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Physiological And Perceptual Responses To Alternate Modes Of Exercise At Self Selected Or Prescribed Intensity Between Overweight And Non-Overweight Individuals

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PHYSIOLOGICAL AND PERCEPTUAL RESPONSES TO ALTERNATE MODES OF EXERCISE AT SELF SELECTED OR PRESCRIBED INTENSITY BETWEEN OVERWEIGHT AND NON-OVERWEIGHT INDIVIDUALS

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ABSTRACT

Purpose: To investigate the influence of body weight, exercise modality, and pace on physiological and perceptual responses during walking. Also, to determine if the relationship between physiological and perceptual responses was altered by modality, pace, or weight status. **Methods:** Aerobically untrained males (n=80, 22.85 ± 3.61 years) and females (n=80, 21.18 ± 1.52 years) classified as either overweight or non-overweight participated. Individuals completed two sessions separated by 72 hours. Session 1 included familiarization, whole body DXA scan, treadmill test to exhaustion, and a 70 foot walk test to determine self selected walking speed. For session 2, participants were randomly assigned to an exercise condition for a one mile walk (track at self selected intensity, treadmill at self selected intensity, track at prescribed intensity, treadmill at prescribed intensity) while physiological, perceptual, and metabolic parameters were collected. **Results:** Factorial ANOVA controlling for sex showed at prescribed pace, the track increased blood lactate significantly from pre to post-exercise when compared to the treadmill. Prescribed pace produced a greater increase in blood lactate from pre to post-exercise compared to self selected pace. Prescribed pace resulted in greater increases in blood pressures, longer heart rate recovery, greater average oxygen consumption, higher average and final heart rates, and higher energy expenditure during exercise (kcal/min). Overweight individuals showed higher values for final heart rate, percentage of maximal heart rate worked, and total energy expenditure. Greater perceived effort and higher pain ratings were seen on the treadmill and at prescribed pace. The variation in RPE responses during prescribed pace was found to be significantly greater than the self selected exercise. **Conclusion:** A novel finding of this study was the increased physiological stress and perception of effort during prescribed pace exercise and on the treadmill while total energy expenditure showed no significant differences. This could indicate an unfavorable perception and less affective response to the treadmill. With energy balance as a primary concern with overweight and obese populations, these results indicate that exercise at self selected pace in the preferred environment promotes an enjoyable experience with similar health benefits as those seen during exercise at prescribed higher intensity.

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CHAPTER I

INTRODUCTION

Cardiovascular disease (CVD), which encompasses coronary artery disease, is the leading cause of early death in adults in the United States. An established set of risk factors for CVD include but are not limited to cigarette smoking, sedentary lifestyle, hypertension, dyslipidemia, prediabetes, and obesity (ACSM, 2014; Loftin et al., 2010). Evidence continues to accumulate to support the inverse relationship between physical activity and premature mortality, CVD, stroke, osteoporosis, Type 2 diabetes mellitus, certain cancers, depression, cognitive function, obesity, and many other debilitating conditions (PA Guidelines Advisory Committee Report, 2008; Freitas et al., 2015). In recognition of the health risks associated with obesity, the American College of Sports Medicine (ACSM) lists obesity and physical inactivity among the major risk factors for coronary artery disease (Greene et al., 2009; Dunn et al., 1999). Despite the documented relationship of physical inactivity and adverse health conditions, the rates of physical inactivity continue to rise and become increasingly alarming (Dunn et al., 1999; Cox et al., 2002). Obesity is one of the modifiable risk factors where a large focus should be placed on encouraging a healthier lifestyle to decrease the prevalence of mortality associated with the condition and with CVD. Obesity in older adults has become a serious health related concern in the United States over the last several decades with the number of obese adults markedly increasing (Villareal et al., 2011; Peyrot et al., 2012; Haskell et al., 2007). While information continues to grow regarding the varied causes of obesity, the importance of public health efforts to emphasize energy expenditure and energy intake remains paramount (Haskell et al., 2007) due to the improvement in the cardiovascular system that assists in the prevention of chronic diseases and its critical influence on weight loss (Freitas et al., 2015). Attempting to maintain a healthy weight can be influenced by a plethora of complex factors. Haskell et al. (2007) state factors related to cultural, psychosocial, physiological, and biological influences make it difficult to accurately identify the exact etiology for any individual. It can be argued that an individual becomes obese due to the excessive energy intake and lack of expenditure, but this does not tell us why the imbalance is present and the best way to care for it.

For effective weight management to take place an accurate knowledge of the level of metabolic energy expended during exercise is needed and adequate focus should be placed on the increased energy expenditure of obese adults over normal weight adults when exercising at any given intensity (Browning and Baker 2005; Peyrot et al., 2012; Morris et al., 2010). Physical activity targeting the increase in energy expenditure, even creating a negative energy balance, for the prevention of obesity is the first choice of intervention due to the reduction of body fat, risk factors for diseases, and risk of musculoskeletal problems (Caserta et al., 1998; Freitas et al., 2015). An important aspect of everyday life is the inclusion of this regular physical activity, which elevates the metabolic rate above resting levels, and aids in the control of excess adipose tissue (Morris, 2014; Haskell et al., 2007). The inclusion of physical activity recommendations remains a vital part of weight management and continues to be a focus of major organizations including the ACSM, Center for Disease Control (CDC), National Heart, Lung, and Blood Institute (NHLBI), American Heart Association (AHA), and various other medical societies (Donnelly et al., 2009; Morris, 2014). Meaningful physical activity guidelines to assist in the prevention and treatment of unhealthy weight gain have been modified by medical societies to reach a common recommendation today. The Surgeon General, AHA, and ACSM endorse a recommendation of at least 30 minutes of moderate intensity aerobic physical activity on most, preferably, all days of the week (Manson et al., 2002; Haskell et al., 2007; Loftin et al., 2010). Studies have shown that the accumulation of 30 minutes of moderate intensity exercise can confer significant health benefits (Hall 2012). These benefits include but are not limited to, weight management, weight loss, CVD risk management, along with the avoidance of metabolic dysfunction such as Type 2 diabetes mellitus (Hall 2012).

As stated previously, despite the knowledge of health benefits associated with physical activity, it remains a continuous challenge to promote this behavioral modification. One aspect of this challenge is how to initiate physical activity into the sedentary lifestyle and once initiated, how to maintain an active lifestyle such as developing effective and positively perceived programs (Cox et al., 2002; Dunn et al., 1999). Barriers to initiation may include lack of time, lack of social support, disruptions in routine, lack of access to facilities and cost, along with a dislike for or misinterpretation of different levels of intensity (Dunn et al., 1999; Hall, 2012). When sedentary and overweight individuals initially engage in exercise, adherence often drops dramatically after 6 months (Caserta et al., 1998) with one study stating an attrition rate of 50% in that time frame (Cox et al., 2002). Therefore, following initiation of exercise, adherence is of great importance and this success relies partly on the proper prescription that fits the individual's lifestyle and functional capacity (Hall et al., 2012; Dunn et al., 1999; Caserta et al., 1998; Haskell et al., 2007). Those who are motivated by enjoyment or satisfaction are more likely to maintain regular exercise programs (Morris et al., 2014; Caserta et al., 1998).

This has led many to believe walking is the aerobic exercise of choice for the majority of sedentary and/or overweight and obese population. Walking is a rhythmical, dynamic, aerobic activity, which can generate the necessary intensity to produce positive health outcomes (Fabre et al., 2010) due to the consumption of energy from muscular contractions which aid in the balance of energy intake and expenditure (Taboga et al., 2012; Hall et al., 2004; Loftin et al., 2010). Because walking can be considered a lifestyle form of physical activity when it is incorporated into activities of daily living, it is a popular and convenient method of weight management and assists in reduction of CVD risk (Browning and Baker, 2005; Peyrot et al., 2012; Donnelly et al., 2009; Manson et al., 2009; Loftin et al., 2010). The perception of enjoyment assists in the attempt for incorporating leisure time physical activity into daily life due to the vast amount of time spent sitting whether at work or home. As stated by Donnelly et al. (2009), this elevated sitting time is likely to be an important cause of the obesity epidemic.

Moderate intensity exercise, previously mentioned in the ACSM guidelines, is the common recommendation and could be misinterpreted by those who are sedentary and/or overweight which establishes a barrier to initiation of exercise. This may result in an insufficient effort to reach workloads that are beneficial to cardioprotection, glucose control, and weight loss and maintenance (Hall 2012). Also, Fabre et al. (2010) state the walking speed necessary to reach the training intensity sufficient for health benefits may be inappropriate for individuals who need to increase caloric expenditure and have walking limitations. According to ACSM recommendations, to maintain a moderate intensity during walking, the speed must be between 3 and 4 mph. Although this speed may correspond to active, healthy individuals, Browning and Baker (2005) state the average walking speed of overweight adults to be approximately 2.68 mph. Similar to these findings, Amorin et al. (2009) found the habitual walking speed to be 3-6 km/h (1.86 – 3.7 mph) in active lifestyle. The impact of the intensity of exercise on compliance, one of the major issues in sedentary populations, has not been widely investigated (Cox et al., 2002 and Freitas et al., 2015). Although, Cox et al. (2002) states a population based study reported twice as many adults adopted a new routine of moderate intensity activities when compared to a more demanding fitness program and with lower dropout rates. The wide range of preferred walking speed creates concern when compared to general recommended guidelines. One area of concern with the wide range of walking speed is the limitation that excess adipose tissue poses on the body due to the additional energy expenditure required to propel more body weight through space. Walking at a prescribed pace may be an exhausting task that requires a considerable fraction of an overweight individual's maximal aerobic capacity (VO_{2max}) (Browning and Baker, 2005; Morris et al., 2010; Peyrot et al., 2012), with studies showing greater than 50% VO_{2max} reached in this population (Browning and Baker, 2005). Peyrot et al. (2012) stated obese individuals reached 56% of VO_{2max} while walking and this could be due to reductions of both relative aerobic capacities per kilogram of total body mass and walking economy. Walking economy is generally represented by the net metabolic rate per kilogram body weight during walking at a given speed (Peyrot et al., 2012 and Morris et al., 2010,). Good walking economy is associated with a low net metabolic rate during walking. Supporting findings were stated by Morris et al. (2010) where studies have found overweight participants to work at a higher percentage of aerobic capacity when prescribed to a fixed submaximal treadmill speed. Similar findings were also seen in children who required additional energy to perform work as body mass increased (Treuth et al., 1998). Browning and Kram (2005) reported overweight women to exercise at 51% of VO_{2max} during walking while normal weight women walked at 36% of their VO_{2max}. Ekkekakis and Lind (2006) also noted that overweight women performed the walk at the preferred pace at a significantly higher percentage of their VO_{2max} than normal weight women. The greater net metabolic rate of obese adults may partly due to the heavier and larger legs that require an increase in step width and leg swing circumduction, which have both been shown to substantially increase net metabolic rate (Browning and Baker, 2005 and Morris et al., 2014). Limited research has compared the energetic cost of overweight with normal weight adults during walking (Loftin et al., 2010), especially at alternate speeds. Morris et al. (2010) concluded that in order to perform an equal amount of work as a normal weight person, the overweight individual must put forth greater levels of effort to overcome the greater body mass.

Due to the greater physical exertion by those who carry excess adipose weight, the negative perception of physical activity presents another concern for initiation and adherence to regular exercise. Exercise behavior is particularly reinforced when an individual perceives and enjoys its benefits (Caserta et al., 1998). The ability to control the intensity and the intrinsic feelings of exercise would lead to a positive perception of the activity aiding in the enjoyment and adherence to habitual physical activity. The process of self monitoring and self regulation in exercise involves how well an individual is able to adjust the intensity in order to obtain a level that is best suited to their personal state of fitness, health, or any other limiting factor, such as guidelines from professionals concerning how hard one should work (Ceci and Hassmen, 1991). Subjective perception of exercise intensity can be considered a continuous and simultaneous interpretation of internal cues (perceived exertion, proprioception, chemoreception, respirations, etc.) as well as external cues (Ceci and Hassmen, 1991; Lewis et al., 2007; Levinger et al., 2004). Such integration methods can be helpful during everyday activity, especially of aerobic nature, allowing individuals to self select an intensity based on feelings of perceived exertion (Ceci and Hassmen, 1991). Various methods of intensity assessment have been used (Ceci and Hassmen, 1991), but psychophysiologic rating of perceived exertion (RPE) is the most commonly accessed tool with which individuals assess the intensity of effort during acute exercise (Lewis et al., 2007). This scale has been recommended by ACSM and AHA and has become a generally accepted subjective method of estimation in which subjects are asked to rate the degree of exertion they perceive as related to a particular intensity (Ceci and Hassmen, 1991 and Marcora, 2009). This forms a basis of understanding intensity due to the paralleling of increasing RPE with standards of heart rate, respiratory and metabolic functions, and lactate production (Lewis et al., 2007). The RPE instrument commonly used for the past three decades is the 6 to 20 scale, designed and validated by Dr. Gunnar Borg, which posits a relationship between human sensory responses and physiological responses (Lewis et al., 2007; Ceci and Hassmen, 1991; Levinger et al., 2004). The 6 to 20 item instrument was designed according to Borg's earliest discoveries that RPE is highly correlated with heart rate (r=0.85) and the value selected on the scale, times 10, should roughly equate to the exercise heart rate (Lewis et al., 2007 and Marcora, 2009). The RPE scores have also been shown to produce high correlations with respiratory variables and blood lactate in exercising men (Levinger et al., 2004 and Marcora, 2009). Since the scale was designed using healthy individuals, factors such as age, type of exercise, temperature, and body fat could alter the heart rate and RPE relationship and compromise the instrument's validity. It was found by Docktor and Sharkey (1971) the subjective responses to a given workload decline due to a reduction in stimuli stemming from improved physical fitness associated with lower body mass. Studies have seen a large variability in the RPE values between subjects performing at a given workload which establishes a large inter-individual variability and is partly due to current status of fitness level and body composition (Garcin et al., 2003; Levinger et al., 2004; Fabre et al., 2010; Lewis et al., 2007; Ceci and Hassmen 1991). A conception of the RPE scale is the perceived exertion refers to the discomfort experienced during exercise which could also limit the application of the scale for monitoring intensity (Marcora 2009). One method of improving the perception of physical activity, such as walking, could be the use of self selected intensity in opposition to a standard prescribed intensity.

