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COMPARISON OF ENERGY EXPENDITURE IN YOUR SHAPE™ FITNESS

EVOLVED 2012 CALORIE COUNTER AND INDIRECT CALORIMETRY

A Thesis

Presented To

Eastern Washington University

Cheney, Washington

In Partial Fulfillment of the Requirements

for the Degree

Master of Science

By

Robert D. Cimball

Spring 2013

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MASTER'S THESIS

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Abstract

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The primary purpose of this study was to analyze the accuracy of Your Shape™ Fitness Evolved 2012 calorie counter against the indirect calorimetry of the Oxycon Pro™. The secondary purpose of this study was to see if Body Mass Index (BMI) significantly altered the accuracy of energy expenditure (EE) scores in the Your Shape™ Fitness Evolved 2012 calorie counter. Convenient subjects were recruited from Eastern Washington University campus (25 male; 28 Female; N = 53). Using a Within Subjects 2x2 Factorial ANOVA, there was a significant difference in calories expended between the two experimental devices (p = 0.000; F = 172.76; df = 1). There was a significant interaction effect between the two devices and the two BMI classes of normal weight and overweight (p = 0.000; F = 15.23; df = 1). The interaction effect showed Your Shape™ Fitness Evolved 2012 to have greater caloric variation when analyzing overweight BMI individuals. In conclusion, Your Shape significantly over estimates calories expended during game play, and a secondary form of calorie estimation should be used such as, hip mounted accelerometry.

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Chapter 1

Introduction

In the twenty-first century technology has become integrated into our daily lives including many forms of entertainment. New technology has enhanced standards of living and entertainment, which have and will replace old methods of entertainment and living. Over the previous century the use of the physical body has slowly diminished as a tool to complete many activities for example: automobiles being used instead of walking or horseback; machines being used instead of manual labor; and computer/video games being used instead of playing outside. Our technologic-youth have grown accustomed to these new tools and will most likely continue to use and develop new ways to live.

The main problem with technologies like computers, TV or video games is that they are so effective in keeping us sedentary in front of them. A recent study found that 97% of adolescents use computers, TV and video games (Lenhart, Jones, & Macgill, 2008). With the majority of youth using these technologies the time spent sedentary has overtaken time being active, which has led to negative health consequences. Studies have shown that there is an inverse relationship to sedentary screen time and cardio-respiratory fitness (Chinapaw, Proper, Brug, Mechelen & Singh, 2011; Vandewater, Shim & Caplovitz, 2004). Evaluation of these findings have driven researchers to develop a new term called "Sedentarism" to encompass the health effects related to sedentary behavior (Bernstein, Morabia & Sloutskis, 1999; Oehlschlaeger, Pinheiro, Horta, San'Tana & Gelatti, 2004).

As a result of these reports the developers at Microsoft, Nintendo, and Sony set out to make physical activity a priority while playing their video games to help counteract the time being sedentary, especially for youth. These companies developed non-sedentary systems like the Nintendo Wii Fit™, Microsoft Xbox 360 Kinect™, and the Sony PlayStation Move™, which all require physical movement when interacting with their games. These systems are designed to use whole body movement, which forces the player to expend a larger amount of calories than sedentary hand controller play, though some research has suggested that less activity with the Wii controller can have the same or better scores than someone using large movements (Harshman, 2009). Current research into health benefits is variable in significance depending on the game and type of activity being studied, but suggests that interactive gaming can increase energy expenditure, oxygen uptake, and heart rate over sedentary activity; It can also fulfill the cardio-respiratory fitness requirements for ACSM (Mark, Rhodes, Warburton & Bredin, 2008; Peng, Crouse & Lin, 2012).

These systems are all relatively new but have become very popular (Slagle, 2006). Among these is the Microsoft Xbox Kinect™, which sold eight million units in the first 60 days of sales and currently holds the Guinness World Record for fastest selling consumer electronic device (Guinness World Records Press, 2011; Ingham, 2011). The Kinect™ is different from the other platforms, because it utilizes an infrared projector to make a depth map of the player's physical features (Lange, Chang, Rizzo, Suma & Bolas, 2011). The map is then registered to make the body an input device to control interaction in the game compared to the games, which require a device held in the hand called a

wand. Unlike devices that utilize the handheld wand, the Kinect™ insures that the player

cannot cheat by only moving the arms to score points.

Currently rated as one of the top fitness games for the Kinect™, Your Shape™

Fitness Evolved 2012 developed by Ubisoft uses this whole body tracking and

incorporates exercises to focus on specific muscle groups, while calculating energy

expended. There have been reports of underestimating calories burned while playing the

game, and since the game's release, most of the report have been from Ubisoft's forums

stating a perceived inaccuracy in calculating energy expenditure during vigorous activity

(Ubisoft Forums, 2010). Other outside sources, such as IGN, a game review site, and

various YouTube consumer reviews have reported the same problem (IGN, 2010).

This problem with calorie inaccuracy is unknown. The game's programming is

proprietary, and the only known input to the game is 2D mapping, height, weight, and

age. With only these factors being used, the game's programming maybe using the Body

Mass Index (BMI) to calculate expenditure. BMI is a simple measurement and has some

variability when estimating body composition (Cunningham, 1991). BMI can not

account for variations in cell type, which limits its ability to separate more metabolically

active muscle tissue from less metabolically active fat tissue (Kleiber, 1947). It would be

beneficial to compare BMI to see if the video game's programming uses BMI as a major

factor.

Other games with perceived inaccuracy from consumers are Wii™: Walk it out,

Just Dance 2, Gold's Gym Cardio Dance Workout (Butterflyfaer, 2011; Lovemyboys27,

2010; Res, 2011). Inaccurate read outs on calories burned could compel the player to eat

less or imbalance calories for proper weight management, and for younger players who

have no prior reference to total caloric expenditure during play, inaccurate readouts could affect future health/exercise related choices. This perceived inaccuracy not only makes the player a little distressed, but also limits the information needed to accurately track calories for weight management (Clay, 2000).

Problem statement

Due to the increased popularity in video game home entertainment systems and the current obesity epidemic, the video game market has developed home fitness games as tools to lead a healthier lifestyle. Among these new entertainment systems is the Xbox Kinect™, which uses whole body input instead of a handheld wand. Currently, there is limited research using these home fitness games and systems. Therefore the purpose of this study was to compare energy expenditure (EE) from the proprietary internal calorie calculator in the video game Your Shape™ Fitness Evolved 2012 against indirect calorimetry using an Oxycon Pro™ to estimate the game's calorie accuracy.

Hypothesis

Null hypothesis.

There would be no significant difference in EE (kcal/min) between the Oxycon Pro™ and the video game Your Shape™ Fitness Evolved 2012 in college students. It was also hypothesized that there would be no significant difference in Oxycon Pro™ and Your Shape™ Fitness Evolved 2012 EE (kcal/min) scores between subjects with normal or overweight Body Mass Index (BMI). The hypotheses were tested at an alpha level of $p \leq 0.05$.

Operational definitions

Energy expenditure (EE).

The total amount of energy consumed by an individual in kilocalories per minute (kcal/min), and EE was measured by indirect calorimetry using the Oxycon Pro™ to compute caloric expenditure from the measure of O_2 consumed in Liters/minute by the formula 1kcal = 5L/min according to ACSM guidelines.

Limitations

One limitation for this study was related to data collection. The Oxycon Pro™ metabolic cart is stationary, and for standardization, the length of the tube between the cart and the mask is specific and limited some freedom of movement. This confinement of area limited the number of testable game modes, because some of the game modes require horizontal movement past the tubing length, such as the dancing and step aerobics modes.

Delimitations

The sample size was delimited to 53 relatively healthy participants aged eighteen and up. The sample was chosen for its convenience, because consumer purchase reports are needed to accurately have a representative sample of the population, which would require randomized sampling carried out from the one million plus consumers. It should be noted that with an N of one million and one degree of freedom at alpha 0.05 the sample size would be 384 to keep confidence and precision (Krekcie & Morgan, 1970).

Significance of the study

If there is no significant difference between the Oxycon Pro™ and the calorie counter in Your Shape™ Fitness Evolved 2012, then the video game can be reported as a reliable tool to help individuals monitor their caloric expenditure for weight loss, gain, and balance for the game played in the study. If the null hypothesis is rejected, then Your Shape™ Fitness Evolved 2012 should be used in combination with a secondary EE monitor, such as a hip mounted accelerometer or a device similar to the BodyBugg™.

