MEASURING ENERGY EXPENDITURE AND PREFERRED MODE OF EXERCISE IN FEMALES WHO ARE OVERWEIGHT OR OBESE

by

Lauren Gover Killen

A Dissertation Submitted in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy

Middle Tennessee State University
May 2015

Dissertation Committee:

Dr. Jennifer L. Caputo, Chair

Dr. Vaughn W. Barry

Dr. John M. Coons

Dr. Dana K. Fuller

I would like to dedicate this work to my husband, Dustin. Thank you for your continued love and support throughout this journey. You always pushed me to be my very best and continued to be my number one fan. I could not imagine walking through life without you by my side. Thank you for your patience and willingness to be my personal proofreader until the very end.

I love you always,

Lauren

“If you believe in yourself and have dedication and pride – and never quit, you’ll be a winner. The price of victory is high but so are the rewards.”

Paul Bear Bryant

ACKNOWLEDGEMENTS

I would like to acknowledge my dissertation committee, Dr. Jenn Caputo, Dr. John Coon, Dr. Vaughn Barry, and Dr. Dana Fuller for all of their support and guidance. Thank you Dr. Caputo, for your incredible turnaround time and continued advice throughout my time at MTSU. Thank you to Dr. Barry, Dr. Coons, and Dr. Farley for your advice and encouragement throughout this journey. Having this opportunity at Middle Tennessee State University has allowed me to learn and achieve both my personal and professional goals.

I would also like to acknowledge the support and encouragement I have received from other graduate students and friends. Working with each of you the past few years has definitely been a fun experience I will never forget. We have shared both fun and hard times with one another.

A special thank you to all of my family for the continued encouragement and support especially my parents, Charlie and Judy Gover, and my sister, Emily. Finally, thank you Dustin for embarking on this journey with me and for your continued love. While this has been a great experience I look forward to what the future holds.

ABSTRACT

Overweight and obesity are major concerns in the United States because of the negative impact excess adiposity can have on health. Increasing physical activity is beneficial in reducing body mass and improving health and towards these goals, it is important to be able to quantify caloric expenditure during exercise. Therefore, the purpose of the first study was to determine if there were differences in energy expenditure, self-selected exercise intensity, and exercise perception in overweight and obese females ($N = 40$) that completed identical live and video-guided circuit-style exercise sessions. The purpose of the second study was to validate the SenseWear™ armband (SWA) in assessing energy expenditure during an exercise session by comparing it to open-circuit calorimetry.

When comparing the live and video-guided exercise sessions, energy expenditure was significantly higher ($p < .001$), and heart rate approached significance ($p = .061$) during the live exercise session. Participants were significantly more comfortable during the live session ($p = .011$) with the majority (87.5%) self-reporting the live session as preferred over the video-guided session. The SWA was not significantly correlated with the Oxycon, $r(40) = .28$, $p = .075$, and over-predicted energy expenditure when rest periods were excluded ($p < .001$), particularly for vertical punches ($p < .001$), boxer shuffle ($p < .001$), and windmills ($p = .003$). Energy expenditure during the rest periods was significantly under predicted by the SWA ($p = .007$) leading a non-significant difference in total energy expenditure ($p = .882$) for the exercise session.

Overall, it was found that females that are overweight or obese who exercise with a live trainer expend more calories than when exercising with a video. While the SWA was accurate in assessing overall caloric expenditure during the circuit-style sessions, it underestimated caloric expenditure during the rest periods and overestimated energy expenditure during the exercise periods.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Obesity remains a major health concern with approximately 70% of the United States population being either overweight or obese (Fryar, Carroll, & Ogden, 2012; Ogden, Carroll, Kit, & Flegal, 2012). There are many health concerns associated with being overweight or obese such as diabetes, heart disease, arthritis, certain types of cancers, and premature death. However, these health and mortality risks can be decreased or reversed with weight loss (Overweight and Obesity: Health Consequences, n.d.).

Circuit-style exercise could help individuals who are overweight or obese initiate exercise and meet physical activity guidelines as it allows individuals to complete more total work (e.g., higher caloric expenditure) and it has built in rest periods when compared to continuous aerobic activity (Irving et al., 2008). While some individuals are motivated to meet physical activity guidelines on their own, others may need guidance and reinforcement from a personal trainer. Generally, consistent adherence to prescribed exercise is low for individuals who are overweight or obese (Fogelholm & Kukkonen-Harjula, 2000). However, adherence has been shown to improve with the use of a personal trainer or with supervised activity (Colley, Hills, King, & Byrne, 2010; Jeffery, Wing, Thorson, & Burton, 1998). However, there are barriers to exercising with a personal trainer such as trainer availability, lack of enjoyment of exercise, time constraints, and costs (Vickers et al., 2011).

An alternative to overcome some of these potential barriers is to exercise with video-guided exercise (e.g. DVD) at home rather than with a personal trainer. Video-guided exercise can be similar to exercising with a personal trainer in that both methods provide encouragement and explanations of the different exercises throughout the workout. Further, exercising with a DVD offers benefits including flexibility of time, lower cost, and flexible exercise locations (Vickers et al., 2011). Another benefit of using video-guided exercise is that individuals can self-select the intensity at which they wish to work.

Research has shown exercising at home with a population-specific DVD to be beneficial for special populations with intellectual disabilities (Lynnes, Nichols, & Temple, 2009) and individuals with Huntington's disease (Khalil et al., 2012), with both populations having high adherence rates with the DVD. Similarly, individuals who are overweight or obese report greater adherence and enjoyment when intensity is self-selected and exercise is unsupervised compared to supervised and prescribed exercise (Ekkekakis & Lind, 2006; Perri, Martin, Leermakers, Sears, & Notelovitz, 1997). A circuit-style DVD may specifically be beneficial for individuals who are overweight or obese by not only allowing individuals to self-select exercise intensity, but it also allows individuals to rest with built-in rest periods between exercises (Irving et al., 2008).

To help meet physical activity guidelines, objective and subjective measurement tools have been developed to help individual's measure activity levels. While physical activity recall questionnaires are easy to use, the reliability and validity of these subjective measures is limited due to recall ability, misunderstanding of questions, and overestimation of physical activity (Sallis & Saelens, 2000). Heart rate monitors and pedometers are usually easy to use, but a drawback is that the accuracy of measuring physical activity through heart rate or step count can be affected by the type of activity or size of the individual (Bassett & John, 2010; Livingstone et al., 1990). Accelerometers can provide frequency, intensity, and duration of physical activity and provide information to determine energy expenditure (Bassett & John, 2010). Although accelerometers provide objective information about physical activity they have been found to be invalid across a wide range of activities estimating energy expenditure (Bassett & John, 2010; Crouter, Churilla, & Bassett, 2006). An alternative device to measure energy expenditure during physical activity is the SenseWear™ armband (SWA; Body Media, Pittsburgh, PA, USA).

The SWA allows for measurement of acceleration, skin temperature, and heat flux to determine an individual's energy expenditure (Bassett & John, 2010). The SWA has been validated in many settings for individuals who are overweight or obese including at rest (Malavolti et al., 2012), and during free living activities (Johannsen et al., 2010), outdoor aerobic activities (Dudley, Bassett, John, & Crouter, 2012), indoor home-based activities (Dudley et al., 2012), and continuous exercise (Jakicic et al., 2004). However, the SWA has not been studied in circuit-style exercise with an overweight or obese population.

There is a need for researchers to determine the most effective exercise method in terms of heart rate and energy expenditure between exercising with a live trainer and exercising with a DVD. It is also important to determine if the SWA is an effective tool to measure energy expenditure during a circuit-style workout.

Purpose

The investigations within this dissertation were designed to determine the most effective way to increase physical activity through comparing circuit-style, video-guided exercise to live, circuit-style exercise and to determine if the SWA can be used to accurately measure energy expenditure during circuit-style exercise in females who are overweight or obese. The purpose of the first study was to determine how energy expenditure, self-selected exercise intensity, and exercise perception differ for females who are overweight or obese participating in identical video-guided and trainer lead circuit-style exercise sessions. The purpose of the second study was to validate the SWA for use during circuit-style exercise with females who are overweight or obese against an open-circuit, indirect calorimetry measure of energy expenditure.

Significance of Studies

Determining the differences in energy expenditure, self-selected exercise intensity, and perceived enjoyment between live and video-guided, circuit-style exercise will allow researchers to determine the most beneficial mode of exercise for individuals who are overweight or obese. Determining the most beneficial mode of exercise could help these individuals meet daily physical activity recommendations. A validated tool to measure energy expenditure during circuit-style exercise will allow individuals to measure physical activity and understand how many calories have been expended. If found to be valid, individuals could use the SWA in circuit-style training as a tool to assist with weight loss or weight management. The ability to identify an effective mode of exercise and valid tool to measure energy expenditure leads to great potential of increasing physical activity levels which, in turn, could help in decreasing health and mortality risk of females who are overweight or obese.

CHAPTER II

REVIEW OF THE LITERATURE

This review of literature begins with a description of overweight and obesity and their developing definitions in the literature, followed by the prevalence and health-related consequences of being overweight and obese. Physical activity, as a tool to prevent being overweight or obese, is presented with a review of current recommendations. The review then transitions into an overview of measuring physical activity with attention devoted to the application of several measurement techniques. This is followed by an overview of previous research examining the outcomes of overweight and obese individuals exercising with both a personal trainer and a pre-recorded DVD. The review concludes by returning to the importance of adequate physical activity with individuals that are overweight or obese. This includes determining appropriate measurement tools for this population to use in assessing energy expenditure.

Overweight and Obesity

Definitions

Overweight and obese are labels given to individuals when weight exceeds a range of what is considered healthy for a given height (Overweight and Obesity, n.d.). Generally, overweight and obesity ranges are determined for adults using height and weight to calculate a body mass index or BMI (Overweight and Obesity, n.d.). A BMI of 25 kg/m^2 to 29.9 kg/m^2 is classified as overweight; whereas, a BMI of 30 kg/m^2 or above is classified as obese. Although BMI generally correlates with the amount of body fat an individual has, it does not directly measure body fat and could be problematic with some populations, such as athletes. Skinfold thickness is an inexpensive way to more accurately estimate body composition, the ratio of fat to fat free mass, with a standard error of ± 3.5% (Lind, Welch, & Ekkekakis, 2009). Regression equations are used to estimate body density based on an individual's sum of skinfolds with the variables sex, age, and race considered in the estimation. Using this method to determine body fat percentage assumes a third of one's body fat is located subcutaneously (American College of Sports Medicine [ACSM], 2014). Healthy body fat percentage ranges include 10-22% for males and 20-32% for females; however, when males exceed 25% and females exceed 32%, they are classified as obese (Prochaska, 1994). Other methods to estimate body fat include bioelectrical impedance, hydrostatic weighing, air displacement plethysmography, and dual-energy x-ray absorptiometry. Schneider et al. (2009) provided an alternate definition of obesity defining it as a positive energy imbalance, in which an individual's energy intake exceeds energy expenditure.

Prevalence of overweight and obesity

The National Health and Nutrition Examination Survey (NHANES) 2009-2010 documented that nearly 33% (Fryar et al., 2012) of Americans are overweight as defined by BMI with approximately one-third (35.7%) of the population being obese (Ogden et al., 2012). When comparing the 2009-2010 data for men and women 20 years of age and older, the prevalence does not differ with 37 million men and 41 million women who are obese (Ogden et al., 2012). However, when looking at sex-specific rates, obesity significantly increased for men when comparing NHANES data from 1999-2000 to 2009-2010, but neither men nor women saw a significant change from 2007-2008 to 2009-2010 data (Ogden et al., 2012). When comparing NHANES data from 2007-2008 and 2009-2010, there appears to be a leveling off of the prevalence of obesity across the United States as compared to the rates over the previous 10 years (Ogden et al., 2012). While it is difficult for researchers to determine why obesity rates have leveled off, a possible explanation is health interventions aimed at targeting facets of the energy imbalance environment.

Although obesity rates appear to be leveling off across the United States, obesity remains a major health concern with approximately 70% of the population being overweight or obese (Fryar et al., 2012; Ogden et al., 2012). Researchers have determined this epidemic is due to environmental changes of overconsumption of large portion sizes, energy dense foods, and a reduction in energy expenditure due to an increase in sedentary time in both school and daily living, as well as a reduction in physical labor at job sites (Hill, Wyatt, Reed, & Peters, 2003). Church et al. (2011) suggested the daily occupation-related energy expenditure has decreased by more than 100 calories over the last 50 years in the U.S. While heredity could contribute to an individual's "energy balance" it is suggested that both environmental and behavioral influences played a strong role in the steep increase of obesity rates in the United States in the past decades (Hill & Melanson, 1999; Hill et al., 2003). Even though biology contributes to individual heights and weights, researchers agree this rapid increase in weight can be linked with environmental changes (Hill et al., 2003). Regardless of the cause, the current levels of obesity within the population are concerning given the myriad of health consequences associated with being obese.

Health consequences of being overweight or obese

Being overweight or obese poses health, social, psychological, and economical challenges (Wang, Beydoun, Liang, Caballero, & Kumanyika, 2008). The Surgeon General estimates that as many as 300,000 deaths each year could be the result of obesity (Overweight and Obesity: Health Consequences, n.d.). Risk of premature death increase 50% to 100% for individuals who are obese (Overweight and Obesity: Health Consequences, n.d.). Although overweight and obesity rates seem to be slowing down, the current generation may still be at risk for having a shorter life span unless this epidemic can be controlled (Wang et al., 2008).

Individuals who are overweight or obese have an increased risk of many health concerns such as heart disease, cancer, arthritis, and even respiratory problems. These individuals have an increased risk of having a heart attack, congestive heart failure, and sudden cardiac death, as well as being twice as likely to have high blood pressure as individuals who are not obese (Overweight and Obesity: Health Consequences, n.d.). Not only are 80% of people who have diabetes either overweight or obese, but an individual's risk of developing diabetes doubles with weight gain of 11-18 pounds compared to an individual that does not gain weight (Overweight and Obesity: Health Consequences, n.d.). Colon, prostate, and kidney cancers are associated with overweight and obesity, with the likelihood of women developing postmenopausal breast cancer doubling with a weight gain of more than 20 pounds from age 20 to 59 years (Overweight and Obesity: Health Consequences, n.d.). Being overweight or obese can also play a significant role in the development of arthritis. An example is that for every 2 pounds gained, the risk of having arthritis increases by 9-13% (Overweight and Obesity: Health Consequences, n.d.). While individuals who are overweight or obese have an increased risk of many health concerns, disease risk can be reduced by decreasing body weight 5-15%, particularly related to heart disease risk (Overweight and Obesity: Health Consequences, n.d.). Weight loss can also reduce blood pressure, blood sugar, and improve cholesterol levels for individuals who are overweight or obese (Overweight and Obesity: Health Consequences, n.d.).

Being overweight or obese can not only lead to an increased risk of many health concerns, but also result in premature death. Even a small weight gain can increase an individual's risk of developing certain types of cancer, arthritis, and diabetes (Overweight and Obesity: Health Consequences, n.d.). Fortunately, disease risk and mortality can be decreased with weight loss for an individual who is overweight or obese. An effective way for individuals to decrease body weight is to meet the recommended physical activity guidelines.

Physical activity guidelines

The ACSM (2014) currently recommends adults achieve 30 minutes of moderate intensity activity, at 40-59% of heart rate reserve, at least five or more days of the week or 20 minutes of vigorous intensity activity, at 60-89% of heart rate reserve, three or more days per week. While an accumulation of ≥ 150 minutes of moderate intensity physical activity per week or ≥ 75 minutes of vigorous intensity physical activity is recommended to improve health, > 250 minutes of moderate-to-vigorous intensity physical activity is suggested for long term weight loss (ACSM, 2014).

Therefore, recommendations for individuals exercising for weight control or weight loss will vary from the general physical activity recommendations. Ekkekakis et al. (2010) recommended 60 minutes of daily physical activity for weight control. The ACSM (2014) recommends individuals who are overweight or obese should initially exercise at a moderate intensity (40-59% of heart rate reserve) for a minimum of 30 minutes five or more days per week and progress to 60 minutes per day. It is also encouraged that this population progress to a vigorous exercise intensity (≥ 60% of heart rate reserve) which can help further health and fitness benefits (ACSM, 2014). The accumulation of 10 minute bouts of exercise is also an effective alternative to continuous exercise and could be beneficial for individuals starting an exercise program (ACSM, 2014).