The term self selected is commonly used in the literature and is identified as the most efficient walking speed, with increased efficiency defined by lower oxygen uptake per unit of mechanical work (Amorim 2009). Studies have shown that individuals participating in exercise programs tend to exercise at a self selected intensity rather than a prescribed intensity (Cox et al., 2003; Freitas et al., 2015; Dunn et al., 1999) and this self selected walking pace performed as continuous exercise can aid in weight loss and provide desired beneficial health effects (Freitas et al., 2015). The benefits of exercising at a self selected intensity are related to the positive parameters of perceived exertion and effect, which may contribute to the intrinsic motivation of individuals to adhere to an exercise program. King et al. (1991) compared prescribed exercise versus home based exercise (self selected) and found that self selected had higher adherence rates 1 and 2 years following. Similar findings were expressed by Dunn et al. (1999) in stating a behaviorally based lifestyle physical activity intervention, in which individuals increase their daily leisure moderate intensity physical activity, would result in higher levels of physical activity, adherence, and cardiorespiratory fitness at 24 months when compared to those of a traditional structured prescribed intervention. There are numerous observational studies supporting the hypothesis that higher levels of lifestyle physical activity prevent initial weight gain (Donnelly et al., 2009). Part of the concern with implementing self selected pace is the use of descriptors such as “walk briskly” or “preferred pace” but may not reach a pace equivalent to that selected when asked to walk at “moderate intensity” (Hall 2012).

Although this may be true, moderate intensity is the terminology of recommended physical activity guidelines. This should be the focus of research associated with the overweight and obese population. Further, the relationship between this pace and heart rate, RPE, and energy expenditure should be investigated across alternate modalities.

PROBLEM STATEMENT AND PURPOSE OF STUDY

A regular exercise program that includes stimuli for cardiorespiratory, musculoskeletal, and neuromotor fitness is paramount for the health of most adults. Weight management and fitness are largely comprised of an exercise prescription along with nutritional recommendations and evaluations. Exercise prescription consists of many facets that are specific to the individual who will be performing the exercise although often times these components of the exercise program are not individualized which creates inquiry as to whether the program is providing maximum benefits. As an example, the American College of Sports Medicine, Guidelines for Exercise Testing and Prescription, 9th edition (2014) recommends 30 minutes of moderate intensity physical activity on most if not all days of the week. These guidelines are frequently overused as a general recommendation. The exercise program should be modified based on the individual's daily physical activity, functional capacity, health status, stress level, psychophysiological perceptions, and their goals. Adults who are unwilling or unable to meet the ACSM exercise guidelines can still benefit from engaging in physical activity and reducing sedentary behavior. Previous data have shown that alternate modalities of exercise provide differing physiological and perceptual responses in normal weight individuals. Therefore, the purpose of this investigation was to determine the relationship between the perceptual behavior and actual physiological response to walking in two commonly used environments and also between a commonly prescribed intensity and self selected intensity. Also of interest, was to determine if differences are present between overweight and non-overweight individuals. This information will provide insight into exercise prescription and its individualization for those attempting to improve their health status.

HYPOTHESES

Specific Aim 1 : To determine perceptual and physiological responses to walking one mile.

To investigate the physiological and perceptual responses to exercise during a one mile walk between overweight and non-overweight individuals on both a treadmill and track at self selected and prescribed paces.

H_{01}: Individuals' perceptual response will not differ significantly by interaction of weight status, modality, or pace.

H_{02}: Individuals' physiological response will not differ significantly by interaction of weight status, modality, or pace.

H_{03}: Individuals' perceptual responses will not differ significantly between exercise modality during a one mile walk.

H_{04}: Individuals' physiological responses will not differ significantly between exercise modality during a one mile walk.

H_{05}: Individuals' perceptual responses will not differ significantly between exercise pace during a one mile walk.

H_{06}: Individuals' physiological responses will not differ significantly between exercise pace during a one mile walk.

H_{07}: Acute physiological responses will not differ significantly between overweight and non-overweight individuals during and following a one mile walk.

H_{08}: Perceptual response will not differ significantly between overweight and non-overweight individuals during and following a one mile walk.

H_{A1}: Perceptual responses will differ significantly due to interaction between weight status, modality, and pace.

H_{A2}: Physiological responses will differ significantly due to interaction between weight status, modality, and pace.

H_{A3}: Individuals' perceptual responses will differ significantly between exercise modality during a one mile walk.

H_{A4}: Individuals' physiological responses will differ significantly between exercise modality during a one mile walk.

H_{A5}: Individuals' perceptual responses will differ significantly between exercise pace during a one mile walk.

H_{A6}: Individuals' physiological responses will differ significantly between exercise pace

H_{A7}: Acute physiological responses will differ significantly between overweight and non-overweight individuals during and following a one mile walk.

H_{A8}: Individuals' perceptual responses will differ significantly between weight status groups during a one mile walk.

Specific Aim 2 : Determine the relationship between perceptual and physiological variables during one mile walk.

To investigate the relationship between perceptual response (rating of perceived exertion and numerical pain rating) and physiological responses (heart rate, energy expenditure, blood lactate accumulation, and blood pressure) of walking one mile.

H_{09}: There will be no interaction effect on the relationship between physiological and perceptual responses to exercise.

H_{010}: The relationship between perceptual and physiological responses will not differ significantly by weight status.

H_{011}: The relationship between perceptual and physiological responses will not differ significantly by exercise modality.

H_{012}: The relationship between perceptual and physiological responses will not differ significantly by pace.

H_{A9}: An interaction between weight status, modality, and pace will significantly alter the relationship between physiological and perceptual responses to exercise

H_{A10}: The relationship between physiological and perceptual responses will differ significantly by weight status during a one mile walk.

H_{A11}: The relationship between physiological and perceptual responses will differ significantly by exercise modality.

H_{A12}: The relationship between physiological and perceptual responses will differ significantly by pace.

OPERATIONAL TERMS AND DEFINITIONS

ACSM : American College of Sports Medicine

AHA : American Heart Association

CDC : Centers for Disease Control

BMI : Body Mass Index

An assessment of weight relative to height and is calculated by dividing body weight in kilograms by height in meters squared ($kg \cdot m^2$). Used to classify individuals as normal weight, overweight, or obese. (ACSM 9th edition, 2014; Villareal et al., 2011; Taboga et al., 2012; Greene et al., 2009; Hall et al., 2012; Morris et al., 2014; Freitas et al., 2015)

EE : Energy Expenditure

HRmax : Estimated Maximal Heart Rate

Maximal heart rate obtained during VO_{2max} test.

Moderate Intensity

Classified as 3 to 6 metabolic equivalents (METs) or 50-60 % of heart rate reserve.

NHLBI : National Heart, Lung, and Blood Institute

Normal weight

As defined by ACSM 9^{th} edition (2014), a BMI between 18.5 and 24.9 kg · m^2.

Overweight

As defined by ACSM 9^{th} edition (2014), a BMI between 25.0 and 29.9 kg · m^2.

Obese

As defined by ACSM 9^{th} edition (2014), a BMI greater than 30.0 kg · m^2.

Physical Activity

Any bodily movement produced by the contraction of skeletal muscles that results in an increase in caloric requirements above resting energy expenditure (ACSM 9^{th} edition, 2014).

RPE : Rating of Perceived Exertion

A subjective measurement of one's functional response to exercise (ACSM 9^{th} edition, 2014). Also defined as a clinical tool with which to assess intensity of effort during dynamic exercise based on peripheral and central input from muscle kinesthetic proprioceptors, chemoreceptors, and thermoreceptors (Lewis et al., 2007; Marcora, 2009; Garcin et al., 2003; Levinger et al., 2004).

Sedentary

Those engaged in less than 60 minutes of aerobic exercise per week for the last 3 to 6 months (Fabre et al., 2010; Caserta et al., 1998; Greene et al., 2009; Dunn et al., 1999; Cox et al., 2002).

Vigorous Intensity

Classified as greater than 6 metabolic equivalents (METs) or >77 % of estimated maximal heart rate (ACSM 9th edition, 2014)

VO_2 : Oxygen Consumption

The amount of oxygen consumed at the muscular level during exercise.

VO_{2max} : Maximal Oxygen Consumption

The maximal amount of oxygen consumed at the muscular level during maximal exercise. This variable is the product of maximal cardiac output and arterial-venous oxygen difference and is typically expressed in either absolute (L · min) or relative (ml · kg · min) form (ACSM 9th edition, 2014)

CHAPTER II

REVIEW OF LITERATURE

i. <u>**Role of walking and health benefits**</u>

The role of walking for health benefits has been shown to produce an inverse relationship with increasing intensity and volume of walking resulting in greater reductions in adverse health conditions (Manson et al., 2002 and Donnelly et al., 2009). A study conducted by Donnelly et al. (2000) resulted in a significant dose-response effect for physical activity where greater amounts of physical activity resulted in larger weight loss. Donnelly et al. (2000) targeted 90 minutes of continuous moderate intensity physical activity (30 min for 3 days/week) compared to 150 minutes of moderate intensity intermittent physical activity (30 min for 5 days/week) in women for 18 months. The continuous group lost significantly greater weight than the intermittent group (1.7 vs. 0.8 kg, respectively). Given the increasing prevalence of obesity, which presents a concern for vigorous exercise, walking at a continuous comfortable pace provides the sufficient stimulus for weight reduction and desired health outcomes (Manson et al., 2002; Villareal et al., 2011; Donnelly et al., 2009; Loftin et al., 2010). As stated by Manson et al. (2002), continuous moderate intensity activity, such as walking, produces reductions in diastolic blood pressure similar to those achieved by vigorous exercise and can produce substantial reductions in systolic blood pressure. A cohort of 3,653 women and 2,626 men in

Denmark followed up for 5 years did not show that inactivity led to obesity but did suggest that those who became obese also became more inactive (Petersen et al., 2004). However, there is consistency across studies showing that the more active people gained less weight or were less likely to become obese (Donnelly et al., 2000 and Donnelly et al., 2009). After weight loss, both VO2max and walking economy (net metabolic rate · kg) improve (Peyrot et al., 2011). The main hypotheses presented to explain the decrease in net metabolic rate per kilogram during walking after weight loss were due to an increase in relative strength and decrease in isometric muscular contractions required to support body weight and balance during walking (Peyrot et al., 2011; Browning and Baker 2005; Taboga et al., 2012; Morris et al., 2014). The results of Peyrot et al. (2010) support the hypothesis that the decrease in the net metabolic rate per kilogram during walking after weight loss may be due to a decrease in the metabolic rate of the isometric muscular contractions required to support body weight and maintain balance at each step rather than to a decrease in the metabolic rate associated with muscle contractions required to move the center of mass and limbs. Peyrot et al. (2011) found reductions in weight loss following a walking protocol and this weight loss was correlated with reduced fluctuations in kinetic energy required to stabilize the body in the mediolateral direction. These researchers further state that weight loss could have induced a decrease in the cost of supporting body weight during the single limb support phase of walking because an increased relative strength could result in a lower relative intensity for walking at a given speed. This would cause a reduction in muscle activation of fast glycolytic fiber recruitment to support body weight. These fibers have been shown to be less economical than slow oxidative fibers. Changes in muscle activation along with mediolateral movements of the center of mass following weight loss might explain the decrease in the metabolic rate of the isometric muscle contractions required to support body weight and maintain balance during walking (Peyrot et al., 2011).

In summary, the relationship between continuous regular exercise and improved overall health is well established with a large focus on the loss of excess body fat. Thus, it appears the importance of investigations into alternate modes of exercise are eminent to establishing their relationship with physiological and perceptual responses in different populations of weight categories. These investigations will assist in understanding the relationship between modes of exercise, physiological and perceptual responses, and health benefits associated with weight loss.

ii. **Perceptual versus physiological response to walking**

People are often introduced to exercise through programs where an exercise regimen is prescribed and involves supervision, but as mentioned earlier, comfort and enjoyment are paramount for the adherence to regular physical activity and this is greatly improved with self selected modalities (Caserta et al., 1998; Cox et al. 2003; Freitas et al., 2015; Dunn et al., 1999). Programs involving home based regimens or leisure physical activity allow for individuals to continue to follow the habitual exercise with a greater perception of the activity (Caserta et al., 1998). Although, it is of concern to establish a reliable relationship between the individual's RPE and physiological responses to ensure the activity is of adequate intensity to produce beneficial outcomes in health categories. Garcin et al. (2003) found during walking at a constant load, at the fifth minute trained subjects rated "hard" an exercise intensity they were able to maintain for one hour, whereas for untrained subjects, the same rating of perception corresponded to an exhaustion time equal to approximately 15 minutes. These researchers stated since previous studies have established that an RPE value between 12 and 16 (somewhat hard and hard) corresponds to 50-85% VO2max and this is a common prescription, it is important to account for the fitness level of individuals because fitness level plays a crucial role in the validity of the RPE scale. The accumulation of lactate and metabolic changes take place around this level of exercise also and could contribute to the signals of perception of effort independent of fitness level (Garcin et al., 2003). Similar findings were produced by Lewis et al. (2007) when reports of RPE and corresponding heart rates were inconsistent. During this study, heart rate was only related to RPE during the first work stage of incremental exercise. As RPE continued to increase with successive workloads, the difference in heart rate and VO2 did not correspond to the perceived level of exertion (Lewis et al., 2007). These authors concluded the validity of the perceptual-physiologic relationship during exercise and the relationship between heart rate and RPE for people outside the healthy population is questionable. These findings have been further supported by Hall et al. (2012) which found heart rate to remain similar between trials while RPE was significantly higher in obese individuals at a prescribed pace of 60% VO2peak when compared with their self selected pace. This could be due to the introduction of perception from central cues (Lewis et al., 2007; Ceci and Hassmen, 1991; Levinger et al., 2004). In a study of RPE as an intensity indicator for unhealthy individuals, a wide range of RPE scores were seen at exercise test termination and presented a large inter-individual variability between patients (Levinger et al., 2004). It is important to note that overall perceived exertion is a subjective measure of effort and encompasses both local factors, such as sensations from exerting muscles, and central factors, such as sensations from the cardiopulmonary system (Levinger et al., 2004). The translation of these sensations can become difficult in populations other than the healthy in which the RPE scale was designed (Levinger et al., 2004). Fabre et al. (2010) also found conflicting relationships between heart rate and RPE during different walking modalities.

Contrary results in heart rate and RPE relationships were also seen on a treadmill when compared to a field situation (Ceci and Hassmen 1991). It was suggested by these authors that the feeling of exertion during outdoor exercise could be reduced by interfering perceptions, such as feelings of wind and visual input because these factors could act as "reducers" of sensory input.

The disparity remains in results of the relationship between RPE and physiological measures during exercise in those outside the health normal weight population, for which the RPE scale was designed. Therefore it appears investigations of perceptual responses and their relation to physiological measures are essential in those classified as overweight or obese. These relationships require further examination when comparing alternate exercise modalities also.

iii. Responses of normal weight versus overweight individuals in physical activity measures

An accurate method for determining and interpreting the energy expenditure associated with exercise in both normal weight and overweight populations is important (Morris et al., 2010) and allows for an individualized program to be established for optimal health benefits. Limited research has investigated the energy expenditure of walking a mile at varying speeds for overweight men and women (Morris et al., 2010 and Browning and Kram, 2005). Although Mayhew et al. (1979) found untrained men who weight 10.6 kg more than trained men expended more energy when expressed per kilometer for specific walking exercise. Different methods are available to increase an individual's total energy expenditure during exercise, such as an increase in duration or intensity. However, overweight individuals are at greater risk for muscular discomfort, skeletal pain, and adverse events with increases of intensity (Morris et al., 2010 and

Greene et al., 2009) and this creates a barrier with adherence to regular exercise. Additionally, previous research reported that overweight and obese individuals expressed higher RPE scores with increased exercise intensity when compared to normal weight participants as well as an inability to tolerate an increase in intensity (Ekkekakis and Lind, 2006). It was suggested by Morris et al. (2014) and Loftin et al. (2010) that individuals who are overweight and able to walk continually for one hour at their self selected pace can expect to cover a distance of 3 miles and this amount meets the daily recommended guidelines from ACSM for walking. Morris et al. (2014) concludes if individuals can begin exercise with a light intensity and continue at self selected pace they could perform the necessary amount of exercise while decreasing the overall risk for injury or over exertion. This aids in the promotion of physical activity in overweight and obese individuals because this reduced pain or discomfort could potentially lead to a greater likelihood of completing the exercise regimen (Ekkekakis and Lind, 2006).