Summary

Research regarding home fitness platforms like the Wii Fit™, Xbox 360 Kinect™ and the Sony Eye Toy™ is minuscule compared to their recent popularity, and research should answer some common questions related to them. These fitness games were developed for the avid customer seeking the benefits of exercise, and to use them as a tool for weight loss, gain and balance. Therefore, the primary purpose of this study was to analyze the accuracy of Your Shape™ Fitness Evolved 2012 calorie counter against the indirect calorimetry of the Oxycon Pro™. The secondary purpose of this study was to see if normal or overweight BMI significantly alters the accuracy of EE scores in the Your Shape™ Fitness Evolved 2012 calorie counter. The research hypothesis, assumption, limitations, and delimitations were stated above.

Chapter 2

Review of Literature

Introduction

Due to the increased popularity in video game home entertainment systems and the current obesity epidemic, the video game market has developed home fitness games as tools to lead a healthier lifestyle. There is currently limited research using these home fitness games. Therefore, the purpose of this study was to compare energy expenditure (EE) from the internal calorie calculator in Your Shape™ Fitness Evolved 2012 against indirect calorimetry. In support of the project purposes, this literature review covers the following topics: (a) obesity, sedentary video gaming, and physical inactivity; (b) video games using motion sensing as input devices, and physical activity; and (c) consumer interests related to correct EE analyses.

Obesity, sedentary video gaming, and physical inactivity

Obesity in the United States has risen dramatically since the 1980's (Wang & Beydoun, 2007). In 2010 34.2% of U.S. adults over 20 years old were overweight, 33.8% were obese, and 5.7% were extremely obese (Ogden & Carroll, 2010). Washington State's obesity rate was at 25.5%, and Spokane County was slightly higher at 28% (CDC, 2012). If the numbers continue to rise, the economic burden of obesity could account for 16% - 18% of the total US health-care costs by 2030 (Wang, Beydoun, Caballero, Kumanyika & Liang, 2008).

Sedentary behaviors in combination with physical inactivity play major roles in obesity and its relationship to health. Studies have shown that obesity has a strong correlation to cancers, respiratory diseases, diabetes, heart disease, bone diseases and

depression (Calle, Rodriguez, Walker-Thurmond & Thun, 2003; Danaei et al., 2009; Pedersen & Saltin, 2006). These studies support that sedentary obesity is a key contributing factor in the health of the U.S. population, and has made researchers adopt the term "Sedentarism" to reference its prevalence. Sedentarism represents life style choices in people who expend less than 10% of their daily energy and rarely perform moderate or high intensity activities (Oehlschlaeger et al., 2004).

The obesity problem has been shown to have the same relationship to both sedentary time and cardio-respiratory fitness, with video game, television, and computer screen time being the major contributor to sedentary time (Chinapaw et al., 2011; Vandewater et al., 2004). This would suggest sedentary video game screen time is a likely contributor to the problem. Reported in 2008 when active games were just beginning to get popular, approximately one in five adults (21%) played most days of the week (Lenhart et al., 2008). Adding to the problem is that Generation Y has grown up with computers and videogames. Generation Y demonstrates their fandom each time a new game releases and sales skyrocket (Blair & Brodney, 1999; Slagle, 2006; Video Game Charts, 2012). According to one poll, more than half of all college students play video games, and 69% of them started in elementary school (Jones, 2003). The game industry is pushing to create active games, but the inactive games still make up the majority of offerings and sales (Video Game Charts, 2012).

Physical activity, and video games using motion sensing as input devices

To attenuate this lifestyle-related obesity problem ample research suggests physical activity can decrease mortality and reduce the health risks associated with obesity (Blair & Brodney, 1999; Peng, Crouse & Lin, 2012; Sesso, Paffenbarger & Lee,

2000). The American College of Sports Medicine (ACSM) is currently a major leader in establishing research and guidelines to promote physical activity. For weight gain prevention, ACSM recommends extra daily expenditure of multiple cardio-respiratory intensities in combination with healthy dieting to acquire the health benefits from exercise. For modest weight loss, ASCM recommends 150 minutes of moderate-intensity aerobic exercise per week, or 30-60 minutes of moderate-intensity aerobic exercise five days per week, or 20-60 minutes of vigorous-intensity exercise three days per week, or one continuous 150 minute session, or multiple shorter sessions of at least 10 minutes (ACSM, 2012).

For obese individuals ACSM recommends moderate-intensity of >250 minutes/week over daily expenditure to acquire the associated health benefits. It also recommends strength training as part of this health and fitness regimen; in order to increase fat-free mass and further reduce health risks (ACSM, 2012). Your Shape™ Fitness Evolved 2012 utilizes EE as its parametric fitness measurement for clients. ACSM recommends a target EE of 150 to 400 net kcals expended per day or 250 to 500 kcals/day for weight loss, with the lower end of this range equaling 1000 net kcals per week, and the upper approximately 3000 net kcals per week (ACSM, 2009).

A novel way to acquire the physical activity prescription requirements is by using physically taxing video games. Research on games has found a range in activity level with whole body movement as the input device yielding greater outputs around 6-10 kcal per minute, and half bodied IR controls (such as a Wii™ remote) yielding lower outputs around 1-6 kcals per minute (Noah, Spierer, Tachibana & Bronner, 2011; Staiano & Calvert, 2011; Whitehead, Johnston, Nixon & Welch, 2010; Worley, Rogers & Kraemer,

2011). The difference in EE is related to how the subject interacts with the game, whether a controller with limited movement is used as the input device like the Wii™ remote and PlayStation Move™ controller, or the whole body as the input device like the Kinect™ (Whitehead et al., 2010).

There is other variability in the experience level of the subjects when using whole body movement as the input device. There is evidence that shows 20 cumulative hours or more of game play is needed in male and female subjects older than 18 years of age for standardized testing in complex whole body movement games with the Kinect™ like Dance Dance Revolution. The game requires subjects to learn new, fast paced dance routines, which linearly increases the EE with skill level and beats per minute (Noah et al., 2011; Trout & Zamor, 2008).

Whole bodied input devices increase activity with skill level, while the opposite has been found with the half bodied IR controller input devices like the Wii™ remote. EE decreases by the subject's willingness to participate, for example, Harshman (2009) found that subjects could interact with Wii™ tennis by using only the flick of the wrist and not a full backhand or fore hand swing, which significantly reduced the subjects EE during play.

This way of playing is common in individuals who do not want to mimic the games designed format but are only interested in scoring points, which makes whole bodied input devices better at increasing physical activity, because they require the whole body and not just the hand to interact with the platform. Your Shape™ Fitness Evolved 2012 uses whole bodied movement and has its own EE counter built into the game to estimate physical activity.

Your Shape™ Fitness Evolved 2012 utilizes the Xbox 360 Kinect™ platform. The Kinect™ sensor consists of an Infrared projector along with standard RGB and infrared complementary metal–oxide–semiconductor image sensors (Lange et al., 2011). The Kinect™ laser source emits a single beam, which is split into multiple beams by a diffraction grating to create a constant pattern of speckles projected onto the scene. This pattern is captured by the infrared camera and is correlated against a reference pattern. The reference pattern is obtained by capturing a plane at a known distance from the sensor, and is stored in the memory of the sensor. When a speckle is projected on an object whose distance to the sensor is smaller or larger than that of the reference plane the position of the speckle in the infrared image will be shifted in the direction of the baseline between the laser projector and the perspective center of the infrared camera. These shifts are measured for all speckles by a simple image correlation procedure, which yields a disparity image (Khoshelham, 2011).

Essentially, the sensor constructs a depth map of the subject using a proprietary algorithm to resolve the pattern produced by projecting coded infrared light onto the scene geometry, thus the game allows for full range of movement to be captured (Lange et al. 2011). Your Shape™ Fitness Evolved 2012 captures and analyzes the subject's whole fitness session.

The Kinect™ came to the market in the United States on November 4, 2010 so, it is relatively new (Chen, 2010). Your Shape™ Fitness Evolved 2012 is the latest version of the series Your Shape™ and uses the Kinect™ sensor device to track over 90 hours of fitness activities (Ubisoft, 2012). Currently, the information about how the game converts IR images to caloric expenditure is proprietary information, and it is unknown if

Ubisoft programmed the game to use accelerometry to register the bodies motion. The

act of keeping information proprietary is common in new exercise equipment. Exercise

bikes and treadmills have calorie tracker formulas that are proprietary, and they have

shown to facilitate a larger population variance (Clay, 2000). ACSM guidelines can be

referred to for the metabolic equations in bikes, treadmill, and elliptical. Accelerometry

is any devices that tracks limb movement and calculates acceleration of the movement by

a mathematical formula.

