr., playing a sedentary video game, and playing Wii Sports Boxing. RPE and liking were assessed during the treadmill walking and video game conditions. The results show that the average HR (121.2 ± 12.4 beats/min Wii, 94.1 ± 13.4 beats/min next greatest), VO_2 (15.4 ± 4.5 ml/kg/min Wii, 10.4 ± 0.9 ml/kg/min next greatest), RPE (13.3 ± 1.7 Wii, 9.8 ± 1.7 next greatest) and liking (9.1 ± 1.0 cm Wii, 5.6 ± 3.2 cm next greatest) were significantly greater for Nintendo Wii ($P \leq 0.001$) than all other conditions. It was concluded that Wii Sports Boxing was a well-liked activity capable of eliciting a physiologic challenge greater than both a sedentary alternative and treadmill walking in adults.

Chapter III

Methodology

Subjects

Subjects for this study included apparently healthy individuals with characteristics of age 20.1 ± 1.64 years, weight 69.7±16.4 kg, height 167.8±9.91 cm and Body Mass Index (BMI) 24.6 ± 4.01 kg/m^2 (see table 1) with no adverse medical history as determined by a health status questionnaire (Appendix B). Additionally, there were gender differences for descriptives such as resting and max HR, and BMI (see table C1, Appendix C). An additional questionnaire was administered (Appendix D) to determine each subject's skill level when playing Xbox Kinect and Wii Fit Plus, and only those subjects with no experience or at the "beginner" level were included in the study. Also, the subjects were untrained, meaning they were not athletes nor were they participating in a structured workout regimen of 3 days of cardiovascular and/or 2 days of resistance training per week. Subjects were recruited from the Western Kentucky University student population. A power analysis was performed using the measurements provided by Lanningham-Foster et. al. (2009) with an effect size of 0.707 and α 0=.05 and β= 0.95. Based on the results of this power analysis, it was determined that 21 subjects in each group would be sufficient to detect a difference if one is present. Prior to testing, the Western Kentucky University Institutional Review Board approved the study (HS11-188), and all subjects provided informed consent (Appendix E).

Table 1. Demographics of participants.

Characteristics	M	SD
Age (yrs)	20.1	1.64
Weight (kg)	69.7	16.4
Height (cm)	167.8	9.91
Sex: Females Males	8 6	
BMI (kg/m^2	24.6	4.01
VO_2max	45.6	12.2
VO_2 METS	13.1	.45
Sedentary Video Game Experience (yrs)	None 2-5 5-10 10+	7 3 3 1
Game System Owned	Wii Xbox Neither	4 1 10

Note. n = 14.

Protocol

The first visit to the Exercise Physiology lab consisted of performing a max aerobic test to exhaustion (VO_{2max} test), during which maximal running speed was determined.

Maximal Exertion Test

The VO_{2max} test began with a 5-min warm-up at 3 mph on a motor driven treadmill (TrackMaster TMX22, Full Vision, Newton, KS). Following the warm-up period, subjects ran at 6.0 mph for 3-min and then speed increased by .6 mph with each subsequent stage until maximal speed and exertion was attained. If the subject completed at least 1-min of the final stage, it was considered to the maximal running velocity. Oxygen uptake (VO_2) and energy expenditure (Kcals) were obtained using a metabolic analysis unit (True One 2400, Parvo Medics Inc., Sandy UT), which is an open-circuit spirometry system. Heart rate (HR) was measured using telemetry (Polar Oy, Finland).

Design of Investigation

Prior to the VO_{2max} test, height and weight were measured using a physician's scale (DR550C, Detecto, Brooklyn, NY) for weight and a stadiometer (Seca 213, Hanover, MD) for height. For weight, subjects were informed to remove shoes and any item(s) that may deter the measurement. For the height measurement participants stood straight without shoes and backs against the wall. Subjects completed the Kinect Adventures (K) (Xbox 360, Microsoft Corporation, CyberCiti, India) or Wii Obstacle Course game (WOC) (Nintendo of America Inc. Redmond, WA) in a counterbalance order. All participants faced a television screen. During the K trial, participants stood where the motion sensors could detect them, and they used their body as the controller for this game. During the WOC trial, participants faced the television and held the Wii remote in their dominant hand while standing on the balance board. Subjects did not engage in any rigorous activity for 24 hours before the date of testing, and they refrained from eating at least 2 hours prior to test. All participants were given a 5-min familiarization period on each game system to data collection. After this practice session, there was a 10-min resting period; following this period was 30-min completion of continuous play on the beginner's level of K, while connected to the metabolic cart using open-circuit spirometry. HR and rate of perceived exertion (RPE 6-20, an indication of effort at that instant) were recorded for each 5-min bout of game play.

Statistical Analysis

Data were analyzed using a dependent t-test and one-way ANOVA. Significance was accepted at $p \leq 0.05$.

Chapter IV

Results

Energy Expenditure

The game system x gender x time interaction was not significant (P = 0.467). There was, however a significant gender by time interaction with males expending greater calories at each timepoint than females with the exception of the first measurement (i.e. 5 min) (P = 0.001, see figure 1).

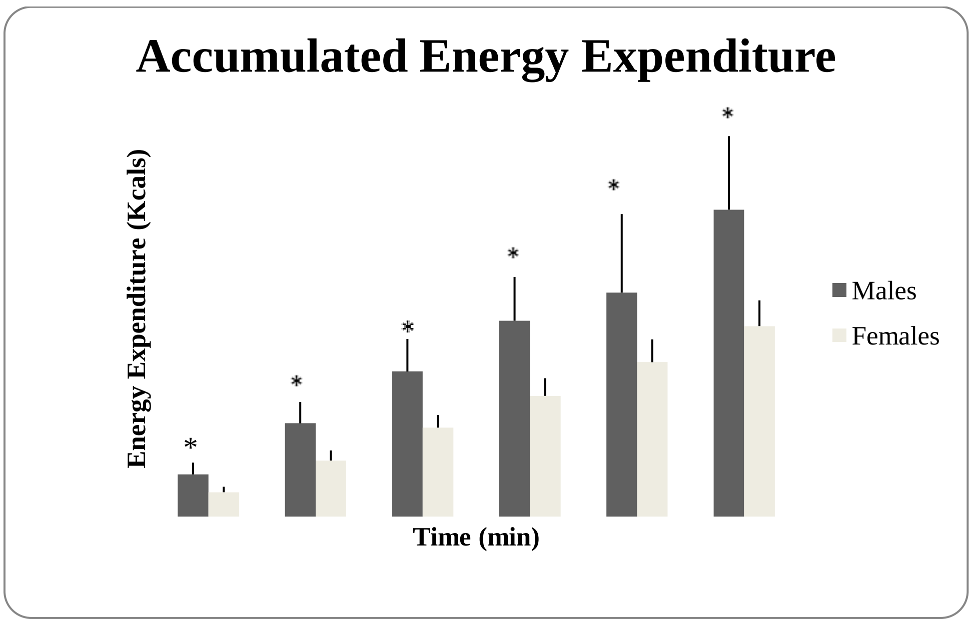

Figure 1. A significant difference in energy expended between the two gaming sytems at the end of game play as shown above.