Browning and Baker (2005) examined the walking speed and energy expenditure of overweight and obese individuals. Their findings showed obesity greatly increased the total energy expenditure for walking and gross VO2 was up to 70% greater in these individuals when compared to normal weight participants. This could be due to the wider step width in obese individuals, twice that of normal weight persons (Spyropoulos et al., 1991). It was also found the obese individuals walking speed was significantly slower than normal weight individuals, which is similar to results found by Mattson et al. (1997) and Melanson et al. (2003) where speeds of 1.18 m/s (2.64 mph) and 1.19 m/s (2.66 mph) were seen in Class II obese individuals. These speeds do not meet the recommended speed of ACSM that corresponds to moderate intensity, but walking faster than this preferred speed could result in the negative effects stated earlier. Supporting results were seen in a study conducted by Hall et al. (2012) where obese subjects were allowed to walk at their preferred speed but when asked to increase workload to the high end of the moderate intensity range, 68% of the subjects could not complete the prescribed regimen and the workload had to be reduced after 15 to 20 minutes of exercise. These results parallel those found by Ekkekakis and Lind (2006) who noted an imposed speed that is just 10% higher than what overweight women self selected led to a decline in reported pleasure and affective responses. The best predictor of walking speed in the study by Hall et al. (2012) was fat mass, which explained 32% of the variability in the self selected speed. These data support an inverse relationship between adiposity and self selected walking speed and suggested that obese individuals may choose lower walking speeds in their daily exercise regimens as compared to lean individuals. When imposing a walking speed in the middle of the moderate intensity recommendation, many individuals cannot maintain that workload for 30 minutes (Hall et al., 2012). A study by Hall et al. (2004) found more fit individuals used less energy per unit of lean mass for 1600 m than less fit. Moderately strong correlations ($p<0.01$) were found between percent body fat and energy expenditures normalized for body weight for both track and treadmill exercising conditions (Hall et al. 2004).

It seems apparent from previous research that a prescribed walking speed that equates to moderate intensity presents unfavorable results in those classified as overweight or obese. Muscular discomfort, pain, and the risk of adverse events constitute a pivotal role in behavioral modification and promotion of regular exercise. Additionally, a prescribed walking speed exceeding that of the preferred speed induces a greater metabolic demand on the individual and the level of that demand has been found to relate to the degree of adiposity. Therefore, it is imperative for a proper recommendation to incorporate the individual’s functional capacity and is relative to their body weight. One method of altering the walking prescription is to allow for a self selected walking pace in opposition to prescribed walking pace due to the slower walking speed of those with excess adipose tissue.

iv. **<u>Self selected versus prescribed walking pace</u>**

Individuals participating in an exercise regimen tend to exercise at a self selected intensity rather than a prescribed intensity (Cox et al., 2003) and the benefits of a self selected workload are related to positive parameters of perceived physical exertion which assists in the motivation of individuals (Freitas et al. 2015). These benefits are more consistent and pronounced in obese subjects along with those who are sedentary (Freitas et al. 2015). Freitas et al. (2015) also found those who engage in moderate self selected continuous exercise obtain the same benefits as those engaged in vigorous intensity activity. This study also showed a greater fat oxidation during post-exercise in the self selected pace group. An investigation from Cox et al. (2002) found those in the moderate intensity home based group performed significantly more sessions compared to the vigorous center based group. These two groups could be seen as self selected and prescribed, respectively.

One study states that long term exercise frequency and compliance are not related to being involved with group-based exercise but, rather, having a better perception of exercise (Caserta et al. 1998). Motivation for exercise is enhanced when the activity is enjoyable. These findings indicate that the intensity of the prescribed exercise was a factor in retention and those in the moderate intensity group had higher retention rates than those in the vigorous intensity group. By the same token, other research has shown a 50% attrition rate for vigorous exercise and 30% for moderate exercise (Cox et al. 2002). At 18 months there were more withdrawals from the vigorous intensity group suggesting that those who had perceived the intensity to be unsustainable may have left the program (Cox et al. 2002). The home based program can also be considered a lifestyle physical activity whereas the center based program is thought of as structured prescribed exercise. This allows for a comparison to the results of Dunn et al. (1999) who found the lifestyle group increased their moderate intensity activity approximately three times more than the structured group. From 6 to 24 months post exercise program, the lifestyle group decreased VO2peak by 0.7 mL/kg per minute ($p=.04$) and the structured exercise group decreased their VO2peak by 2.4 mL/kg per minute ($p<.001$) (Dunn et al. 1999). As stated by these researchers, this supports the hypothesis that a lifestyle physical activity intervention can significantly increase physical activity and fitness and improve adherence. This allows for health care professionals who are counseling their patients about physical activity to provide options beyond traditional center–based prescribed recommendations.

A comparison of energy expenditure, RPE, and heart rate during self selected and prescribed walking pace was conducted by Hall et al. (2012). These researchers included participants with a body mass index greater than 25 (overweight and obese) who were not previously trained. Results showed energy expenditure to be greater in the prescribed walking pace (60% VO2peak) when compared to the self selected pace. The self selected pace resulted in a workload of 52% of VO2peak while prescribed pace resulted in participants exercising at 58% of VO2peak causing the RPE of those exercising at the prescribed intensity to be significantly higher (Hall et al., 2012). Although there was no difference in the exercise heart rate between self selected and prescribed trials, RPE values significantly higher in the prescribed workload highlight the idea there may be a mismatch between perceived exertion and physiological responses in sedentary obese individuals (Hall et al. 2012).

A concern arises when using absolute recommendations for physical activity prescriptions due to the lack of adherence to individuality. When using the absolute intensity recommendations, the subject's prior training status and individual heart rate characteristics are not accounted for and could alter the perceptual and physiological responses. Strath et al. (2000) examined the relationship between physiological responses and heart rate reserve and VO2 reserve. When using these reserve methods, the intensity is presented in a relative form and takes into account the individual's characteristics. Using a percentage of heart rate reserve has been found to improve adherence and shown to be a significant predictor of energy expenditure ($r=0.87$) (Strath et al., 2000). ACSM (2010) recommends an intensity of 40-60 % of heart rate reserve to maintain a moderate intensity. A study conducted by Perri et al. (2002) used 45-55 % of heart rate reserve to represent moderate intensity and 65-75 % of heart rate reserve as vigorous intensity. In their study comparing the two prescriptions, the moderate intensity showed a much greater adherence rate ($p=0.02$) while led to more physical activity being accumulated longitudinally.

These results underline the necessity of making an individualized exercise regimen in order to maximally benefit each person. Individualization could occur by taking into account body weight and/or composition or by using a self selected pace in comparison to a general recommended prescribed pace. The perceptual aspect of walking is important due to its crucial role in adherence for long term health benefits. Alternate environments for walking is another possible alteration to improve the outcomes of exercise and adherence rates. Differences have been found between walking on a track and walking on a treadmill, the two most common environments for this activity.

v. **Track versus treadmill walking**

Results from treadmill walking when applied to a non-controlled environment such as track walking should be done with caution (Pugh 1970). As mentioned previously, some factors could act as "reducers" of sensory input (visual, auditory, thermal, etc.) and air resistance in a non-controlled environment such as a track should be considered when comparing to a controlled environment such as a treadmill (Ceci and Hassmen, 1991; Pugh, 1970; Jones and Doust, 1996; Devi et al., 2014; Chakravarthy et al., 2013). This could have an effect on the perception of effort and/or lead to different physiological responses. It has been seen, the RPE response of individuals walking on a treadmill were higher when using a within subjects comparison to their responses walking on a level track (Ceci and Hassmen, 1991), and a less positive valence during treadmill walking than over ground walking (Dasilva et al., 2011). This led these researchers to conclude that a subtraction of approximately two RPE units from the treadmill to the track yields equivalent levels in both velocity and physiological responses.

Another potential difference is in regards to energy expenditure during track and treadmill exercises which is crucial in prescribing exercises for weight loss in the obese population (Chakravarthy et al., 2013 and Devi et al., 2014). For the purpose of both studies (Chakravarthy et al., 2013 and Devi et al., 2014) energy expenditure was compared between treadmill and track walking and running. It has been hypothesized by these authors when running on a treadmill an individual is running at a fixed pace, and not moving through the air, whereas when running outside, the air creates resistance. Theoretically, the lack of wind means less energy required (Chakravarthy et al., 2013 and Devi et al., 2014). Other factors of interest between track and treadmill walking are the flat unchanging surface of treadmill deck and the effect of moving belt on the walking (Devi et al., 2014). This reduces the required metabolic cost of propelling the body through space because the leg swing phase of locomotion on a treadmill is strictly used to move the foot under the body for balance. The rearward movement of the belt decreases the need to use specific muscular actions to propel the mass through space, requiring less work (Chakravarthy et al., 2013 and Devi et al., 2014). These authors both concluded the energy cost of weight bearing movement varies greatly with differing body mass and increases proportionately with the person's body mass. It was seen during ambulation that when body weight is supported, propelled, and translocated there are substantial increases in energy expenditure (Amorim et al., 2009). Chakravarthy et al. (2013) also found more energy utilization per unit time for equal workloads by an individual on the track compared to the treadmill while the track produced lower perceived exertion. Similar results were produced prior to this study with Jones and Doust (1996) finding the oxygen cost and metabolic stress of running outdoors to be greater than when running indoors on a treadmill. A potential difference between treadmill and track running is the runner may experience changes in the pattern of locomotion due to differing surfaces on the track which elevates energy cost (Jones and Doust, 1996). These researchers also found a heart rate difference of 8 beats per minute higher on the track compared to treadmill. Hall et al. (2004) investigated the energy expenditure associated with walking and running on a track and treadmill. The research found running to elicit greater total energy expenditure when compared to walking for both the treadmill and the track. No difference was seen in the comparison of track and treadmill with energy expenditure but more fit individuals used significantly less energy per unit of fat free mass when compared to the less fit (Hall et al. 2004). This would be consistent with previous literature suggesting that trained individuals optimize locomotion from the biochemistry of muscle tissue to gait economy to minimize energy expenditure (Hall et al., 2004; Leger and Mercier, 1984; Hall et al., 2012). The individual with a lower percent body fat is carrying less excess weight, and therefore consumes less energy per unit of fat free mass. A separate but interesting difference in treadmill and track locomotion was seen in horses, where less energy was needed on the treadmill and was due to the shorter stride length during performance (Buchner et al. 1994). These results were similar to those seen in humans with shorter stride length on the treadmill (Elliot et al., 1976 and Nelson et al., 1972).

A pilot study conducted in preparation for this research produced interesting results. The results of this study are presented here. A total of 30 subjects (N=30, 15 males and 15 females, age = 21 ± 1.23 years) were included in the study to evaluate differences in walking and running one mile on a treadmill as compared to a track. A one way ANOVA was used to compare between group differences (treadmill vs. track). Comparison of track and treadmill showed higher values on treadmill walk and run for HR ($p<0.0001$ and $p=0.012$), RER ($p<0.0001$ and $p=0.024$), and RPE ($p=0.001$ and $p=0.001$). A comparison of genders showed significant differences between males and females. Males running speed was significantly greater than females in both conditions ($p=0.018$). Females showed to have a significantly higher heart rate while walking on the track and treadmill ($p=0.003$ and $p<0.0001$, respectively). Running energy expenditure (EE) and treadmill EE were significantly higher than walking EE and track EE, respectively ($p<0.0001$ and $p<0.0001$). EE was significantly greater in males during each of these conditions: treadmill walk ($p<0.0001$), treadmill run ($p<0.0001$), track walk ($p=0.009$), and track run ($p<0.0001$). It is worth noting that participants averaged running at 90.6% of VO_{2max} on the treadmill and only 84.9% of VO_{2max} on the track (Average VO_{2max}=37.73 ml/kg). Also worth noting, four participants could not complete the one mile run on the treadmill at determined self selected pace. Correlations were found between treadmill and track energy expenditure during running ($r=0.953$, $p<0.0001$). Also, correlations were found between HR and RPE during both treadmill (r =0.426, p=0.019) and track run (r=0.408, p=0.25). A 2x2 Repeated Measures ANOVA was used to determine a gender by group effect on VO2 (ml/kg) during the walk and run and also for energy expenditure (kcal/min) during the walk and run. A significant effect of condition (group) was found for VO2 during the walk (p=0.041). When examining the VO2 during the run, a significant effect was seen between gender (p=0.013), condition (p=0.005), and an interaction effect of gender by condition (p=0.030). There was a significant effect of gender on energy expenditure for the walk (p=0.001). When examining the energy expenditure for the running there was a significant effect of gender ($p < 0.0001$), condition (p=0.006), and an interaction effect of gender by condition (p=0.002). A pairwise comparison showed the following results. Walking VO2 was significantly higher for the treadmill (p=0.041).Males EE was significantly higher during walking (p=0.001). Males' running VO2 was significantly higher on the treadmill when compared to the track (p=0.002) and also higher than females on the treadmill (p=0.007). Also, males' running EE was significantly higher on the treadmill than the track during running ($p<0.0001$) with no difference for females. Descriptive data for this pilot investigation can be found in Table A-1 with results of the study being found in Table A-2 of the Appendix.

Discrepancies in physiological and perceptual responses from walking on a track when compared to walking on a treadmill show the need for further investigation to determine the superior modality of walking to promote health benefits, especially in those classified as overweight or obese. With energy expenditure being a primary concern for healthy weight loss, it would aid the exercise prescription and promotion process to know how the treadmill and track environments differ in relation to obese and non-obese individuals, physiological and perceptual responses, and self selected and prescribed paces. The literature shows inconsistencies in these areas and large gaps are present in how each of these variables relate to one another. A large focus should be placed on the interrelationship of exercise environment and modality, individuals' responses both physiological and perceptual, body mass and composition, and whether or not walking at a self selected pace or prescribed pace (such as the 3 to 4 mph recommended by ACSM) plays a significant role in attaining desired health benefits. This study attempts to investigate these relationships in order to provide further insight into exercise physiology, exercise metabolism, and the process of exercise testing and prescription.