The game mode chosen for analysis was Run the World and the level was New

York (Hard), which required the participant to run in place through a 3D city. For

interaction in the game, the subject's running, which was picked up by the Kinect™, was

registered to power their 3D avatar to run in the game. During game play, information

icons were projected on the scene, such as distance ran in meters or feet, speed in

kilometers per hour or mile per hour, time, and calories burned. Within play, there were

three high-knee challenge point bonuses and one speed challenge, which were mini

challenges build into the session to expend more energy. Upon completion of the

running in place game session, points were tallied and reported by total score, and

calories expended. This whole process can be viewed on YouTube at

http://www.youtube.com/watch?v=duJOqmrhLI8 (Xbox Fitness Org, 2011).

Consumer interests related to correct energy expenditure analyses

EE analysis has become a major concern for consumers, and has encouraged new

research on the subject. A similar study conducted, which used 500 subjects and

analyzed EE during a stationary running mode to calculate distance ran, found EE in

relationship to distance almost doubled compared to game estimations (Moratt & Swain, 2012). Moratt & Swain (2012) evaluated the Wii™ fit in game distance calculator.

Among the Your Shape™ Fitness Evolved 2012 game's customer demographic, there have been reports of inaccuracy with the energy-expended read out (Ubisoft Forums, 2010). Customers have taken it upon themselves to calculate their own expenditure by using a compendium of physical activities and EE from the Mayo Clinic (Ubisoft Forums, 2010). The compendium uses physical activities like aerobics and tai chi, which are used in Your Shape™ Fitness Evolved 2012 (Mayo Clinic Staff, 2011). By comparing similar activities and the compendium together, the customer can get an unrefined estimation of EE.

Other ways to find EE would be to use commercial EE estimator devices such as, a hip mounted accelerometer or a BodyBugg™. The BodyBugg™ uses accelerometers in combination with heat flux, skin conductivity and temperature, which gives this device a closer estimation of EE than just hip mounted accelerometers (BodyBugg, 2012). The devices work by measuring how fast specific points on the body move while in translation, then input the data into a mathematical formula to calculate EE (Tapia, et al., 2011).

Devices like hip or wrist mounted accelerometers have a wide range of accuracy in estimating EE, and the hip mounted accelerometer, being less sophisticated, yields an accuracy range of 79% to 89% depending on how rhythmic the activity is (Lester, Hartung, Pina, Libby, Boriello & Duncan, 2009). A study conducted in 2006 found variable differences in accelerometer prediction between children and adults when doing 10 different activities at different intensities (Heil, 2006). Predictions of child scores

were under predicted, while adults were slightly over predicted, and variability was found

in accuracies between hip mounted accelerometers and limb mounted ones (Heil, 2006).

It was hypothesized that the possible prediction differences were due to sensitivity of the

sensors in relation to body type. Sensitivity was too low for the children giving under

prediction and too high for adults yielding over prediction.

  With devices such as the BodyBugg™, accuracies are at 90% for lying down and

sleeping and 97.6% to 99.8% accuracy while doing physical activity (Andre, et al., 2006;

Tapia, 2008). EE accuracy is beneficial to the customer, because it allows him/her to

balance energy in and out, whether it is for weight loss, gain or balance. BodyBugg™

also deals with the inaccuracy associated with children and has a suitable algorithm

released in 4.2 version (Andre, et al., 2006).

  The most novel way to find accurate EE is by using indirect calorimetry (IC) to

evaluate the EE during game play. IC is the method by which the type and rate of

substrate utilization, and energy metabolism are estimated in vivo starting from gas

exchange measurements (Ferrannini, 1988). Ample research has established IC as the

"gold standard" for EE measurement (Carter & Jeukendrup, 2002; Ferrannini, 1988;

Reeves, Capra, Bauer, Davies & Battistutta, 2005; Sun & Reed, 1994).

  The IC of the Oxycon Pro™ has an established validity of 3.3% - 7.5% error in

determining EE against the previous gold standard of the Douglas bag method (Carter &

Jeukendrup, 2002). To minimize error and increase reliability it is noted that the

presence of water vapor in the analyzer, temporal alignment of gas flows, and an average

of four minutes to reach a steady state can cause significant differences in measuring

metabolic equivalencies in gas concentrations, because it can analyze breath-by-breath

with activities that change intensity (Hodges, Brodie & Bromley, 2005). The system uses

direct measurement instead of formulas to increase accuracy of caloric expenditure,

assuming the subject is at steady state.

Resting and active EE in relationship to IC has been known to be greater in

individuals with a larger mass (Cunningham, 1991). An individual with more cells will

require more energy to fuel those cells (Kleiber, 1947). Variations in cell type make

energy expenditure fluctuate, because some tissues are more metabolically active, for

instance highly active muscle tissue compared to fat tissue (Cunningham, 1991; Kleiber,

1947). Differences in lean muscle mass compared to fat mass will represent different EE,

so if the null hypothesis is rejected, normal or overweight BMI may be a major factor in

the game's programming to estimate EE.

Body Mass Index is a formula that uses weight for height to classify underweight,

normal, overweight, and obese (WHO, 2006). For years, health professionals have been

using BMI to estimate relative fat percentages, but it has been well established that BMI

can not estimate percent fat between individuals, because it does not account for tissue

type and anthropometrics (Deurenberg, Yap & Straveren, 1998; WHO, 2006). BMI was

set as an independent variable in this study, because BMI is gender neutral and will

reveal possible inaccuracies in the video game related to mass, height, and weight.

Summary

By accurately determining EE, the consumer can balance their energy needs and

take advantage of the health benefits from physical activity. Due to the increase in

obesity, and the growing use of Video game entertainment, the Xbox Kinect™ fitness

game Your Shape™ Fitness Evolved 2012 could serve as a viable means to expend

calories, and lead a healthy active lifestyle. To fully appreciate the benefits of the

Kinect's full body analysis in fitness games, this tool will be scrutinized and sent through

the rigors of testing.

Chapter 3

Methods

Introduction

Due to the increasing popularity in video game home entertainment systems and the current obesity epidemic, the video game markets are developing home fitness games as tools to lead a healthier lifestyle. There is currently limited research using these home fitness games, therefore the purpose of this study was to compare energy expenditure (EE) from the internal calorie calculator in Your Shape™ Fitness Evolved 2012 against indirect calorimetry. The game mode chosen for testing was Run the World, which was a stationary running activity. This chapter describes in detail the participants, instruments, procedures, and statistical analyses of this study.

Subjects

53 convenient subjects 18 or older were recruited through Eastern Washington University campus advertising fliers. Descriptive data for the subject population are summarized in Table 1. All subjects were relatively healthy and screening was done by using the PAR-Q. All subjects met these guidelines and none were rejected. No prior experience with the Xbox Kinect™ was necessary for participation, because the game mode activity mostly entails running in place.

No attempt was made to select by sex, weight, or anthropometrics. Sample size was calculated using an online power analysis tool from DSS Research (DSS Research, 2012). Indirect calorimetry data from previous studies that used stationary running games and simulated dancing were used to give expected means, standard deviations, and

effect size for calculation (Moratt & Swain, 2012; Sell, Lillie & Taylor, 2008). Alpha was set at 0.05 and Beta at 50%.

Table 1

Descriptive Statistics of the Sample (N = 53)

	Mean	Std. Deviation	Minimum	Maximum
Height	67.09	± 4.37	56.00	76.25
Weight	158.28	± 35.56	94.00	237.00
Age	22.60	± 3.51	20.00	39.00
BMI	24.47	± 3.75	17.75	39.43

Instruments

The equipments for testing in this study include: Xbox 360 with Kinect™ (Microsoft Corp., Redmond, Washington), Oxycon Pro™ (Jaegar, Hoechberg, Germany), and the video game Your Shape™ Fitness Evolved 2012 (Ubisoft Entertainment, Montreal, Canada).

Xbox 360 with Kinect™.

The Xbox 360 is an interactive video game system developed in 2005 by Microsoft Corp., (Redmond, Washington). It has sold 67.2 million units as of April 2012 (Dutton, 2012). The Kinect™ sensor is an attachment to the Xbox 360 and consists of an Infrared projector along with standard RGB and infrared complementary metal–oxide–semiconductor image sensors (Lange et al., 2011).