When the total accumulated energy expended between each game console was analyzed, a main effect was observed with participants expending significantly greater total calories while using the Xbox ($P < 0.001$, see figure 2).

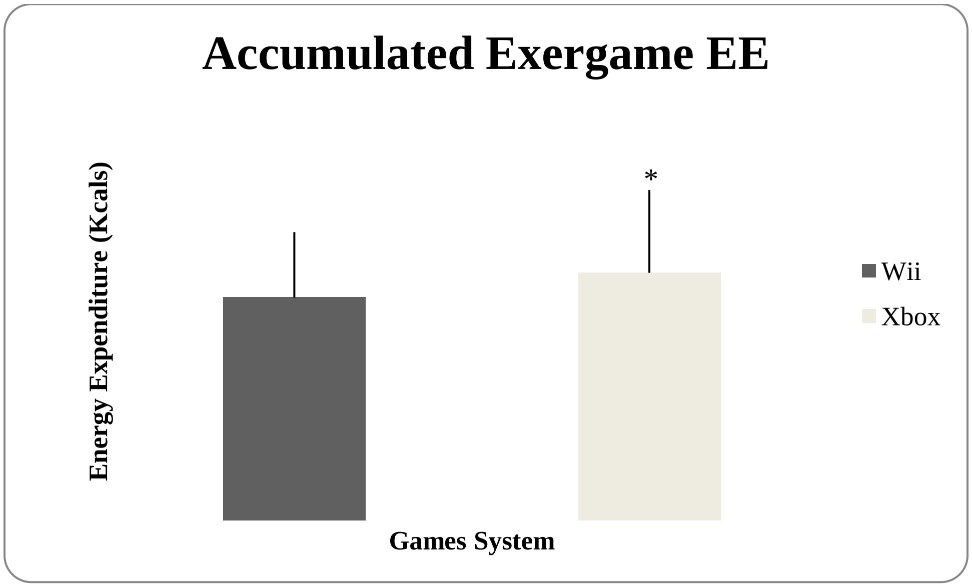

Figure 2. There was a significant difference in energy expended between the two gaming sytems at the end of game play.

There was a kcal reporting method (metabolic cart, Wii console) x gender interaction observed with EE ($P = 0.004$). Males had a significantly greater kcal expenditure when measured on the metabolic cart versus the Wii, however there was no difference between these systems for females (see figure 3).

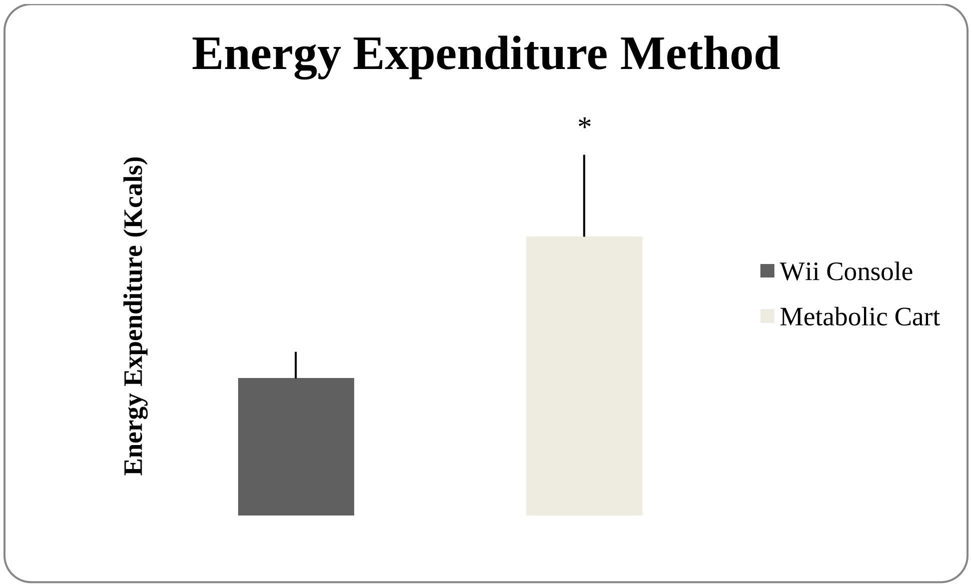

Figure 3. EE measure using the metabolic cart and Nintendo Wii were found to be significanlty different (P =0.004).

With regards to METS, no game system x gender interaction was observed (P = 0.078). However, there was a main effect for game system when total METS were considered (P=0.015, see Table 2).

Table 2.Total METS of each gaming system and MET values between males and females of each game console (P =0.015).

Game System	M	SD
Wii	5.13	1.02
Xbox	8.02	2.19

Note. n = 14.

For accumulated absolute oxygen uptake ($L \cdot min^{-1}$) the game system x gender x time interaction was not significant (P = 0.773). There was, however a significant game system interaction with Xbox allowing participants to consume greater amounts of oxygen overall than the Wii (P = 0.00015, see figure 4).

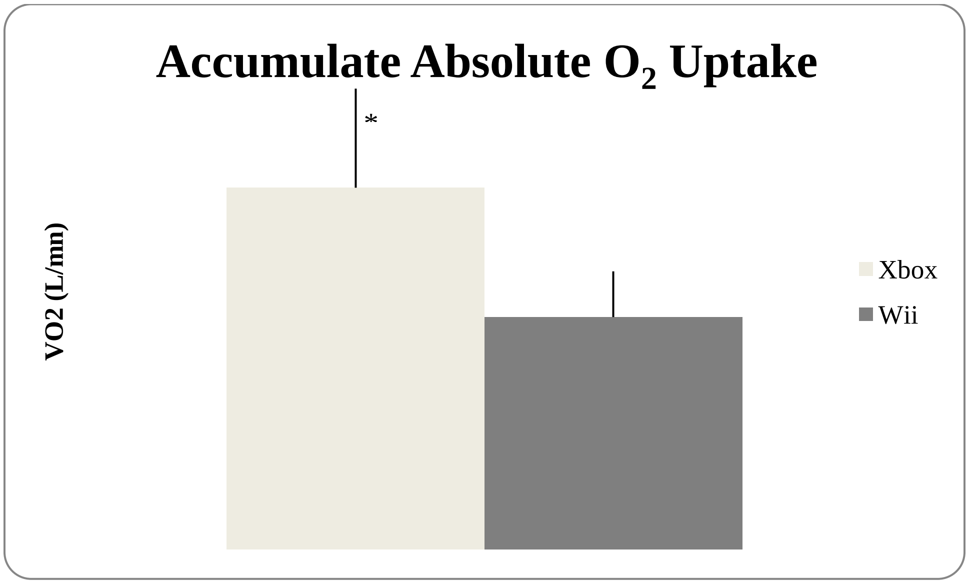

Figure 4. There was a significant difference in the oxygen uptake during game play between the gaming system (P = 0.00015)

Heart Rate

For HR, there was not a game system x gender x time interaction (P = 0.804). A significant game system x time interaction was observed such that HR was higher on the Xbox console at minutes 10 (P = 0.025) and 25 (P = 0.006) when compared to the Wii (see figure 5).