Physical activity among individuals who are overweight or obese

Research has shown individuals with higher body weights or BMIs perform less physical activity and exhibit poorer adherence to exercise programs (Bautista-Castano, Molina-Cabrillana, Montoya-Alonso, & Serra-Majem, 2004). While 66.6% of men who are overweight and 62.2% of women who are overweight reported using physical activity to lose weight, only 22.2% of men and 19.0% of women who are overweight actually meet the recommended physical activity guidelines (Centers for Disease Control and Prevention [CDC], 2000). However, even fewer individuals who are obese, 18.8% of men and 16.1% of women, meet the recommended 30 minutes of moderate physical activity on five or more days per week (CDC, 2000). Even more concerning, only 3% of women who are obese achieve the daily physical activity recommendations of 60 minutes (Ekkekakis et al., 2010).

When individuals who are obese and non-obese were compared, non-obese individuals completed significantly greater amounts of physical activity based on step rate per minute (Ayabe et al., 2011). Fogelholm and Kukkonen-Harjula (2000) also reported adherence to prescribed exercise is low in both overweight and obese individuals when compared to active individuals. In order for individuals to effectively lose weight, regular physical activity is a necessary component to a weight loss program. Therefore, it is important to develop a balanced physical activity program with adequate intensity and duration to promote high caloric expenditure, as well as encourage adherence and minimize injury risk (Ekkekakis et al., 2010). Further, while higher intensity exercise decreases the time needed to reach caloric expenditure goals and helps overcome the lack of time as a perceived barrier to exercise, individuals who are obese often are not successful at these higher intensity programs (King, Castro, Wilcox, Eyler, & Sallis, 2000).

Schneider et al. (2009) stressed the importance of exercise enjoyment in individuals who are overweight and sedentary to avoid an increase in energy intake following exercise completion. It was found some overweight individuals had an increased energy intake following short bouts of exercise when mood deteriorated (Schneider et al., 2009). These physical activity findings for individuals who are overweight or obese make it a challenge for researchers and personal trainers to create an exercise prescription that individuals who are overweight and obese will see as a challenge, but still encourage adherence to or maintenance of the program (Ekkekakis et al., 2010). Therefore, the ACSM (2014) recommends individuals who are overweight or obese reduce energy intake by 500-1,000 kcal per day with dietary fat comprising < 30% of total energy intake and progressing to > 250 minutes of physical activity per week to promote long term weight control.

Even though the importance of daily physical activity is known, less than 23% of men or women who are overweight report meeting physical activity recommendations (CDC, 2000). Even fewer individuals who are obese meet recommended daily physical activity levels (CDC, 2000). While the ACSM (2014) recommends a sustained change in eating and exercise behaviors will result in significant and long term weight loss, it is often difficult for researchers and personal trainers to prescribe exercise of an adequate intensity and duration to promote high caloric expenditure (Ekkekakis et al., 2010). When determining exercise programs for individuals who are overweight or obese, intensity selection is an important component of exercise in that it should be high enough to expend sufficient calories, but low enough to be tolerable and comfortable. Physical activity monitors could be a beneficial tool for individuals who are overweight and obese, researchers, and personal trainers to measure intensity during an exercise session.

Measurement Tools of Physical Activity

It is important to increase levels of physical activity to prevent unhealthy weight gain and, ultimately, reduce rates of obesity (Scheers, Philppaerts, & Lefevre, 2012). In order to improve the quantity of physical activity, one must first be aware of current activity patterns. However, accurate data on the physical activity levels of individuals who are overweight or obese are limited due to measurement difficulties.

Physical activity questionnaires

Currently, many researchers rely on physical activity questionnaires to assess daily physical activity (Scheers et al., 2012). Physical activity questionnaires are beneficial in that researchers can collect data from large groups at one time with low cost. Recall questionnaires can be used with a wide range of ages and can be used to measure physical activity without the risk of altering patterns of activity. Despite ease of use, the reliability of these measures is limited due to recall ability of the individual, misunderstanding of questions, or overestimation of physical activity by participant in order to feel socially accepted (Sallis & Saelens, 2000). Scheers et al. suggested the validity of using questionnaires to determine an individual's physical activity varied based on BMI. More specifically, individuals who are obese over report physical activity when compared to non-obese individuals (Slootmaker, Schuit, Chinapaw, Seidell, & van Mecheien, 2009). This overemphasis of the amount of physical activity decreases the validity of using questionnaires to estimate physical activity in individuals with higher BMI values (Scheers et al., 2012). Due to the reliability and validity problems associated with the use of subjective measures for reporting physical activity, many researchers use objective measures.

Objective measures of physical activity: Heart rate monitors and pedometers

Heart rate monitors and pedometers are objective measures used in research to measure physical activity. Advantages of these devices include lack of need to recall physical activity or judge the frequency, intensity, or duration of physical activity periods. These activity monitors can store minute-by-minute data and provide the total quantity of accumulated physical activity (Bassett & John, 2010). Not only can these devices be useful as measurement tools, but they can also be useful as motivational tools for individuals who are sedentary to increase their physical activity (Tudor-Locke, 2002).

While physical activity monitors, such as heart rate monitors and pedometers, are often used in research, they still have limitations when used to assess physical activity. While heart rate can be useful in predicting energy expenditure, Livingstone et al. (1990)

found heart rate less valid when estimating light activity energy expenditure versus moderate-vigorous physical activity energy expenditure. Another limitation of using heart rate to predict energy expenditure is that it can be influenced by non-physical activity factors such as changes in emotion, body temperature, fatigue, and caffeine consumption. Pedometers can be useful in measuring physical activity because they are small and inexpensive; however, they provide little information on intensity of activity. Pedometers are unable to evaluate the intensity and patterns of physical activity at which an individual moves. The accuracy of some pedometer step counts can be affected when worn by individuals who are obese because the devices become less sensitive when it tilts forward and away from the vertical axis with waist mounted pedometers.

Bassett and John (2010) reported the Yamax SW digi-walker pedometer undercounted steps when used with individuals who are obese or while walking at a slow speed (≤ 1.5 mph). While the New Lifestyle NL-2000 pedometer is accurate in both individuals who are obese and non-obese, it showed a similar underestimation as the digi-walker at slower walking speeds (Bassett & John, 2010). Similar, to the previous pedometers, the Omron HJ-720 ITC fails to detect all steps at slower walking speeds, but is not affected by an individual's BMI (Bassett & John, 2010). However, the Omron pedometer has a limitation in that it has a 4 second filter, meaning it will not record steps unless the individual is walking for 4 seconds or longer (Bassett & John, 2010). Overall, the accuracy of the pedometers listed above can be affected due to an individual's slow walking speed or by obesity.

Because the Step Watch 3 is worn on the ankle as opposed to the waist, the StepWatch 3 pedometer is the most accurate to measure step count, across a variety of body shapes and sizes (Bassett & John, 2010). The StepWatch 3 can be used to record the number of steps an individual takes, the number of bicycle pedal revolutions, and the amount of leg swing. However, some areas of potential error include car driving or tapping the foot. These examples could potentially cause overestimation of step count due to the mounting location on the ankle (Bassett & John, 2010). While pedometers can provide step count information they lack the ability to provide additional information about physical activity such as duration, intensity, or pattern of physical activity. An accelerometer is a measurement tool that can provide this additional information such as frequency, intensity, and duration when measuring ones physical activity.

Accelerometers

While pedometers provide step count, other characteristics of the activity such as duration, intensity, and frequency remain unknown. Accelerometers can provide information about frequency, intensity, and duration of physical activity and allow determination of energy expenditure (Bassett & John, 2010). ActiGraph (Pensacola, FL, USA) is one of the most widely used accelerometers in physical activity research. Various levels of physical activity can be effectively distinguished when using the ActiGraph (Bassett & John, 2010). While many researchers have developed regression models to determine energy expenditure during physical activity with the ActiGraph, there is a lack of consistency in which regression equation to use making activity comparisons between studies difficult (Bassett & John, 2010). While ActiGraph accelerometers provide objective information on physical activity it has been found invalid for estimating energy expenditure across a wide range of activities (Crouter et al., 2006). This is because regression equations developed for this device are able to predict energy expenditure for activities such as walking, yard work, and house work fairly well, but are not reliable to use with light or vigorous activities (Crouter et al., 2006). The ActiGraph can accurately differentiate across walking speeds of 2-5 mph, but is inaccurate at distinguishing speeds when running or jogging 6-12 mph (Bassett & John, 2010). When estimating energy expenditure of moderate intensity activities, it has been reported that measures can be as much as 50% underestimated, with activity often being classified as light rather than moderate intensity when the ActiGraph monitor is used (Bassett & John, 2010).

It has been stated that triaxial accelerometers, such as the Tritrac, may be the most accurate activity monitors due to the ability to detect body acceleration in three planes (Fruin & Rankin, 2004). However, Tritrac triaxial accelerometers have been found to overestimate energy expenditure during walking and running by 12-49% (Campbell, Crocker, & McKenzie, 2002; Nichols, Morgan, Sarkin, Sallis, & Calfas, 1999; Welk, Blair, Wood, Jones, & Thompson, 2000) and underestimate energy expenditure when an individual is walking up an incline by 8-21% (Jakicic et al., 1999; Nichols et al., 1999) and 53-68% when cycling (Campbell et al., 2002; Jakicic et al., 1999). Although there are limited validity studies regarding triaxial accelerometers, it is thought they may perform in a similar manor to the ActiGraph, a uniaxial accelerometer, which assesses accelerations in one direction (Bassett & John, 2010). Therefore, an alternative device to assess energy expenditure during physical activity could be a new type of activity monitor, the SenseWear™ Pro Armband (Body Media, Pittsburgh, PA), that uses a combination of acceleration, skin temperature, skin galvanic response, and heat flux sensors to determine energy expenditure (Bassett & John, 2010).

Armbands

The SWA Pro is a newly developed activity monitor that can be used to continuously measure different physiologic parameters and allow energy expenditure and physical activity to be more accurately measured. The armband is a physical activity measuring device worn on the back of the upper left arm in the tricep area, which uses a combination of sensors to determine energy expenditure (Andre et al., 2006). The sensors in the armband include heat-flux sensors measuring the amount of heat being dissipated from the body, sensors measuring both skin and ambient temperatures, and sensors measuring skin conductivity. Body position and upper arm movement can also be tracked with a two-axis accelerometer located inside the armband. Data from the sensors, along with the individual's sex, height, weight, and age are used to estimate energy expenditure. The ability for the armband to measure heat flux may improve the estimate of energy expenditure compared to other commercially available devices (Andre et al., 2006; Jakicic et al., 2004). The armband is relatively inexpensive, can store 2 weeks' worth of data, and the location on the body does not interfere with physical activity. Also, with multiple sensors, the armband is able to accurately assess physiological states that a single sensor may confuse (Andre et al., 2006).

The SWA is also able to differentiate different activities such as weight-lifting, walking, running, and even riding in a car (Andre et al., 2006). Jakicic et al. (2004) was one of the first to validate the SWA with various modes and intensities of exercise. Individuals (20 males and 20 females) completed four exercises (walking, cycling, stepping, and arm ergometry) with each exercise lasting 20-30 minutes and workload intensity increasing at 10 minute intervals (Jakicic et al., 2004). When the manufacturer's algorithm was applied to determine energy expenditure, walking, cycling, and stepping values were significantly underestimated, but when exercise-specific algorithms were applied, no significant difference was found in total energy expenditure between the SWA and indirect calorimetry (Jakicic et al., 2004). However, when arm ergometry was examined, energy expenditures were significantly overestimated (Jakicic et al., 2004).

A significant overestimation of energy expenditure was also found, when comparing the SWA to indirect calorimetry, in light, everyday activities such as housework and occupation duties (Dudley et al., 2012). The SWA was used in a validation study with 68 participants (30 male, 38 female) in which participants completed 1 of 3 routines, with each routine consisting of six activities that lasted approximately 10 minutes (Dudley et al., 2012). The different routines included an indoor, home-based routine with activities such as television watching, laundry and cleaning, a miscellaneous routine comprised of activities such as driving a car, gardening, and loading/unloading 15 lb boxes, and an outdoor routine of aerobic activities such as walking, playing tennis, and running (Dudley et al., 2012). Dudley et al. (2012) concluded the SWA overestimated energy expenditure in light-to-moderate activities, and underestimate energy expenditure with higher intensity activities, with future studies needed to determine if modifications are needed to improve accuracy. Similar to Dudley et al., Galvani, Andreoletti, Besi, and Faina (2007) examined activities of daily living such as occupation, housework, and recreation when comparing the SWA to indirect calorimetry. Galvani et al. found similar results as Dudley et al. in that as activity intensity increased, energy expenditure underestimation increased with the SWA.

For lean and overweight adults, the armband has been shown to be reliable in estimating energy expenditure during rest. When determining energy expenditure for children and individuals who are obese it has been suggested specific algorithms may need to be used for estimates to be accurate during exercise (Arvidsson, Slinde, Larsson, & Hulthen, 2007; Papazoglou et al., 2006). While previous studies suggest the inaccuracies in estimating energy expenditure in children are due to using adult algorithms, Dudley et al. (2012) suggested the difference may be due to the type of activity completed because these inaccuracies of energy expenditure estimation still occur within an adult population. Therefore, Dudley et al., recommended adjusting the SWA algorithms energy expenditure estimation will improve in activities such as walking and running.

With the algorithms continuously being updated, it is sometimes difficult to compare research using the SWA energy expenditures. However, researchers have concluded the SWA provides a valid and reliable estimate of energy expenditure when compared to indirect calorimetry during exercise periods when using specific activity algorithms (Fruin & Rankin, 2004; Jakicic et al., 2004; Malavolti et al., 2005; Wadsworth, Howard, Hallam, & Blunt, 2005). Johannsen et al. (2010) examined the validity of energy expenditure between the SenseWear™ Pro3 armband and the SenseWear™ Mini armband monitor using free living conditions. The average total energy expenditure values were within 112 kcal/d for the SenseWear™ Pro3 Armband and 22 kcal/d for the SenseWear™ Mini Armband when compared to the doubly labeled water criterion (Johannsen et al., 2010). Therefore, the two previous mentioned armbands show potential to accurately measure daily energy expenditure with free living conditions

(Johannsen et al., 2010). With the multiple sensors in the SWA can accurately assess different physiological states and differentiate different physical activities to estimate energy expenditure that a single sensor may confuse (Andre et al., 2006).

While the importance of physical activity to prevent unhealthy weight has been established (Scheers et al., 2012), only 20% of U.S. adults meet the recommend amount of physical activity (Centers for Disease Control and Prevention, 2013). To aid in this unhealthy weight problem, many physical activity monitors have been created and validated to assist individuals in measuring physical activity. However, while some individuals are motivated to be physically active based on measurements from the activity monitors, others may need the guidance and reinforcement of a personal trainer in order to be physically active.

Exercise with a Personal Trainer

One way for individuals to increase physical activity is by exercising with a personal trainer. A personal trainer can offer many benefits including support, guidance, and reinforcement (Perri et al., 1997). Generally, consistent adherence to a prescribed exercise is low for individuals who are overweight or obese (Fogelholm & Kukkonen-Harjula, 2000). Exercise adherence has been shown to improve with the use of a personal trainer or supervised activity (Colley et al., 2010; Jeffery et al., 1998). Exercising with a personal trainer not only leads to greater adherence and an effective way to change one’s readiness to increase physical activity, but also to higher energy expenditures and higher heart rates (Killen, Barry, Cooper, & Coons, 2014).

Colley et al. (2010) examined the response to a moderate walking program in women who are obese and sedentary. The women (N = 13) who participated in this walking intervention performed 4 weeks of supervised exercise followed by 4 weeks of unsupervised walking, both with a target energy expenditure of 1,500 kcal per week of the 8 week study (Colley et al., 2010). Colley et al. (2010) found individuals who are obese (BMI > 30 kg/m^2) who were supervised had greater adherence to a new exercise program than those not supervised. It was suggested adherence was high in a walking intervention because participants were monitored, reminded of exercise sessions, and provided flexible times to schedule their walks (Colley et al., 2010).