The sensor constructs a depth map of the subject using a proprietary algorithm to resolve the pattern produced by projecting coded infrared light onto the scene geometry

(Lange et al. 2011). The sensor registers whole body movement in place of a standard

handheld controller, and is used in fitness games for this purpose. Currently, the only

known problem with the sensor's accuracy is distance from the subject (Khoshelham,

2011), and the video game being tested has a built-in calibration tool to automatically

adjust distance and alignment, so sensor failure is minimal.

Oxycon Pro™.

Measurement of Oxygen consumption using IC was done with the Oxycon Pro™

(Jaegar, Hoechberg, Germany). IC is the method by which the type and rate of substrate

utilization, and energy metabolism is estimated in vivo starting with means of the

respiratory differences of oxygen and carbon dioxide in the inspired and expired air

(Ferrannini, 1988). Ample research has established IC as the "gold standard" for EE

measurement (Carter & Jeukendrup, 2002; Ferrannini, 1988; Reeves et al., 2005; Sun &

Reed, 1994).

Your Shape™ Fitness Evolved 2012.

The game is a product of Ubisoft Entertainment (Montreal, Canada) and is the

third version of the Your Shape™ series. It uses the Kinect™ sensor device to track over

90 hours of fitness activities; activities include: yoga, running in place, dancing, and other

mini games (Ubisoft, 2012). For the purposes of this study only one game mode was

analyzed. Stationary running was the mode chosen, because it has the ability to induce

vigorous rhythmic activity, and stay within the limitation of the Oxycon Pro™ tube

length. The stationary running mode in the game is called Run the World New York

(hard) and takes the players on a four to five minute 3-D virtual run through the city of

New York. The game session requires three high knee challenges and one speed

challenge, which were mini challenges to score more points and expend more calories. The Kinect™ sensor registers stationary running from the player, which propels the 3D avatar through the virtual world. The stationary running session was simple and required very little experience to play.

Procedures

With the permission of the Institutional Review Board for Human Subjects at Eastern Washington University to conduct the study, participants were recruited using advertising fliers on Eastern Washington University's Campus. All subjects aged eighteen and up, and with no prior experience with the Xbox Kinect™ were recruited. No prior experience was applicable, because the mode of testing only requires the participant to run in place. An explanation of the study's procedures, responsibilities and risks of participation was given to all subjects. All subjects interested in participating were screened for health problem using the PAR-Q (see Appendix A), and acceptance to participate was limited to those who answered no to all questions. An informed consent (see Appendix B) was used to assure all participants understood the legal consent, and the risks, and the potential benefits of involvement in the study.

Subjects who agreed and understood were scheduled for testing in one hour blocks and told to refrain from vigorous activity 24 hours before testing and to eat a light snack two hours before testing to prevent fatigue and standardize metabolic measurements. Also, they were told to wear light fitness clothes to prevent impingement while running in place. All testing was conducted in the Human Performance Lab at Eastern Washington University.

On their scheduled date of testing, measurements of weight, height, age, and % body fat were documented on the custom data sheet (see Appendix C) along with all other data from testing IC and videogame. Height and weight were measured with a Dectecto Physician Scale (Cardinal Scale Manufacturing Co., Webb City, MO). BMI was then calculated using the U.S. units formula [mass (lb) / ((height (in))^2] * 703.

Upon initial testing resting heart rate was taken for data collection. The Karvonen formula was used to calculate 50% of heart rate range (HRR) to ensure proper warm-up. The researcher then started up the Xbox and Oxycon Pro™ for the first subject of the day, or continued to calibration if the subject was the second of the day.

Required information was then put into the Oxycon Pro™ to ensure accuracy. Height, weight, and age were inputted into the profile option settings to ensure accuracy of the Your Shape™ game. Participants who had no prior experience with the Kinect™ were given a short period of time to familiarize themselves to the game, which was not extensive, because the game mode being tested only required the participant to run in place. Familiarization mostly entailed the subject proficiently interacting with the menu display, which was done by them playing the mini-game called Wall Breakers. At this time a simple visual test of being able to view the subject's whole body on the screen was made to insure the Kinect™ was calibrated properly.

At the start of testing the subjects began by being fitted with a Polar heart rate monitor and fitted with the Oxycon Pro™ mask to ensure accurate gas collection. The subjects then performed a single three to five minute session of the running in place game mode to reach 50% of HRR for warm up. Starting and final HR and time was recorded along with total oxygen consumption from IC and total kilocalories burned in the game

mode. If the subject did not reach the 50% HRR for proper warm-up the session was repeated and data was documented. All subjects in this study reached target heart range.

Once the subject reached warm up, they performed another session to ensure steady state. The final session was the only one used for statistical analysis to find an interaction. The time period between the warm up and final test were as short as possible to maintain intensity level. There were no breaks between tests. Analysis was documented starting at the beginning of the warm up and finished at the final test session.

Upon collection of the subject's final session, total measured oxygen consumption in milliliters per minute, calculated by the IC, was added together based on total time spent doing the activity. Then total oxygen in milliliters was converted to Liters, and using the ACSM 2012 guidelines one liter of oxygen is equal to five kilocalories of metabolic work. Kilocalories were then calculated to represent total EE.

Design/ Analysis

Oxycon Pro™ analysis reported oxygen consumption in milliliters per minute with averaged scores every 30 seconds. Only the final session test scores were used to find an interaction. Statistical analysis was a 2 x 2 Within subjects ANOVA using SPSS 20.0 (SPSS Inc., Chicago, IL) to see if the hypothesis were accepted or rejected, and whether there was a significant difference in distribution of scores between the EE of the Oxycon Pro™ and that reported by the game Your Shape™ Fitness Evolved 2012 at an alpha level of $p \leq 0.05$. The second hypothesis tested by the ANOVA was to see if there was an interaction between normal (<24.9) or overweight (>25) BMI and calories burned between the two devices at an alpha level of $p \leq 0.05$.

Summary

53 subjects from Eastern Washington University volunteered to test their caloric expenditure while playing Your Shape™ Fitness Evolved 2012. The running in place mode was the only testing session conducted, which included a warm up session and a final test session of the same mode. This mode was chosen because of the Oxycon Pro™ mask tube length limitation and the modes simplicity to increase subject familiarity with the game. Testing compared the accuracy of the Your Shape™ Fitness Evolved 2012 calorie counter against the Oxycon Pro™, and highlighted any effect BMI had on the accuracy of Your Shape™ Fitness Evolved 2012 by using a Within subjects 2 x 2 Factorial ANOVA at an alpha level ≤ 0.05.

Chapter 4

Results

Introduction

The purpose of this study is to compare the accuracy of EE estimation from the internal calorie calculator in Your Shape™ Fitness Evolved 2012 against the Oxycon Pro™, and also to see if there is an interaction effect between the accuracy of the two devices and the BMI of normal to overweight individuals by using a within subjects 2 x 2 factorial ANOVA. This chapter will present the descriptive data of testing and report the statistical finding of data collected.

Data Analysis

Descriptive statistics for heart rate (HR) and kilocalories (kcal) measures during the final sessions of testing are summarized in Table 2.

2 x 2 Factorial ANOVA

The ANOVA was set up with two independent variables with each having two levels. The first independent is devices with two levels: Your Shape™ Fitness Evolved 2012 and Oxycon Pro™. The second independent is BMI with two levels: normal weight and overweight. The dependent variable was kilocalories, and the final test sessions for each variable's description are summarized in Table 2. Summarized in Table 3, there was a significant difference between the two experimental devices (p = 0.000; F = 172.76; df = 1; Effect size = .772). There was a significant interaction effect between the two devices and the two BMI classes of normal weight and overweight (p = 0.000; F = 15.23; df = 1; Effect size = .230). In Table 4 it shows the expected significant mean

difference between the two classes of normal and overweight BMI ($p = 0.000$; $F = 26.75$;

$df = 1$; effect size $= .344$). Figure 1 shows the interaction between factors.