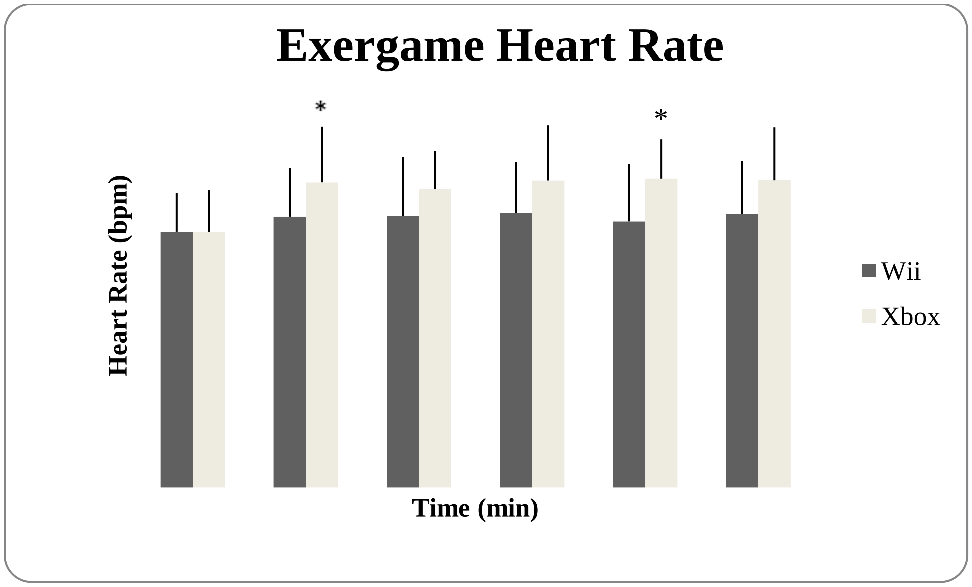

Figure 5. As shown above, there as a significant difference in both 10 and 25 minutes of game play.

Ratings of Perceived Exertion

The game system x gender x time interaction for RPE was not significant (P = 0.272). We did observe a gender x time interaction where females perceived the exergaming experience to be greater than males all each time point except minutes 25 and 30 (see table F1, Appendix F).

Chapter V

Discussion

The purpose of this thesis was to assess the performance, ratings of perceived exertion, metabolic responses, and energy expenditure in individuals participating in the two exergaming systems. It was proposed that the K would show a greater increase in the above-mentioned measurements than in WOC. The primary finding of this study was that Xbox Kinect game play increased cardiovascular and metabolic measures, specifically total EE, to a greater extent than primarily upper body exercise reflected on the WOC system. Also, in the WOC system, there was inaccuracy in the EE calculated compared to the metabolic cart calculations, meaning the WOC may need some improvements due to its use for fitness. Indirect spirometry has shown to be accurate due to the measurement of oxygen intake as participants are connected throughout game play.

We found that participants playing the exergame, K, expended more energy than those who played WOC ($P < 0.001$), which supports the previous hypothesis that EE would be greater in K than WOC. Our results were similar to those of Sell et al. in that HR, RPE, VO_2 and overall energy expenditure for lower body play was significantly higher than the upper body during the 30-min exercise bout (2008). The findings from Siegel et al. suggests that exergames increases EE significantly and is effective in requiring sufficient EE to meet ASCM recommendations of 150-400 kcal as suggested for healthy adults (2009). In Siegel et al. study whose EE mean was significantly higher in males than in females, 9.10 ±0.48 kcal/min and 6.20 ± 0.74 kcal/min, respectively

(2009). Compared to Siegel et al, EE in males and females was 200.3± 46.24 kcal/min and 121.75 ± 16.87, respectively, which is higher than the participants in the 2009 study. Participants of both studies played different exergames, thus the difference in EE. Although in the current study with Xbox was the only exergame who expended in the healthy adult range, combined the two games totaled 295 kcals expended. In a study by Lannningham-Foster, children played the Nintendo Wii Boxing and a sedentary game for PlayStation 2. It was found that children between the ages of 9 and 15 increased EE when playing Wii Boxing with an average of 284 calories burned each day if the game is played 8 hours a week.

Previous research has shown that interactive video games expend more energy than sedentary video games, yet this is the first study to compare these two popular interactive games which meet ACSM recommendations. Based on established boundaries for PA intensity classification, which is light <3, moderate 3-6, or vigorous > 6 METS (Graves, 2010). With both exergame consoles combined the participants reached 8.03 ± 2.15 METS, which is at a vigorous intensity, yet comparing the consoles WOC reached 5.13± 1.03 and K reached 8.03 ± 2.19 METS, which are moderate and vigorous intensities, respectively. Furthermore, recommendations for healthy adults 18-65 need moderate intensity of aerobic activity for at least 30 min for five days and for vigorous intensity, aerobic activity needs to be at least 20 min for 3 days of the week (Sell, 2011). Compared to handheld sedentary game play, Wii Fit aerobic activities were significantly greater as reported in the study by Graves (2010). The findings in the study by Graves indicated vigorous intensity in exergames yet in this current study, vigorous intensity was found in the exergame K. Also in a study by Graf et al the DDR and Wii boxing games accomplished greater than moderate intensity walking (2009). While working at a moderate intensity, participants indicated working somewhat hard to hard from the RPE scale used with values of 14.21±2.02, which is similar to RPE in Siegel et al study, which was an average of 14.0 ± 2.04, also between somewhat hard and hard (2009).

Exergames such as K and WOC may motivate users more than traditional exercise modes (Graf et al., 2010). These games offer an alternative to sedentary screen games and may soon be incorporated into exercise programs. Heart rate (HR) significantly increased above baseline values while participants were given access to play with the exergames (Siegel et. al., 2009). Based on the data collected from this study, the previous statement is identifiable with our HR data. We found that HR increased progressively with each game play and there was a main effect in genders having males HR greater than females, which may be due to male's competitive nature. Physical fitness is a very important component of life and the assessment of PA when looking at these exergames need to be examined. Although, in this current study BMI was observed, an in-depth observation did not take place. The average BMI was 24.6 ± 4.01 kg/m^2 meaning these participants were normal weight, following the listed guidelines: Underweight = <18.5, Normal weight = 18.5–24.9, Overweight = 25–29.9, Obesity = BMI of 30 or great. This may be due to participants being college-aged, yet in the questionnaire taken none of them were active more than 3 consecutive months.

During the course of this study, it was determined that both obstacle course games were easily played. While playing WOC some participants struggled to find their “rhythm”, even with the practice session due to the sensitivity of the balance board, which became a limitation. Furthermore, the WOC and K games have been out for a couple of years, yet K all but one participant had played the game, while 4 had experience with the WOC game. Also, the fitness level of the individuals varied so it may have affected the results, even though all participants were college-age. Future studies should include the comparison of traditional ergometers, such as cycle and treadmill, to compare with interactive video games and view the differences in them. In addition, this study can be assessed with children to observe the differences in them and possibly incorporate these exergames into their daily activity rather than the traditional stationary video games they are accustomed to.