Jeffery et al. (1998) found similar results in a walking study involving 29 males and 167 females who were obese (14 to 32 kg overweight) who were assigned to 1 of 5 treatment groups. The groups ranged from a standard behavior therapy group, considered the control group, where participants received behavioral counseling, to the most involved group where participants received standard behavior therapy, supervised walks with a personal trainer, and monetary incentives for completed walks. Each participant was assigned a caloric expenditure goal based on current weight status, with participants weighing less than 91 kg having a caloric expenditure goal of 1,000 kcal/day and participants weighing 91kg or more assigned an energy expenditure goal of 1,500 kcal/day (Jeffery et al., 1998). Participants who were overweight were twice as likely to attend an exercise session when assigned a personal trainer or when they received a financial incentive than participants not receiving personal training services or financial incentives. Additionally, attendance tripled with the combination of a personal trainer and financial incentive. The high adherence results from these two studies are attributed to the positive social support a personal trainer provides to the exercising individual (Colley et al., 2010; Jeffery et al., 1998).

Personal trainers have also been shown to be effective in changing an individual's attitude toward exercise (Fischer & Bryant, 2008; McClaran, 2003). McClaran (2003) conducted a 10 week study with 129 participants to determine the effectiveness of a personal trainer using the stages of the Transtheoretical Model. After a 10 week intervention of using a personal trainer, McClaran found 57% of the participants showed upward movement in the stages of the Transtheoretical Model, which determines how ready one is to exercise. Even more impressive, when individuals in the highest stage were excluded, 73% of participants showed upward movement in readiness to exercise, indicated a greater readiness to be physically active, following the 10 week intervention (McClaran, 2003).

Fischer and Bryant (2008) found similar results to McClaran (2003) when 31 female, college students receiving personal training services were cross-matched with female, college students not receiving personal training services to determine the effect of the services on exercise behavior through the Transtheoretical Model of Behavioral Change. Participants assigned to work with a personal trainer showed significantly more positive change in readiness to exercise behavior (Fischer & Bryant, 2008). When compared to similar studies not using personal trainers, Fischer and Bryant found participants were twice as likely to improve attitudes toward exercise when using one-on-one personal training. Individuals receiving personal training services reported engaging in physical activity more often than individuals in the control group; therefore, leading to a greater amount of energy expenditure (Fischer & Bryant, 2008). This evidence suggests personal training services can be effective through the one-on-one interaction in changing attitudes toward exercise which could thereby lead to an increase in physical activity (Fischer & Bryant, 2008; McClaran, 2003).

Killen et al. (2014) compared heart rates and energy expenditures when 20 low-to-moderate fit females completed two exercise sessions, one with a personal trainer and the other with an identical exercise DVD. The session with a live personal trainer resulted in significantly higher heart rates and energy expenditure. It was suggested the significant differences were due to an individual being able to select exercise intensity, during the DVD session, in how much effort to put into completing each exercise. Participants also reported they felt they worked harder through rating of perceived exertion scores which were significantly higher for the personal training session versus the DVD session (Killen et al., 2014). Interestingly, 89% of participants reported that the personal trainer session was preferred over the pre-recorded DVD session even though data indicated participants were exercising at a greater intensity.

While it has been established exercising with a personal trainer versus exercising alone can increase adherence, improve attitude, and may even be preferred by the individual, the dose of exercise can contribute to the outcome of these factors. Colley, Hills, O'Moore-Sullivan, Hickman, & Byrne (2008) examined exercise adherence when 29 women who were obese (BMI > 30 kg/m^2) underwent a lifestyle intervention trial in which participants were encouraged to lose 5% of their baseline body weight through an unsupervised, exercise energy expenditure of 1,500 kcal/week and a decreased dietary intake of 500 kcal/day. The prescribed 1,500 kcal/week represents a compromise between what is recommended for health benefits (1,000 kcal/week) and weight loss (> 2,000 kcal/week); whereas, 1,000 kcal/week was used as a reference to define adherence to exercise (Colley et al., 2008).

While participants did not exercise with a personal trainer, they were given a heart rate monitor to estimate energy expenditure during exercise and met with research staff weekly to verify exercise adherence using the memory of the heart rate monitor as well as to receive encouragement to continue weekly energy expenditure (Colley et al., 2008). Only 14% of participants achieved expending 1,500 kcal/week with some individuals failing to exercise at all throughout the intervention (Colley et al., 2008). Colley et al. (2008) found females who are obese have a highly inconstant adherence to a prescription of unsupervised exercise of 1,500 kcal/week. These findings represent the importance of supervised exercise for individuals who are obese. Later, Colley et al. (2010) suggested the need for a period of supervision before individuals are asked to exercise independently. Colley et al. (2010) found a supervised period of 4 weeks was adequate to educate individuals about starting a new exercise program and how to use heart rate monitors to self-monitor exercise intensity during their 8 week exercise intervention. Providing appropriate educational information to individuals who may be new to exercise could improve intervention outcomes.

With the importance of physical activity for health established, it is critical to determine the best practices for an individual who is obese and is trying to meet the daily recommendations for physical activity. Exercising with a personal trainer is one way an individual could increase physical activity. Personal trainers not only offer many benefits such as guidance and reinforcement during exercise, but have also been shown to increase adherence and improve attitudes toward readiness to exercise (Colley et al., 2010; Jeffery et al., 1998; Perri et al., 1997). While research shows individuals exercised at a higher intensity and even preferred working with a personal trainer, compared to exercising alone with a DVD, there are many barriers that could prevent an individual from exercising with a personal trainer (Killen et al., 2014).

Video-Guided Exercise

Despite the many benefits of an individual exercising with a personal trainer, there remain barriers to exercising in this fashion such as trainer availability, lack of enjoyment of activity, costs, and time (Vickers et al., 2011). With lack of time being one of the top barriers to individuals exercising (King et al., 2000), an alternative to exercising with a personal trainer that maybe more convenient to schedule is to use video-guided exercise (e.g., DVD) at home. Video-guided exercise can be similar to exercising with a personal trainer in that both methods provide motivation to the exerciser, as well as providing the workout and explanations of the different exercises throughout the workout. Sales of exercise DVD’s have increased from $155.4 million in 2007 to $264.5 million in 2012 with an average growth of 11.2% per year (IBISWorld Analysts, 2012; IBISWorld: Personal trainer, 2012; International Health, Racquet and Sportsclub Association, 2012).

Exercising with a DVD offers additional benefits including lower cost, flexibility of time, and versatile exercise location (Vickers et al., 2011). When exercising with a DVD, an individual has the option to exercise at home or other locations such as at a hotel, something that is not always an option with a personal trainer. Exercising with a DVD has also been shown to benefit special populations such as individuals with intellectual disabilities and individuals with Huntington’s disease (Khalil et al., 2012;

Lynnes et al., 2009). Exercise adherence and program satisfaction were examined with individuals with intellectual disabilities through DVD exercise (Lynnes et al., 2009). Individuals (*N* = 4) participated in the DVD exercise study which consisted of one face-to-face session of aerobic exercise, strength training, a recreational game, and a cool down and two DVD exercise sessions consisting of aerobic exercise and strength training (identical to the face-to-face session) completed at home. All sessions were completed weekly for 10 weeks. Prior to starting the program, all participants were familiarized with each exercise and how to navigate the DVD. Of the 4 participants, 3 participants showed a high adherence to the at home DVD exercise sessions as well as a threefold increase in exercise frequency per week when compared to initial exercise frequency (Lynnes et al., 2009).

Khalil et al. (2012) found similar results in individuals with Huntington's disease. Individuals (*N* = 15) with mid-stage Huntington's disease were asked to complete DVD exercises at least 3 sessions per week for 8 weeks (Khalil et al., 2012). The DVD exercises were developed based on what a physical therapist would have them complete and tailored to their activities of daily living (Khalil et al., 2012). All adherence barriers were disease-specific factors, such as commitment of the caregiver, caregiver-patient relationship, or physical/cognitive impairments (Khalil et al. 2012). Khalil et al. found 11 participants with Huntington's disease reported 83.3% exercise adherence; whereas, only 4 participants with Huntington's disease reported a maximum of 41.7% of exercise adherence when using the exercise DVD. Participants perceived the DVD exercises as a supportive aid to complete exercises by providing real-life demonstrations of each exercise rather than written instructions (Khalil et al., 2012). The results of these two studies (Khalil et al., 2012; Lynnes et al., 2009) suggest developing an exercise DVD specific to the population could result in higher adherence rates of the participants.

Researchers have found individuals participating in group exercise, at either community or clinical centers, have significantly lower adherence rates compared to home-based programs (King, Haskell, Taylor, Kraemer, & DeBusk, 1991; Perri et al., 1997). King et al. (1991) determined the effectiveness of group-based versus home-based exercise sessions with 160 females and 197 males between 50-65 years of age. Participants were assigned to one of 4 groups including the following: high intensity group-based exercise, high intensity home-based exercise, low intensity home-based exercise, or the control group (King et al., 1991). The group-based exercise was designed to stimulate a supervised group session with multiple sessions offered six days of the week; whereas, the home-based session participants were educated on how to measure an exercise heart rate, provided an activity log, and phoned by staff to monitor progress and provide feedback on current exercising (King et al., 1991). Both high intensity groups were assigned to exercise three times per week at 73-88% of their peak exercise heart rate for 40 minutes, with the low intensity group exercising five days per week for 30 minutes at 60-73% of their peak heart rate. King et al. (1991) found both higher and lower intensity home-based groups exercise adherence was significantly greater than individuals in the group-based exercise. Generally, both group-based and home-based exercises consisted of walking or jogging.

Perri et al. (1997) conducted a similar study comparing group exercise versus home-based exercise with 49 female participants who were obese (BMI 27-45 kg/m^2). All participants were encouraged to complete a moderate intensity (60-70% of max heart rate) walking program of 30 minutes per day and five days a week. The group-based exercisers were provided with three sessions per week for the first 26 weeks of the program and two sessions per week for the remainder of the program and encouraged to complete the remaining sessions on their own time (Perri et al., 1997), whereas, home-based exercise participants completed all sessions in their home environment. Early in the study, both groups demonstrated significant improvements in exercise participation; however, the home-based exercisers showed significantly higher exercise participation by month 12 when compared to the group-based exercisers (78.2% vs. 48.2%).

Although Perri et al. (1997) found exercise participation improvement in both groups, participation in the second 6 months of the exercise program decreased for the group-based participants with the majority of dropouts reporting time demand as the primary reason to withdraw, regardless of facilities being generally available on week nights. These results suggest individuals may effectively start and maintain a home-based exercise program due to the convenience and flexibility of time to exercise. Findings were especially interesting for Perri et al. in that the research sample included women who were obese, a population generally thought to need a supervised exercise program to maintain adherence (Colley et al., 2010; Jeffery et al., 1998).

An additional benefit of an individual exercising at home with a DVD is the exerciser can select the intensity at which he or she wishes to work. This could be beneficial, especially with adults who are overweight, in that adherence and enjoyment are higher when participants self-select and are unsupervised during exercise compared to supervised and prescribed exercise (Ekkekakis & Lind, 2006; Perri et al., 1997). As previously mentioned, King et al. (1991) found older men and women were more likely to adhere to exercise in a home-based setting of lower intensity and even higher intensity compared to a group exercise setting. Overall, a moderate intensity was preferred by the lower intensity exercise group as individuals in this group tended to exercise at the upper end of the heart rate range and individuals in the high intensity group tended to exercise at the lower end of the range when comparing group-based versus home-based exercise (King et al., 1991). Similarly, Jeffery et al. (1998) found when participants were given exercise recommendations to walk or bike the equivalent of 250 kcal per week and increase to a minimum of 1,000 kcal per week by themselves, long-term weight loss was significantly higher than weight loss for individuals assigned to exercise with a personal trainer, when comparing different strategies to improve exercise adherence. Together, this suggests individuals are more likely to continue an exercise program when intensity is self-selected and unsupervised in the beginning of exercise programs.

Individuals who are overweight may also be more likely to continue an exercise program when intensity is self-selected versus prescribed due to an increased feeling of control. Ekkekakis and Lind (2006) compared ratings of perceived exertion and pleasure/displeasure of exercise between 16 females who were overweight (BMI $\geq$ 25 kg/m^2) and 9 females who were not overweight (BMI $<$ 25 kg/m^2) with two, 20 minute treadmill trials, one where the participant self-selected speed and the other in which speed was imposed at a 10% higher speed than self-selected. It was found females who were overweight exercised at a higher percentage of peak aerobic capacity than females who were not overweight when intensity was self-selected (Ekkekakis & Lind, 2006). When treadmill speeds were both self-selected and imposed (10% higher than self-selected speed) no significant difference was found in speed of the treadmill between the overweight and non-overweight groups; however, ratings of perceived exertion and pleasure-displeasure were different due to the individuals who were obese working at a higher percentage of peak aerobic capacity (Ekkekakis & Lind, 2006).

Although imposed intensity was only 10% higher than self-selected speed, the pleasure-displeasure ratings of the group that was overweight decreased over time. Therefore, it can be speculated individuals may not adhere to exercise when enjoyment is not achieved during exercise (Ekkekakis & Lind, 2006). Self-selected intensity can be similar to DVD or home-based exercise because at home or when using a DVD, individuals are able to feel in control of the exercise session by self-selecting exercise intensity (Ekkekakis & Lind, 2006). By self-selecting intensity, individuals avoid feeling signs of poor physical conditioning and social anxiety due to one's physique that may be caused by someone else selecting a greater intensity than he or she would have selected (Ekkekakis & Lind, 2006). Exercising with a DVD may be beneficial to individuals who are overweight or obese to avoid the perceived, negative emotion that one's body is being assessed by observers as it might be in a gym setting. It is also interesting to note Ekkekakis and Lind (2006) found a decrease in exercise pleasure as ratings of perceived exertion increased, but only when intensity was imposed in women who were overweight.

Positive results were also found for home-based exercise when 52 participants, who were obese (BMI $\geq$ 30), were assigned to either complete physical activity at home, through a structured educational program, or to a control group given general advice about physical activity (Tumiati et al., 2008). All participants were evaluated on anthropometric measures, 2km walking test, Polar Fitness Test, and leg extensions every

3 months for 9 months. While cardio pulmonary fitness variables significantly changed for both groups, the home-based group had positive changes for all variables including 2 km walk test time, hear rate reserve, and fitness index score (Tumiati et al., 2008). In the control group, reported time to complete the 2km walk test significantly increased, heart rate reserve significantly decreased, and fitness index score significantly decreased (Tumiati et al., 2008). Tumiati et al. (2008) concluded the current study was both practical and showed improvements in physiological and anthropometric aspects for sedentary individuals who were obese. Exercising at home with a structured program can be similar to exercising with a DVD and could possibly provide the same results for individuals who are overweight or obese.

In summary, video guided exercise offers many benefits such as low cost, flexibility in when to exercise, enjoyment, personal intensity selection of the activity, and the portability to be completed at home or in other locations. Exercising with a DVD not only offers flexibility of time in which the exercise is completed, but also flexibility of intensity in which the individual exercises. It has been found exercise adherence increases when individuals have the opportunity to participate in home-based exercise where both time and exercise intensity are self-selected versus a group-based exercise program (Ekkekakis & Lind, 2006; King et al., 1991; Perri et al., 1997). These findings could be beneficial for individuals who are overweight or obese in that exercise adherence rates and enjoyment of activity increase due to unsupervised and self-selected exercise intensity versus prescribed and supervised exercise such as a personal trainer (Jeffery et al., 1998).

Overall Conclusions

Although obesity remains a major health concern throughout the United States, with nearly 70% of the population being overweight or obese, there is evidence that obesity rates are leveling off (Fryar et al., 2012; Ogden et al., 2012). Individuals who are overweight or obese have an increased risk of many health concerns such as heart disease, cancer, arthritis, and respiratory disease. Even with the known importance of daily physical activity, fewer than 23% of individuals who are overweight report achieving daily physical activity recommendations and even fewer individuals who are obese report meeting recommendations (CDC, 2000).