Table 2

Descriptive Statistics the Final Sessions Video Game (VG) vs. Indirect Calorimetry (IC)

	Mean	Std. Deviation	Minimum	Maximum
Final Start HR	132.58	± 17.83	90.00	163.00
Final End HR	178.09	± 11.23	157.00	204.00
Final End Time (sec)	232.96	± 30.52	195.00	331.00
Final kcals from VG	34.33	± 9.11	19.00	56.00
VG kcals w/ Normal BMI	31.75	± 8.59	19.00	56.00
VG kcals w/ Overweight BMI	38.60	± 8.48	25.00	51.00
Final kcals from IC	51.56	± 13.89	24.00	85.10
IC kcals w/ Normal BMI	44.81	± 10.22	24.00	69.30
IC kcals w/ Overweight BMI	62.69	± 11.94	37.60	85.10
Warm-up kcals from IC	49.62	± 12.74	26.80	77.80

Table 3

Tests of Within-Subjects Effects

Measure: calories

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Device	Sphericity Assumed	8595.80	1	8595.80	172.76	.000	.772
Device * BMIClass	Sphericity Assumed	758.11	1	758.11	15.23	.000	.230
Error(device)	Sphericity Assumed	2537.53	51	49.75			

Note. Device = Your Shape™ and Oxycon Pro™; BMIClass = Normal weight <24.9 and Overweight <25

Table 4

 Tests of Between-Subjects Effects

Measure: calories

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	196991.36	1	196991.36	1385.20	.000	.964
BMIClass	3804.59	1	3804.59	26.75	.000	.344
Error	7252.74	51	142.21			

Note. BMIClass = Normal weight <24.9 and Overweight <25

Figure 1

Interaction Effect between Devices and BMI class
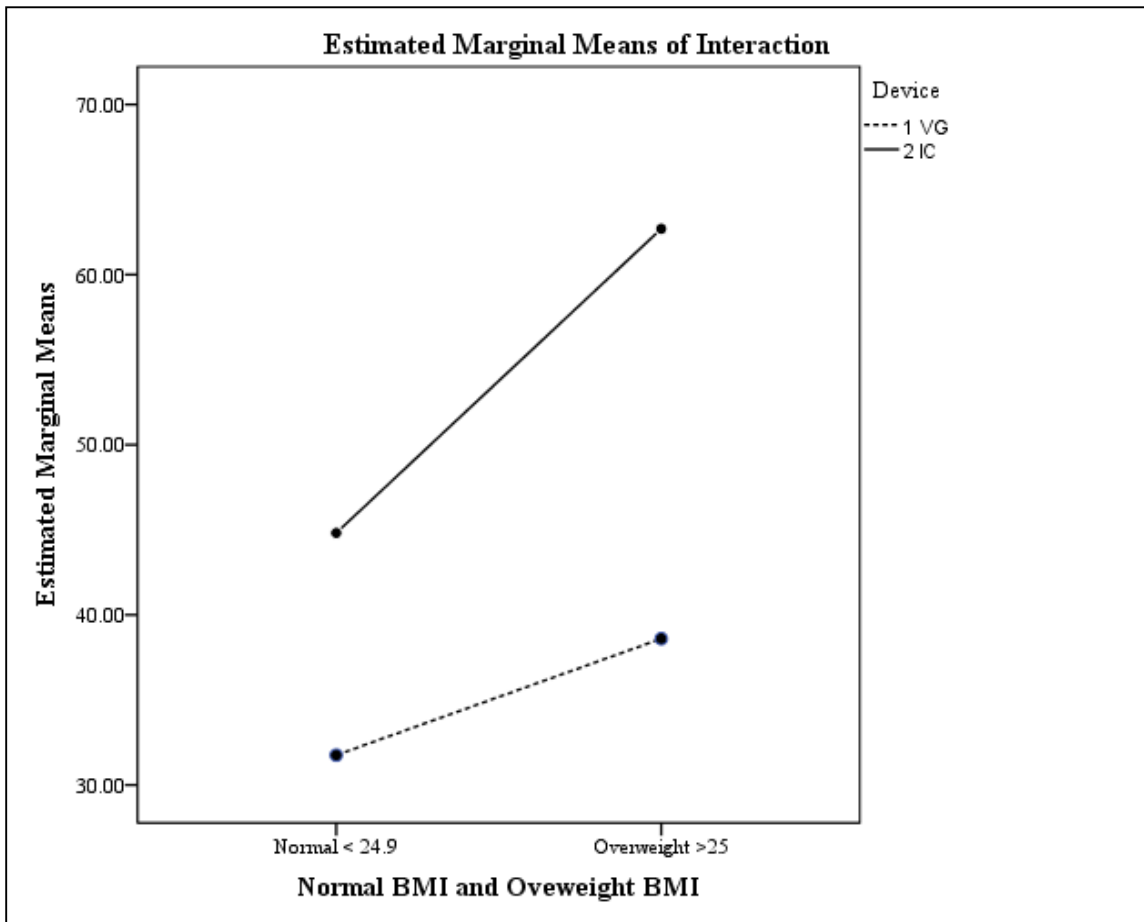
Summary

A Within Subjects 2 x 2 Factorial ANOVA was employed to compare mean scores of kilocalories burned between the two devices Your Shape™ Fitness Evolved 2012 and the Oxycon Pro™, also to analyze the interaction effect of the devices on BMI. There was a significant within subjects difference between the two devices mean scores ($p = 0.000$; $F = 172.76$; $df = 1$). There was a significant difference between the two BMI classes of normal weight and overweight ($p = 0.000$; $F = 26.75$; $df = 1$). There was a significant interaction effect between devices and BMI ($p = 0.000$; $F = 15.23$; $df = 1$).

Chapter 5

Discussion

Introduction

Exergaming platforms like the Wii Fit™, Xbox 360 Kinect™ and the Sony Eye Toy™ were developed to increase physical activity to offset the time being sedentary, and currently there is limited research about these platforms. This study focused on analyzing the Xbox 360 Kinect's abilities and accuracy to increase EE by researching Your Shape™ Fitness Evolved 2012. This chapter discusses the accuracies of the video game, and formulates possible limitations with the system, gives insight for future research, and explains the benefits of the system.

Primary Purpose

The primary purpose of this study was to analyze the accuracy of the calorie tracker in Your Shape™ Fitness Evolved 2012. If the proprietary calorie formula had a significant difference from IC, the secondary purpose was to see if inaccuracy was related to BMI. It was hypothesized that there would be no significant difference in kilocalories expended between the internal calorie tracker in Your Shape™ Fitness Evolved 2012 and the indirect calorimetry machine Oxycon Pro™. It was also hypothesized that there would be no significant difference in kilocalories expended between normal BMI and overweight BMI while playing Your Shape™ Fitness Evolved 2012. Lastly, it was also hypothesized that there would be no significant interaction effect between kilocalorie scores on Your Shape™ Fitness Evolved 2012 and the Oxycon Pro™.

Discussion

The Factorial ANOVA results revealed that there was a significant difference between the two devices IC and Your Shape™ (p = 0.000), and a significant difference between BMI classes overweight and normal weight (p = 0.000). The ANOVA also revealed that there was an interaction effect between independent variables devices and BMI class (p = 0.000). Therefore, all null hypotheses were rejected and the alternatives were accepted.

Figure 1 in the results section visually summarized the interaction. IC reported significantly higher kcal scores compared to the video game. IC also reported a significantly higher difference between scores of normal and overweight subjects. The interaction shows that the video game has greater inaccuracy with overweight BMI subjects as compared to normal weight subjects.

To account for this interaction, Moratt & Swain (2012) found similar result when analyzing Wii™ Fit in a stationary running type game mode. Results of their data calculated expenditure, but were looking at total distance ran in the game, and concluded that the game roughly doubles estimated distance ran. Moratt & Swain (2012) noted that due to a player's unique playing style and relative effort to play the game it altered the accuracy of the game. Harshman (2009) also reported playing style and effort key components to accuracy when using the Wii™.

Your Shape™ Fitness Evolved 2012 uses the Kinect™ to track whole body movement, so effort is factored into the accuracy formula, but playing style is not. Results of this study and direct observation by the researcher revealed that playing style is a key component to the accuracy of the game much like what has been found with

games requiring a wand (Harsman, 2009). It appears that playing style accounts for some of the observed accuracy differences between devices.

The researcher directly observed this playing style effect. There were two common running styles while playing the game. The expected running style involved the hip flexors in a mid/high knee type stationary running with arm swing. The unexpected running style involved the hip extensors with the heel of the foot swinging vertically to the gluteals in a butt-kicker style exercise. Some individuals would accidently toe push off, which would move them forward and reach the limits of the IC tube length. This forward movement would also decrease the Kinect's ability to analyze properly. There were no noticeable differences between BMI and playing style.