In the study by Graf et al. VO_2 was higher in Dance Dance Revolution (DDR) than in walking and boxing just like in the current study VO_2 in K was greater compared to WOC (2008). Although, there was not a significant difference in VO2 between the two exergames, total for all participants was a peak VO_2 of 28. 05 ± 7.54 L/min, this was similar to participants in Siegel et al who reached a peak $VO_2$of 27.87 ±4.60 ml/kg/min during game play. In addition, RPE was greater in DDR was greater than boxing in walking in the same study, while in the present study there was only a main effect between the games, which participants indicated increasing rates of exertion during the 30 minutes of gameplay. Although. There were were fourteen participants in this study, the power analysis performed using a post-hoc analysis identified a power of 1.000, which showed this population was effective to show significance in the data collected. Limitations of this study include when participants jumped too hard on the balance board the game would start from the beginning level and the calories counted were voided as if they never played the session; the Kinect sensor was sometimes too sensitive, so with the face mask and tubing that participants wore, it caused a slight delay in the game; if feet are not in designated sensored boxes on the balance board, the game Wii fit will be delayed; WOC uses the Metabolic Equivalent Task (MET) calculation system. This system assigns a certain MET value to every exercise in WOC, which is then multiplied by your weight and the time you've spent exercising to reveal how many calories you've managed to burn. Also, the game for Wii Fit was set at 3.0 METs but the average METS were above that at an average of 5.13 ±1.02. Therefore, depending upon what level you made it to determine the amount of calories that were burned. Both gaming systems give you warnings to ensure that the player is safe and/or game play will not be interrupted. The Wii Fit warns you when you're stepping too hard on the balance board: Step lightly and keep your feet squared" is what will be displayed at the bottom of the screen. K displays at the top "Feeling tired or sore? Take a break!" which is great and a lawsuit protector so no one can say that they are were hurt due to playing the Kinect because they saw that message. For varying numbers between genders during game play, higher numbers in males may result from their intensity while playing, yet the females had a higher RPE value. RPE is a subjective measurement causing variations in numbers between the two genders which may explain the differences. Many studies did not compare differences in gender due to the sample size. In a study by Sell et all 2011, sex differences were not analyzed due to the small sample size of males compared to females, which was 8 to 18. In addition, other studies observed children rather than young adults, who are the problem generation when it comes to obesity.

Future research includes the use of active reinforcement in K if the participant is to miss a jump or get hit by an obstacle, then they would feel a vibration or sensation notifying them of their shortcoming. Next, WOC could be used in a 6-12 week training study, comparing the game to the actual Yoga class to see if it actually works, along with the assessment of body composition before and after a training study to observe possible improvements of individuals. In K, unanticipated competition will be utilized. The rounds would be randomized so the participant wouldn't know, but randomly there would be someone to jump in the game and compete with them on various levels. This idea stems from an example of when you work out around others you tend to feel a sense of competition and you want to impress your cohort who is either bench pressing the same weight or running right beside you on a treadmill. Further research on gender effects needs to occur, in the current study participants were different in various variables yet an explanation for these differences is unknown. Looking at these phenomena, one could compare the outcomes of the competitiveness nature/aspect of individuals while playing different games. Lastly, we can observe WOC game with and without shoes and compare training protocols of both of these.

In conclusion, we found that exergames are upcoming revolutionary game systems that promote physical activity, thus giving individuals another way to exercise. In addition, these games collectively act as option for individuals who cannot afford gym membership. Some games such as Wii Fit actually calculate the calories for you and the

METS of the activity you are performing. This was shown inaccurate in our study compared to the measured calories from the metabolic cart, which can be compared to similar games in future studies. Research on this popular topic has shown that interactive/exergames is more beneficial than stationary video games, specifically ones that inhibit the usage of the entire body rather just the lower/upper body itself.

Appendix A

APPLICATION FOR APPROVAL OF INVESTIGATIONS

INVOLVING THE USE OF HUMAN SUBJECTS

PLEASE TYPE OR USE A WORD PROCESSOR

Submit to the Office of Sponsored Programs, 301 Potter Hall, by the first working Monday of the month for screening prior to the IRB meeting. Please add additional space between items as needed to describe your project.

The human subjects application must stand alone. Your informed consent document(s), survey instrument, and site approval letter(s) should be attached to the application and referred to in your write up of the appropriate sections so that reviewers may read them as they read your application. Thesis proposals or other documents that are meant to substitute for completing the sections of the application will not be read and should not be attached.

1. Principal Investigator's Name: Demetrice Kirkwood

   Email Address: demetrice.kirkwood766@topper.wku.edu

   Mailing Address: 2135C Stonehenge Ave Bowling Green, KY 42101

   Department: Kinesiology, Sport and Recreation Phone: 270-839-4086

Completion of the Citi Program Training? Yes X No______

Found at www.citiprogram.org Date 10/07/10

Co-Investigator:

____

Email Address:

____

Mailing Address:

____

Department: _____________________ Phone: ____________

Completion of the Citi Program Training? Yes _____ No______

Found at www.citiprogram.org Date _______________

2. If you are a **student**, provide the following information:

Faculty Sponsor: James Navalta Department: Kinesiology, Sport and Recreation

Phone270-745-6037

Faculty Mailing Address: 1906 College Heights Blvd. #11089

Completion of the Citi Program Training? Yes ___X__ No______

Found at www.citiprogram.org Date _8/21/09

Student Permanent Address (where you can be reached 12 months from now):

2135C Stonehenge Ave Bowling Green, KY 42101

Is this your thesis or dissertation research? Yes X No______

Policy of Research Responsibility. The Western Kentucky University Institutional Review Board defines the responsible party or parties of the research project as the Principal Investigator and Co- Principal Investigator. In those cases when a student holds the title of Principal Investigator, the Faculty Sponsor (Advisor, Supervisor, Administrator, or general managing Council) will conduct oversight of the research project and share in the accountability to assure the responsible conduct of research. Researchers outside of the Western Kentucky University campus system are required to provide proof of training to obtain approval for WKU Human Subjects protocols. This proof must be presented by the Compliance Official at the researcher's institution to the WKU Compliance official. When no training requirement exists at the researcher's host institution, training must be conducted through affiliation of Western Kentucky University CITI Program.org requirements. WKU faculty, staff, and students are required to complete the CITI Program Training modules outlined by the WKU HSRB.

3. Title of project: The Effects of Playing Exergames on Energy Expenditure

4. Project Period: Start __upon HSRB approval__ End November 18, 2011
month, day, year

Note: *Your project period may not start until after the HSRB has given final approval.*

5. Has this project previously been considered by the HSRB? Yes ____ No X

If yes, give approximate date of review:

6. Do you or any other person responsible for the design, conduct, or reporting of this research have an economic interest in, or act as an officer or a director of, any outside entity whose financial interests would reasonably appear to be affected by the research?

Yes ______ No X

If "yes," please include a statement below that may be considered by the Institutional Conflict of Interest Committee:

7. Is a proposal for external support being submitted? Yes____ No X

If yes, you must submit (as a separate attachment) one complete copy of that proposal as soon as it is available and complete the following:

a. Is notification of Human Subject approval required? Yes ____ No_____

b. Is this a renewal application? Yes _____ No _____

c. Sponsor's Name:

d. Project Period: From: To:

8. You must include copies of all pertinent information such as, a copy of the questionnaire you will be using or other survey instruments, informed consent documents, letters of approval from cooperating institutions (e.g., schools, hospitals or other medical facilities and/or clinics, human services agencies, individuals such as physicians or other specialists in different fields, etc.), copy of external support proposals, etc.