Many physical activity questionnaires and physical activity monitors have been developed and validated to assist in measuring levels of physical activity. While using a physical activity monitor offers sufficient motivation for some individuals, others may benefit from the guidance and reinforcement of a personal trainer to help encourage attainment of physical activity recommendations. Not only can personal trainers offer reinforcement and guidance during exercise, but they have also been shown to increase exercise adherence and improve attitudes toward readiness to exercise (Colley et al., 2010; Jeffery et al., 1998; Perri et al., 1997). However, there are barriers that could prevent an individual from exercising with a personal trainer (Killen et al., 2014). Exercising with a DVD is an alternative to exercising with a personal trainer. By exercising with a DVD, the individual has the flexibility of when and where to exercise and flexibility in self-selecting exercise intensity. Research has also shown special populations (Huntington's disease and intellectual disabilities) had high exercise adherence rates when using DVD exercises (Khalil et al., 2012; Lynnes et al., 2009).

Developing an exercise DVD specific to the overweight and obese population could potentially result in higher exercise adherence rates. The outcome of DVD exercise versus in-person training on exercise intensity and energy expenditure for individuals who are overweight or obese has not been studied. Therefore, with the availability of objective measures of physical activity for individuals who are overweight or obese and the growing knowledge of the importance of daily physical activity, determining the most effective way to increase physical activity in this population is justified and necessary.

CHAPTER III

LIVE AND VIDEO-GUIDED EXERCISE WITH FEMALES WHO ARE OVERWEIGHT OR OBESE

Introduction

Obesity remains a major health concern in the United States with approximately 70% of the population being either overweight or obese (Fryar, Carroll, & Ogden, 2012; Ogden, Carroll, Kit, & Flegal, 2012). Currently, only 22.2% of men and 19.0% of women who are overweight and 18.8% of men and 16.1% of women who are obese meet physical activity recommendations (American College of Sports Medicine, 2014). There is a need to develop methods that improve physical activity levels and maximize caloric expenditure within this population. One method for individuals who are overweight or obese to increase activity levels is to exercise with a personal trainer.

Exercising with a personal trainer offers support, guidance, and reinforcement, and has been shown to increase exercise adherence, as well as encourage individuals to exercise at higher intensities (Colley, Hills, King, & Byrne, 2010; Jeffery, Wing, Thorson, & Burton, 1998; Killen, Barry, Cooper, & Coons, 2014; Perri, Martin, Leermakers, Sears, & Notelovitz, 1997). For individuals who are obese, using a personal trainer can provide additional benefits by providing accountability, educational information, and individualized programs to meet specific health or caloric goals (Colley, Hills, O’Moore-Sullivan, Hickman, & Byrne, 2008; Colley et al., 2010). However, while using a personal trainer offers many benefits, a drawback could be the individual cost and time restraints of exercise sessions. An option that overcomes these drawbacks (Vickers et al., 2011) is using video-guided exercise, such as exercising at home with an exercise DVD.

Exercising with a DVD has become popular. Gross exercise DVD sales were $264.5 million dollars in 2012 with an expected growth of 9.8% over the next 5 years (International Health, Racquet and Sportsclub Association, 2012). More recently, the fitness DVD industry reported revenues of $297 million dollars with 7.7% annual growth (IBISWorld: Fitness DVD Production, 2014). Individuals who are overweight or obese may benefit from video-guided exercise in that it offers versatility of exercise location for those who prefer not to exercise in public. Additionally, drawing comparisons to other populations, it has been shown that individuals with Huntington's disease and intellectual disabilities who exercised at home with population-specific video-based exercise programs had high adherence rates (Khalil et al., 2012; Lynnes, Nichols, & Temple, 2009). Similarly, self-selected and unsupervised exercise resulted in greater adherence and enjoyment than supervised and prescribed exercise for individuals who are overweight or obese (Ekkekakis & Lind, 2006; Perri et al., 1997). Therefore, exercising with a DVD could offer many benefits to increase levels of physical activity to individuals who are overweight or obese.

Despite the known importance of being physically active and the growing market of video-guided exercise, little research exists comparing the benefits of live and video-guided training for individuals who are overweight or obese. Therefore, the purpose of this study was to determine how energy expenditure, self-selected exercise intensity, rate of perceived exertion (RPE), and exercise perception varied for females who are overweight or obese participating in identical video-guided and live exercise sessions.

Methods

Participants

Females (*N* = 40) who were overweight or obese as defined by a body mass index (BMI) of 25 kg/m^2 or greater participated in this study. Participants had to be low to moderate risk according to ACSM guidelines. To be eligible, participants had to be able to walk continuously for 30 minutes (based on self-report) and be between 20 years and 60 years of age.

Instrumentation

Anthropometric measurements. Body mass was measured using a digital scale (SECA Corporation, Model 770, Germany) to the nearest 0.1 kg. Height was assessed using a stadiometer (SECA Corporation, Model 222, Germany) to the nearest 0.1 cm. Anthropometric measurements were taken with participants wearing gym shorts and t-shirts, without shoes. Body mass index was calculated using body mass divided by height in meters squared.

Single stage treadmill test. Maximal oxygen consumption (ml/kg/min) was estimated using the single stage treadmill test (Ebbeling, Ward, Puleo, Widrick, & Rippe, 1991). Participants completed the test in gym shorts, t-shirts, and tennis shoes. The treadmill test began with a warm-up at 0% grade and a speed between 2 mph and 4.5 mph that elicited a heat rate between 50% to 70% of the participant's age-adjusted maximal heart rate, 220-age (Fox, Naughton, & Haskell, 1971). After walking for 4 minutes, the grade was raised to 5% with participants walking at the same speed for an additional 4 minutes. Maximal oxygen consumption was estimated using age, final recorded heart rate, and treadmill speed used throughout the test for each participant (Ebbeling et al., 1991).

Oxygen consumption. The Oxycon Mobile™ (CareFusion, Hoechberg, Germany) was used to measure participants' oxygen consumption during each exercise condition. This system measures ventilation in a breath by breath manner as well as expired oxygen and carbon dioxide through an open-circuit calorimetry system. This system allows participants to move outside of a lab in a free-living environment wearing a light weight, small pack (950g) and mask. Prior to each session, the Oxycon Mobile™ was calibrated using both an automatic gas analyzer and volume calibration unit. Following calibration, participant height, body mass, and age were entered into the system software. Metabolic data collected included oxygen consumption (VO_2), carbon dioxide production (VCO_2), and respiratory exchange ratio (RER). Energy expenditure was determined throughout the entire exercise session as kcal/min.

Heart rate. A Polar transmitter (T31 Transmitter, Polar Electro, Kempele, Finland) was used to assess heart rate response throughout each exercise session and recorded through the Oxycon Mobile™ to assess self-selected exercise intensity. Participants were blinded to heart rate response during the exercise sessions.

Rate of perceived exertion (RPE). A written Borg 6-20 scale (Borg, 1970) was use to assess RPE by having participants circle how they felt after each exercise during the rest period and following the completion of each exercise condition.

Exercise perception questionnaire. An exercise perception questionnaire was completed by each participant following each exercise condition to determine perceived enjoyment of the exercise conditions. This researcher-designed questionnaire was used to assess perceived comfort, confidence, enjoyment, stress, and anxiety during each exercise condition (see Appendix A). Participants answered 5 questions (Killen et al., 2014) on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Following completion of both exercise conditions, participants were also asked which of the 2 conditions they most preferred.

Procedures

Preparticipation assessment. Prior to data collection, participants signed a written informed consent approved by the university Institutional Review Board (see Appendix B). Anthropometric measures were completed and a resting blood pressure was assessed following a 5 minute seated rest on the right side of the body with the arm at heart level using an aneroid sphygmomanometer (Adcuff, American Diagnostic Corporation, New York United States) and a stethoscope. All participants were risk classified using ACSM’s (2014) risk classification to assure participants were not high risk.

Exercise conditions. Participants completed both a live exercise session and a video-guided session in a counterbalanced order. Participants were asked to refrain from eating or drinking, with the exclusion of water, 2 hours prior to the exercise sessions. Each exercise session began with a dynamic warm-up, lasting 8 minutes. The warm-up involved 8 exercises (i.e., grapevine with a hamstring curl, swing kicks, boxer shuffle, windmills, wall push-ups, knee-ups, step-ups, and vertical punches) with each exercise lasting 1 minute. During the workout portion of the session, the same 8 exercises were performed in sequential order twice, for 1 minute, with each exercise separated by 1 minute of rest. Participants assessed how they felt after each exercise using the RPE scale during the rest period. Following completion of the entire workout, participants also assessed session RPE and completed an exercise perception questionnaire. The workout portion of the session lasted approximately 32 minutes. The same personal trainer and setting were used in the live and the video-guided exercise sessions.

Statistical Analysis

International Business Machines Corporation Statistical Packages for the Social Sciences (version 19.0) software was used to conduct data analysis. Descriptive statistics for participants were calculated as means and standard deviations. For the session and each exercise, one-way repeated measures ANOVAs with exercise condition (live, video-guided) as the within-subject independent variable were performed for each dependent variable: exercise energy expenditure with rest periods, energy expenditure excluding rest periods, heart rate with rest periods, heart rate excluding rest periods, and RPE. For the session, one-way repeated measures ANOVAs were used to compare the exercise perception questionnaire and session RPE between the exercise sessions. For the session, one-way repeated measures ANCOVAs were used to evaluate average heart rate, excluding rest periods, and total energy expenditure, excluding rest periods, by exercise condition (live, video-guided) when controlling for average exercise perception. Lastly, a chi-square goodness of fit test was used to assess a question focused on which exercise session (live or video-guided), if any, was preferred for each participant. For this study, the alpha level was set at $p \leq .05$ when analyzing the session and $p \leq .01$ for each exercise.

Results

All participants (N = 40) were either overweight or obese and ranged in age from 20 to 59 years of age. Participant's BMI ranged from 25.0 to 57.3 (kg/m^2). Descriptive statistics are reported in Table 1. Overall energy expenditure was significantly higher, including (F (1, 39) = 21.95, p = < .001, n_p^2 = .360) and excluding (F (1, 39) = 29.01, p = < .001, n_p^2 = .427) rest periods, for the live exercise session as was the energy expenditure for each exercise during the live session versus the video-guided session (see Table 2 and Figure 1).

Heart rate was not significantly different for the live and video-guided conditions when rest periods were included, F (1, 39) = 2.55, p = .118, n_p^2 = .061, and excluded, F (1, 39) = 3.71, p = .069, n_p^2 = .087. Participants had similar heart rates, including and excluding rest periods, for the live and video-guided conditions overall and for each exercise, see Table 3 and Figure 2. Figures 1 and 2 show results excluding rest periods. The patterns were the same when rest periods were included.

Overall exercise session RPE and for each exercise was not significantly different between the live (12 ± 2) and video-guided (12 ± 2) sessions, F (1, 39) = 0.44, p = .509, n_p^2 = .011, F (1, 39) = 2.54, p = .119, n_p^2 = .061 (see Table 4 and Figure 3). All exercise perception questions (confidence, enjoyment, stressfulness, anxiety) were not significantly different, except for comfort (see Figure 4). Participants were significantly more comfortable in the live session than in the video-guided session, F (1, 39) = 7.20, p = .011, n_p^2 = .156. Participants' enjoyment, stress, confidence, and anxiety were similar

Table 1

Descriptive Characteristics of Participants (N = 40)

	M	*SD*
Age (yrs)	38.30	14.22
Height (cm)	162.67	5.91
Body mass (kg)	82.59	16.18
BMI (kg/m^2)	31.23	5.96
Single stage VO_2max (ml/kg/min)	30.31	7.71

Note. BMI = body mass index; VO_2max = maximal oxygen consumption.

Table 2

Paired Samples t-Tests and Descriptive Statistics for Live versus Video-Guided EE

			Live		*Video-Guided*	
Variable	*t*	*p*	*M*	*SD*	*M*	*SD*
EE excluding rest						
Knee-ups	3.19*	.003	5.37	0.91	5.04	0.92
Vertical punches	2.76*	.009	3.28	0.92	2.92	0.61
Boxer shuffle	3.20*	.003	4.92	0.90	4.55	0.91
Wall push-ups	3.62*	.001	3.35	0.75	2.95	0.64
Grapevine	5.70*	< .001	4.17	0.86	3.69	0.76
Step-ups	5.40*	< .001	5.00	0.83	4.53	0.86
Windmills	3.15*	.003	3.63	0.73	3.32	0.69
Swing kicks	3.62*	.001	4.34	0.69	4.00	0.75
All exercises rate	5.39*	< .001	4.26	0.67	3.88	0.72
EE including rest						
Knee-ups	3.92*	< .001	5.04	0.87	4.65	0.88
Vertical punches	3.02*	.004	3.17	0.69	2.89	0.58
Boxer Shuffle	3.16*	.003	4.75	0.88	4.41	0.92
Wall push-ups	3.53*	.001	3.24	0.62	2.93	0.59
Grapevine	5.50*	< .001	4.11	0.85	3.66	0.78
Step-ups	4.53*	< .001	4.70	0.79	4.36	0.86
Windmills	3.06*	.004	3.49	0.61	3.23	0.65
Swing kicks	3.50*	.001	4.27	0.70	3.98	0.77
All exercises rate	4.69*	< .001	4.10	0.67	3.76	0.71

Note. df = 39. * $p < .01$. EE = energy expenditure.

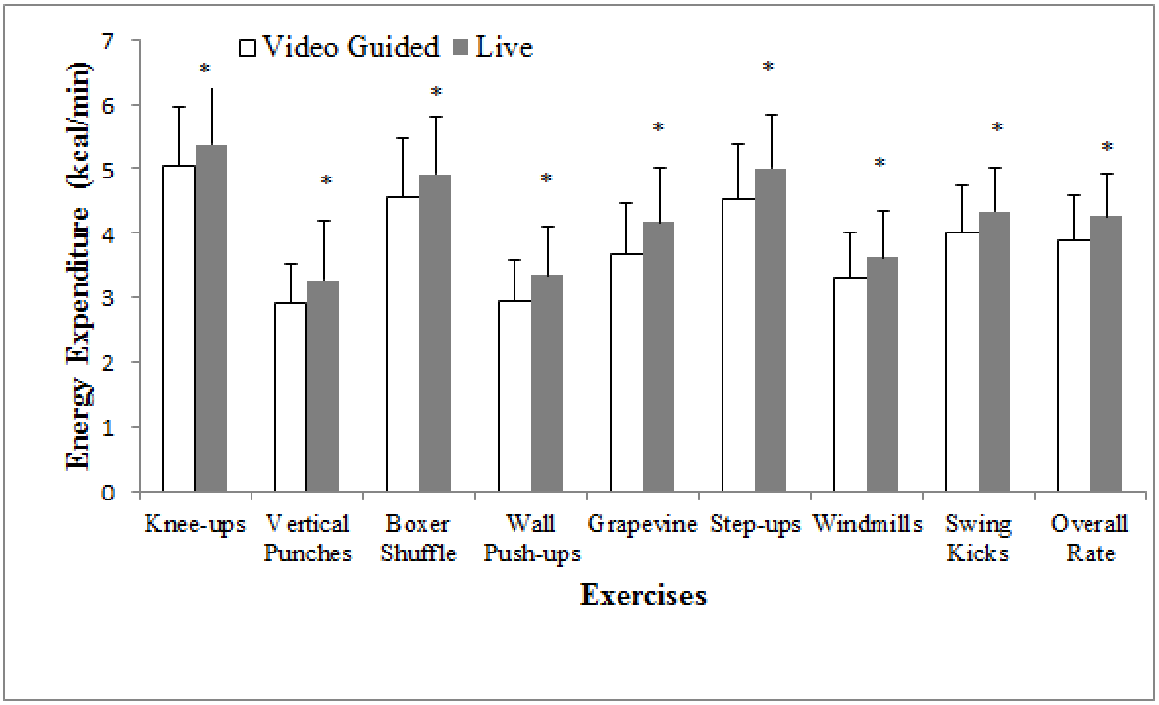

Figure 1. Energy expenditure for individual exercises in live versus video-guided exercise sessions, excluding rest periods. Values are mean ± standard deviation.

* = significantly higher energy expenditure for live exercise sessions compared to video-guided sessions $p < .01$.