This unexpected running style may be a partition of the inaccuracy. Khoshelham (2011) and Lange et al. (2011) describe the functioning of the Kinect™ and explained that the Kinect™ uses a laser to map the play, and the inaccuracy may be explained by how the Kinect™ functions. To make a map of the body the Kinect™ projects a laser beam on the body to make a reference point; let's say the hip.   The beam bounces off the target and comes back to the Kinect™ camera and is measured by time. It then simultaneously projects multiple beams; let's say to the right leg. Beams hit the quadriceps, knee, shin, and ankle; then bounces back to the camera where the time is measured to give distance traveled and orientation to the reference point, which makes a 2D model of the player.

The Kinect™ may not be able to pick up the movements of the lower leg, because the knee may block the lasers path to the ankle when using hip extension to run in place. To the Kinect™ laser the quadriceps may barely move as compared to the running style

that uses hip flexion. It should be noted that Kinect™ height position would benefit laser registration in a lower position when playing a game that focuses on the lower limbs. In this study the Kinect™ was positioned on top of the monitor, which may have added to the inaccuracy. Future studies with the Kinect™ should place the Kinect™ in a position to give symmetrical coverage of the object being modeled.

Another consideration that affects the accuracy of the Kinect™ is how loose the subject's clothes were while playing. Lange et al. (2011) and Khoshelham (2011) noted the abilities of laser registration with loose clothes, but did not state sensitivity. Inaccuracy was observed with one subject who wore normal sweat pants. During the warm-up, it took them five minutes to complete the running mode, while working at a moderate to high intensity using hip flexion style. The subject was then instructed to change their clothes, and complete another session.

With each session being the same distance in the game, the next session reported 3:36 minutes. This shows how easily the laser can miss interpret the body, because the legs are covered. To the Kinect™, a person with sweat pants looks to have large wide legs that do not move, while in actuality the person has normal legs and is moving very fast underneath the clothes. It should be required to wear tight flexible clothes for future Exergaming studies using the Kinect™.

The Kinect™ proprietary formula for estimating calories is unknown. The secondary interaction effect reported the video game formula to underestimate caloric expenditure in both BMI classes, but it had a greater overestimation for the overweight class. There is currently no other research for comparison on the accuracy of the Kinect™ to estimate caloric expenditure. This data supports the idea that the video

game's accuracy is skewed, and a secondary device like accelerometry should be utilized to attenuate the inaccuracy. Accelerometry was not tested in this study, but one subject had a Nike Fuel band at the time of testing. The subject reported burning 60 calories with the Fuel band, and the IC reported 61 calories in a single four-minute session, which means a simple omnidirectional wrist accelerometer could provide reasonable accuracy for rhythmic Exergames.

Overall Your Shape™ Fitness Evolved 2012 is an excellent Exergame and should continue to monitor calories burned, because the games primary goal is to promote health. The ability to see how much exercise it takes to burn off excess calories from food is beneficial for balancing overall health. Your Shape™ is essentially a simple private personal training session.

Playing this game could easily fulfill the ACSM guideline of 150 to 400 net kcals expended per day or 250 to 500 kcals/day for weight loss. After the first four-minute session of play, average kcals expended reached 49±12. During the second session, calories expended reached 51±13. This workload is equivalent to moderate to high intensity work. Staiano & Calvert (2011), and Worley et al. (2011) reported around 1-6 kcals per minute with the Wii, while Noah et al. (2011), and Whitehead et al. (2010) reported around 6-10 kcal per minute for whole bodied exergames like Dance Dance Revolution. The running in place mode for Your Shape™ Fitness Evolved 2012 expends about 10-12 kcals per minute, which is similar to Dance Dance Revolution and intense enough to reach the physical benefits of exercise.

Recommendations for Future Research

This study used 53 convenient subjects for sampling. To properly test and account for the entire U.S. population of Kinect™ Your Shape™ Fitness Evolved 2012 users; sample size would have to be much greater to account for variances. Future research should utilize different ages, genders, body types, and ethnicities in order to test for significant differences between variables.

A major limitation in this study was the IC tube length. This made analysis of all game modes impossible. Future research to analyze the whole game would require a portable IC machine. It should also be noted that IC accuracy to measure caloric expenditure is based on aerobic work, so game modes to be tested should be intense enough and long enough to reach steady state.

Future investigation of the Kinect™ requires proper positioning to give symmetrical mapping of object being tested. As noted above, variability can be seen if Kinect™ is not centered on the object. Another variability that affects the Kinect™ is clothing. Clothing should be tight to allow proper registration mapping and flexible enough to not hinder player movement.

While there was an assumption that running in place would not require training, two observable differences in playing style were noted above. Future research should require playing protocol, because out of the two styles one was more accurate. Although one was more accurate, the other playing style was within the confines of the in game description of how to play, which means the researcher needs to thoroughly investigate possible playing styles before testing and make proper judgment to confine extraneous variables.

Summary

In conclusion, the present study found that Your Shape Fitness Evolved 2012 internal calorie calculator significantly underestimates caloric expenditure between normal and overweight individuals. The present study also found that between normal and overweight individuals the internal calorie calculator inaccuracy was greater in overweight individuals. Inaccuracy in the game can be associated to Kinect™ positioning, playing style when interacting with the game, and clothing type worn while playing. Based on these results, recommendations can be made to use an accelerometer to attenuate the inaccuracies of the Your Shape™ Fitness Evolved 2012 internal calorie estimator.

References

American College of Sports Medicine, Thompson, W., Gordon, N., & Pescatello, L. (2009). *ACSM's Guidelines for Exercise Testing and Prescription.* (8 ed.). Philadelphia: Lippincott Williams & Wilkins.

American College of Sports Medicine, Thompson, W., Gordon, N., & Pescatello, L. (2012). *ACSM issues new recommendations on quantity and quality of exercise.* Retrieved from http://www.acsm.org/about-acsm/media-room/news-releases/2011/08/01/acsm-issues-new-recommendations-on-quantity-and-quality-of-exercise

Andre, D., Pelletier, R., Farringdon, D., Safier, S., Talbott, W., Stone, R., Vyas, N., & Trimble, J. (2006). *The development of the sensewear armband, a revolutionary energy assessment device to assess physical activity and lifestyle.* Retrieved from http://powerhousegym-aiea.dotfit.com/sites/63/templates/categories/images /1783/Dev_SenseWear_articla.pdf

Bernstein, M., Morabia, A., & Sloutskis, D. (1999). Definition and prevalence of sedentarism in an urban population. *American Journal of Public Health*, *89*(6), 862-867.

Blair, S., & Brodney, S. (1999). Effects of physical inactivity and obesity on morbidity and mortality: Current evidence and research issues. *Medicine & Science in Sports & Exercise*, *31*(11), s646-s662.

BodyBugg. (2012). *The science behind BodyBugg*. Retrieved from http://www.bodybugg.com/science_behind_bodybugg.php

Butterflyfaer. (2011, January 01). Topic: Calorie burn of just dance 2? [Online forum comment]. Retrieved from http://www.myfitnesspal.com/topics/show/156919-calorie-burn-of-just-dance-2

Calle, E., Rodriguez, C., Walker-Thurmond, K., & Thun, M. (2003). Overweight, obesity, and mortality from cancer in a prospectively studied cohort of US adults. *The New England Journal of Medicine*, *348*(17), 1625-1638.

Carter, J., & Jeukendrup, A. (2002). Validity and reliability of three commercially available, breath by breath, respiratory systems. *European Journal of Applied Physiology*, *85*(5), 435-441.

Centers for Disease Control and Prevention. (2012, February 27). *Overweight and obesity*. Retrieved from http://www.cdc.gov/obesity/data/trends.html

Chen, J. (2010, June 14). *Microsoft Xbox 360 Kinect launches November 4*. Retrieved from http://gizmodo.com/5563148/microsoft-xbox-360-kinect-launches-november-4

Chinapaw, M., Proper, K., Brug, J., Mechelen, W., & Singh, A. (2011). Relationship between young peoples' sedentary behaviour and biomedical health indicators: A systematic review of prospective studies. *Obesity Reviews*, *12*(7), e621-e632.

Clay, D. (2000). *Comparing kilocalorie expenditure between a stair-stepper, a treadmill, and an elliptical trainer*. (Master's thesis), Available from Eastern Washington University Library Catalog. (RA781.15 .C52).

Cunningham, J. (1991). Body composition as a determinant of energy expenditure: a

synthetic review and a proposed general prediction equation. *American Journal of*

Clinical Nutrition,*1*(54), 963-969. Retrieved from

http://ajcn.nutrition.org/content/54/6/963.full.pdf

Danaei, G., Ding, E., Mozaffarian, D., Taylor, B., Rehm, J., Murray, C., & Ezzati, M.