9. Does this project SOLELY involve analysis of an existing database? Yes ____ No X

   If yes, please provide the complete URLs for all databases that are relevant to this application, then complete Section A and the signature portion of the application and forward the application to Sponsored Programs:

   If the database is not available in an electronic format readily available on the internet, please provide evidence that the data were collected using procedures that were reviewed and approved by an Institutional Review Board, then complete Section A and the signature portion of the application and forward the application to Sponsored Programs.

In the space below, please provide complete answers to the following questions. Add additional space between items as needed.

I. PROPOSED RESEARCH PROJECT

A. Provide a brief summary of the proposed research. Include major hypotheses and research design.

Based on previous literature, traditional sedentary video games have been shown to affect the cardiovascular system and energy expenditure in a negative manner. This is a major risk to the body, which may lead to diabetes, hypertension, and obesity just to name a few. In addition, active video games, such as Wii games, were found to move the body more in the trunk, back and thighs. To date there has not been a study on whole-body active video games. Studies have evaluated the addiction, engagement, scholastic achievement and cardiovascular effects in adolescents (Skoric et al., 2009), yet there has not been a study involving two exergame systems that focus on the entire body, such as Wii Fit and Xbox Kinect. This study will assess the energy expenditure, VO_2, and heart rate of these young adults who are untrained.

B. Describe the source(s) of subjects and the selection criteria. Specifically, how will you obtain potential subjects, and how will you contact them?

Are the human subjects – under 18 years of age, pregnant women, prisoners, or fetus/neonates? ☐ *Yes* ☐ *No*

The desired characteristics will include an age range18-30 years old with these individuals being apparently healthy. Also, these individuals will untrained meaning they are not athletes at the collegiate level. The desired participants for this study consist of individuals who are college aged. The individuals should be apparently healthy, having no medical history that will distort results. They will have no or beginners training level, determined by a questionnaire, of playing Xbox Kinect and Wii Fit Plus. Participants will be recruited from the Western Kentucky University student population. Participants will be recruited from WKU Physical Education graduate and undergraduate courses as well as by word of mouth, such as through notification of classmates (for example) of the opportunity to participate as well as possibly notifying other individuals who have previously participated and expressed interest in participating in future studies. Flyers may be posted on campus regarding the opportunity to participate (Smith Stadium, Preston Center, etc.). In each case participants will be made aware of the risks and requirements for participating and will be made aware that participation is completely voluntary. Contacting subjects will involve a) announcements in Physical Education courses, b) e-mail/phone calls to participants who have previously participated and indicated they would be interested in participating in future projects, c) in the case of participants responding to a flyer, the potential participants will contact the principle investigator via the phone number indicated on the flyer.

C. Informed consent: Describe the consent process and attach all consent documents.

All participants will complete a written informed consent (see attachment) indicating requirements for participation, risks involved, and benefits. The form also will indicate that participation is completely voluntary and that a subject may choose to drop out at any point. In addition, participants will be screened for safety according to the most recent guidelines of the American College of Sports Medicine (2006). These guidelines classify individuals as “low”, “moderate”, or “high” risk for exercise participation. ONLY participants classified as “low” risk will be allowed to participate in the current study. All participants for this study will be between the ages of 18 – 25 years of age and will be classified as “low risk” according to American College of Sports Medicine (ACSM) guidelines. “Low Risk” means that they are either females < 55 years of age or males < 45 years of age, that they are asymptomatic, and meet no more than one risk factor threshold for coronary artery disease.

D. Procedures: Provide a step-by-step description of each procedure, including the frequency, duration, and location of each procedure.

Participants will be asked to report to the Exercise Science Laboratory on one occasion to complete an incremental maximal effort exercise test on the treadmill. The test protocol detailed next is designed to gradually bring the subject to maximal effort within 8-12 minutes, but may last longer depending on the fitness level of the individual (i.e. an individual with superior cardiovascular fitness may run on the treadmill for up to 20 minutes before reaching their maximal aerobic capacity). The VO_{2max} test will begin with a 5-min warm-up at 3 mph on a motor driven treadmill (TrackMaster TMX22, Full Vision, Newton ,KS). Following the warm-up period, participants will run at 6.0 mph for 3-min and then speed increases by .6 mph with each subsequent stage until maximal speed is attained. If the subject completed at least 1-min of the final stage, it was considered to the maximal running velocity. The metabolic variable of oxygen uptake (VO_2) be obtained using a metabolic analysis unit (True One 2400, Parvo Medics Inc., Sandy UT), which is an open-circuit spirometry system. Heart rate will be measured using telemetry (Polar Oy, Finland). Prior to the VO_{2max} test, height and weight will be measured using a scale from Detecto Physicians scale (Detecto, Brooklyn, NY) for weight and a stadiometer (Seca 213, Hanover, MD) for height. For weight, participants will be informed to remove shoes and any item(s) that may deter the measurement. For height they will be instructed the same and to stand straight with their backs against the wall. On the first day of testing participants will come in and complete the Kinect Adventures(K) (Microsoft Corporation, CyberCiti, India) and Wii Obstacle Course game (WOC) (Nintendo of America Inc., Redmond, WA). Each participant will face a television screen and for the Kinect Adventures, participants will need to stand where they can be detected by the motion sensors and use their entire body for the Xbox Kinect. While facing the television, participants will hold the Wii remote placed in the dominant hands while standing on the balance board for the Wii Fit Plus game (Nintendo Wii Plus).The participants will be counter balanced so that everyone is not completing the same game each day, which may affect results. Participants should not engage in any rigorous activity 24 hours before the date of testing and refrain from eating at least 2 hours prior to test. All participants will be given a 5-min practice session so they can get used to how the game works. After this practice session, there will be a 10-min resting period; following this period will be 30-min completion of continuous play on the beginner's level of Xbox Kinect, while connected up to the metabolic cart using open-circuit spirometry. HR and rate of perceived exertion (RPE, which is an indication of effort at that instant) will be recorded for each 10-min bout of game play. They will complete a cool-down of 5-min and following HR will be recorded. Energy expenditure will be calculated using VO_2 calculations. On day two of testing, participants will come in and resting heart rate will be obtained. They will be granted a 5-min practice session on the Xbox Kinect (K) or Wii Fit Plus game (WOC). Each participant will face a television screen and for the Kinect Adventures, participants will need to stand where they can be detected by the motion sensors and use their entire body for the Xbox Kinect. While facing the television, participants will hold the Wii remote placed in the dominant hand, while standing on the balance board for the Wii Fit Plus game (Nintendo Wii Plus). HR and rate of perceived exertion (RPE) will be recorded for each 10-min bout of game play. After this practice session, there will be a 10-min resting period; following this period will be 30-min completion of continuous play on the WOC game, while connected up to the metabolic cart using open-circuit spirometry; HR and energy expenditure using the measurements of VO_2. They will complete a cool-down of 5-min and following HR will be recorded.

E. How will confidentiality of the data be maintained? (Note: Data must be securely kept for a minimum of three years on campus.)

Data will be numerically coded and stored on computer disks, which will be locked in the primary investigators office (Smith Stadium 1058).

F. Describe all known and anticipated risks to the subject including side effects, risks of placebo, risks of normal treatment delay, etc.