Table 3

Paired Samples t-Tests and Descriptive Statistics for Live versus Video-Guided HR

			Live		Video-Guided	
Variable	*t*	*p*	*M*	*SD*	*M*	*SD*
HR excluding rest						
Knee-ups	0.24	.811	128	18	127	15
Vertical punches	0.92	.363	117	16	115	15
Boxer shuffle	1.72	.094	126	15	123	16
Wall push-ups	1.83	.075	114	18	110	18
Grapevine	2.51	.016	117	16	113	15
Step-ups	2.68	.011	122	17	117	14
Windmills	1.23	.226	119	17	116	17
Swing kicks	2.06	.046	123	17	119	18
Session	1.93	.061	121	15	117	15
HR including rest						
Knee-ups	0.43	.672	126	17	125	14
Vertical punches	0.69	.492	113	15	112	15
Boxer Shuffle	1.48	.146	124	16	122	15
Wall push-ups	1.14	.261	112	17	110	17
Grapevine	2.36	.023	117	16	113	15
Step-ups	2.44	.019	122	17	118	15
Windmills	1.19	.240	115	15	113	16
Swing kicks	1.81	.078	121	17	118	17
Session	1.60	.118	118	15	116	15

Note. $df = 39$. * $p < .01$. HR = heart rate.

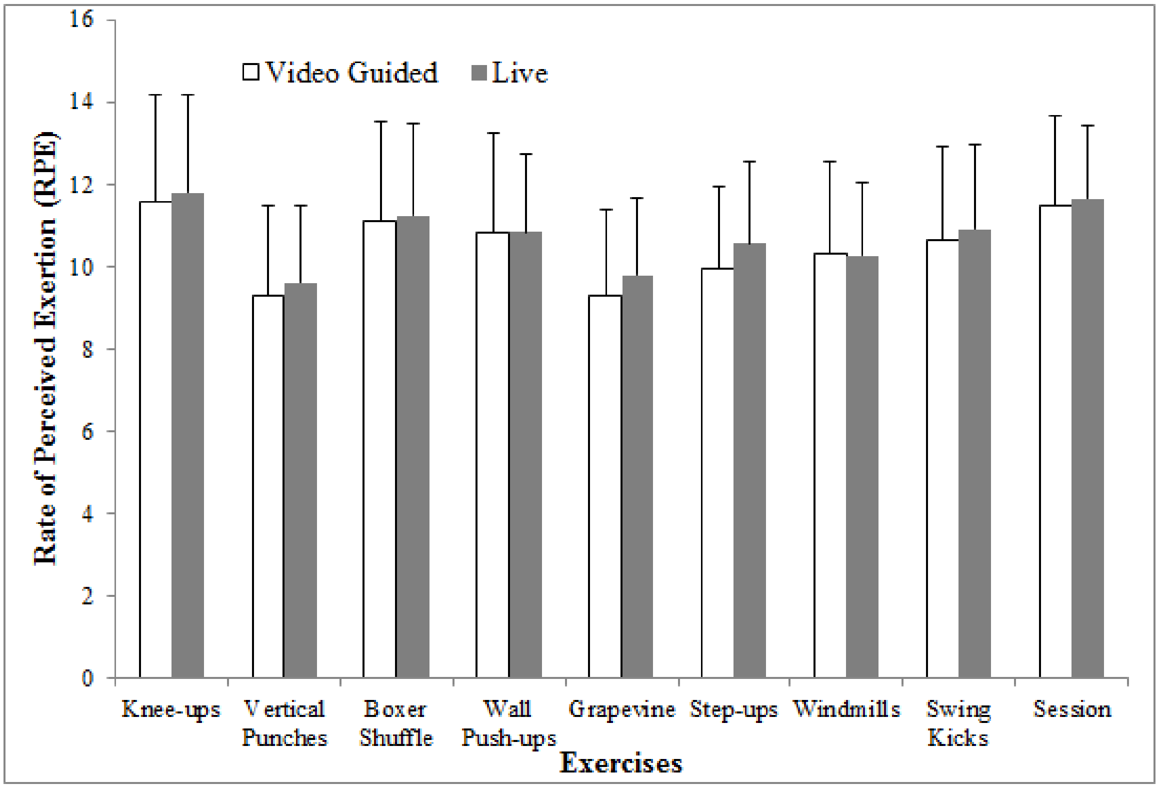

Figure 2. Heart rate for individual exercises in live versus video-guided exercise sessions, excluding rest periods. Values are mean ± standard deviation. * = significantly higher heart rates for live exercise sessions compared to video-guided sessions $p < .01$.

Table 4

Paired Samples t-Tests and Descriptive Statistics for Live versus Video-Guided RPE

			Live		*Video-Guided*	
Variable	*t*	*p*	*M*	*SD*	*M*	*SD*
Knee-ups	1.06	.296	11.80	2.35	11.58	2.59
Vertical punches	1.50	.141	9.61	1.87	9.28	2.18
Boxer shuffle	0.62	.538	11.24	2.24	11.1	2.42
Wall push-ups	0.00	1.000	10.83	1.90	10.83	2.40
Grapevine	2.12	.040	9.83	1.86	9.30	2.09
Step-ups	2.55	.015	10.56	1.99	9.96	1.98
Windmills	-0.27	.792	10.28	1.76	10.34	2.21
Swing kicks	1.20	.238	10.90	2.08	10.65	2.27
Session	0.66	.509	11.65	1.81	11.50	2.18

Note. df = 39. * $p < .01$. RPE = rate of perceived exertion.

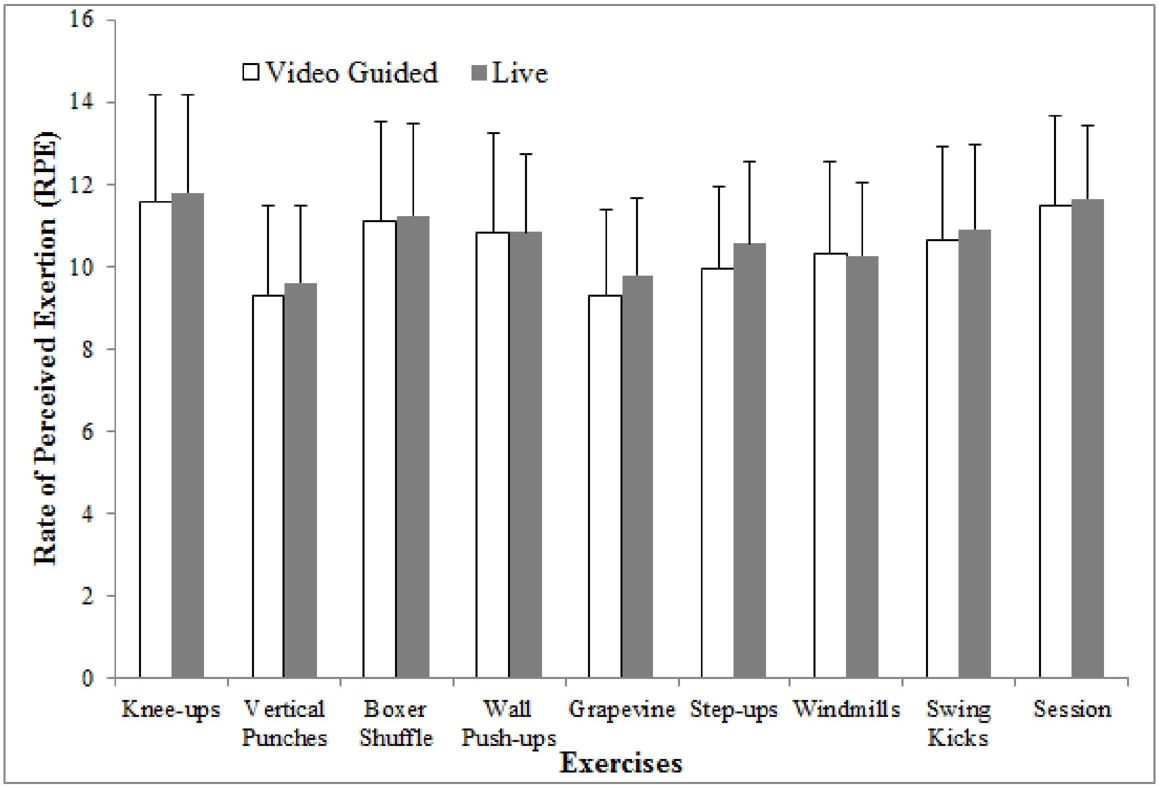

Figure 3. Rate of perceived exertion for individual exercises in live versus video-guided exercise sessions. Values are mean ± standard deviation. * = significantly higher rate of perceived exertion for live exercise sessions compared to video-guided sessions $p < .01$.

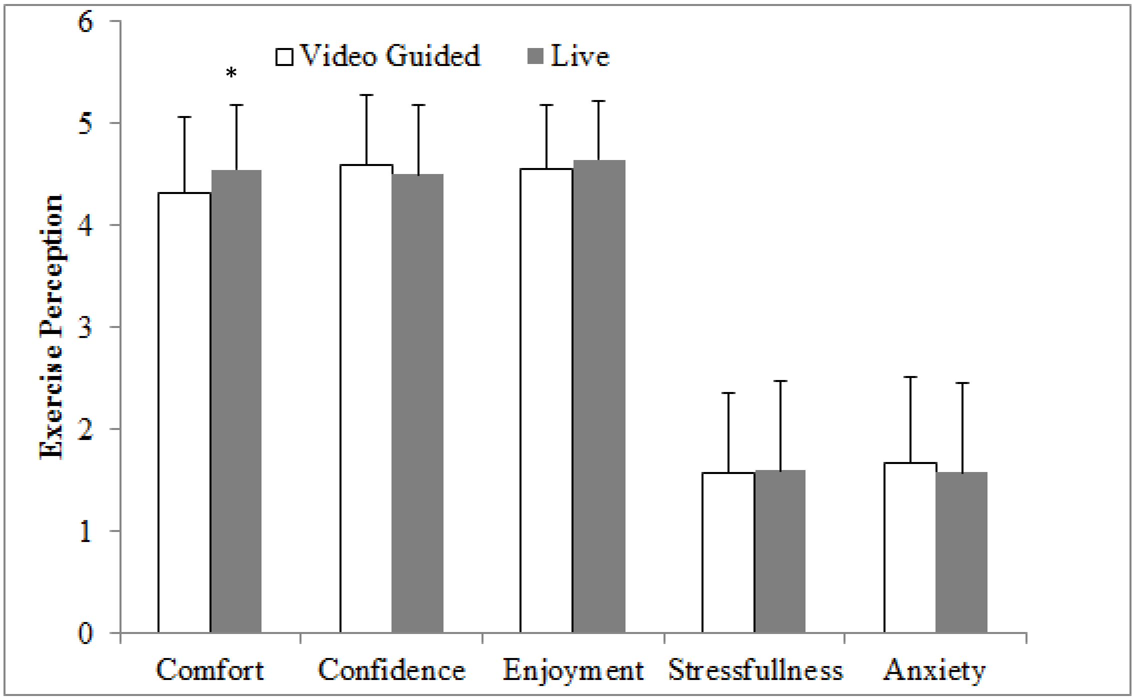

Figure 4. Exercise perception questionnaire for live versus video-guided exercise sessions. Values are mean ± standard deviation. * = significantly higher perception for live exercise sessions compared to video-guided sessions $p < .05$.

in the live and video-guided sessions, F (1, 39) = 0.89, 0.03, 0.66, 0.80, respectively. Neither heart rate (live 121 bpm ± 15, video-guided 117 bpm ± 15) nor energy expenditure (live 4.26 kcal/min ± .67, video-guided 3.88 kcal/min ± .72) were significantly different by exercise condition when controlling for average exercise perception, F (1, 38) = 0.62, p = .435; F (1, 38) = 0.36, p = .550, respectively. Overall more participants preferred the live session (n = 35, 87.5%) than the video guided session (n = 5, 12.5%), $\chi^2(1, N = 40) = 22.50$, $p < .001$.

Discussion

Despite the widely known importance of physical activity to health, fewer than 20% of women who are overweight or obese actually meet daily physical activity recommendations (ACSM, 2014). Therefore, determining the most effective exercise condition (i.e., live vs. video-guided) for increasing energy expenditure in this population is beneficial. While live versus video-guided exercise has been examined in college-aged females, the current study, to the best of our knowledge, is the first in comparing live versus video-guided exercise with females who are overweight or obese. Although it was hypothesized that video-guided exercise could offer benefits to this population, caloric expenditure was higher during the live exercise session.

The overweight or obese participants in the current study expended significantly more calories when exercising for 32 minutes with a live trainer (126.99 kcals ± 20.63) versus completing an identical exercise session with a pre-recorded video (116.69 kcals ± 22.11). These findings are similar to Killen et al. (2014) where college-aged females also had higher energy expenditure during a live exercise session compared to an identical video-guided exercise session. In conjunction with results from Colley et al. (2010) and

Jeffery et al. (1998), who showed that exercise adherence was greater for females who were obese when they met with a personal trainer, use of a live trainer in this population may lead to greater exercise adherence and weight loss goal attainment. This is significant in determining the most appropriate strategy for exercise with women who are overweight or obese, especially since ACSM (2014) places an emphasis on increasing energy expenditure for individuals who are overweight or obese in order to reduce body mass and improve health.

Adding to the data supporting the use of live training sessions is the finding that even though caloric expenditure was greater, RPE was not different between sessions, indicating participants did not perceive higher exertion in the live exercise session. Additionally, 87.5% of participants self-reported preferring the live session over the video-guided session while concurrently expending a greater number of calories. Overall, when comparing energy expenditure of individual exercises within each session, all resulted in greater caloric expenditure during the live sessions than in the video-guided sessions. Therefore, the impact of the live session was equal across a variety of upper and lower body movements for females who are overweight or obese.

Previous research suggests exercise adherence and enjoyment are higher when individuals who are overweight or obese are able to self-select intensity and are unsupervised throughout the workout, such as exercising with a DVD at home (Ekkekakis & Lind., 2006; Jeffery et al., 1998; Perri et al., 1997). When exercising with a DVD, individuals will self-select and self-monitor the intensity of the movements they are viewing. Likewise, individuals working with a trainer also self-select the intensity of exercises; however, they are likely to receive some manner of feedback to adjust intensity if it differs from that desired by the personal trainer (Perri et al., 1997). The impact of verbal motivation was controlled in the current study by having the personal trainer follow the same script in both the live and video-guided sessions. Even with motivation remaining constant, energy expenditure was found to be significantly higher during the live personal trainer session. These findings are similar to Killen et al (2014) in that energy expenditure was significantly higher when exercising with a personal trainer, even though motivation remained constant.

While there was no difference in enjoyment from one session to the other, the perceived level of comfort while exercising was found to be significantly higher during the live exercise session. Therefore, not only did participants expend more calories, but they also self-reported a higher level of comfort during the one-on-one exercise session with the live trainer versus exercising alone with the pre-recorded video.

With the levels of overweight and obesity within the United States, further research is still needed to highlight methods to increase the success of movement interventions aimed at increasing caloric expenditure. While the video-guided session was not completed in the participant's home, a strength of the study is that each session was completed in a private room similar to a home setting. Exercise conditions were also consistent in that participants had to travel outside of the home to complete both sessions. In future endeavors, it would be beneficial to compare exercise adherence across time of working with a live trainer or with a DVD in circuit-style exercise. Determining if exercising with a live trainer increases motivation would also be valuable for the current population. Participation was restricted to females in the current study, limiting generalization to males. It is also important to include a variety of ages and male participants in future research to illustrate any age-related differences. The impact of being in a group exercise session would also be valuable to highlight in future research on caloric expenditure, perceived effort, and exercise enjoyment.

In summary, the current study suggests exercising with a personal trainer significantly increases energy expenditure for females who are overweight or obese. Results provide evidence that using a personal trainer maybe more effective at increasing energy expenditure than when exercising with a DVD. Additionally, the personal training session was preferred by the majority of the participants over the video-guided session. Overall, these findings suggest females who are overweight or obese may be more successful at achieving weight loss goals when exercising with a personal trainer.

CHAPTER III REFERENCES

American College of Sports Medicine. (2014). *Guidelines for exercise testing and prescription*. Philadelphia, PA: Williams & Wilkins.

Borg, G. (1970). Perceived exertion as an indicator of somatic stress. *Scandinavian Journal of Rehabilitation Medicine, 2*, 92-98.

Colley, R. C., Hills, A. P., O'Moore-Sullivan, T. M., Hickman, I. J., & Byrne, N. M. (2008). Validity in adherence to an unsupervised exercise prescription in obese women. *International Journal of Obesity, 32,* 837-844.

Colley, R. C., Hills, A. P., King, N. A., & Byrne, N. M. (2010). Exercise-induced energy expenditure: Implications for exercise prescription and obesity. *Patient Education and Counseling, 79,* 327-332.