CHAPTER III

METHODOLOGY

i. <u>Protocol</u>

Participants were asked to engage in two sessions (one in the Applied Physiology Laboratory of the Department of Health, Exercise Science, and Recreation Management and potential for one session on the Turner Center indoor track) each lasting approximately one hour and separated by at least 48 hours to provide ample time to attenuate any acute muscular soreness but not to exceed one week. Participants were instructed to partake in no vigorous physical activity during the 48 hour minimal rest period. Pre-exercise instructions regarding exercise and consumption were provided during the familiarization session and upon completion of each exercise session. Participants were asked to refrain from food and caffeine at least 4 hours prior to each exercise session and alcohol at least 48 hours prior. Also included in the pre-exercise instructions was the requirement to refrain from any moderate intensity physical activity for at least 12 hours prior to each exercise session and no vigorous physical activity 48 hours prior. Lastly, participants were instructed to maintain adequate fluid intake to aquire proper hydration status. Similar to ACSM (2010) and McArdle et al. (2010) recommendations, participants were advised to consume approximately 20 ounces of water at least 2 hours prior to arrival for testing. Each of these pre-exercise instructions were confirmed at the start of each session using verification questions on each data collection sheet. If any criteria was not met prior to commencement of exercise, the participant was asked to reschedule to session. To avoid any discrepency of diurnal variation, participants were asked to attend each session at the same time of day and follow their regular nutritional and hydration pattern. Due to the impact of ambient temperature and relative humidity on heart rate and perceived exertion, a temperature of 22° C (71.6° F) is considered proper for exercise testing (Pina et al., 1995 and Vogel et al., 1988). With shorter exercise periods and submaximal exercise, this temperature can vary by 4° C (Pina et al., 1995 and Vogel et al., 1988). Relative humidity should remain less than 60% to enhance proper cutaneous heat exchange and heat dissipation (Pina et al., 1995 and Vogel et al., 1988). Using the weather station, the proper temperature (°F) and relative humidity was verified prior to exercise testing for all sessions. Any temperature outside 70 ± 8.0° F or relative humidity of 50 ± 20% resulted in the rescheduling of that session. Prior to the commencement of the first session, informed consent and the ACSM health history questionnaire was completed by each participant.

ii. **<u>Participants</u>**

A total of 80 individuals aged 18-44 years and classified as overweight and 80 individuals classified as non-overweight (N=160), according to the body fat percentage criteria published in the American College of Sports Medicine's Guidelines for Exercise Testing and Prescription, 9th edition (2014) were recruited to participate in the study. These participants were further balanced to groups of 40 non-overweight males, 40 overweight males, 40 non-overweight females, 40 overweight males. Recruitment was conducted by verbal presentations by the investigator to classrooms within the Department of Health, Exercise Science, and Recreation Management. Verbal recruitment by the investigator was also extended to classrooms of the Department of Nutrition and Hospitality Management and Department of Pharmacy Administration. Recruitment emails were also sent within these respective departments and to the University of Mississippi Graduate School. Sample size calculations were determined via G*Power (Version 3.1, Faul, 2007) which produced a required total sample size of 159 participants with allocation ratio of one (α=0.05, Power=0.80, effect size=0.36). This effect size, between medium (0.25) and large (0.40) was calculated using the mean and standard deviation of heart rate values from the pilot data collected by the investigator with an ANOVA statistical test under the F-test family. With a total sample size of 160 participants, participants were randomly assigned to an exercise condition while accounting for weight status and sex. This lead to equal sample size (n=40) for the four exercise conditions, while participants were further separated by sex and weight status within their respective exercise condition. To account for any attrition, sample size was divided by (1-attrition rate). Using the pilot data for preparation of this study, attrition rate was less than 2 percent. This resulted in the sample size for the four exercise conditions remaining at 40 (N=160). Participants were considered untrained, defined as less than 60 minutes of aerobic exercise per week for the last 3 to 6 months, which was verified through completion of a health history questionnaire. Participants were considered for exclusion due to any history of lower body musculoskeletal system or central nervous system functions relating to posture and motor control within the last year that would hinder them from walking on a treadmill or indoor track. Participants were also excluded if classified as high risk for exercise as determined by the ACSM health history questionnaire and associated algorithm (Morris, 2014).

iii. <u>Session 1 – Familiarization</u>

At the start of this session, an informed consent document was explained and voluntarily signed by each participant. Once consent was established, standard anthropometrics were measured including body weight (lbs. and kg), height (in. and cm), and body composition were determined for each participant. Using height and weight measurements, participants were screened and qualified for the study if they are classified as overweight or non-overweight as determined by BMI criteria established by ACSM guidelines (ACSM, 2010). Body fat percentage was determined using dual energy x-ray absorpitometry (DXA) as measured by a Hologic Dephi, QDR series (Bedford, MA). The DXA software used algorithms to quantify fat, fat-free soft tissue, and bone mineral density. This software was capable of these measures using differential attenuation of the dual x-ray signals as they reflected through the body. The maximal x-ray dose for non-occupational exposure is 500mR per year (Boudousq et al., 2003), whereas the effective dose of radation for a whole body DXA scan was approximately 1.5mR per scan. This establishes the DXA scan to be minimal radiaiton exposure. Body fat percentage ranges for consideration in the study were determined using prevously published recommendations accounting for gender and age (ACSM, 2010). Overweight but otherwise healthy males considered for the study possessed a body fat percentage greater than 22% and females possessed a body fat percentage greater than 32% (ACSM, 2010). Using the body fat percent measured, participants were classifed into a weight category (overweight or non-overweight) for purposes of the study and for statistical analysis. Due to the radiation exposure associated with DXA, all females were required to complete a urine analysis pregnancy test. All female participants were required to not be pregnant for use of the DXA. Following procedures similar to Morris (2014), written and oral instructions were provided for completion of a urine pregnancy test. The pregnancy testing kit was provided and each participant was directed to the restroom. The urine samples were collected from each participant upon return to the laboratory where the researcher was responsible for conducting pregnancy analysis. This analysis had to show conclusive negative results for the participant to continue in the study. If positive or inconclusive results were found, individuals were not allowed to complete the DXA body scan and were advised to check with a physician for confirmation.

Informed consent documents were collected and the ACSM health history questionnaire along with the Physical Activity Readiness Questionnaire (PAR-Q) were completed and collected prior to commencement of exercise and/or testing (Morris et al., 2013). During the familiarization session all equipment was introduced to minimize any discomfort and/or anxiety during exercise and the second session. Participants were fitted to proper blood pressure cuff which was used for all measurement procedures in both sessions. According to Wofford et al. (2002), an arm circumference less than 9.5 inches requires a child size cuff, 9.5 to 12 inches requires a regular adult cuff, 13 to 16.5 inches requires a large adult cuff, and greater than 16.5 inches requires an adult extra large cuff. Circumference of the arm was taken half way between the acromion process and lateral epicondyle. Two of the four exercise conditions were conducted on a treadmill in the Applied Physiology laboratory (Trackmaster, Full Vision, Fulton, KS) which required introduction of this equipment during this familiarization session. All four exercise conditions (session 2) used the portable metabolic system (Cosmed K4b2, Rome, Italy) for collection of oxygen consumption and relevant metabolic data. Also included in familiarization was the headgear which stabilizes the breathing turbine for the participant, and a gas transfer tube that moves the expired collected gases to the collection chamber on the metabolic system for continuous sampling. This unit is light weight (3.2 lbs for the unit and 0.4 lbs. for the headgear) and includes a pack strap style carrying case where the portable metabolic collection unit is attached on the front of the participant and rests slightly below the level of the sternum and the portable battery rests on the back of the participant around the level of the inferior angle of scapula. Following equipment familiarization, participants were introduced to the rating of perceived exertion (RPE) scale to be used during sessions in order to monitor subjective measurement of physical exertion (Borg's 6-20 RPE rating scale). The 0-10 Category Ratio (CR) Pain Intensity scale was also introduced to the participants as it was used as a secondary measure of physical exertion. This scale and its reliability have been validated in previous research (Cook et al., 1997 and Micalos et al., 2004). Each participant's rating of perceived exertion from both scales was recorded every two minutes of exercise during the treadmill test to volitional fatigue and exercise test during session 2.

As previously published by CDC (2015), the following instructions were given to each participant in an attempt to explain the Borg RPE scale and its purpose: "While doing physical activity, we want you to rate your perception of exertion. This feeling should reflect how heavy and strenuous the exercise feels to you, combining all sensations and feelings of physical stress, effort, and fatigue. Do not concern yourself with any one factor such as leg pain or shortness of breath, but try to focus on your total feeling of exertion. Look at the rating scale while you are engaging in the physical activity; it ranges from 6 to 20, where 6 means 'no exertion at all' and 20 means 'maximal exertion'. Choose the number from below that best describes your level of exertion. this will give us a good idea of the intensity level of your activity. Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is. Your own feeling of effort and exertion is important, not how it compares to other people's."

Participants were also instructed on the use of the CR-10 Pain Intensity Scale using a script similar to Cook et al. (1997), which is as follows. "The scale before you contains the numbers 0-10. You will use this scale to assess perceptions of pain during the exercise test. In this context, pain is defined as the intensity of hurt that you feel. Don't underestimate or overestimate the degree of hurt you feel, just try to estimate it as honestly and objectively as possible. The numbers on the scale represent a range of pain intensity from “very faint pain” (number 0.5) to “extremely intense pain-almost unbearable” (number 10). When you feel no pain, you should respond with the number 0. If you feel extremely strong pain that is almost unbearable, you should respond with the number 10. If the pain is greater than 10, respond with the number that represents the pain intensity you feel in relation to 10. For example, if the pain is twice as intense as 10 give the number 20. Repeatedly during the test you will be asked to rate the feelings of pain in your legs. When rating these pain sensations, be sure to attend only to the specific physiological sensations and not report other pains you may be feeling(e.g., seat discomfort). Do not use your ratings as an expression of fatigue (i.e., inability of the muscle to produce force) or relief that the exercise task is completed.

Participants were also introduced to the blood lactate analysis equipment (Lactate Plus, Nova Biomedical, Waltham, MA) and procedures (see below). Estimated heart rate max (HRmax) was determined via the common standard equation (220-age) and used for evaluation of VO_{2max} attainment and monitoring of heart rate during all exercise for adverse risks. Following familiarization of VO_{2max} testing and the protocol being used, all potential risks of maximal exercise were discussed with the participant. The potential risks may include but are not limited to: muscular discomfort, fatigue, and/or falling due to increased treadmill speed, and myocardial infarction. Although inherent risks are present during exercise testing, participants were then assured of investigators’ experience and training of VO_{2max} testing which significantly minimizes these potential risks. In addition, the principal investigator holds a license as a certified emergency medical technician.

Using a telemetry Polar heart rate monitor (Polar Electro, Polar FT1, Kempele, Finland) resting heart rate was determined during a 5 minute rest period and heart rate information was monitored and collected during all exercise sessions. Resting blood pressure was also measured by way of blood pressure cuff and stethoscope following the rest period. Each participant's self selected walking pace was determined by use of pre-determined distance trials as explained by Browning and Kram (2005), Loftin et al. (2010), and Morris et al. (2013). Briefly, this procedure required each participant to walk at their desired pace for a total of seven trials for a distance of 70 feet. The participants time to complete the inner 50 feet was recorded as their preferred pace and the average pace of the final six trials was calculated. Using time to pace conversion equations, this averge pace was used to determine each particpant's self selected speed in miles per hour (mph).

The last portion of the familiarization session consisted of a treadmill exercise test to volitional fatigue conducted in the Applied Physiology Laboratory. Due to the nature of this exercise, all participants were screened using the answers of the completed health history questionnaire and risk stratification algorithm established in the American College of Sports Medicine's Guidelines for Exercise Testing and Prescription, 9th edition (2014). Participants were allowed to participate in the remainder of the research investigation if they were classified as low or moderate risk for exercise. The VO_{2peak} test allows the establishment of baseline values for comparison of succeeding sessions. The maximal test also provides individual reference values to express submaximal variables, obtained in succeeding sessions, as a percentage of VO_{2peak}. Obtaining VO_{2peak} is important when attempting to determine energy expenditure for an individual and, in turn, attempting to compare submaximal energy expenditure (from certain activities, intensities, and environments) to a percentage of maximal aerobic capacity and the energy expenditure that corresponds. Using the VO_{2peak} testing protocol, individual maximal heart rate was determined and used for exercise prescription during session 2. Each VO_{2peak} test was conducted on the treadmill (same treadmill as previously mentioned) and the metabolic cart (ParvoMedics TrueOne 2400, Sandy, UT) was used for metabolic data collection, all under the supervision of at least 2 experienced investigators. Maximal exercise testing procedures followed the modified Bruce protocol which progresses as follows:

Stages	MPH	% inclination	Minutes
1	1.7	0	3
2	1.7	10	3
3	2.5	12	3
4	3.4	14	3
5	4.2	16	3
6	5.0	18	3
7	5.5	20	3

The Modified Bruce protocol was followed until the participant reached volitional fatigue. At this point, testing was ceased and participants were allowed a self selected walking cool-down. As mentioned previously, heart rate was collected from the Polar heart rate monitor every minute along with the subjective measure of exertion using the Borg RPE scale. Testing was ceased if at any point the participant requested to stop or adverse events were recognized. Following VO_{2peak} cool-down, participants were instructed to complete a stretching routine to minimize any muscular discomfort or delayed onset muscle soreness

iv. **Blood lactate sampling**

Blood lactate was sampled via finger prick from capillary blood flow in the middle finger of the right hand (pre-test) and middle finger of the left hand (post-test) for each participant. The procedures for blood lactate sampling are explained below and this process has been established as effective and reliable by previous research (Medbo et al. 2000, Buckley et al. 2003, Abe et al. 2015, Coutts et al. 2007). The Lactate Plus analyzer was calibrated prior to each exercise session according to Nova Biomedical specifications using a Level 1 quality control solution. This particular analyzer used lactate test strips (Lactate Plus strips 40813, Nova Biomedical, Cheshire UK) which collect a single drop of capillary blood for analysis. Once the test strip was inserted into the analyzer, an automatic system check is completed and participant's identification number was entered. The participant's finger was wiped clean using a sanitary alcohol preparation pad, then moistened paper towel, and dried via paper towel before sampling. This allowed for the removal of any contaminants or lactate associated with sweat production. Following preparation of the finger, the automatic lancing device (Autolet Impression, Owen Mumford, Oxford UK) was used with an ultra-fine 30 gauge lancet (BD Ultra-Fine lancet, Becton Dickson and Company, Franklin Lakes, NJ) to puncture the superficial layer of the medial aspect of the middle finger. Once the initial blood drop was wiped and discarded, the finger was lightly squeezed by an experienced researcher to avoid the collection of strictly interstitial fluid, and the second blood drop was collected on the lactate test strip for lactate measurement. This process requires a minute amount of blood (approximately 5-15 microliters) before the analyzer will beep indicating an adequate sample has been collected. Approximately 13 seconds following the collection of the blood sample, on screen results were displayed for blood lactate concentration. Following blood sampling, a sterile cotton ball was used to wipe away any capillary blood residue and a sterile band-aid provided to cover the puncture site. Due to the inherent potential danger of exposure to blood, investigators were protected with powder free vinyl exam gloves, which were disposed of in the proper biohazard container in the Applied Physiology Laboratory of the Turner Center. All equipment used for blood sampling, including but not limited to, lancet, test strip, alcohol swaps, and cotton ball were also disposed of in the proper biohazard container. The lactate analyzer was then sterilized using alcohol swabs in accordance with Nova Biomedical recommendations. These procedures for blood sampling were not required to be approved by the Institutional Biosafety Committee (IBC) due to the exclusion criteria stated on the IRB application. This states "Excluded from the IBC requirement are: saliva, urine, and simple blood collections/sampling/typing using lancet drawn samples of less than 1/2 ml." This protocol meets the exclusion criteria of blood sample size and lancet drawn.