The main risks associated with this study are in performing the maximal effort exercise. The treadmill test is an incremental run to exhaustion that maximally stresses the cardiorespiratory system. The increased myocardial demand of maximal intensity exercise may precipitate cardiovascular events in individuals with heart disease. However, the American College of Sports Medicine has stated that the risk of death during or immediately after an exercise test is less than or equal to 0.01%, while the risk of an acute myocardial infarction is less than or equal to 0.04%. Data from these surveys included a wide variety of healthy **and** diseased individuals. The use of screening tools and healthy "low risk" individuals (as in our proposed study) would speculatively lower these risks considerably. Statements are included in the informed consent regarding these risks. The primary investigators will have current first aid and AED certification. In addition, an AED is located within the Exercise Physiology Laboratory should a cardiovascular even occur.

There is also a possibility that participants will be uncomfortable with the open-circuit spirometry head gear and mouthpiece.

G. Describe the anticipated benefits to subjects, and the importance of the knowledge that may reasonably be expected to result.

The direct benefit to the individuals participating in the study is the information that they will receive regarding their aerobic fitness level. Maximal exertion tests generally cost between $75-200, and participants will be receiving this service at no cost. Also, the participants will be able to play two different types of interactive games for free, Wii and Kinect, and some participants may not have access to these games and may be encouraged to purchase them. They get a free analysis on how many calories they burned during each single play of these games.

H. List of references (if applicable):

Additions to or changes in procedures involving human subjects, as well as any problems connected with the use of human subjects once the project has begun, must be brought to the attention of the IRB as they occur.

II. SIGNATURES

A. I certify that to the best of my knowledge the information presented herein is an accurate reflection of the proposed research project.

____________________________________ ______________

Principal Investigator Date

____________________________________ ______________

Co-Investigator Date

B. Approval by faculty sponsor (required for all students):

I affirm the accuracy of this application, and I accept the responsibility for the conduct of this research, the supervision of human subjects, and maintenance of informed consent documentation as required by the IRB.

____________________________________ ______________

Faculty Sponsor Date

C. Approval by Department Head is not required (Some departments require approval by the Department Head. Please verify with your department head if their signature is required). If PI is a director or department head, then the PI's immediate superior should sign.

I confirm the accuracy of the information stated in this application. I am familiar with, and approve of the procedures that involve human subjects.

____________________________________ ______________

Department Head (or immediate superior) Date

D. Advising Physician*:

I certify that I am a duly licensed physician in the State of Kentucky and that, acting as advising physician, I accept the procedures prescribed herein.

____________________________________ ______________

Physician’s Name and Signature Date

*Physician signature is needed only if the project involves medical procedures and the investigator is not a licensed physician.

Project Title: The Effects of Playing Exergames on Energy Expenditure

Investigator: _Demetrice Kirkwood, Kinesiology, Recreation, and Sport, (270) 839-4086____

(include name, department and phone of contact person)

(This portion is for IRB use only.)

HSRB Determination:

Exempt from Full Review ( ) Expedited Review ( ) Full HSRB Review ( )

( ) Disapproval ( ) Approval

( ) Above minimal risk ( ) Minimal risk

a. approval, subject to minor changes

b. approval in general but requiring major alterations, clarifications or assurances

c. restricted approval

Date of review: ______________________

Comments:

____ __________________

Institutional Review Board Chair Date

____ __________________

Compliance Manager Date

If you have questions regarding review procedures or completion of this IRB application, contact the **Office of Sponsored Programs**:

Director -- Dr. Steve Haggbloom, Human Protections Administrator, (270) 745-4652

E-mail: Steven.Haggbloom@wku.edu

Compliance Coordinator -- Mr. Paul Mooney, Human Protections Administrator, (270) 745-2129

E-mail: Paul.Mooney@wku.edu

(Note: This format is suggested by the IRB and may be adapted for your project.)

Project Title: The Effects of Playing Exergames on Energy Expenditure

Investigator: Demetrice Kirkwood, Kinesiology, Recreation, and Sport, 745-5555

You are being asked to participate in a project conducted through Western Kentucky University. The University requires that you give your signed agreement to participate in this project.

The investigator will explain to you in detail the purpose of the project, the procedures to be used, and the potential benefits and possible risks of participation. You may ask him/her any questions you have to help you understand the project. A basic explanation of the project is written below. Please read this explanation and discuss with the researcher any questions you may have.

If you then decide to participate in the project, please sign on the last page of this form in the presence of the person who explained the project to you. You should be given a copy of this form to keep.

1. **Nature and Purpose of the Project:** Traditional sedentary video games have been shown to affect the cardiovascular system and energy expenditure in a negative manner. This is a major risk to the body, which may lead to diabetes, hypertension, and obesity just to name a few. In addition, active video games, such as Wii games, were found to move the body more in the trunk, back and thighs. To date there has not been a study on whole-body active video games. Studies have evaluated the addiction,

engagement, scholastic achievement and cardiovascular effects in adolescents (Skoric et al., 2009), yet there has not been a study involving two exergame systems that focus on the entire body, such as Wii Fit and Xbox Kinect. This study will assess the energy expenditure, VO_2, and heart rate of these young adults who are untrained.

2. **Explanation of Procedures:** Your first visit to the Exercise Science Laboratory will be to perform a maximal aerobic test to exhaustion in which your maximal running speed is determined. The VO_{2max} test will begin with a 5-min warm-up at 3 mph on a motor driven treadmill. Following the warm-up period, participants will run at 6.0 mph for 2-min and then speed increases by .6 mph with each stage until your maximal running speed is attained. You will be asked to wear a mask attached to your face so that expired breath can be measured. In addition, your heart rate will be measured using a strap that is placed around your chest. In day one of testing you will complete either Just Dance 2 or Wii Sport Boxing and you will be asked to wear a mask attached to your face so that expired breath can be measured while playing each game on both days of testing. Blood pressure will be assessed before and after each game.

3. **Discomfort and Risks:** The main risks to you are associated with performing the maximal effort exercise. The treadmill test is an incremental run to exhaustion that maximally stresses the cardiorespiratory system. The increased myocardial demand of maximal intensity exercise may precipitate cardiovascular events in individuals with heart disease. However, the American College of Sports Medicine has stated that the risk of death during or immediately after an exercise test is less than or equal to 0.01%, while the risk of an acute myocardial infarction is less than or equal to 0.04%. Data from these

surveys included a wide variety of healthy **and** diseased individuals. The use of screening tools and healthy "low risk" individuals (as in our proposed study) would speculatively lower these risks considerably. Statements are included in the informed consent regarding these risks. The primary investigators will have current first aid and AED certification. In addition, an AED is located within the Exercise Physiology Laboratory should a cardiovascular even occur.

4. **Benefits:** The direct benefit to you participating in the study is the information that you will receive regarding your aerobic fitness level. Maximal exertion tests generally cost between $75-200, and participants will be receiving this service at no cost. Your personal data will be provided following the study upon request.

5. **Confidentiality:** You will be assigned a numerically coded identification number. Your data will be stored on computer disks, which will be locked in the primary investigators office (Smith Stadium 1058).

6. **Refusal/Withdrawal:**

Refusal to participate in this study will have no effect on any future services you may be entitled to from the University. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

(consent form continued)

You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks.