Ebbeling, C. B., Ward, A., Puleo, E. M., Widrick, J., & Rippe, J. M. (1991). Development of a single-stage submaximal treadmill walking test. *Medicine and Science in Sports and Exercise, 23,* 966-973.

Ekkekakis, P., & Lind, E. (2006). Exercise does not feel the same when you are overweight: The impact of self-selected and imposed intensity on affect and exertion. *International Journal of Obesity, 30*(4), 652-660.

Fox, S. M. III., Naughton, J.P., & Haskell, W.L. (1971). Physical activity and the prevention of coronary heart disease. *Annals of Clinical Research, 3*(6), 404-432.

Fryar, C. D., Carroll, M. D., & Ogden, C. L. (2012). Prevalence of overweight, obesity, and extreme obesity among adults: United States, trends 1960-1962 through 2009-2010. National Center for Health Statistics. Retrieved from: http://www.cdc.gov/nchs/data/hestat/obesity_adult_09_10/obesity_adult_09_10.htm

IBISWorld: Fitness DVD production in the US - Market research report (2014). Retrieved from: http://www.ibisworld.com/industry/fitness-dvd-production.html

International Health, Racquet and Sportsclub Association, IHRSA. (2012). The 2012 IHRSA global report analyzes industry performance and outlook. Retrieved from: http://www.ihrsa.org/media-center/2012/5/23/the-2012-ihrsa-global-report-analyzes-industry-performance-a.html

Jeffery, R. W., Wing, R. R., Thorson, C., & Burton, L. R. (1998). Use of personal trainers and financial incentives to increase exercise in a behavioral weight-loss program. *Journal of Consulting and Clinical Psychology*, *66*(5), 777-783.

Khalil, H., Quinn, L., van Deursen, R., Martin, R., Rosser, A., & Busse, M. (2012). Adherence to use of a home-based exercise DVD in people with Huntington Disease: Participants' perspectives. *Physical Therapy*, *92*(1), 69-82.

Killen, L. G., Barry, V. W., Cooper, C., & Coons, J. M. (2014). Live versus digital video disk exercise in college-aged females. *Journal of Strength and Conditioning Research, 28*(12), 3393-3398.

Lynnes, M. D., Nichols, D., & Temple, V. A. (2009). Fostering independence in health-promoting exercise. *Journal of Intellectual Disabilities, 13*(2), 143-159.

Ogden, C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2012). Prevalence of obesity in the United States, 2009-2010. *NCHS Data Brief*, No 82.

Perri, M. G., Martin, A. D., Leermakers, E. A., Sears, S. F., & Notelovitz, M. (1997). Effects of group versus home-based exercise in the treatment of obesity. *Journal of Consulting and Clinical Psychology, 65,* 278-285.

Vickers, K. S., Nies, M. A., Dierkhising, R. A., Jumean, M., Squires, R. W., & Kopecky, S. L. (2011). Exercise DVD improves exercise expectations in cardiovascular outpatients. *American Journal of Health Behavior, 35,* 305-317.

APPENDICES FOR STUDY I

Appendix A

Exercise Perception Questionnaire

Session

Date Completed | Staff Initials | Participant ID

Part 1 – Complete after each exercise session

These questions are about how you felt about the exercise session you just completed. For each question, please give the one answer that comes closest to the way you felt.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I was comfortable during the exercise session	O	O	O	O	O
2. I was confident performing the exercises during the exercise session	O	O	O	O	O
3. I enjoyed participating in this exercise session	O	O	O	O	O
4. I felt stressed during the exercise session	O	O	O	O	O
5. I felt anxiety during the exercise session	O	O	O	O	O

Answer question 6 if this is your second exercise session. (circle one)

6. Which exercise session was preferred?

Personal trainer session or video-guided session

Appendix B

IRB Letter of Approval

6/25/2014

Investigator(s): Lauren Killen, Dr. Jenn Caputo, Dr. John Coons, Dr. Vaughn Barry, and Dr. Dana Fuller
Department: Health and Human Performance
Investigator(s) Email: llg2w@mtmail.mtsu.edu, jenn.caputo@mtsu.edu

Protocol Title: "Measuring Energy Expenditure and Preferred Mode of Exercise in Females who are Overweight or Obese "

Protocol Number: 14-399

Dear Investigator(s),

The MTSU Institutional Review Board, or a representative of the IRB, has reviewed the research proposal identified above. The MTSU IRB or its representative has determined that the study poses minimal risk to participants and qualifies for an expedited review under 45 CFR 46.110 and 21 CFR 56.110, and you have satisfactorily addressed all of the points brought up during the review.

Approval is granted for one (1) year from the date of this letter for 50 participants.

Please note that any unanticipated harms to participants or adverse events must be reported to the Office of Compliance at (615) 494-8918. Any change to the protocol must be submitted to the IRB before implementing this change.

You will need to submit an end-of-project form to the Office of Compliance upon completion of your research located on the IRB website. Complete research means that you have finished collecting and analyzing data. **Should you not finish your research within the one (1) year period, you must submit a Progress Report and request a continuation prior to the expiration date.** Please allow time for review and requested revisions. Failure to submit a Progress Report and request for continuation will automatically result in cancellation of your research study. Therefore, you will not be able to use any data and/or collect any data. Your study expires **6/25/2015**.

According to MTSU Policy, a researcher is defined as anyone who works with data or has contact with participants. Anyone meeting this definition needs to be listed on the protocol and needs to complete the required training. **If you add researchers to an approved project, please forward an updated list of researchers to the Office of Compliance before they begin to work on the project.**

All research materials must be retained by the PI or faculty advisor (if the PI is a student) for at least three (3) years after study completion and then destroyed in a manner that maintains confidentiality and anonymity.

Sincerely,

Kellie Hilker
Compliance Officer/ MTSU Institutional Review Board Member

CHAPTER IV

VALIDATION OF A PHYSICAL ACTIVITY MONITOR AS A MEASURE OF ENERGY EXPENDITURE DURING A CIRCUIT-STYLE WORKOUT WITH FEMALES WHO ARE OVERWEIGHT OR OBESE

Introduction

In the United States, the prevalence of obesity remains a major health concern with 154.7 million adults (Go et al., 2013) who are overweight (body mass index [BMI] ≥ 25 kg/m^2) or obese (BMI ≥ 30 kg/m^2). Individuals who are overweight or obese have an increased risk for heart disease, type 2 diabetes, hypertension, arthritis, and cancer (Deitel, 2003). In 2008, $209.7 billion was spent nationally to treat obesity-related illness in adults with women who are overweight or obese having an added annual medical cost of $3,613 (Cawley & Meyerhoefer, 2012).

Fortunately, a reduction in disease risk and health care costs can be achieved with weight loss through interventions aimed at increasing physical activity (Ross et al., 2000). It has been reported that active individuals (i.e., meeting the federal physical activity recommendations) have at least a 50% reduction in cardiovascular disease or all-cause death (Myers et al., 2004). However, only 19% of females who are overweight and 16.1% females who are obese meet federal physical recommendation of accumulating 30 minutes of moderate intensity physical activity on five or more days per week (Centers for Disease Control and Prevention, 2000). To help initiate exercise and meet the current physical activity guidelines, circuit-style exercise may be beneficial for women who are overweight or obese because it allows performance of more total work (i.e., higher caloric expenditure) and includes built-in rest periods in comparison to continuous aerobic activity (Irving et al., 2008). Individuals can track total work performed in circuit-style exercise through measuring energy expenditure. A simple way for individuals to track energy expenditure during a circuit-style workout is by wearing an activity monitor.

The SenseWear™ armband (SWA) is a non-invasive, light weight activity monitor that is worn on the upper left arm that has been validated to measure energy expenditure during exercise (Fruin & Rankin, 2004; Jakicic et al., 2004; Papazoglou et al., 2006) and at rest (Fruin & Rankin, 2004; Malavoiti et al., 2012; Papazoglou et al., 2006; Welk, McClain, Eisenmann, & Wickell, 2007). While the armband has been validated for free-living activities (Johannsen et al., 2010), a variety of indoor home-based activities (Dudley, Bassett, John, & Crouter, 2012), outdoor aerobic activities (Dudley et al., 2012), and continuous exercise (Jakicic et al., 2004), it has not been validated for measuring energy expenditure during circuit-style workouts with people who are overweight or obese.

If the energy expenditure estimates from the SWA are shown to be valid during circuit-style training with individuals who are overweight or obese, it could be used as a tool to assist with weight loss or weight management programs that use this mode of activitity. Therefore, the purpose of this study was to validate the SWA in measuring energy expenditure in overweight or obese females during circuit-style training.

Methods

Participants

Females (*N* = 40) who were overweight or obese as defined by a BMI of 25 kg/m^2 or greater participated in this study. Each participant had to be risk classified as low or moderate risk by American College of Sports Medicine guidelines in order to participate. Participants were between 20 years and 59 years of age and able to perform 30 minutes of continuous walking (self-reported) to be eligible to participate.

Instrumentation

Anthropometric measurements. A digital scale (SECA Corporation, Model 770, Germany) was used to assess body mass to the nearest 0.1kg. Height was assessed using a stadiometer (SECA Corporation Model 222, Germany) to the nearest 0.1 cm. Participants wore gym shorts and t-shirts, without shoes, during anthropometric measurements. Body mass index was calculated as body mass divided by height in meters squared.

Single stage treadmill test. Maximal oxygen consumption (ml/kg/min) was estimated using the single stage treadmill test (Ebbeling, Ward, Puleo, Widrick, & Rippe, 1991). The test was completed with participants wearing gym shorts, t-shirts, and tennis shoes. The test began with a warm-up speed between 2 mph and 4.5 mph and a 0% grade that elicited a heart rate between 50% to 70% of each participant's age-adjusted maximal heart rate calculated as 220-age (Fox, Naughton, & Haskell, 1971). After walking for 4 minutes, participants continued walking at the same speed with a 5% grade for an additional 4 minutes. Maximal oxygen consumption was estimated using each participant's age, final recorded heart rate, and treadmill speed in the prediction equation (Ebbeling et al., 1991).

SenseWear™ armband (SWA). The SWA (BodyMedia, Inc., Model MF-SW, Pittsburgh, PA, USA) armband was used to assess energy expenditure during the exercise session. The armband was worn on the upper left arm (over the triceps muscle), halfway between the acromion and olecranon processes. The armband was programmed with each participant's sex, age, height, and body mass prior to the exercise session. Several sensors on the SWA device (i.e., accelerometer, skin temperature sensor, galvanic skin response, and heat flux) gathered information to determine energy expenditure (Andre et al., 2006). Proprietary algorithms (software version 7.0, firmware 9.02.22) were used to estimate the minute-by-minute energy expenditure (1 minute epoch) that was compared to the energy expenditure derived from the Oxycon Mobile™.

Oxygen consumption. The Oxycon Mobile™ (CareFusion, Hoechberg, Germany) measured oxygen consumption during the exercise sessions. The Oxycon Mobile™ is a portable open-circuit indirect calorimetry system that can measure volume of expired oxygen and carbon dioxide in breath-by-breath ventilation. This system allows participants to move in a free-living environment wearing only a light weight, small pack (950g) and mask. Prior to each exercise session, the Oxycon Mobile™ was calibrated using an automatic gas analyzer and volume calibration unit. After calibration, participant height, body mass, and age were entered into the software system. Oxygen consumption (VO_2), carbon dioxide production (VCO_2), respiratory exchange ratio (RER), and energy expenditure (kcal/min) were recorded throughout the exercise session. Energy expenditure was derived as kcal/min from the gas exchange data throughout the exercise session. The Oxycon Mobile™ was used as the criterion measure of energy expenditure.

Procedures

Preparticipation assessment. Participants signed a written informed consent approved by the University Institutional Review Board (see Appendix A) prior to data collection. Following 5 minutes of seated rest, resting blood pressure was assessed using an aneroid sphygmomanometer (Adcuff, American Diagnostic Corporation, New York) and stethoscope. Blood pressure was assessed with the arm at heart level on the right side of the body for risk classification. Height and weight measurements were used to calculate BMI. All participants were risk classified using American College of Sports Medicine's (2014) risk classification to assure they were not high risk.

Exercise session. Participants completed a live circuit-style exercise session lead by the same person each time. Each participant was asked to refrain from eating or drinking, with the exclusion of water, 2 hours prior to reporting to the lab for the exercise session. All exercise sessions took place in the same enclosed room with participants wearing both the SWA and Oxycon Mobile™ throughout the entire session. The exercise session began with a dynamic warm-up, lasting 8 minutes. The warm-up consisted of eight exercises (i.e., grapevine with a hamstring curl, swing kicks, boxer shuffle, windmills, wall push-ups, knee-ups, step-ups, and vertical punches) with each exercise lasting 1 minute. Following the warm-up, participants completed the workout that consisted of identical exercises to the warm-up. Throughout the workout portion of the session, each exercise was performed twice in sequential order, for 1 minute, followed by 1 minute of rest. The workout portion of the session lasted approximately 32 minutes.

Statistical Analysis

International Business Machines Corporation Statistical Packages for the Social Sciences (version 19.0) software was used to conduct data analysis. Descriptive statistics for participants and for energy expenditure were calculated as means and standard deviations. Pearson correlations between SWA and Oxycon were reported for each exercise. Two-way repeated measures ANOVAs, with a Greenhouse-Geiser adjustment, were used to compare energy expenditures excluding rest periods and energy expenditures including rest periods by device (Oxycon, SWA) and exercise (knee-ups, vertical punches, boxer shuffle, wall push-ups, grapevine, step-ups, windmills, and swing kicks). A one-way repeated measures ANOVA was used to compare differences in rest period energy expenditure between the SWA and the Oxycon Mobile. The alpha level was set at $p \leq .05$ for the ANOVAs. Post-hoc simple effect tests were performed using the paired samples *t*-test and an alpha of .01 per test.

Results

Participants' descriptive statistics are available in Table 1. Pearson correlations of energy expenditure for each exercise from both measurement devices are included in Table 2. The average energy expenditure excluding rest periods differed between Oxycon (*M = 3.76 kcal/min)* and *SWA* (*M* = 3.78 *kcal/min*) devices, F (1, 39) = 14.65, $p < .001$, $\eta_p^2 = .273$, which equates to average energy expenditures for the session of 62.02 kcals (*SD* = 11.45) for Oxycon and 70.82 kcals (*SD* = 12.81) for SWA. The main effect for exercise was significant, F (4.3, 167.9) = 81.08, $p < .001$, $\eta_p^2 = .675$.

Table 1

Descriptive Characteristics of Participants (N = 40)

	M	*SD*
Age (yrs)	38.30	14.22
Height (cm)	162.67	5.91
Body mass (kg)	82.59	16.18
BMI (kg/m^2)	31.23	5.96
Single stage VO_2max (ml/kg/min)	30.31	7.71

Note. BMI = body mass index; VO_2max = maximal oxygen consumption.

Table 2

Pearson Correlations Between Oxycon EE and SWA EE by Exercise

Exercise	Without rest periods		With rest periods	
	r	*p*	*r*	*p*
Knee-ups	.18	.279	.28	.084
Vertical Punches	.26	.103	.44*	.004
Boxer Shuffle	.43*	.005	.24	.134
Wall Push-ups	.17	.288	.09	.588
Grapevine	.19	.242	.09	.568
Step-ups	.40*	.011	.29	.070
Windmills	-.02	.895	-.04	.830
Swing Kicks	.20	.226	.17	.296
Total EE	.28	.075	.20	.220

Note. * $p < .05$; SWA = SenseWear™ armband; EE = energy expenditure; $N = 40$.

Importantly, a significant interaction indicated the amount of difference between the devices varied by exercise, F (4.3, 167.2) = 14.49, $p < .001$, $n_p^2 = .271$.

When rest periods were included in the analysis, results were similar in that there was a significant interaction between the device and exercise, F (5.1, 198.2) = 22.96, $p <$ .001, $\eta_p^2 = .371$. However, while the main effect for exercise was significantly different, F (4.9, 191.3) = 99.85, $p < .001$, $\eta_p^2 = .719$, the main effect for device was not significant, F (1, 39) = 0.02, $p = .882$, $\eta_p^2 = .001$. Since there were significant interactions, paired samples *t*-tests (alpha = .01 each) were used to compare caloric expenditure between device methods (i.e. the Oxycon and the SWA) for each exercise; see Table 3. When rest periods were excluded, significant differences in energy expenditure between the Oxycon and SWA existed in vertical punches, boxer shuffle, and windmills (see Table 3, Figure 1). Comparing caloric expenditure with rest periods included, however, indicated the devices differed only for vertical punches and swing kicks (see Table 3, Figure 2).