v. **Exercise conditions**

Upon completion of the familiarization session, each participant was randomized to an exercise condition for their second and final session. The four conditions were titled “condition 1-4” and included the following modality and intensity. Condition 1 was a one mile walk at self selected pace on the indoor track of the Turner Center. Condition 2 was a one mile walk at self selected pace on the treadmill in the Applied Physiology Laboratory. Condition 3 was a one mile walk at a prescribed pace to ellicit 50 – 60 % of heart rate reserve (HRR) on the indoor track. Lastly, condition 4 was a one mile walk at a prescribed pace to ellicit 50 – 60% of HRR on the treadmill. The procedure for calculating HRR is explained under the section of the respective conditions using this intensity measure.

vi. Session 2

Following the mandatory 48 hour rest, participants were asked to report to the Applied Physiology Laboratory in the Turner Center for collection of body weight, height, blood pressure, and resting blood lactate before moving to the specified location for the assigned exercise condition. Using data from the pilot study, the mean systolic blood pressure was 126 ± 18 mmHg. For any pre-exercise blood pressure outside 1 standard deviation from the blood pressure obtained during the familiarization session, participants were required to reschedule the second session. Restrictions were also applied for pre-exercise blood lactate measurement where measurement must not exceed the normal limits of 0.8 – 2.2 mmol/L as described in previous research (Ali et al., 2008). Ambient temperature, barometric pressure, and relative humidity were provided via electronic monitoring device referred to as the weather station (Davis, Vantage Vue, Hayward, CA). This information was also used for calibration of the portable unit to be used for collection of metabolic data during the exercise session. Participants were fitted to the Cosmed K4b2 unit and Polar heart rate monitor, and allowed 5 minutes of rest to make sure all pieces of equipment were correctly fitted and as comfortable as possible in attempt to eliminate any effect of anxiety or psychological stress. The light weight unit allows for metabolic field testing in an activity familiar to the individual without limitation to a stationary device.

As previously mentioned, participants were randomly assigned to an exercise condition for their second session. These conditions and the testing procedures used are explained below.

vii. **Condition 1 – Walking on indoor track at self selected pace**

Condition 1 consisted of a one mile walk at self selected pace on the indoor track of the Turner Center. Prior to escort to the indoor track, body weight, height, blood pressure, and resting blood lactate was obtained. Participants were also fitted to a Polar heart rate monitor. Upon arrival to the indoor track, participants were instructed to walk at their self selected pace that was determined during the familiarization session. A designated start and finish line were marked for use of measuring a precise mile on the indoor track and these markings were shown to each participant assigned to this exercise condition. Participants were instructed to walk along designated markings assigned to the middle portion of the track. By walking in this middle lane, the distance of one lap around the track equated to 617 feet and 9 inches per lap. This distance per lap required the partcipant to walk 8.54 laps in order to reach a distance of one mile. Testing commenced once the participant reached the established starting line and ceased upon completion of the one mile walk. Using the mph walking pace determined from the familiarization session, a time to complete the mile was calculated and a time to complete each lap was further calculated. From this time to complete each lap, walking pace was monitored and participants were encouraged to increase or decrease walking speed when passing the researcher on each lap. The same Borg RPE and CR-10 Pain Intensity scales as explained earlier were used for participants to provide a perceptual rating upon completion of each lap during the one mile walk. These two scales were held by researchers to provide a visual reminder of the numerical scale and its verbal anchors. Also upon completion of each lap, heart rate was observed and recorded from the Polar heart rate monitor and its corresponding telemetry watch. All variables were continuously monitored via telemetry mode of Cosmed K4b2 unit and a laptop computer with appropriate Cosmed software and programming. This mode allows visual observation of variables on the appropriate laptop computer screen within 50 meters of the portable unit. Telemetry mode was considered advantageous by allowing investigators to monitor heart rate and VO_2 continusously during exercise. This provides the researcher to monitor any risk of adverse events during exercise. Upon completion of the one mile walk, the portable metabolic unit was removed and participants were directed to the seating area and instructed to be seated in the bench seat at the corner of the track. In this location, participants were secluded from other individuals while blood pressure was obtained three times with the average being recorded. During the three measurements of blood pressure, adequate time elapsed for blood lactate circulation to occur in order to take the measurement during the time frame of peak values. Blood lactate was sampled at minute 4 of the post-exercise period. Following these post-exercise physiological measurements, one lap of self selected pace walking was implemented as cool-down and a stretching routine was advised by investigators to minimize any muscular discomfort or potential muscle soreness.

viii. **Condition 2 - Walking on treadmill at self selected pace**

For Condition 2, participants were asked to report to the Applied Physiology Laboratory for collection of body weight, height, blood pressure, and resting blood lactate before the equipment for the portable metabolic system was fitted. Similar to the previously explained condition, Condition 2 implemented a one mile walk at self selected pace on the treamill in the Applied Physiology Laboratory. Ambient temperature, barometric pressure, and relative humidity were again collected via the electronic weather station. Participants were fitted to a Polar heart rate monitor for observation of heart rate during test via telemetry. Participants were allotted a five minute resting period allowing for adjustments of equipment to ensure optimal comfort. Following the resting period and fitting of the portable metabolic unit, participants began testing by walking on the treadmill at the mph corresponding to the self selected pace determined during familiarization session. Participants were instructed to walk for a time period equivalent to one mile at this pace and the distance gauge on the treadmill was used to verify proper duration of a one mile walk. With this being a laboratory test using the portable metabolic system, all variables were again visible and readily available for investigators to monitor any potential adverse risks of exercise. At two minute intervals, heart rate, RPE, and CR-10 pain ratings were recorded. The Borg RPE scale and CR-10 pain scale were posted on the wall in front of the treadmill and particpants were instructed to give hand signals of the numerical rating from each scale. Participants were instructed not to verbally give their rating due to the change in respiration that occurs during speech. Upon completion of the one mile, the portable metabolic system was removed and participants were instructed to be seated behind a privacy screen and blood pressure was obtained three times. Following this measurement, blood lactate was sampled. A cool-down consisting of a walk at self selected pace was implemented once physiological measures were obtained. This cool-down was then followed by an advised stretching routine to minimize any muscular discomfort or potential muscle soreness.

ix. **Condition 3 – Walking on indoor track at prescribed pace.**

Condition 3 consisted of a one mile walk at a prescribed speed to ellicit 50 - 60 % of HRR on the indoor track of the Turner Center. Following the mandatory 48 hour rest after the familiarization session, participants reported to the Applied Physiology Laboratory for collection of body weight, height, blood pressure, and resting blood lactate before moving to the indoor track where this session took place. Ambient temperature, barometric pressure, and humidity were recorded via the electronic weather station. Participants were fitted to the Cosmed K4b2 unit and Polar heart rate monitor, and allowed 5 minutes of rest to make sure all pieces of equipment were correctly fitted and as comfortable as possible. This also allowed for participants to return to a resting state before exercise commencement. Participants were then instructed to walk at 50 – 60 % of their calculated HRR for the duration of one mile. This relative intensity value was determined using the following equation: 50% HRR = [(HRmax – HRrest) x 0.50] + HRrest while 60% HRR = [(HRmax – HRrest x 0.60] + HRrest. The maximal heart rate obtained from VO_{2max} testing during the familiarization session was used for this equation. Resting heart rate was considered as the obtained value from pre-exercise measurements of this particular session. Testing started once the participant reached established starting line and ceased once one mile was completed. Proper intensity was verified via Polar heart rate monitor and corresponding watch. As participants completed each lap, heart rate was observed and recorded. Participants were encouraged to increase or decrease speed based on the available data (heart rate values) in order to maintain proper pace. Also as participants completed each lap of the one mile walk, a measure of RPE and CR-10 pain was recorded from the available scales and non-verbal numerical signs provided from the participant. All variables were continuously monitored via telemetry mode of Cosmed K4b2 and laptop computer. Similar procedures were followed as Condition 1 on the indoor track upon completion of the one mile walk. The portable metabolic system was removed and participants were directed to the secluded seating area and instructed to be seated in the corner bench seat where blood pressure was measured three times and blood lactate was sampled at minute four. Following blood pressure and blood lactate measurements, one lap of walking at self selected pace was allotted for cool-down and a stretching routine was advised by investigators to minimize any muscular discomfort or potential muscle soreness.

x. **Condition 4 – Walking on treadmill at prescribed pace.**

Condition 4 consisted of a one mile walk at a prescribed speed to ellicit 50 - 60 % of HRR on the treadmill in the Applied Physiology Laboratory. Following the mandatory 48 hour rest after the familiarization session, participants reported to the lab for collection of body weight, height, blood pressure, and resting blood lactate. Similar to previous sessions, ambient temperature, barometric pressure, and relative humidity were collected via the electronic weather station for use on the portable metabolic system. Participants were fitted to a Polar heart rate monitor for observation of heart rate during test via telemetry. This exercise condition included a similar protocol as Condition 3 with a 5 minute resting period following equipment fitting to allow for adjustments of equipment and return to a resting state. Following the resting period, participants began testing by walking on the treadmill at self selected speed and speed was adjusted to an intensity elliciting 50 – 60 % of HRR. This speed was maintained for a duration of one mile as long as participants remained within the target heart rate range. This relative intensity value was determined as previously described in Condition 3 using the appropriate equations. Heart rate was continuously monitored from the Polar heart rate watch to ensure proper intensity for the duration of the one mile walk. At two minute intervals, RPE and CR-10 pain ratings were obtained from each participant via non-verbal numerical hand signals. Upon completion of the one mile and removal of the portable metabolic system, participants were directed to the secluded seating area behind a privacy scrren for blood pressure and blood lactate measurement. Following the collection of these physiological measures, a cool-down was implemented consisting of a walk at self selected pace on the treadmill. This cool-down was followed by a stretching routine to minimize any muscular discomfort or potential muscle soreness.

xi. Variables observed during and after exercise

Pre-exercise blood pressure, heart rate, blood lactate, and mean arterial pressure were collected upon arrival for each testing session. Blood pressure was obtained three times with the average of systolic and diastolic measurements being recoreded as similar to Loenneke et al. (2014). During each exercising session, heart rate and rating of perceived exertion were recorded for each lap on the track. Heart rate and RPE was collected on the treadmill at time intervals equivalent to each lap on the track (approximately every 2 minutes). Post-exercise measures were obtained for blood pressure, heart rate, blood lactate, and mean arterial pressure. Energy expenditure was calculated via integrated equations of the Cosmed K4b2 unit and further verified according to Weir's equation:

Kcal = [(1.1 * RER) + 3.9] * VO2 (L/min). This equation has established reliability and validity in previous research (Weir, 1949; Segal, 1987; Puyau et al., 2004; Treuth et al., 1998; Weinsier et al., 2000).

xii. Limitations

There were several limitations to this study. First blood lactate, blood pressure, and heart rate have been seen to fluctuate throughout the day following diurnal patterns and sex differences have also been seen. Second, diet was not controlled during this study, and previous research has found that a change in dietary patterns could alter responses to exercise. Third, the phase of menstral cycle in females was not controlled for which could alter physiological and perceptual responses to exercise. Fourth, conducting a maximal exercise test on individuals with excess adipose weight presents concern and difficulty in attainment of a true VO_{2max}. Lastly, when prescribing a speed to ellicit 50 – 60% of HRR, those in the overweight category were required, on average, to walk at a significantly higher speed than their preferred speed which could create concern for adverse health outcomes.

xiii. <u>Delimitations</u>

Variability of the information collected during this study was controlled within the scope of this research. First, since known diurnal fluctuations are present in physiological vaiables, participants were asked to return for their second session within one hour of the scheduled time of the first session. Second, participants were instructed to maintain normal dietary habits to limit any variation in responses due to dietary intake. Participants were also required to refrain from any food and caffeine at least 4 hours prior to exercise session and alcohol at least 48 hours prior. Also, participants were asked to maintain adequate hydration and consume approximately 20 ounces of water at least 2 hours prior to the scheduled start of each session. Third, each participant was asked to schedule the second session approximately 48 hours after the first session which assists in limiting any effect of mensturation. Fourth, those classified as high risk for exercise in accordance to the ACSM risk stratification guidelines were excluded from the study. These restrictions strengthened the study by screening certain subjects who had preexisting conditions that could alter the exercise response. Fifth, participants were recruited from a diverse population across the University of Mississippi campus which helps to eliminate any bias of a nesting effect within one particular department. Sixth, all testing procedures, blood pressure measurements, and blood analyses were conducted by the same investigator to reduce error due to inter-observer data collection and this increased reliability of the measures. All blood draws were conducted by a trained, experienced, and calm technician which served to decrease apprehensiveness and perceived invasiveness. Lastly, other than instruction to speed up or slow down, all participants were given no verbal encouragement during the VO_{2peak} test or during the one mile walk which eliminated any risk of altering the oucomes of exercise.

xiv. <u>**Statistical Analysis**</u>

All data were organized according to the four independent variables each consisting of two levels (prescribed and self selected pace, track and treadmill, overweight and non-overweight, male and female) and two dependent variables (physiological and perceptual responses). Data have been presented as mean ± standard deviation (SD). To investigate each of the aforementioned specific aims of this study, all variables mentioned above have been used for a between groups analysis using a Factorial Analysis of Variance (ANOVA) procedure. Initially, a 2x2x2x2 Factorial ANOVA [Four between groups factors with two levels each (treadmill vs. track, self selected vs prescribed pace, overweight vs. non-overweight, male vs. female)] was used for the evaluation of effect of weight status, modality, pace, and sex on the physiological and perceptual values. A test for the presence of a significant 4-way interaction effect was determined initially. Following this, the presence of any 3-way or 2-way interactions were determined. If any two-way interactions were present, they were further analyzed for simple effects. If no 2-way interactions were found, the main effects of modality, pace, and weight status were determined. Relationships were determined between a perceptual measure (Final Rating of Perceived Exertion) and a physiological measure (Final Heart Rate) for all between group conditions using a Multiple Regression Analysis. For purpose of this anaylses, heart rate values were used to predict RPE values across all exercise conditions by way of dummy variable coding. Fifteen dummy variables were created along with 15 interaction dummy variables for a total of 31 predictor variables. All statistical analyses were conducted using SPSS software

(Version 22, SPSS, Inc., Chicago, IL). Statistical significance (α) was defined as a *p*-value less than 0.05.