____ _______________

Signature of Participant Date

____ _______________

Witness Date

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT

THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY

THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD

Paul Mooney, Human Protections Administrator

TELEPHONE: (270) 745-4652

Appendix B

ACSM Initial Risk Stratification Questionnaire

Name: ____

Date of Birth: __________________

Write a **Y** for all statements that are true, write a **N** for all statements that are false, and write a **U** for all statements that are unknown.

Cardiovascular Risk Factors

_____ Men ≥ 45 yr; Women ≥ 55 yr
_____ You have a first-degree relative who had a heart attack or coronary revascularization **or** sudden death before age 55 (father or brother) **or** age 65 (mother or sister).
_____ You smoke cigarettes **or** you quit smoking cigarettes within the last 6 months. Second hand smoke.
_____ Your systolic blood pressure is ≥ 140 **or** your diastolic blood pressure is ≥ 90 mmHg **or** you take blood pressure medication.
_____ Your LDL-cholesterol is ≥ 130 mg/dl (if LDL not known: your total cholesterol is ≥ 200 mg/dl) **or** your HDL-cholesterol is < 40 mg/dl **or** you take lipid lowering medication.
_____ Sedentary lifestyle (Not participating in at least 30 min of moderate intensity PA on at least 3 days per week for at least 3 months)
_____ Obesity. BMI ≥ 30 kg/m^2 or waist girth ≥ 102 cm (men) and ≥ 88cm (women)
_____ Prediabetes, Impaired fasting glucose ≥ 100 mg/dl but ≤ 126 mg/dl. Impaired glucose tolerance ≥ 140 mg/dl ≤ 200mg/dl.
_____ Your HDL-cholesterol is ≥ 60 mg/dl

Symptoms

_____ You experience pain or discomfort in the chest, neck, or arms.
_____ You experience shortness of breath at rest or with mild exertion.
_____ You experience dizziness or have had episodes of blackouts.
_____ You have swelling of the ankles
_____ You experience shortness of breath with change of posture or while sleeping
_____ You experience episodes of rapid heart beats or skipped heart beats.
_____ You experience pain or cramping sensations in your legs when walking.
_____ You experience fatigue or shortness of breath with unusual activities.

Medical History **List all other notable health problems, injuries, or conditions**

You have or have had: ________________________________ _____
_____ Heart murmur _____ heart attack ________________________________
_____ heart surgery _____ a lung disease ________________________________
_____ a metabolic disease (diabetes, thyroid disorder, kidney or liver disease)

List names/doses/frequency of all medications taken (if not taking any medications, write "NONE")
________________________________ ________________________________

Staff Comments (explain all Y or U responses)
________________________________ ________________________________

____

ACSM initial risk stratification (circle classification): LOW MODERATE HIGH

Recommendations for: medical exam, GXT, and MD supervision. ________________________________
____

Appendix C

Table C1. Descriptives for males and females of this study. Significance was shown and is indicated in the below variables (*, P = 0.01).

Characteristic	Sex	M	SD
Height (cm)	Male	*177.8	4.31
	Female	160.2	4.18
	Total	167.8	9.91
Weight (kg)	Male	*80.93	19.11
	Female	61.28	7.23
	Total	69.70	16.44
VO_2max ml/kg/min	Male	*53.70	11.38
	Female	39.53	9.30
	Total	45.61	12.22
BMI (kg/m^2)	Male	*25.53	5.52
	Female	23.83	2.57
	Total	24.56	4.00
Resting HR	Male	73.50	11.50
	Female	*87.50	16.08
	Total	81.50	15.55
VO_2max Max HR	Male	177.5	13.23
	Female	*188.6	16.91
	Total	183.8	15.94
Mets VO_2max	Male	*15.35	3.26
	Female	11.37	2.60
	Total	13.07	3.45
RPE VO_2	Male	17.3	2.58
	Female	*18.3	1.28
	Total	17.8	1.92

Appendix D

Active Video Game Experience

Name (please print):____

Gender (please circle one): Male Female

Age:______________________ Major:____________________________________

Directions: Please circle the best answer for each of the following questions, or write your answer in the space marked "other".

1. Have you ever played video games? Yes No

2. Do you currently play video games? Yes No

If yes are any of them active video games? Yes No

If your answer was "No" to either question, why don't you play video games?

a. cost d. lack of skill

b. not interested e. other____

c. not enough time

If your answer to # 1 or # 2 was "No", answer please skip to question # 12.

3. How long have you been playing video games?

a. 6 months d. 5-10 years

b. 1 year e. 10 or more years

c. 2-5 years

4. How did you get started playing video games; who or what motivated you to play?

a. self-interest d. advertisements (magazines, TV, newspaper)

b. other female/s e. the internet

c. other male/s f. other____

5. How often (approximately) do you currently play video games (active)?

a. daily d. once in 6 months

b. weekly e. once a year

c. once a month f. less than once a year or never

6. If you play active video games, how many hours a week do you spend playing them?

a. 2-5 c. 10-15

b. 5-10 d. none-occasional

7. What consoles do you own (if any) or play? Please list all.

____

8. If you play active games, do you use them for exercise or just in leisure time? Briefly explain.

9. What are your Top 5 (in order) video games that you like to play?

#1.______________________________#4__________________________________

#2.______________________________#5__________________________________

#3.______________________________

11. Based on your Top 5, what attracts you to these games?

____

____

____

12. Would you be interested in playing video games in the future? Yes No

Appendix E

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INFORMED CONSENT DOCUMENT

Project Title: I The Effects of Playing Exergames on Energy Expenditure

Investigator: Demetrice Kirkwood, Kinesiology, Recreation, and Sport, (270) 839-4086

You are being asked to participate in a project conducted through Western Kentucky University. The University requires that you give your signed agreement to participate in this project.

The investigator will explain to you in detail the purpose of the project, the procedures to be used, and the potential benefits and possible risks of participation. You may ask him/her any questions you have to help you understand the project. A basic explanation of the project is written below. Please read this explanation and discuss with the researcher any questions you may have.

If you then decide to participate in the project, please sign on the last page of this form in the presence of the person who explained the project to you. You should be given a copy of this form to keep.

1. **Nature and Purpose of the Project:** Video games have proven to affect the cardiovascular system and increase energy expenditure. In addition, active video games, such as Wii Fit and Xbox Kinect were found to move the body more in the trunk, back and thighs. To date there is yet to be a study of the upper body movement with the active video games. Studies have evaluated the addiction, engagement, scholastic achievement and cardiovascular effects in adolescents. We wish to assess the energy expenditure, VO_2, respiratory exchange ratio, and heart rate of these young adults who are untrained

2. **Explanation of Procedures:** Your first visit to the Exercise Science Laboratory will be to perform a maximal aerobic test to exhaustion in which your maximal running speed is determined. The VO_{2max} test will begin with a 5-min warm-up at 3 mph on a motor driven treadmill. Following the warm-up period, subjects will run at 6.0 mph for 2-min and then speed increases by .6 mph with each stage until your maximal running speed is attained. You will be asked to wear head gear and mouthpiece attached to your face so that expired breath can be measured. In addition, your heart rate will be measured using a strap that is placed around your chest. In day one of testing you will complete either Wii Fit and Xbox Kinect, which are both obstacle course games, and you will be asked to wear head gear and mouthpiece attached to your face so that expired breath can be measured while playing each game on both days of testing.