Rest period only energy expenditure between the Oxycon and the SWA was significantly different, F (1, 39) = 8.06, $p = .007$, $n_p^2 = .171$. Resting energy expenditure was under predicted by the SWA (M = 3.13 kcal/min, SD = 0.92) in comparison to the Oxycon (M = 3.63 kcal/min, SD = 0.73).

Discussion

Circuit-style exercise may be more beneficial for women who are overweight or obese as it allows for greater caloric expenditure than continuous exercise and includes built in rest periods (Irving et al., 2008). In the current study, each participant completed a circuit-style exercise session while wearing an SWA and an Oxycon Mobile device.

Table 3

Paired Samples t-Tests and Descriptive Statistics for Oxycon EE versus SWA EE

			Oxycon		*SWA*	
Variable	*t*	*p*	*M*	*SD*	*M*	*SD*
EE excluding rest						
Knee-ups	-0.96	.344	5.04	0.92	5.30	1.58
Vertical punches	-9.05**	< .001	2.92	0.61	4.22	0.85
Boxer shuffle	-7.37**	< .001	4.55	0.91	6.06	1.40
Wall push-ups	-1.76	.087	2.95	0.64	3.29	1.18
Grapevine	-0.57	.572	3.69	0.76	3.81	1.25
Step-ups	-2.04*	.049	4.53	0.86	4.93	1.30
Windmills	-3.20**	.003	3.32	0.69	4.05	1.25
Swing kicks	1.46	.153	4.00	0.75	3.75	0.98
All exercises	-0.15	.882	3.88	0.72	4.43	0.80
EE including rest						
Knee-ups	1.71	.096	4.65	0.88	4.38	0.79
Vertical punches	-7.45**	< .001	2.89	0.58	3.86	0.90
Boxer Shuffle	-2.06*	.047	4.41	0.92	4.78	0.90
Wall push-ups	-0.20	.840	2.93	0.59	2.97	0.99
Grapevine	1.02	.312	3.66	0.78	3.45	1.07
Step-ups	1.59	.121	4.36	0.86	4.07	1.04
Windmills	-0.80	.427	3.23	0.65	3.36	0.75
Swing kicks	3.73**	.001	3.98	0.77	3.41	0.73
All exercises	-3.83**	< .001	3.76	0.71	3.78	0.68

Note. df = 39. * $p < .05$, ** $p < .01$. EE = energy expenditure (kcal/min); SWA = SenseWear™ armband.

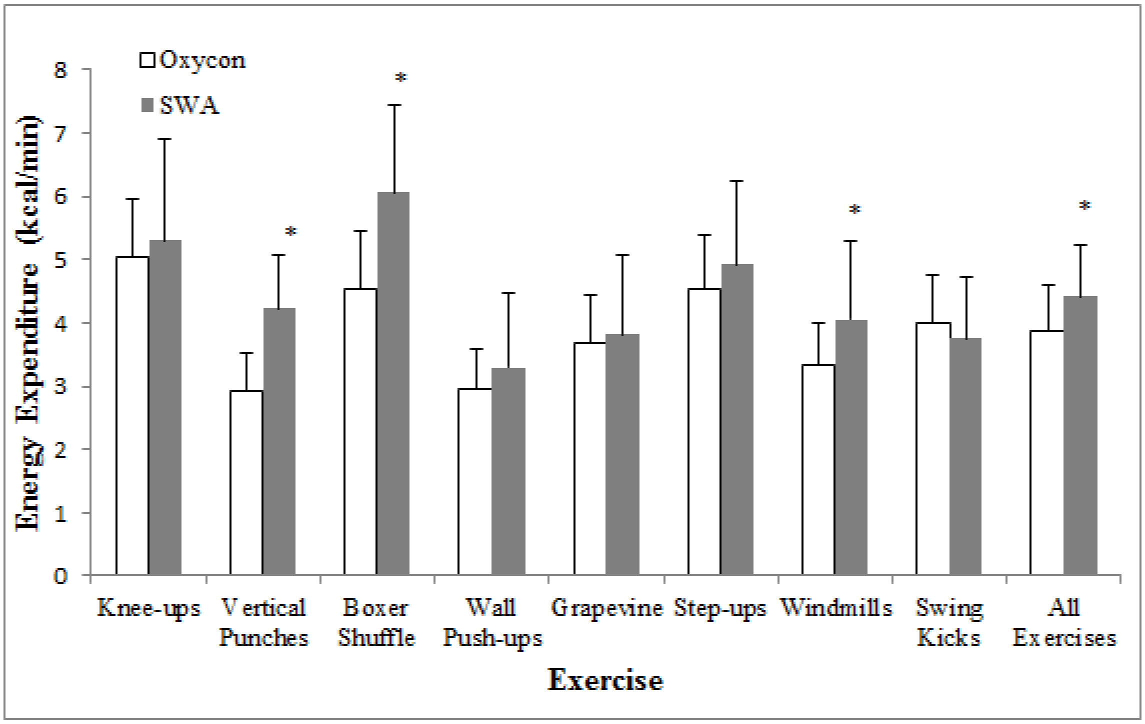

Figure 1. Exercise energy expenditure for SWA versus Oxycon Mobile, excluding rest periods. Values are means ± standard deviations. **p* < .01. *Note.* SWA = SenseWear™ armband.

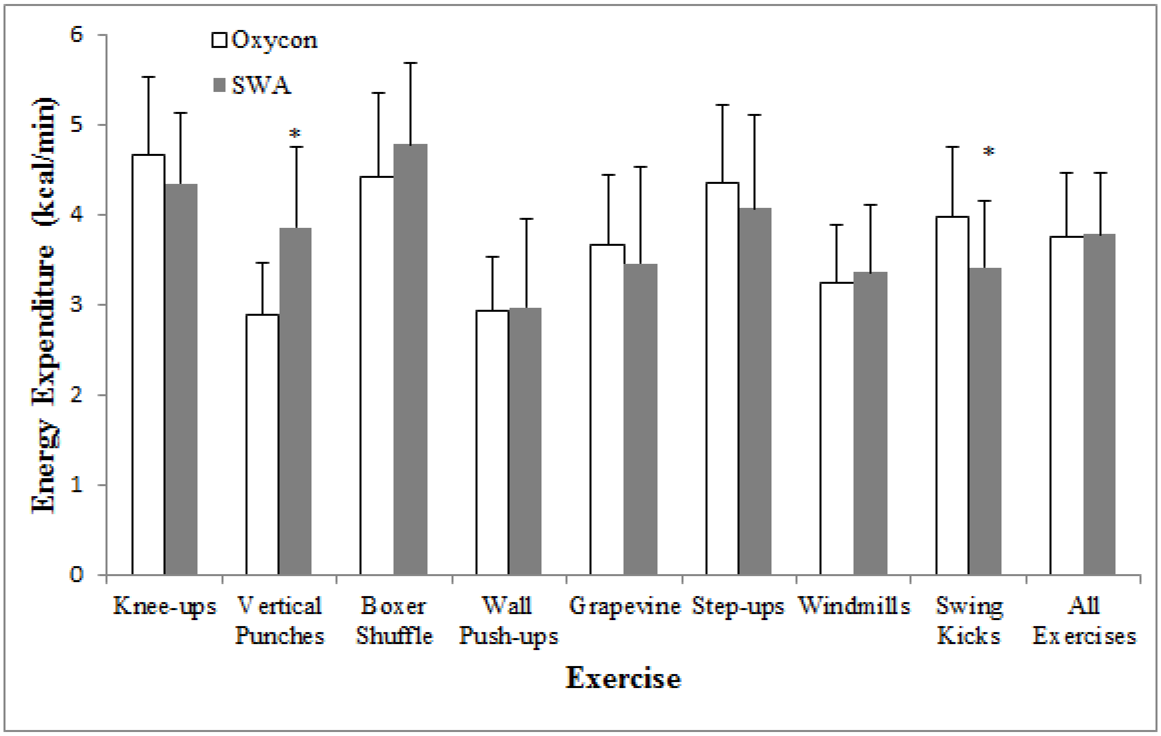

Figure 2. Exercise energy expenditure for SWA versus Oxycon Mobile, including rest periods. Values are means ± standard deviations. *$p < .01$. *Note.* SWA = SenseWear™ armband.

The estimated energy expenditure from the SWA was not significantly correlated to indirect calorimetry values. The SWA overestimated exercise energy expenditure, especially for exercises that isolated muscle movements such as vertical punches, boxer shuffle, and windmills. Further, rest period energy expenditure was significantly under predicted. After combining these two measurements (i.e., exercise and resting period energy expenditures), total energy expenditure estimates were not significantly different between the SWA and indirect calorimetry (see Figure 2).

These findings are similar to those of Dudley et al. (2012) that showed the SWA overestimated energy expenditure during light office and house work. Furthermore, in an investigation by Jakicic et al. (2004), energy expenditures were significantly overestimated during arm ergometry when using the proprietary equations developed by the manufacturer. In the current study the SWA specifically overestimated exercise energy expenditure during vertical punches, the boxer shuffle, and windmill exercises. Two of these movements (i.e., vertical punches and windmills) use arm movements similar to arm ergometry. These data suggest that repetitive arm movements cause an overestimation of the SWA's energy expenditure estimate. In addition, it has been suggested that the SWA will overestimate energy expenditure in individuals who are obese due to excessive body movement (Papazoglou et al., 2006).

Few studies have been performed to validate the SWA specifically for standing rest periods. In one study, Reese, Barry, Fuller, and Caputo (2015) documented significantly underestimated energy expenditure by the SWA during standing rest. This consistent underestimation by the SWA during low activity periods is particularly important for energy expenditure assessments when using the SWA during circuit- or interval-style training which may incorporate periods of standing rest.

Papazoglou et al. (2006) examined the validity of the SWA during rest and three modes of activity (cycle ergometry, stair stepping, and treadmill walking). Their outcomes mirror those of the current investigation with the SWA producing an underestimation of resting energy expenditure and overestimates of energy expenditure during the exercise conditions. Potential excess body motion in individuals who are overweight or obese in conjunction with reduced mechanical efficiency may contribute to the overestimation of the SWA during exercise in this population (Papazoglou et al., 2006).

While the current study included both upper and lower body exercises, results are limited to the exercises selected for the circuit. Future studies should also be conducted to evaluate any sex-specific differences in the validity of the SWA. Furthermore, in addition to issues associated with excess body movement in overweight or obese individuals during exercise, the existing SWA manufacturer algorithms may not account for the increased heat flux during exercise associated with excess body fat. Further research is suggested on the continued need for population-specific algorithms.

In conclusion, estimated energy expenditure from the SWA was not correlated to indirect calorimetry during circuit-style exercise with overweight and obese females and did not accurately assess the exercise or rest components of the exercise session. It is important to understand as overall energy expenditure estimates do not vary when comparing the SWA to indirect calorimetry. Females who are overweight or obese can wear a SWA to assist in overall tracking of energy expenditure of a circuit-style exercise session, but must use care if looking specifically at the exercise components of a workout.

CHAPTER IV REFERENCES

Andre, D., Pelletier, R., Farringdon, J., Safier, S., Talbott, W., Stone, R., … Teller, A. (2006). The development of the SenseWear® armband, a revolutionary energy assessment device to assess physical activity and lifestyle. *BodyMedia Inc.*

American College of Sports Medicine. (2014). *Guidelines for exercise testing and prescription*. Philadelphia, PA: Williams & Wilkins.

Cawley, J., & Meyerhoefer, C. (2012). The medical care costs of obesity: An instrumental variables approach. *Journal of Health Economics, 31*(1), 219-230.

Centers for Disease Control and Prevention. (2000). Prevalence of leisure-time physical activity among overweight adults: United States, 1998. *Morbidity & Mortality Weekly Report, 49,* 326-330.

Deitel, M. (2003). Overweight and obesity worldwide now estimated to involve 1.7 billion people. *Obesity Surgery, 13*(3), 329-330.

Dudley, P., Bassett, D. R., John, D., & Crouter, S. E. (2012). Validity of a multi-sensor armband for estimating energy expenditure during eighteen different activities. *Obesity and Weight Loss Therapy, 2*(7), 1-7.

Ebbeling, C. B., Ward, A., Puleo, E. M., Widrick, J., & Rippe, J. M. (1991). Development of a single-stage submaximal treadmill walking test. *Medicine and Science in Sports and Exercise, 23,* 966-973.

Fox, S. M. III., Naughton, J. P., & Haskell, W. L. (1971). Physical activity and the prevention of coronary heart disease. *Annals of Clinical Research, 3*(6), 404-432.

Fruin, M. L., & Rankin, J. W. (2004). Validity of a multi-sensor armband in estimating rest and exercise energy expenditure. *Medicine and Science in Sports and Exercise, 36*(6), 1063-1069.

Go, A. S., Mozaffarian, D., Roger, V. L., Benjamin, E. J., Berry, J. D., Borden, W. B., . . . Turner, M. B. (2013). Heart disease and stroke statistics – 2013 update: A report from the American Heart Association. *Circulation, 127,* e6-e245.

Irving, B. A., Davis, C. K., Brock, D. W., Weltman, J. Y., Swift, D., Barrett, E. J., . . . Weltman, A. (2008). Effect of exercise training intensity on abdominal visceral fat and body composition. *Medicine and Science in Sports and Exercise, 40*(11), 1863-1872.

Jakicic, J. M., Marcus, M., Gallagher, K. I., Randall, C., Thomas, E., Goss, F. L., & Robertson, R. J. (2004). Evaluation of the SenseWear Pro Armband™ to assess energy expenditure during exercise. *Medicine and Science in Sports and Exercise, 36*(5), 897-904.

Johannsen, D. L., Calabro, M. A., Stewart, J., Franke, W., Rood, J. C., & Welk, F. J. (2010). Accuracy of armband monitors for measuring daily energy expenditure in healthy adults. *Medicine and Science in Sports and Exercise, 42*(11), 2134-2140.

Malavolti, M., Bellentani, S., Pietrobelli, A., Tardini, L., Bellucci, A., Busacchi, M., & Battistini, N. C. (2012). Reliability of a multisensory armband in estimating energy expenditure according to degree of obesity. *Journal of Obesity and Weight Loss Therapy, 2*(2), 116. doi:10.4172/2165-7904.1000116

Myers, J., Kaykha, A., George, S., Abella, J., Zaheer, N., Lear, S., ... Froelicher, V. (2004). Fitness versus physical activity patterns in predicting mortality in men. *The American Journal of Medicine, 117*(12), 912-918.

Papazoglou, D., Augello, G., Tagliaferri, M., Savia, F., Marzullo, P., Maltezos, E., & Liuzzi, A. (2006). Evaluation of a multisensory armband in estimating energy expenditure in obese individuals. *Obesity, 14*(12), 2217-2223.

Reese, J. D., Barry, V., Fuller, D. K., & Caputo, J. (2015). Validation of the SenseWear™ armband as a measure of sedentary behavior and light activity. *Journal of Physical Activity and Health*, in press.

Ross, R., Dagnone, D., Jones, P. J., Smith, H., Paddags, A., Hudson, R., & Janssen, I. (2000). Reduction in obesity and related comorbid conditions after diet-induced weight loss or exercise-induced weight loss in men. *Annals of Internal Medicine, 133*(2), 92-103.

Welk, G. J., McClain, J. J., Eisenmann, J. C., & Wickell, E. E. (2007). Field validation of the MTI ActiGraph and BodyMedia Armband monitor using the IDEEA monitor. *Obesity, 15*(4), 918-928.

APPENDIX FOR STUDY II

Appendix A

IRB Letter of Approval

MIDDLE TENNESSEE STATE UNIVERSITY

6/25/2014

Investigator(s): Lauren Killen, Dr. Jenn Caputo, Dr. John Coons, Dr. Vaughn Barry, and Dr. Dana Fuller
Department: Health and Human Performance
Investigator(s) Email: llg2w@mtmail.mtsu.edu, jenn.caputo@mtsu.edu

Protocol Title: "Measuring Energy Expenditure and Preferred Mode of Exercise in Females who are Overweight or Obese "

Protocol Number: 14-399

Dear Investigator(s),

The MTSU Institutional Review Board, or a representative of the IRB, has reviewed the research proposal identified above. The MTSU IRB or its representative has determined that the study poses minimal risk to participants and qualifies for an expedited review under 45 CFR 46.110 and 21 CFR 56.110, and you have satisfactorily addressed all of the points brought up during the review.