CHAPTER IV

RESULTS

There were multiple aims of this study designed to investigate the physiological and perceptual responses to walking one mile. The purpose for this study was to determine any interaction or main effect of modality, pace, weight status, and sex on the exercise response variables measured. Also of interest was the relationship between the physiological response (HR) and perceptual response (RPE) and if this relationship was altered by modality, pace, weight status, or sex which will be discussed at the end of this section. These predictor variables (modality, pace, weight status, and sex) were used to evaluate the effect on physiological responses as represented by the difference in systolic and diastolic blood pressure from pre-exercise to post-exercise, time to return to resting heart rate, oxygen consumption (VO2), metabolic equivalent worked (METS), respiratory exchange ratio (RER), respiratory rate (RR), energy expenditure per minute (Kcal/min), total energy expenditure (Kcal), blood lactate difference from pre-exercise to post-exercise (BLa), average heart rate during exercise (HRavg), final heart rate at cessation of exercise (HRfinal), and the percentage of heart rate max during exercise (%HRmax). The same predictor variables were also used to evaluate an effect on perceptual responses as represented by rating of perceived exertion average (RPEavg), final rate of perceived exertion at cessation of exercise (RPEfinal), category rating of pain intensity 0-10 average score (CR10avg), and final category rating of pain intensity 0-10 at cessation of exercise (CR10final). The results of this study are presented in the following sections as groups by sex and groups by weight status. Aerobically untrained individuals were recruited to participate in this study (N=161). Out of the 161 total participants, one female did not return for the second session and thus was excluded from analysis which provided a total sample size of 160 participants (80 males and 80 females) resulting in a 99.38% retention rate. Due to the observation that not all participants achieved established criteria for VO_{2max} attainment, data representing these values will be expressed as VO_{2peak}.

i. **Descriptive statistics by sex**

Of the males who participated in this study, the mean age was 22.85 ± 3.59 years, while females were 21.18 ± 1.59 years (overall age of 22.01 ± 2.90 years). In comparison between males and females, height and weight were significantly different (F=87.95, p<.001 and F=33.13, p<.001, respectively). Body Mass Index and body fat percentage for males was significantly correlated (r=0.541, p<0.001) and also for females (r=0.725, p<0.001). BMI was significantly higher for males (F=5.59. p=0.019) while body fat percentage was significantly higher for females (F=53.35, p<0.001). Significant differences were seen between males and females for maximal heart rate and VO_{2peak} with males possessing higher values for both (F=4.46, p=0.036 and F=34.94, p<0.001, respectively). Although no differences were seen between males and females for resting heart rate or resting blood lactate, systolic (F=16.28, p<0.001) and diastolic blood pressures (F=7.22, p=0.008) were significantly different with males having higher blood pressure. By way of the 70 foot walk test, self selected walking speed was determined and no difference in speed was seen between males and females. No differences were seen in 50% and 60% of HRR when males were compared to females. Descriptive data are presented as mean ± SD for these participants in Table A-3 of the Appendix.

ii. Descriptive statistics by weight status

The participants were further assigned to groups of overweight males (n=40), overweight females (n=40), non-overweight males (n=40), and non-overweight females (n=40) by use of body fat percentage recommendations for age (ACSM, 2010). For the purpose of the comparison of descriptive statistics between overweight and non-overweight participants, sex was controlled for. The comparison between overweight and non-overweight participants revealed no difference in height but a significant difference in weight with the overweight participants averaging higher values ($F=12.04$, $p=0.001$). Body mass index and body fat percentages were significantly higher for the overweight participants as compared to the non-overweight ($F=21.95$, $p<0.001$ and $F=110.94$, $p<0.001$, respectively). No differences were seen in maximal heart rate while the non-overweight participants produced higher VO_{2peak} values compared to the overweight ($F=39.30$, $p<0.001$). Resting blood lactate showed no difference between groups while resting heart rate was significantly higher for the overweight participants ($F=4.43$, $p=0.037$). Systolic and diastolic blood pressures were significantly higher for the overweight participants also ($F=6.46$, $p=0.012$ and $F=6.88$, $p=0.010$, respectively). No significant differences were seen in self selected speed, 50% of HRR, or 60% of HRR when the overweight participants were compared to the non-overweight. Descriptive data are presented as mean ± SD for these participants in Table A-3 of the Appendix.

iii. Physiological responses to alternate modalities and intensities of exercise between weight status

Table A-4 of the Appendix provides the mean and standard deviations of descriptives for each outcome variable separated into the four conditions (track at self selected pace, treadmill at self selected pace, track at prescribed pace, treadmill at prescribed pace) and weight status groups (overweight and non-overweight). When using the 2x2x2x2 Factorial ANOVA design, no 4-way interactions or 3-way interactions were seen for any outcome variables. Further analyses were conducted and showed all effects remained the same when sex was removed as an independent variable. Therefore, for all interaction and main effect differences, sex as a categorical variable was controlled for. With sex collapsed and removed from the model to be used as a control factor, all significant differences in physiological and perceptual responses remained. Factorial ANOVA results using pace, modality, and weight status as independent variables indicated significant two-way interactions in three of the physiological response outcome variables. A significant two-way interaction was found for respiratory rate ($p=0.003$), the blood lactate difference from pre to post-exercise ($p=0.037$), and post exercise blood lactate concentration ($p=0.049$). The results of the interaction effects can be seen in Table A-5. For respiratory rate, an interaction was found between modality and pace and can be seen in Figure B-1. At the prescribed intensity, a significant difference was seen between the track and treadmill ($p=0.001$) with the track producing a higher respiratory rate as compared to the treadmill. Also for respiratory rate, there was a significant difference between self selected pace and prescribed pace at the track ($p=0.006$) with prescribed pace resulting in higher values. No difference in respiratory rate was seen between pace on the treadmill and no difference was seen between modality during the self selected pace one mile walk. For the blood lactate difference between pre and post-exercise, a significant interaction was found between modality and pace and can be seen in Figure B-2. During prescribed intensity, a difference was seen between modality ($p=0.041$), with the track increasing blood lactate to a greater extent than the treadmill. Also, on both the track and the treadmill, prescribed intensity increased blood lactate significantly ($p<0.001$ and $p<0.001$, respectively). No significant increase in blood lactate was seen at self selected pace on either the track or the treadmill. In fact, an overall decrease in blood lactate was apparent from exercising at self selected pace. The same results of this interaction between modality and pace were seen on post exercise blood lactate values. At prescribed intensity, a difference was seen between modality ($p=0.001$) with the track resulting in higher post exercise blood lactate concentration. For prescribed intensity, post-exercise blood lactate concentration was higher on both the track and the treadmill ($p<0.001$ and $p=0.013$, respectively). No difference was seen in post-exercise blood lactate concentration when exercising at self selected pace.

Table A-6 provides the mean and standard deviations of descriptives separated by exercise condition and weight status for each of the physiological outcome variables effected by pace. Factorial ANOVA using condition and weight status as independent variables indicated a main effect of pace in 11 physiological outcome variables. The average self selected speed equated to 3.01 mph while the average prescribed pace was 3.45 mph. Those participants in the prescribed pace exercise conditions increased their walking speed 17.38% above their self selected pace in order to reach the 50-60% of HRR, creating a higher intensity level for the one mile walk. The results discussed below of the main effect of exercise pace can be seen in Table A-7. Prescribed pace resulted in significantly greater increases in both systolic and diastolic blood pressure from pre-exercise to post-exercise measurement ($p<0.001$ and $p<0.001$, respectively). Significant differences were also seen for post-exercise systolic and diastolic blood pressure values with higher pressures being the result of prescribed pace ($p<0.001$ and $p=0.004$, respectively). One variable of interest is heart rate recovery defined as the time taken for heart rate to return to within 10 beats per minute of individual resting heart rate. A significant difference was seen between self selected and prescribed pace with the later resulting in a longer time to return to resting heart rate ($p<0.001$). With the average amount of oxygen consumed during exercise, represented by average VO_2, prescribed pace caused individuals to consume more oxygen during exercise when compared to self selected pace ($p<0.001$). For metabolic equivalent, METS, prescribed pace also resulted in higher values ($p<0.001$). The average heart rate during exercise and final heart rate at cessation of exercise were significantly higher as a result of prescribed pace as compared to self selected pace ($p<0.001$ and $p<0.001$, respectively). Also during exercise, the percent of maximal heart rate individuals worked at was significantly higher during prescribed intensity ($p<0.001$). Lastly, one of the primary variables of interest, energy expenditure during exercise expressed as kilocalories per minute showed significant differences with prescribed pace causing higher expenditure ($p<0.001$).

Table A-8 provides the mean and standard deviations of descriptives separated by exercise condition and weight status for each of the physiological outcome variables with a significant main effect due to weight status. Factorial ANOVA using condition and weight status as independent variables indicated a main effect of weight status in five physiological outcome variables. These results of differences due to weight status can be seen in Table A-9. The average amount of oxygen consumed was significantly higher for non-overweight individuals as compared those considered overweight for each pace and modality ($p=0.037$). For metabolic equivalents, those classified as non-overweight produced higher values across all conditions ($p=0.027$). With respect to weight status, individuals classified as overweight showed a higher final heart rate at cessation of exercise and worked at a higher percentage of maximal heart rate during exercise when compared to those classified as non-overweight ($p=0.049$ and $p=0.016$, respectively). The total amount of energy expenditure throughout exercise, represented by total energy expenditure, was significantly higher for overweight individuals compared to the non-overweight in all exercise conditions (p=0.019).

iv. **Perceptual responses to alternate modalities and intensities of exercise between weight status**

Means and standard deviations as related to exercise condition and weight status for perceptual response outcome variables can be found in Table A-10, while the results of the main effect due to modality can be found in Table A-11. As with the physiological response variables, a Factorial ANOVA was used to determine any differences in perceptual responses due to modality, pace, or weight status. While controlling for sex, differences across conditions remained the same indicating the differences were similar across sex. For the average rating of perceived exertion (RPE) during exercise, the treadmill produced higher feelings of exertion when compared to the track (p=0.004). Final RPE, the final value at cessation of exercise, was significantly higher for the treadmill when compared to the track at both self selected and prescribed pace (p=0.017). Lastly, the category ratio 0-10 pain intensity rating (CR-10) showed a higher score on the treadmill as compared to the track at both paces (p=0.038).

Table A-12 of the Appendix presents the mean and standard deviations of descriptives separated by exercise condition and weight status for perceptual responses with a main effect due to exercise pace and the statistical results of the differences due to pace can be found in Table A-13. The average RPE during exercise was significantly higher during exercise of prescribed pace on both the track and treadmill when compared to self selected pace (p<0.001). Similar results were seen for the final RPE at cessation of exercise with prescribed pace resulting in higher feelings of exertion on both the treadmill and track (p<0.001). The average rating of pain during exercise as represented on the CR-10 scale was significantly higher on the treadmill and track at prescribed pace compared to self selected pace ($p=0.005$). Lastly, similar results were found for the final CR-10 rating of pain at the cessation of exercise with prescribed pace leading to higher values when compared to self selected pace on both exercise modalities ($p<0.001$).

v. <u>Relationship between physiological and perceptual responses across exercise conditions.</u>

As mentioned previously, a secondary aim of this study was to investigate the relationship between the physiological response (HR) and perceptual response (RPE) and if this relationship was altered by modality, pace, weight status, or sex. Using a multiple regression analysis with 15 dummy variables and 15 dummy interaction variables, final HR was used as an additional predictor of final RPE to determine the effect of exercise condition on physiological and perceptual response relationships. Across the exercise conditions, results from the regression analysis showed no significant difference in the relationship between HR and RPE ($F_{(15,128)}=1.36$, $p=0.177$). No effect of weight status was seen on the relationship between HR and RPE ($F_{(1,156)}=541$, $p=0.463$). When Figure B-3 was created for the representation of this relationship, interesting variations were seen in HR and RPE within groups. As seen in Figure B-3, the variability in HR seems to be greater in Conditions 1 and 2 (self selected pace) when compared to Conditions 3 and 4 (prescribed pace). Also when comparing these conditions, the variability in RPE appears to be greater in Conditions 3 and 4 when compared to Conditions 1 and 2. To test the null hypothesis of equality of variance across groups, the Levene test of Homogeneity of Variances was used to determine any significant differences. This test showed the variability in HR and RPE was significantly different within the exercise groups ($p<0.001$ and $p<0.001$, respectively). In the comparison of exercise condition, the variation in HR was significantly higher for the track at self selected speed compared to the track at prescribed speed (p<0.001) and also when compared to the treadmill at prescribed speed (p<0.001). Similar results were seen for the variation in HR between the treadmill at self selected speed when compared to the track at prescribed speed (p<0.001) and the treadmill at prescribed speed (p<0.001). When comparing the variability in RPE among exercise conditions, the track at prescribed speed was significantly higher than the track at self selected speed (p<0.001) and the treadmill at self selected speed (p=0.014). These results were also seen with the variability in RPE being greater for the treadmill at prescribed speed when compared to the track at self selected speed (p<0.001) and the treadmill at self selected speed (p<0.001).

vi. Summary of formal hypotheses and statistical conclusions

The following are the formal null hypotheses and statistical statements in relation to the test statistics.

Specific Aim 1 : To determine perceptual and physiological responses to walking one mile.

H_{01}: Individuals' perceptual response will not differ significantly by interaction of weight status, modality, or pace. **Fail to reject.**

H_{02}: Individuals' physiological response will not differ significantly by interaction of weight status, modality, or pace. **Reject.**

H_{03}: Individuals' perceptual responses will not differ significantly between exercise modality during a one mile walk. **Reject.**

H_{04}: Individuals' physiological responses will not differ significantly between exercise modality during a one mile walk. **Reject.**

H_{05}: Individuals' perceptual responses will not differ significantly between exercise pace during a one mile walk. **Reject.**

H_{06}: Individuals' physiological responses will not differ significantly between exercise pace during a one mile walk. **Reject.**

H_{07} : Acute physiological responses will not differ significantly between overweight and non-overweight individuals during and following a one mile walk. **Reject.**

H_{08} : Perceptual response will not differ significantly between overweight and non-overweight individuals during and following a one mile walk. **Fail to reject.**

Specific Aim 2 : To determine the relationship between perceptual and physiological variables during one mile walk.