(2009). The preventable causes of death in the United States: Comparative risk

assessment of dietary, lifestyle, and metabolic risk factors. *PLos Medicine*, *6*(4),

1-23.

Deurenberg, P., Yap, M., & Straveren, W. (1998). Body mass index and percent body fat:

A meta analysis among different ethnic groups. *International Journal of Obesity*,

(22), 1164-1171. Retrieved from http://edepot.wur.nl/197425

DSS Research. (2012). *Sample size calculators*. Retrieved from

http://www.dssresearch.com/KnowledgeCenter/toolkitcalculators/samplesizecalcu

lators.aspx

Dutton, F. (2012, April 19). *Global Xbox 360 sales down nearly 50% year-on-year*.

Retrieved from http://www.eurogamer.net/articles/2012-04-19-global-xbox-360-

sales-down-nearly-50-percent-year-on-year

Ferrannini, E. (1988). The theoretical bases of indirect calorimetry: A

review. *Metabolism*, *37*(3), 287-307.

Guinness World Records Press. (2011, January 3). *Kinect confirmed as fastest-selling*

consumer electronics device. Retrieved from

http://community.guinnessworldrecords.com/_Kinect-Confirmed-As-Fastest-

Selling-Consumer-Electronics-Device/blog/3376939/7691.html

Harshman, J. (2009). *The effectiveness of actical accelerometry for energy expenditure measurement during nintendo wii game play*. (Master's thesis), Available from Eastern Washington University Library Catalog. (TL589.2 .A3 H277)

Heil, D. (2006). Predicting activity energy expenditure using the Actical activity monitor. *Research Quarterly for Exercise and Sport*, *77*(1), 64-80. doi: 10.5641/027013606X13080769703920

Hodges, L., Brodie, D., & Bromley, P. (2005). Validity and reliability of selected commercially available metabolic analyzer systems. *Scandinavian Journal of Medicine and Science in Sports*, (15), 271-279. doi: 10.1111/j.1600-0838.2005.00477

IGN. (2010, November 08). Your shape: Fitness evolved review. Retrieved from http://xbox360.ign.com/articles/113/1132914p1.html

Ingham, T. (2011, March 9). Kinect cruises past 10m sales barrier Microsoft announces milestone. Retrieved from http://www.computerandvideogames.com/292825/kinect-cruises-past-10m-sales-barrier/

Jones , S. (2003). Gaming technology and entertainment among college students. *Pew Internet & American Life Project*, 1-14.

Khoshelham, K. (2011). *Accuracy analysis of Kinect depth data*. Unpublished manuscript, ITC Faculty of Geo-information Science and Earth Observation, University of Twente, Enschede-Noord, Netherlands. Retrieved from http://www.isprs.org/proceedings/XXXVIII/5-W12/Papers/ls2011_submission_40.pdf

Kleiber, M. (1947). Body size and metabolic rate. *Physiological Reviews*, *27*(4), 511-541.

Retrieved from http://www.planta.cn/forum/files_planta/511_131.pdf

Krekcie, R., & Morgan, D. (1970). Determining sample size for research

activities. *Educational and Psychological Measurement*, (30), 660-610. Retrieved

from http://people.usd.edu/~mbaron/edad810/Krejcie.pdf

Lange, B., Chang, C., Rizzo, S., Suma, E., & Bolas, M. (2011, December). *Markerless*

full body tracking: Depth-sensing technology within virtual environments. Paper

presented at Institute for Creative Technologies Interservice/industry training,

simulation, and education conference, Playa Vista, CA. Retrieved from

http://ntsa.metapress.com/app/home/contribution.asp?referrer=parent&backto=iss

ue,85,150;journal,1,22;linkingpublicationresults,1:113340,1

Lenhart, A., Jones, S. & Macgill, A. (2008) 'Video games: Adults are players too, Pew

Internet & American Life Project, URL (consulted 5 April 2009):

http://pewresearch. org/pubs/1048/video-games-adults-are-players-too

Lester, J., Hartung, C., Pina, L., Libby, R., Boriello, G., & Duncan, G. (2009). *Validated*

caloric expenditure estimation using a single body-worn sensor. Informally

published manuscript, Computer Science and Engineering , University of

Washington, Seattle, Washington. Retrieved from

http://robotics.usc.edu/~gaurav/CS546/readings/lester_icuc2009.pdf

Lovemyboys27. (2010, January 20). Topic: Wii fit plus calorie count, is it accurate

[Online forum comment]. Retrieved from

http://www.myfitnesspal.com/topics/show/77386-wii-fit-plus-calorie-count-is-it-

accurate

Mark, R., Rhodes, R., Warburton, D., & Bredin, S. (2008). Interactive video games and

    physical activity: A review of the literature and future directions. *Health &*

    Fitness Journal of Canada, *1*(1), 1-24. Retrieved from

    http://healthandfitnessjournalofcanada.com/index.php/html/article/viewFile/5/5

Mayo Clinic Staff. (2011, December 01). *Exercise for weight loss: Calories burned in 1*

    hour. Retrieved from http://www.mayoclinic.com/health/exercise/SM00109

Moratt, S., & Swain, C. (2012). *How far did Wii run? Nintendo's Wii Fit overestimates*

    distance. (Master's thesis)Retrieved from

    https://kb.osu.edu/dspace/bitstream/handle/1811/51875/How_Far_Did_WWi_Run

    _Manuscript.pdf?sequence=2

Noah, A., Spierer, D., Tachibana, A., & Bronner, S. (2011). Vigorous energy expenditure

    with a dance exer-game. *Journal of Exercise Physiology*,*14*(4), 13-28.

Oehlschlaeger, M., Pinheiro, R., Horta, B., San'Tana, P., & Gelatti, C. (2004). Prevalence

    of sedentarism and its associated factors among urban adolescents. *Revista de*

    Saúde Pública, *38*(2), 1-6.

Ogden, C., & Carroll, M. (2010). Centers for Disease Control and Prevention, Division

    of Health and Nutrition Examination Surveys. *Prevalence of overweight, obesity,*

    and extreme obesity among adults: United States, trends 1960–1962 through

    2007–2008. Retrieved from National Center For Health Statistics website:

    www.cdc.gov/nchs/data/../obesity_adult../obesity_adult_07_08.pdf

Pedersen, B., & Saltin, B. (2006). Evidence for prescribing exercise as therapy in chronic

    disease. *Scandinavian Journal of Medicine and Science in Sports*, *16*, 3-63.

Peng, W., Crouse, J., & Lin, J. (2012). Using active video games for physical activity promotion: A systematic review of the current state of research. *Health Education & Behavior*, *1*(1), 1-22. doi: 10.1177/1090198112444956

Reeves, M., Capra, S., Bauer, J., Davies, P., & Battistutta, D. (2005). Clinical accuracy of the MedGem indirect calorimeter for measuring resting energy expenditure in cancer patients. *European Journal of Clinical Nutrition*, *59*, 603-610.

Res. (2011, July 29). Is the calorie count at all accurate? [Online forum comment]. Retrieved from http://www.nutwiisystem.com/forum/index.php?a=vtopic&t=14

Sesso, H., Paffenbarger, R., & Lee, I-m. (2000). Physical activity and coronary heart disease in men: The Harvard alumni health study. *Journal of the American Heart Association*, *102*, 975-980.

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

Slagle, M. (2006, May 8). Poll: 4 in 10 Americans play video games. *Washington Post*. Retrieved from http://www.washingtonpost.com/wp-dyn/content/article/2006/05/07/AR2006050700172.html

Staiano, A., & Calvert, S. (2011). Wii tennis play for low-income African American adolescents' energy expenditure. *Journal Psychosocial Research on Cyberspace*, *5*(1), Retrieved from http://www.cyberpsychology.eu/view.php?cisloclanku=2011060801&article=(search in Issues)

Sun, M., & Reed, G. (1994). Modification of a whole room indirect calorimeter for

measurement of rapid changes in energy expenditure. *Journal of Applied

Physiology*, *76*(6), 2686-2691.

Tapia, E. (2008). *Using machine learning for real-time activity recognition and

estimation of energy expenditure*. (Doctoral dissertation, Massachesetts Institute

of Technology).

Tapia, E., Larson, K., Wright, J., King, A., Haskell, W., Intille, S., & Friedmand, R.