3. **Discomfort and Risks:** The main risks to you are associated with performing the maximal effort exercise. The treadmill test is an incremental run to exhaustion that maximally stresses the cardiorespiratory system. The increased myocardial demand of maximal intensity exercise may precipitate cardiovascular events in individuals with heart disease. However, the American College of Sports Medicine has stated that the risk of death during or immediately after an exercise test is less than or equal to 0.01%, while the risk of an acute myocardial infarction is less than or equal to 0.04%. Data from these surveys included a wide variety of

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healthy **and** diseased individuals. The use of screening tools and healthy "low risk" individuals (as in our proposed study) would speculatively lower these risks considerably. Statements are included in the informed consent regarding these risks. The primary investigators will have current first aid and AED certification. In addition, an AED is located within the Exercise Physiology Laboratory should a cardiovascular even occur.

4. **Benefits:** The direct benefit to you participating in the study is the information that you will receive regarding your aerobic fitness level. Maximal exertion tests generally cost between $75-200, and participants will be receiving this service at no cost. Your personal data will be provided following the study upon request.

5. **Confidentiality:** You will be assigned a numerically coded identification number. Your data will be stored on computer disks, which will be locked in the primary investigators office (Smith Stadium 1058).

6. **Refusal/Withdrawal:**

Refusal to participate in this study will have no effect on any future services you may be entitled to from the University. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks.

______________________________ ____________

Signature of Participant Date

______________________________ ____________

Witness Date

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT
THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY
THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD
Paul Mooney, Human Protections Administrator
TELEPHONE: (270) 745-4652

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Appendix F

Table F1. Time Intervals and RPE values. Shown below are the time intervals for RPE and the significance ($P < 0.05$).

Time (min)	Sex	Game System	M	SD
5	Male	Wii	8.83	2.04
		Xbox	10.00	1.26
	Female	Wii	10.25	1.16
		Xbox	9.50	2.00
10	Male	Wii	10.33	2.50
		Xbox	11.83	.983
	Female	Wii	11.38	1.68
		Xbox	11.75	3.05
15	Male	Wii	11.33	2.73
		Xbox	12.67	1.03
	Female	Wii	12.25	1.75
		Xbox	12.88	2.53
20	Male	Wii	11.83	2.31
		Xbox	13.33	1.03
	Female	Wii	12.88	2.16
		Xbox	14.38	2.26
25	Male	Wii	12.33	2.06
		Xbox	14.50	1.97
	Female	Wii	13.50	2.61
		Xbox	14.88	1.95
30	Male	Wii	13.33	1.63
		Xbox	13.67	1.03
	Female	Wii	14.13	2.41
		Xbox	15.38	2.20

Note. n = 14.

BIBLIOGRAPHY

Alderman, B.L., Arent, S.M., Landers, D.M., & Rogers, T.J. 2007. Aerobic exercise intensity and time of stressor administration influence cardiovascular responses to psychological stress. *Psychophysiology,* 44, 759-766.

Barkely, J. E., & Penko, A. 2009. Physiologic responses, perceived exertion, and hedonics of playing a physical interactive video game relative to a sedentary alternative and treadmill walking in adults. *Jour Exer Phys*, 12 (3), 12-22.

Blasio, A.D., Sablone, A., CIvino, P., D'Angelo, E., Gallina, S., & Ripari, P. 2009. Arm vs. combined leg and arm exercise: blood pressure responses and ratings of perceived exertion at the same indirectly determined heart rate. *J Sports Sci Med*, 8, 401-409.

Borusiak, Peter, Bouikidis, Anastsios, Liersch, Rudiger, & Russell, Jarrod B. 2008. Cardiovascular effects in adolescents while they are playing video games: A potential health risk factor? *Psychopsychology,* 45, 327-332.

Graf, D.L, Pratt, L.V, Hester, C.N., & Short, K.R. 2009. Playing active video games increases energy expenditure in children. *Pediatric,* 124, 534-540.

Graves, L.E.F., Ridgers, N.D., Stratton, G., Atkinson, G., & Cable, N.T. 2010. The physiological cost and enjoyment of wii fit in adolescents, young adults and older adults. *J Phys Act Health*, 7, 393-401.

Haddock, B.L., Brandt, A.M., Siegel, S.R., Wilkin, L.D., & Han. J. 2008. Active video games and energy expenditure among the overweight children. *I.J Fitness,* 4 (2), 17-24.

Healthy People 2010. (2010, October 10) Retrived from http://www.healthypeople.gov/Document/html/uih/uih_bw/uih_4.htm#physactiv, 2001.

Jin, S. A. 2009 .Avatars mirroring the actual self- versus projecting the ideal self: the effects of self-priming on interactivity and immersion in an exergame, wii fit. *Cyberpsychol Behav*1, 2 (6), 761-765.

Kautianen, S., Koivusilta, L., Lintonen, T., Virtanen, S., & Rimpela, M. 2005. A. Use of information and communication technology and prevalence of overweight and obesity among adolescents. *Int J Obes (Lond),* 29, 925-933.

Lanningham-Foster, L., Foster, R. C., McCrady, Shelly K., Jensen, T. B., Mitre, N., &Levine, J. A.. 2009. Activity-promoting video games and increased energy expenditure. *J Pediatr,* 154, 819-823.

Rasmussen, P. H., Staats, B. A., Driscoll, D. J., Beck, K.C., Bonekat, H. W., & Wilcox, W. D. 1985. Direct and indirect blood pressure during exercise. *Chest,* 87, 743-748.

Sell, K., Lillie, T., & Taylor, J. 2008. Energy expenditure during physically interactive video game playing in male college students with different playing experience. *J Am Coll Healt, 56(5),* 505-511.

Sell, K., Clocksin, B. D., Spierer, D., & Ghigiarelli, J. 2011. Energy expenditure during non-traditional physical activities. *J Exerc Physiol,* 14 (3), 101-112.

Siegel, S.R., Haddock, B. L., DuBois, A. M, and Wilkin, L, D. 2009. Active video/arcade games (exergaming) and energy expenditure in college students. *Int J Exerc Sci,* 2(3), 165-174.

Sinclair, J., Hingston, P., & Masek, M. 2007. Consideration for the design of exergames. *Assoc Comp Mach,* 289-294.

Skoric, M. M., Ching Teo, L. L, &Neo, R.L. 2009. Children and video games: addiction, engagement, and scholastic achievement. *Cyberpsychol Behav,* 12(5), 567-572.

Vincent, H.K., Powers, S. K., Stewart, D. J., Shanely, R.A., Demirel, H., & Naito, H. 1999. Obesity is associated with increased myocardial oxidative stress. *Int J Obes (Lond),* 23, 67-74.

Warburton, D.E.R, Bredin, S.S. D., Horita, L.T. L, Zbogar, D., Scott, J. M., Esch, B.T. A., & Rhodes, R.E. 2007. The health benefits of interactive video game exercise. *Appl Physiol Nutr Metab,* 32, 655-663.

Whittman, G. 2010. Video Gaming Increases Physical Activity. *J Exten,* 48(2), 1-4.