H_{09} : There will be no interaction effect on the relationship between physiological and perceptual responses to exercise. **Fail to reject.**

H_{010} : The relationship between perceptual and physiological responses will not differ significantly by weight status. **Fail to reject.**

H_{011} : The relationship between perceptual and physiological responses will not differ significantly by exercise modality. **Fail to reject.**

H_{012} : The relationship between perceptual and physiological responses will not differ significantly by pace. **Fail to reject.**

CHAPTER V

DISCUSSION

There were two specific aims of this study designed to investigate the physiological and perceptual responses to walking one mile. The primary purpose for this study was to determine an effect of modality, pace, weight status, and sex on the exercise response variables measured. Also of interest was the relationship between the physiological response (HR) and perceptual response (RPE) and if this relationship was altered by modality, pace, weight status, or sex which will be at the end of this section.

i. <u>Interaction of modality and pace on physiological responses</u>

With respect to the primary interests of this investigation, significant differences were found in physiological and perceptual responses as a result of modality, pace, and weight status. Physiological responses are discussed first, while perceptual responses are discussed separately. Respiratory rate and blood lactate levels were seen to be significantly different across exercise conditions as a result of interaction between modality and pace. To begin, respiratory rate, with weight status and sex collapsed, averaged 29.17 ± 5.36 breaths/min for individuals of Condition 3 (track at prescribed pace). This respiratory rate was significantly higher than the respiratory rate of individuals on the treadmill at prescribed pace which was on average 24.98 ± 18.29 breaths/min. This interesting finding could be the result of greater muscle activation when working on the track as compared to the treadmill. (Buchner et al., 1994 and Chakravarthy et al., 2013). With greater required muscle activation of assisting muscles and a greater degree of whole body exercise on the track, a higher level of oxygen consumption may be the determining factor for an increase in respiratory rate. Also, a greater respiratory rate was seen at prescribed pace (29.17 ± 5.36 breaths/min) when compared to self selected pace on the indoor track (25.74 ± 4.61 breaths/min). This could be the direct result of working at a higher intensity during exercise and requiring more oxygen to the muscles in order to meet the metabolic demands (Freitas et al., 2015 and Dunn et al., 1999). The accumulation of blood lactate during exercise showed to be significantly different between exercise modality and pace. The difference between pre-exercise and post-exercise blood lactate was used to determine the level of blood lactate accumulation as a result of the exercise condition. At prescribed pace, blood lactate increased to a greater extent on the track when compared to the treadmill. Pre-exercise blood lactate of individuals exercising at prescribed pace on the indoor track averaged 1.33 ± 0.39 mmol/L and showed a value of 1.90 ± 0.59 mmol/L following completion of the one mile walk. This difference in blood lactate was much greater when compared to those exercising on the treadmill at prescribed pace which started with a pre-exercise blood lactate of 1.16 ± 0.43 mmol/L and completed the one mile walk with a blood lactate level of 1.51 ± 0.49 mmol/L. The higher increase in blood lactate on the track could be the result of greater active muscles which increases the frequency of contractions. These results are in agreement with previous research from Ceci and Hassmen (1991) which discovered differences in blood lactate between the treadmill and field environment. Due to greater muscular contraction, the by-product of lactic acid and lack of present oxygen causes lactate to accumulate at a faster rate than it is removed. Dasilva et al. (2011) state the overground walking involves a greater metabolic requirement because of an increase in agonist-antagonist co-contractions of muscles. Also in blood lactate observation, both modalities at prescribed pace showed a 37% increase from pre-exercise to post-exercise while exercise at self selected pace showed a 19% decrease in blood lactate from pre to post-exercise. Similar interpretations were seen from Ali et al. (2008) and Goodwin et al. (2007) with blood lactate accumulating to a greater extent in those exercising at a higher intensity. Interesting interpretations of increased blood lactate at higher intensities come from Marcora (2009), which stated there is an increase in recruitment of glycolytic fibers resulting in an increase in metabolic stimuli. Dasilva et al. (2011) found that individuals typically select an exercise pace at or near their ventilatory threshold and any prescribed pace above this would elicit exercise above the ventilatory threshold (Lind et al., 2005). This level of exercise would create a threat to homeostasis (Dasilva et al., 2011 and Lind et al., 2005). The findings from Dasilva et al. (2011) offer an explanation to the increase in blood lactate only being seen in prescribed pace exercise conditions of the present study. This could be interpreted as the self selected exercise conditions eliciting an intensity below ventilatory threshold while prescribed pace exercise conditions elicited intensities above ventilatory threshold, leading to increased metabolic stress. Although, further investigation is needed to determine this relationship. These novel findings are of great interest in determining the physiological stress placed on the body at difference exercise intensities. The increase in blood lactate accumulation of those exercising at 50-60% of HRR could be representative of greater stress on the body and possible mechanism for the greater perception of effort which is discussed below. Those exercising at self selected pace were able to maintain sufficient intensity for health benefits while creating minimal physiological stress. The minimal physiological stress was represented by an actual decrease in the blood lactate concentration from pre to post-exercise in those exercising at self selected pace. Comparable results were seen in a study from Goodwin et al. (2007), where the lower intensity (self selected pace) was seen to mobilize existing pre-exercise blood lactate and assist in its removal. These particular results could have important implications on exercise prescription procedures and will be discussed later in this section.

ii. **Main effect of modality, pace, or weight status on physiological responses**

Cardiovascular responses to exercises are highly researched and present valuable information in determining all aspects of exercise prescription. Many outcome variables of this study represent cardiovascular responses and discrepancies were seen as a result of exercise pace and also from weight status classification. Post-exercise systolic and diastolic blood pressures were significantly higher following exercise at prescribed pace (SBP=139.19 ± 13.16 mmHg and DBP=81.38 ± 5.87 mmHg) when compared to the values corresponding to self selected pace (SBP=128.94 ± 10.33 mmHg and DBP=78.36 ± 7.12 mmHg). In a similar manner, the difference between pre and post-exercise systolic and diastolic blood pressures was greater for prescribed pace as compared to self selected. These values represent a greater increase in blood pressure due to the exercise intensity. Heart rate recovery, determined from the time to return to within 10 bpm of RHR following exercise, showed a longer duration for exercise at prescribed pace (4:27 ± 0:37) when compared to self selected pace (2:04 ± 1:42). Other values related to HR were observed as outcome variables and were seen to be higher for prescribed pace. The average HR during exercise was determined to be significantly higher during prescribed pace exercise with an average of 133.38 ± 8.46 bpm while self selected pace exercise elicited an average of 110.85 ± 16.67 bpm. Similarly, the final HR at cessation of exercise (134.36 ± 8.27) and the percentage of maximal HR worked (73 ± 4%) were significantly greater for the prescribed exercise as compared to self selected exercise (111.66 ± 16.63 bpm and 60 ± 9%, respectively). With the significant difference of percent of maximal HR between paces, these results were in contrast to

Hall et al., (2012) which found no significant difference in the percent of maximal HR worked during prescribed and self selected pace. The final HR from this study was 17% higher than the final HR for self selected pace exercise. As mentioned previously, the prescribed pace exercise was consistently a higher intensity exercise which could be the factor leading to greater cardiovascular stress. These results are similar to those stated in a review by Manson et al. (2002) which explain vigorous exercise may produce greater stress on the body when compared to moderate intensity. Although this higher intensity could intensify some health benefits, the risk to reward ratio is of concern especially in overweight and obese populations with higher intensities creating an exhausting task and jeopardizing walking economy and biomechanical stress (Peyrot et al., 2012). This finding is disturbing since it may suggest patients could expose themselves to increased risk of adverse events (Levinger et al., 2004). Also for final HR and percentage of maximal HR worked during exercise, weight status played a significant effect between overweight and non-overweight participants. Those classified as overweight averaged a final heart rate of 134.53 ± 8.03 bpm while the non-overweight averaged only 108.08 ± 11.76 bpm. These findings can be expanded to the percentage of maximal HR during exercise where the overweight individuals worked at a significantly higher percentage (73.49 ± 4.18%) than the non-overweight (58.41 ± 7.33%). On one hand, it has been found that a larger cardiovascular stress can provide greater health outcomes following exercise (Manson et al., 2002). On the other hand, this cardiovascular stress could produce adverse events during or immediately following exercise (Manson et al., 2002). One concern addressed through this research is the perception of the exercise, and this high cardiovascular stress during prescribed pace could result in a negative perception and higher feelings of exertion. Due to these factors, an individual's adherence to the exercise program may decrease and lead to physical inactivity.

Variables related to oxygen consumption and energy expenditure are of primary focus in research on the overweight and obese populations. Several researchers have provided valuable information in regards to these exercise responses which assists in the interpretation of differences seen from this research investigation. Oxygen consumption during exercise, as represented by VO_2 average, was significantly higher during exercise at prescribed pace (17.51 ± 3.63 ml/kg/min) as compared to the self selected pace (15.30 ± 2.63 ml/kg/min), irrespective of exercise modality. In addition to these differences, VO_2 average was significantly higher for all exercise conditions in the individuals classified as non-overweight (18.30 ± 3.78 ml/kg/min) in relation to individuals classified as overweight (15.05 ± 2.57 ml/kg/min). These results contradicted those of Browning and Kram (2005) which found VO_2 during exercise to be higher for those classified as obese. For the difference seen due to exercise pace, the higher oxygen metabolism seen at the higher intensity is the result of greater oxygen demand to the exercising muscles. With the increase of intensity, higher levels or concentrations of oxygen are needed to supply the aerobic requirements of the exercise. As for the higher VO_2 for the non-overweight participants, it is believed to be the result of more lean tissue mass in relation to fat mass. Those in the non-overweight sample showed lower body fat percentages than the overweight and greater lean mass than the overweight. With more lean mass, higher levels of oxygen are consumed during whole body exercise, creating an inflation in VO_2 during the physical activity (Peyrot et al., 2012). With respect to research involving overweight and obese individuals, energy expenditure during exercise and total energy expended are of primary concern to determine optimal methods of energy balance. In agreement with previous research (Donnelly et al., 2009, Hall et al., 2012, Haskell et al., 2007, Browning and Baker, 2005) energy expenditure is a significant influential factor in healthy weight loss and the prevention of weight regain.

Interesting and novel results were seen for energy expenditure during exercise (kcal/min) and for total energy expenditure in this study. Similar to (Donnelly et al., 2009, Hall et al., 2012), energy expenditure during exercise was significantly higher for those working at the prescribed pace (6.49 ± 1.77 kcal/min) as compared to those exercising at self selected pace (5.56 ± 1.39 kcal/min). Although this difference was seen during exercise, total energy expenditure was not significantly different between exercise pace or modality. These results are similar to those seen in the pilot study leading up to this research, but are in contrast to results of other research in this area when looking at total EE (Hall et al., 2012). A study by Hall et al., (2012) showed greater total EE from prescribed pace when compared to self selected pace. The inconsistent results amongst studies could originate from different methods of exercise and populations examined (Donnelly et al., 2009 and Morris et al., 2014). For instance, the study by Hall et al., (2012) which saw significantly higher total EE from prescribed pace when compared to self selected pace could be due to the degree of difference in walking pace. These researchers prescribed a pace equivalent to high end of the vigorous intensity range while self selected was equivalent to the lower end of moderate intensity. Similar to Browning and Kram (2005) when examining total energy expenditure, a difference was seen between overweight and non-overweight individuals for all exercise conditions. Overweight individuals showed an average total energy expenditure from self selected pace walking of 109.06 ± 33.36 kcal while non-overweight individuals only expended 100.88 ± 24.29 kcal during the same self selected pace conditions. These results were also seen in prescribed pace exercise, where the overweight individuals expended significantly more energy (116.43 ± 33.88 kcal) when compared to the non-overweight (103.07 ± 30.47 kcal). This finding could be due to the greater body mass being carried by the overweight population which requires greater physical exertion to propel the body through space. With higher levels of physical exertion, the muscular actions increase metabolism which leads to more energy expended through the duration of the exercise. Also, previous research has stated that those with less body fat work more efficiently than those with excess body fat (Peyrot et al., 2012). In other words, the same amount of absolute volume will be performed with less energy being required in the non-overweight due to a greater work to energy expenditure ratio. For the overweight population, the elevated gross energy expenditure seen during all exercise conditions lends promising results for the loss of excess body fat regardless of exercise modality or pace. These findings and similar findings of others (Hall et al., 2012) which indicate that when participants are allowed to self select exercise intensity, the workload would still be sufficient in weight loss and management. As also stated by Perri et al. (2002), this could play a crucial role in the adherence to exercise and allow an individual to exercise for longer duration in order to optimize the dose response relationship between physical activity and health benefits. These researchers compared moderate intensity continuous exercise to high intensity intermittent bouts and saw the moderate intensity group to accumulate more exercise over a 6 month period and a greater adherence rate. The high intensity exercising group actually saw a drop in adherence rate and completed a lower volume of exercise (Perri et al., 2002).

iii. **Main effect of modality, pace, or weight status on perceptual responses**

Another primary aim of this study was to evaluate the perceptual responses across exercise modality, pace, and weight status. It has been seen in previous research that alternate modes of exercise can produce a negative perception or perception of over exertion and lead to a significant decline in duration of exercise bouts along with decreased adherence (Caserta et al., 1998). For purpose of the current study, the Borg 6-20 Rating of Perceived Exertion (RPE) scale was used to assess subjective perception of effort while the Category Rating 0-10 Pain Intensity

(CR-10) scale was used to assess any pain sensation and ensure reliability of RPE measures. As a result of this study, the average RPE during exercise was seen to be significantly higher on the treadmill (7.66 ± 1.74) when compared to the track (6.93 ± 1.33). This was also seen for final RPE at the cessation of exercise with the treadmill producing a greater perception of effort (8.03 ± 1.96) as compared to the indoor track (7.20 ± 1.71). These results were similar to those found in a comparison between the treadmill and overground walking by Dasilva et al. (2011) which found negative perceptions and less affective responses on the treadmill. Lastly, the average CR-10 during the one mile walk showed higher values of pain sensation on the treadmill (0.30 ± 0.55) when compared to the indoor track (0.07 ± 0.20). Similar to the pilot study prior to this investigation, these results provide compelling evidence that the treadmill leads individuals to consistently measure their effort higher than the track, although the intensity and distance remains the same. The increase in perception of effort could be the result of metabolic stress, such as blood lactate accumulation (Marcora, 2009). This higher perception of effort could lead an individual to misinterpret the intensity of exercise (Hall et al., 2012) and because of this misinterpretation, previous research has stated it causes exercise to become relatively more strenuous and results in exercise participants decreasing intensity, duration, and frequency (Garcin et al., 2003 and Ekkekakis and Lind 2006). These effects have been seen to be further exacerbated by weight status in those classified as overweight or obese (Morris et al., 2014 and Browning and Baker, 2005). Also for perceptual responses to walking one mile, significant differences were seen as an effect of exercise pace. In agreement with Hall et al., (2012) the prescribed pace, for both treadmill and track, led individuals to rate their exertion during exercise higher on the RPE scale with average RPE being significantly greater (8.00 ± 1.71) compared to self selected pace (6.68 ± 1.18). This was also seen for final RPE at the cessation of exercise with prescribed pace being higher than self selected (8.58 ± 2.03 and 6.77 ± 1.11, respectively). Similar to the treadmill inducing greater perception of effort and leading to a negative overall feeling during exercise, this prescribed pace could result in negative perceptions of exercise. For an individual to adhere to an exercise program, creating an enjoyable activity is of significant importance (Caserta et al., 1998). As for CR-10 ratings during and immediately following cessation of exercise, the prescribed pace for both modalities produced increased pain sensation and ratings on the 0-10 scale. The average CR-10 during exercise for prescribed pace was 0.23 ± 0.52 while the self selected pace only elicited ratings on average of 0.04 ± 0.27. At the cessation of exercise, the final CR-10 was significantly higher for participants exercising at prescribed pace (0.37 ± 0.71) in relation to the self selected groups (0.04 ± 0.14). Although ratings on the CR-10 scale were minimal, any sensation of discomfort during exercise could lead an individual to cease exercise and their return to the program could be significantly affected. Similar conclusions were formed by Greene et al. (2009) which stated any sensation of pain is a consistent explanation for discontinuing exercise training. These findings could be used to further expand results of previous research showing exercise intensities too high can lead to a decrease in adherence and become a barrier to initiation for future activity (Hall et al., 2012, Caserta et al., 1998).