(2011). *Real-time recognition of physical activities and their intensities using

wireless accelerometers and a heart rate monitor*. Informally published

manuscript, Massachusetts Institute of Technology, Cambridge, Massachesetts.

Retrieved from http://web.media.mit.edu/~intille/papers-

files/MunguiaTapiaIntilleETAL07.pdf

Trout, J., & Zamor, K. (2008). Dance Dance Revolution: A physiological look at an

interactive arcade game. *Journal of Research in Health, Physical Education,

Recreation, Sport & Dance*, *3*(1), 67-72.

Ubisoft. (2012). *Your Shape™ fitness evolved 2012* . Retrieved from

http://yourshapegame.ubi.com/fitness-evolved-2012/en-us/index.aspx

Ubisoft Forums. (2010, November 7). Calories burned accuracy? [Online forum

comment]. Retrieved from http://forums.ubi.com/showthread.php/230095-

Calories-burned-accuracy

Ubisoft Forums. (2010, November 7). Calorie counter stinks [Online forum comment].

Retrieved from http://forums.ubi.com/showthread.php/658243-Calorie-counter-

stinks-Forums

Vandewater, E., Shim, M., & Caplovitz, A. (2004). Linking obesity and activity level with children's television and video game use. *Journal of Adolescence*, *27*, 71-85.

Video Game Charts. (2012, October 02). *Weekly software chart*. Retrieved from http://www.vgchartz.com/

Wang, Y., & Beydoun, M. (2007). The obesity epidemic in the United States—gender, age, socioeconomic, racial/ethnic, and geographic characteristics: A systematic review and meta-regression analysis. *Epidemiologic Reviews*, *29*, 6-28.

Wang, Y., Beydoun, M., Caballero, B., Kumanyika, S., & Liang, L. (2008). Will all Americans become overweight or obese? Estimating the progression and cost of the US obesity epidemic. *Obesity Journal*, *16*(10), 2323-2330.

Whitehead, A., Johnston, H., Nixon, N., & Welch, J. (2010). Exergame effectiveness: What the numbers can tell us. In Spencer Stephen N. (Ed.), *Sandbox '10 Proceedings of the 5th ACM SIGGRAPH Symposium on Video Games* (pp. 55-62). doi: 10.1145/1836135.1836144

WHO. (2006). *BMI classification*. Retrieved from http://apps.who.int/bmi/index.jsp?introPage=intro_3.html

Worley, J., Rogers, S., & Kraemer, R. (2011). Metabolic response to Wii Fit video games at different game levels. *Journal of Strength and Conditioning Research*, *25*(3), 689-693.

Xbox Fitness Org. (2011, November 11). *Run the world activity - Your Shape: Fitness evolved 2012 - Xbox Fitness*. Retrieved from http://www.youtube.com/watch?v=duJOqmrhLI8

Appendix A

Physical Activity Readiness Questionnaire (PAR-Q) and You

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

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly:

YES	NO		
☐	☐	1.	Has your doctor ever said that you have a heart condition <u>and</u> that you should only do physical activity recommended by a doctor?
☐	☐	2.	Do you feel pain in your chest when you do physical activity?
☐	☐	3.	In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	4.	Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	5.	Do you have a bone or joint problem that could be made worse by a change in your physical activity?
☐	☐	6.	Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
☐	☐	7.	Do you know of <u>any other reason</u> why you should not do physical activity?

If you answered:	Talk to your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES. • You may be able to do any activity you want – as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice. • Find out which community programs are safe and helpful for you.

	Delay becoming much more active:
If you answered NO honestly to <u>all</u> PAR-Q questions, you can be reasonably sure that you can: Start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.	If you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or If you are or may be pregnant – talk to your doctor before you start becoming more active.
Take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.	Please note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

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

Name _____

Signature _____   Date _____

Signature of Parent (if applicable) _____   Witness_____

CONFIDENTIAL

<u>Informed use of the PAR-Q: Reprinted from ACSM's Health/Fitness Facility Standards and Guidelines, 1997 by American College of Sports Medicine</u>

Appendix B

Wendy E. S. Repovich, Ph.D., FACSM
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Informed Consent Form
"Comparison of energy expenditure in Your Shape Fitness Evolved 2012 calorie counter and indirect calorimetry"
In partial fulfillment of Master's Thesis for Robert Cimball

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Responsible Project Investigator
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Physical Education, Health and

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Purpose and Benefits
The objective of this study is to investigate the accuracy of built-in calorie track of the video game Your Shape Fitness Evolved 2012 against a standardized caloric estimation machine (Oxycon Pro). The benefits of this research will give insight to how accurate caloric estimations are in the Your Shape 2012 video game. And society will receive information on whether the video game is a reliable tool for monitoring caloric expenditure to regulate weight loss, gain, or balance. This study will be conducted to fulfill the Master's thesis requirements.

Procedures
As a volunteer in this study, you will be asked to complete two different tests in the Human Performance Lab a percent fat estimation and a caloric estimation while playing the video game. Over all time commitment for the tests will be about 1 hour
Body Composition % Body Fat:
This study will use the TANITA BC-418 MA to determine % body Fat. The BIA is non intrusive and only requires the individual to stand barefoot on the metal footplate and hold the handles with the arms relaxed by their side. The BIA runs a weak electrical signal that cannot be felt to estimate % fat.
Caloric estimation when playing game:
You will take part in a caloric estimation while playing the game Your Shape Fitness Evolved 2012. The game mode chosen is stationary running exercise through a virtual city that is projected on the TV. This activity consists of brief 4 minute warm-up followed by a final 4 minute test, a total of about 8 minutes playing the game. Metabolic analysis will be done using an Oxycon Pro metabolic cart measuring O_2 consumption, which requires the volunteer to wear a mask, so facial hair should be removed prior to testing. This test will be used to determine your caloric expenditure. Throughout the testing, the researcher will ask the volunteer if there is any discomfort with the exercise, and the volunteer will respond by a thumbs up, because their voice may be muffled by the face mask. The volunteer will be able to stop at anytime.

Risk, Stress or Discomfort

The room where the test is done is completely private to minimize your concerns. Adverse effects you may experience during or after the video game tests could include muscle soreness, muscle cramping, nausea, fatigue, and possible joint or muscle injury. Every effort will be made to minimize these risks by evaluation of preliminary information relating to your health and fitness and by careful observations during testing and training. Your job will be to inform us if you experience any unusual feelings or discomfort during the test. We will be monitoring various physiological measures so we may stop the test if we feel you are at risk. Emergency equipment and trained personnel are available to deal with any unusual situations that may arise.

Inquiries

Any questions about the procedures used in this study are encouraged. If you have an concerns, questions, or would like more information please contact Wendy Repovich or Robert Cimball prior to signing the informed consent form. We can be reached at (509)-359-7960; wrepovich@ewu.edu and (509)-668-8806; robertcimball@hotmail.com respectively.

Other Information

You are requested to not engage in an alternate training program or to alter your diet while you are taking part in the study. If you have any concerns about your rights as a participant in this research or any complaints you wish to make, you may contact Ruth Galm, Human Protection Administrator, (509) 359-6567 or rgalm@ewu.edu.

_____   _____

Signature of Principal Investigator   Date

Subject Statement

My participation in this study is completely voluntary. I am free to refuse participation and to stop at any point in this study. I understand the study procedures that I will perform, and the possible risks that go along with the testing and training. Knowing all of the risks and discomforts, and being allowed to ask questions that have been answered to my satisfaction, I consent to take part in this study and financial responsibility is mine in the event of injury. I am not waiving my legal rights by signing this form. I understand I will receive a signed copy of this consent form.

_____   _____

Signature of Participant   Date

Appendix C

Subject #:   Height:
Name: Weight

Date and Time:
Age:

Resting HR:

Karvonen Formula:
$220 - (age\quad) = (\quad\quad\quad)$
$\quad\quad\quad - (resting\ HR\underline{\quad\quad\quad})$
$\quad\quad\quad\quad\quad\quad\quad (\quad\quad\quad) * .5 + (resting\ HR\quad\quad) = $ target warm-up zone

BMI
First Test warm –up
Save file name on IC:
Starting HR:
Starting Time:
Ending HR:
Ending Total Time:
Total O2 in Liters:
Total Calories from game:
Total Calories from Oxycon:

Final Test
Save file name on IC:
Starting HR:
Starting Time:
Ending HR:
Ending Total Time:
Total O2 in Liters:
Total Calories from game:
Total Calories from Oxycon:

VITA

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