Approval is granted for one (1) year from the date of this letter for 50 participants.

Please note that any unanticipated harms to participants or adverse events must be reported to the Office of Compliance at (615) 494-8918. Any change to the protocol must be submitted to the IRB before implementing this change.

You will need to submit an end-of-project form to the Office of Compliance upon completion of your research located on the IRB website. Complete research means that you have finished collecting and analyzing data. **Should you not finish your research within the one (1) year period, you must submit a Progress Report and request a continuation prior to the expiration date.** Please allow time for review and requested revisions. Failure to submit a Progress Report and request for continuation will automatically result in cancellation of your research study. Therefore, you will not be able to use any data and/or collect any data. Your study expires **6/25/2015**.

According to MTSU Policy, a researcher is defined as anyone who works with data or has contact with participants. Anyone meeting this definition needs to be listed on the protocol and needs to complete the required training. **If you add researchers to an approved project, please forward an updated list of researchers to the Office of Compliance before they begin to work on the project.**

All research materials must be retained by the PI or faculty advisor (if the PI is a student) for at least three (3) years after study completion and then destroyed in a manner that maintains confidentiality and anonymity.

Sincerely,

Kellie Hilker
Compliance Officer/ MTSU Institutional Review Board Member

CHAPTER V

OVERALL CONCLUSIONS

The theme of this dissertation revolved around an effective way to increase physical activity through circuit-style exercise for females who are overweight or obese. The first study of this dissertation was designed to compare video-guided circuit-style exercise to live circuit-style exercise. In the second study, the validity of the SWA to estimate energy expenditure for circuit-style exercise in females who are overweight or obese was examined.

In study 1, energy expenditure, self-selected exercise intensity, rate of perceived exertion (RPE), and exercise perception were compared between an identical live and video-guided exercise sessions. Energy expenditure for all exercises (i.e., knee-ups, vertical punches, boxer shuffle, wall push-ups, grapevine, step-ups, windmills, and swing kicks), including and excluding rest periods, was significantly higher when participants exercised with the live trainer versus with the video. Heart rates were not significantly different between exercise conditions (i.e., live and video-guided) when rest periods were included and excluded in the analysis. Exercise perception questions (i.e., confidence, enjoyment, stressfulness, anxiety) were not found to be significantly different between exercise conditions except for the level of comfort being higher during the live training session. In addition, the majority (87.5%) of participants reported preferring the live trainer led session. In light of the excessive rates of overweight and obesity in this country and the concurrent need to improve health and well-being these results illustrate a potential mechanism to increase the success of weight loss interventions.

Data from study 2 illustrated the concerns over the validity of the SWA in estimating energy expenditure during rest and exercise. There was an overestimation of energy expenditure when the females performed the exercises and an underestimation of energy expenditure rest periods between exercises. In combination, the total energy expenditure estimates did not differ between the SWA and the criterion measure of indirect calorimetry. As such, while the SWA can be useful for overweight or obese females to monitor energy expenditure, care must be used when looking at specific components of a workout. Further, as the balance between rest and exercise length changes during multiple workouts, this may shift the total energy expenditure estimate towards an over- or underestimation. With no apparent decline in obesity rates, the importance of continued research into population specific algorithms that can be used with the SWA is necessary.

In conclusion, the overall results from study 1 and 2 highlight the feasibility of modifying exercise prescriptions to increase and track caloric expenditure in females who are overweight or obese. In this dissertation live sessions resulted in greater caloric expenditure than DVD sessions for the overweight and obese. Working with a personal trainer and wearing a device, such as the SWA, to monitor caloric expenditure may result in greater accountability when working to achieve weight loss.

REFERENCES

American College of Sports Medicine. (2014). *Guidelines for exercise testing and prescription*. Philadelphia, PA: Williams & Wilkins.

Andre, D., Pelletier, R., Farringdon, J., Safier, S., Talbott, W., Stone, R., … Teller, A. (2006). The development of the SenseWear® armband, a revolutionary energy assessment device to assess physical activity and lifestyle. *BodyMedia Inc.*

Arvidsson, D., Slinde, F., Larsson, S., & Hulthen, L. (2007). Energy cost of physical activities in children: Validation of SenseWear™ Armband. *Medicine and Science in Sports and Exercise, 39*(11), 2076-2084.

Ayabe, M., Aoki, J., Kumahara, H., Yoshimura, E., Matono, S., Tobina, T., . . . Tanaka, H. (2011). Minute-by-minute stepping rate of daily physical activity in normal and overweight/obese adults. *Obesity Research & Clinical Practice, 5,* e151-e156.

Bassett, D. R., & John, D. (2010). Use of pedometers and accelerometers in clinical populations: Validity and reliability issues. *Physical Therapy Reviews, 15*(3), 135-142.

Bautista-Castano, I., Molina-Cabrillana, J., Montoya-Alonso, J. A., & Serra-Majem, L. (2004). Variables predictive of adherence to diet and physical activity recommendations in the treatment of obesity and overweight, in a group of Spanish subjects. *International Journal of Obesity Related Metabolic Disorders, 28*, 697-705.

Campbell, K. L., Crocker, P. R., & McKenzie, D. C. (2002). Field evaluation of energy expenditure in women using Tritrac™ accelerometers. *Medicine and Science in Sports and Exercise, 34*, 1667-1674.

Centers for Disease Control and Prevention. (2000). Prevalence of leisure-time physical activity among overweight adults: United States, 1998. *Morbidity & Mortality Weekly Report, 49*, 326-330.

Centers for Disease Control and Prevention. (2013, May 2). One in five adults meet overall physical activity guidelines. Retrieved from http://www.cdc.gov /media/releases/2013/p0502-physical-activity.html

Church, T. S., Thomas, D. M., Tudor-Locke, C., Katzmarzyk, P. T., Earnest, C. P., Rodarte, R. Q., …Bouchard, C. (2011). Trends over 5 decades in U.S. occupation-related physical activity and their associations with obesity. *PloS one, 6*(5), e19657.

Colley, R. C., Hills, A. P., O'Moore-Sullivan, T. M., Hickman, I. J., & Byrne, N. M. (2008). Validity in adherence to an unsupervised exercise prescription in obese women. *International Journal of Obesity, 32,* 837-844.

Colley, R. C., Hills, A. P., King, N. A., & Byrne, N. M. (2010). Exercise-induced energy expenditure: Implications for exercise prescription and obesity. *Patient Education and Counseling, 79*, 327-332.

Crouter, S. E., Churilla, J. R., & Bassett, D. R. (2006). Estimating energy expenditure using accelerometers. *European Journal of Applied Physiology, 98*, 601-612.

Dudley, P., Bassett, D. R., John, D., & Crouter, S. E. (2012). Validity of a multi-sensor armband for estimating energy expenditure during eighteen different activities. *Obesity and Weight Loss Therapy, 2*(7), 1-7.

Ekkekakis, P., & Lind, E. (2006). Exercise does not feel the same when you are overweight: The impact of self-selected and imposed intensity on affect and exertion. *International Journal of Obesity, 30*(4), 652-660.

Fischer, D. V., & Bryant, J. (2008). Effect of certified personal trainer services on stage of exercise behavior and exercise mediators in female college students. *Journal of American College of Health, 56*(4), 369-376.

Fogelholm, M., & Kukkonen-Harjula, K. (2000). Does physical activity prevent weight gain - a systematic review. *Obesity Reviews, 1,* 95-111.

Fruin, M. L., & Rankin, J. W. (2004). Validity of a multi-sensor armband in estimating rest and exercise energy expenditure. *Medicine and Science in Sports and Exercise, 36*(6), 1063-1069.

Fryar, C. D., Carroll, M. D., & Ogden, C. L. (2012). Prevalence of overweight, obesity, and extreme obesity among adults: United States, trends 1960-1962 through 2009-2010. National Center for Health Statistics. Retrieved from http://www.cdc.gov/nchs/data/hestat/obesity_adult_09_10/obesity_adult_09_10.htm

Galvani, C., Andreoletti, L., Besi, M., & Faina, M. (2007). Comparison of activity monitors' accuracy to estimate energy expenditure of daily living activities [Abstract]. *Medicine and Science in Sports and Exercise, 39*, 182.

Hill, J. O., & Melanson, E. L. (1999). Overview of the determinants of overweight and obesity: Current evidence and research issues. *Medicine and Science in Sports and Exercise, 31*(11), S515-S521.

Hill, J. O., Wyatt, H. R., Reed, G. W., & Peters, J. C. (2003). Obesity and the environment: Where do we go from here? *Science*, *299*, 853-855.

IBISWorld Analysts (June 2012). Fitness industries pump up revenue, *IBISWorld Special Report*: 1-4.

IBISWorld: Personal trainers in the US - Market research report (2012). Retrieved from: http://www.ibisworld.com/industry/personal-trainers.html.

International Health, Racquet and Sportsclub Association (2012). The 2012 IHRSA global report analyzes industry performance and outlook. Retrieved from: http://www.ihrsa.org/media-center/2012/5/23/the-2012-ihrsa-global-report-analyzes-industry-performance-a.html.

Irving, B. A., Davis, C. K., Brock, D. W., Weltman, J. Y., Swift, D., Barrett, E. J., . . . Weltman, A. (2008). Effect of exercise training intensity on abdominal visceral fat and body composition. *Medicine and Science in Sports and Exercise, 40*(11), 1863-1872.

Jakicic, J. M., Winters, C. Lagally, K., Ho, J., Robertson, R. J., & Wing, R. R. (1999). The accuracy of the TriTrac-R3D accelerometer to estimate energy expenditure. *Medicine and Science in Sports and Exercise, 31,* 747-754.

Jakicic, J. M., Marcus, M., Gallagher, K. I., Randall, C., Thomas, E., Goss, F. L., & Robertson, R. J. (2004). Evaluation of the SenseWear Pro Armband™ to assess energy expenditure during exercise. *Medicine and Science in Sports and Exercise, 36*(5), 897-904.

Jeffery, R. W., Wing, R. R., Thorson, C., & Burton, L. R. (1998). Use of personal trainers and financial incentives to increase exercise in a behavioral weight-loss program. *Journal of Consulting and Clinical Psychology*, *66*(5), 777-783.

Johannsen, D. L., Calabro, M. A., Stewart, J., Franke, W., Rood, J. C., & Welk, F. J. (2010). Accuracy of armband monitors for measuring daily energy expenditure in healthy adults. *Medicine and Science in Sports and Exercise, 42*(11), 2134-2140.

Khalil, H., Quinn, L., van Deursen, R., Martin, R., Rosser, A., & Busse, M. (2012). Adherence to use of a home-based exercise DVD in people with Huntington Disease: Participants' perspectives. *Physical Therapy, 92*(1), 69-82.

Killen, L. G., Barry, V. W., Cooper, C., & Coons, J. M. (2014). Live versus DVD exercise in college age females. *Journal of Strength and Conditioning Research, 28*(12), 3393-3398.

King, A. C., Haskell, W. L., Taylor, C. B., Kraemer, H. C., & DeBusk, R. F. (1991). Group vs home-based exercise training in healthy older men and women. *The Journal of the American Medical Association, 266*, 1535-1542.

King, A. C., Castro, C., Wilcox, S., Eyler, A. A., & Sallis, J. F. (2000). Personal and environmental factors associated with physical inactivity among different racial-ethnic groups of U. S. middle aged and older aged women. *Health Psychology, 19*(4), 354-364.

Lind, E., Welch, A. S., & Ekkekakis, P. (2009). Do “mind over muscle” strategies work? Examining the effects of attentional association and dissociation on exertional, affective and physiological responses to exercise. *Sports Medicine, 39*(9), 743-764.

Livingstone, M. B., Prentice, A. M., Coward, W. A., Ceesay, S. M., Straiin, J. J., McKenna, P. G., . . . Hickey, R. J. (1990). Simultaneous measurement of free-living energy expenditure by the doubly labeled water method and heart-rate monitoring. *The American Journal of Clinical Nutrition, 52*(1), 59-65.

Lynnes, M. D., Nichols, D., & Temple, V. A. (2009). Fostering independence in health-promoting exercise. *Journal of Intellectual Disabilities, 13*(2), 143-159.

Malavolti, M., Pietrobelli, A., Dugoni, M., Poli, M., De Cristofaro, P., & Battistini, N. C. (2005). A new device for measuring daily total energy expenditure (TEE) in free-living individuals. *International Journal of Body Composition Research, 3*, 63.

McClaran, S. R. (2003). The effectiveness of personal training on changing attitudes towards physical activity. *Journal of Sports Science and Medicine, 2*, 10-14.

Nichols, J. F., Morgan, C. G., Sarkin, J. A., Sallis, J, F., & Calfas, K. J. (1999). Validity, reliability, and calibration of the Tritrac accelerometer as a measure of physical activity. *Medicine and Science in Sports and Exercise, 31*, 908-912.

Overweight and Obesity: Health Consequences. (n.d.). Retrieved from http://www.surgeongeneral.gov/library/calls/obesity/fact_consequences.html

Ogden, C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2012). Prevalence of obesity in the United States, 2009-2010. *NCHS Data Brief*, No 82.

Papazoglou, D., Augello, G., Tagliaferri, M., Savia, F., Marzullo, P., Maltezos, E., & Liuzzi, A. (2006). Evaluation of a multisensory armband in estimating energy expenditure in obese individuals. *Obesity, 14*(12), 2217-2223.

Perri, M. G., Martin, A. D., Leermakers, E. A., Sears, S. F., & Notelovitz, M. (1997). Effects of group versus home-based exercise in the treatment of obesity. *Journal of Consulting and Clinical Psychology, 65,* 278-285.

Prochaska, J. O. (1994). Strong and weak principles for progressing from precontemplation to action on the basis of twelve problem behaviors. *Health Psychology*, *13*(1), 47-51.

Sallis, J. F., & Saelens, B. E. (2000). Assessment of physical activity by self-report: Status, limitations, and future directions. *Research Quarterly for Exercise and Sport, 71*(2), S1-S14.

Scheers, T., Philippaerts, R., & Lefevre, J. (2012). Patterns of physical activity and sedentary behavior in normal-weight, overweight and obese adults, as measured with a portable armband device and an electronic diary. *Clinical Nutrition, 31*, 756-764.

Schneider, K. L., Spring, B., & Pagoto, S. L. (2009). Exercise and energy intake in overweight, sedentary individuals. *Eating Behaviors, 10*(1), 29-35.

Slootmaker, S. M., Schuit, A. J., Chinapaw, M. J., Seidell, J. C., & van Mechelen, W. (2009). Disagreement in physical activity assessed by accelerometer and self-report in subgroups of age, gender, education and weight status. *International Journal of Behavioral Nutrition and Physical Activity, 1,* 4-15.

Tudor-Locke, C. (2002). Taking steps toward increasing physical activity: Using pedometers to measure and motivate. *Research Digest, 3*(17), 1-8.

Tumiati, R., Mazzoni, G., Crisafulli, E., Serri, B., Beneventi, C., Lorenzi, C. M., . . . Clini, E. M. (2008). Home-centered physical fitness programme in morbidly obese individuals: A randomized controlled trial. *Clinical Rehabilitation*, *22,* 940-950.

Vickers, K. S., Nies, M. A., Dierkhising, R. A., Jumean, M., Squires, R. W., & Kopecky, S. L. (2011). Exercise DVD improves exercise expectations in cardiovascular outpatients. *American Journal of Health Behavior, 35,* 305-317.

Wadsworth, D. D., Howard, T., Hallam, J. S., & Blunt, G. (2005). Validation study of a continuous body-monitoring device: Assessing energy expenditure at rest and during exercise [Abstract]. *Medicine and Science in Sports and Exercise*, *37*(5), S24.

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

Welk, G. J., Blair, S. N., Wood, K., Jones, S., & Thompson, R. W. (2000). A comparative evaluation of three accelerometry-based physical activity monitors. *Medicine and Science in Sports and Exercise, 32*(9), S489-S497.