iv. **Relationship between physiological and perceptual response**

The secondary aim of this study was to investigate the relationship between physiological response (HR) and perceptual response (RPE) and if this relationship was altered by exercise modality, pace, or weight status. As established from previous research, with an increase in HR there should be a corresponding increase in RPE (Lewis et al., 2007). The Borg 6-20 RPE scale was established from the HR of trained individuals, where each item on the scale if multiplied by

10 should represent the HR of the individual exercising (Marcora et al., 2009, Ceci and Hassmen, 1991, Garcin et al., 2003, Lewis et al., 2007). As stated from Marcora et al. (2009), the correlation between an individual's perception of effort and heart rate during exercise is so strong, the 6-20 RPE scale was originally developed to reflect the range of HR found in young and fit subjects (60 bpm – 200 bpm). As a result of this study, the relationship between HR and RPE across all exercise conditions showed no significant differences. These results contradict those found by Ceci and Hassmen (1991) which found differences in this relationship between the treadmill and field situations and other research which found inconsistencies in the HR and RPE relationship as intensity increased (Lewis et al., 2007 and Fabre et al., 2010). Also, the relationship between physiological response and perceptual response between overweight (n=80) and non-overweight (n=80) showed no significant difference. Although no differences were seen in the relationship between these responses from modality, pace, or weight status, the variation in responses was significantly different as a result of modality and pace. The variation of RPE scores during prescribed paced exercise was significantly greater than the variation in RPE during self selected exercise (Levene Statistic=12.86, $F(3,159)=19.21$, $p<0.001$) The variation in RPE response due to exercise pace is of primary concern due to the possibility of misinterpretation of intensity. This is also an interesting finding due to the possibility that the high degree of variation in RPE values from the prescribed pace exercise, regardless of modality, could mean exercise discomfort and negative perception or attitude towards exercise. As stated by Hall et al., (2012) which found RPE values to increase disproportionately with HR, there may be a mismatch between the physiological and perceptual responses of exercise. This could create a less pleasurable and enjoyable exercise experience, negatively affecting one's exercise habits (Hall et al., 2012, Caserta et al., 1998). Several explanations have been proposed for the

mismatch between physiological and perceptual responses. Coutts et al. (2007) suggest that psychobiological factors such as metabolic acidosis, ventilatory drive, catecholamines, and body temperature are related to perception of effort. Further research is needed to determine the contribution of these factors on the relationship between the physiological and perceptual response.

Similar to statements of Caserta et al. (1998), it is believed a key component to intrinsic motivation for exercise is established by self determination where one exercises not because it is imposed but because of internal motives. It is important to identify the aspects of a exercise programs and exercise experiences that are portrayed as enjoyable to the participant. In this way the exercise becomes individualized and the concern of adherence to the program could become miniscule. Subjectively adjusting exercise intensity can be seen as a continuous and simultaneous process of monitoring internal and external cues (Ceci and Hassmen, 1991, Lewis et al., 2007). In certain populations, such as the overweight and obese, a large focus should be placed on reliable and safe guidelines for exercise to promote health benefits and weight loss. Previous research has shown that self selected exercise functions well in providing health benefits and promotes adherence to a program (Ceci and Hassmen, 1991) with twice as many adults adopting a new routine when it is self selected at moderate intensity as compared to prescribed high intensity (Cox et al., 2002). Individualization of exercise programming should also address the aerobic fitness state of the individual (Garcin et al., 2003).

v. Conclusion

The present investigation attempted a) to determine the physiological and perceptual responses to alternate modes of exercise at self selected and prescribed pace between overweight and non-overweight individuals and b) to determine the relationship between physiological and perceptual responses and if this relationship is altered by modality, pace, or weight status. In regards to the first aim, the null hypotheses are rejected as significant differences in physiological and perceptual responses were seen as an effect of modality, pace, and weight status. Some of these differences were in agreement with previous research while others contradicted the findings of previous research. For the secondary aim of the study, the relationship between physiological and perceptual measures was not affected by modality, pace, or weight status. Although, significantly greater variation in RPE evaluation was seen for prescribed pace exercise conditions when compared to self selected pace exercise. Many discrepancies in these responses lend intriguing information to pursue further investigations in this area of exercise prescription. Further research may be needed to confirm these findings or form a general consensus on proper exercise guidelines or recommendations for overweight and obese individuals.

Strengths of the current study include a) a control for diurnal variations within the scope of the research design and investigators capability, b) the large number of participants in attempt to strengthen statistical power for determination of any physiological and perceptual discrepancies, c) the exclusion restrictions strengthened the study by screening certain subjects who had preexisting conditions that could alter the exercise response, d) participants were recruited from a diverse population across the University of Mississippi campus which helps to reduce any bias of a nesting effect within one particular department, e) all testing procedures, blood pressure measurements, and blood analyses were conducted by the same investigator to reduce error due to inter-observer data collection and this increased reliability of the measures, f) incorporating modality, pace, weight status, and sex as independent variables with a large number of dependent variables which created a comprehensive study not previously done in this area of research.

A major focus for this research was directed towards determining an optimal modality and pace, both in physiological and perceptual response, for overweight and obese individuals in order to provide the greatest possible health benefits. With energy balance being a primary concern in overweight and obese populations, the practical applications of the current findings provide encouraging information for increasing exercise adherence. In agreement with Ceci and Hassmen (1991), exercising in a free environment such as a track can provide visual, auditory, and thermal feedback which act as “reducers” of perception of effort. As a result of this study, no significant differences were found in total energy expenditure between exercise modality or exercise pace and a higher perception of effort was seen at prescribed pace and on the treadmill. These results suggest that individuals can foster enjoyable exercise at their self selected intensity in their preferred environment while gaining similar health benefits as those seen during exercise of prescribed intensity, such as the ACSM recommended guidelines. The recommended 30 minutes of at least moderate intensity exercise on preferably all days of the week (ACSM, 2010) could create too large of a stress on overweight or obese individuals such as exercise above the ventilatory threshold. Dasilva et al. (2011) state this could create a threat to homeostasis and affective responses tend to be homogeneously negative. Standard exercise recommendations could also result in individuals forming a misinterpretation of intensity. These factors could both lead to barriers to initiation and nonadherence to exercise. It is believed, in agreement with statements from Dasilva et al. (2011), people are not only predisposed to select exercise intensities that produce positive perceptions and affective responses, but also able to choose an intensity that provides physiological stimuli adequate to promote health benefits. Recent studies have even found that individuals exercising at self selected pace tend to choose an intensity near their ventilatory threshold (Dasilva et al., 2009; Ekkekakis and Lind, 2006; Lind et al., 2005). This reinforces the observation that health benefits and pleasurable experiences may be associated with self selected pace exercise protocols.

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LIST OF APPENDICES

APPENDIX A

TABLES

Table A-1. Descriptive statistics from pilot investigation comparing track and treadmill walk and run.

	Male		Female	
	Mean	**SD**	**Mean**	**SD**
Age	21.07	1.53	21.07	0.88
Height (cm)	180.47	7.76	162.64	6.04
Weight (kg)	85.56	14.42	61.16	9.84
Systolic BP	136.60	14.63	115.00	8.35
Diastolic BP	77.33	14.38	71.60	7.99
Walking mph	3.52	0.40	3.70	0.36
Running mph	7.29	0.91	6.27	1.28
Resting HR (bpm)	71.20	11.11	77.60	8.92
VO_{2peak} (ml/kg/min)	42.40	5.79	35.32	10.10

Values are presented as mean ± SD

Table A-2. Results of pilot investigation. Comparison of responses between track and treadmill walk and run.

	Male		Female	
Variable	**Track Walk**	**Treadmill Walk**	**Track Walk**	**Treadmill Walk**
HR (bpm)	96.00 ± 18.47†*	114.47 ± 16.67†*	116.40 ± 15.70†*	137 ± 11.10†*
RER	0.90 ± 0.07*	0.84 ± 0.03*	0.89 ± 0.08*	0.83 ± 0.04*
RPE	7.27 ± 1.58*	8.27 ± 1.94*	6.67 ± 0.89*	9.00 ± 2.42*
EE (kcal/min)	5.98 ± 1.44†	6.32 ± 1.13†	4.79 ± 0.75†	4.78± 0.96†
VO_2 (ml/kg/min)	16.69 ± 2.71*	18.32 ± 3.35*	18.33 ± 2.81*	18.97 ± 2.44*

Values are presented as mean ± SD.
* $p < 0.05$ between track and treadmill † $p < 0.05$ between males and females

	Male		Female	
Variable	**Track Run**	**Treadmill Run**	**Track Run**	**Treadmill Run**
Speed (mph)	7.30 ± 0.91†	7.30 ± 0.91†	6.27 ± 1.28†	6.27 ± 1.28†
HR (bpm)	175.13 ± 12.05	180.33 ± 12.70	173.93 ± 12.81*	184.20 ± 8.66*
RER	1.03 ± 0.07*	0.97 ± 0.06*	0.97 ± 0.07	0.94 ± 0.06
RPE	13.73 ± 2.98*	15.93 ± 3.63*	13.60 ± 2.20*	16.80 ± 2.65*
EE (kcal/min)	14.42 ± 2.69†	15.80 ± 2.71†	9.05 ± 2.17†	9.25 ± 1.94†
VO_2 (ml/kg/min)	37.83 ± 4.49†*	41.33 ± 3.40†*	34.50 ± 5.79†*	34.85 ± 6.56†*

Values are presented as mean ± SD.
* $p < 0.05$ between track and treadmill † $p < 0.05$ between males and females

Table A-3. Descriptive statistics.

	Male				**Female**			
	Non-obese		Obese		Non-obese		Obese	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Age	22.85	3.29	22.85	3.93	20.80	1.18	21.55	1.85
Height (cm)	177.85*	9.32	175.18*	9.16	164.62	5.94	164.91	6.65
Weight (kg)	80.29*	14.05	85.85*^{t}	16.91	58.99	7.91	74.38^{t}	25.10
BMI	25.26*	3.28	27.98*^{t}	5.46	21.77	2.73	27.17^{t}	8.18
Body Fat %	14.72	3.91	26.80^{t}	5.13	24.34*	5.57	34.88*^{t}	5.76
VO_{2peak} (ml/kg/min)	45.44*^{t}	7.20	37.44*	8.66	37.82^{t}	6.14	29.34	7.21
Systolic BP (mmHg)	127.22*	12.08	131.10*^{t}	11.78	120.05	6.79	124.86^{t}	9.84
Diastolic BP (mmHg)	79.10*	7.87	81.37*^{t}	7.17	75.50	5.49	79.03^{t}	6.71
Resting HR (bpm)	73.43	12.69	74.98^{t}	12.11	74.30	9.90	80.40^{t}	10.70
Max HR (bpm)	186.58*	9.60	184.78*	10.96	183.05	10.13	181.58	9.66
Self selected speed (mph)	3.01	0.42	3.08	0.41	3.02	0.46	2.92	0.36
Blood Lactate (mmol/L)	1.47	0.44	1.44	0.46	1.27	0.44	1.46	0.47

Values are presented as Means ± SD.
*significant difference between sex ^{t} significant difference between weight status
$p<0.05$

Table A-4. Descriptives of physiological responses to walking one mile with interaction between modality and pace.

		Male				Female			
		Non-obese		Obese		Non-obese		Obese	
Variable	**Cond.**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
RR (b/min)	1	23.76	3.76	25.83	5.56	26.65	4.59	26.73	4.54
	2	25.03	6.45	26.50	5.51	26.23	7.04	29.11	8.20
	3	27.91	5.03	29.73	7.22	29.66	5.11	29.38	4.08
	4	22.49	3.99	24.40	5.26	27.91	2.38	25.13	6.66
BLa_diff (mmol/L)	1	-0.25	0.40	-0.33	0.28	-0.23	0.41	-0.56	0.54
	2	-0.34	0.25	-0.29	0.40	-0.18	0.45	-0.18	0.45
	3	0.67	0.32	0.74	0.74	0.46	0.93	0.39	0.45
	4	0.52	0.34	0.46	0.44	0.45	0.31	-0.03	0.42
Post BLa (mmol/L)	1	1.61	0.33	1.19	0.29	1.24	0.42	1.21	0.50
	2	0.99	0.36	1.35	0.55	1.30	0.56	1.30	0.49
	3	2.08	0.50	2.20	0.74	1.66	0.58	1.65	0.36
	4	1.79	0.57	1.60	0.59	1.37	0.29	1.29	0.36

Values are presented as Means ± SD.
Condition : 1 = track at self selected speed, 2 = treadmill at self selected speed, 3 = track at prescribed speed, 4 = treadmill at prescribed speed.
RR = respiratory rate, BLa_diff = difference in blood lactate from pre-exercise to post-exercise, Post BLa = blood lactate concentration after exercise

Table A-5. Interaction between modality and pace on physiological responses to walking one mile.

		Track		Treadmill	
		Mean	**SD**	**Mean**	**SD**
RR (b/min)	**S.S.**	25.74	4.64	26.73	6.77
	Pres.	29.17*t	5.32	24.98	5.05
BLa_diff (mmol/L)	**S.S.**	-0.34	0.42	-0.25	0.39
	Pres.	0.57*t	0.61	0.35t	0.43
Post BLa (mmol/L)	**S.S.**	1.31	0.42	1.23	0.50
	Pres.	1.90*t	0.59	1.51t	0.49

Values are presented as Means ± SD.
*significant difference between modality $p<0.05$ t significant difference between pace $p<0.05$
RR = respiratory rate, BLa_diff = difference in blood lactate from pre-exercise to post-exercise, Post BLa= blood lactate concentration after exercise
S.S. = self selected pace, Pres. = prescribed pace

Table A-6. Descriptives of physiological responses to walking one mile with main effect of pace.

		Male				Female			
		Non-obese		Obese		Non-obese		Obese	
Variable	**Cond.**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Post SBP (mmHg)	1	126.80	10.35	134.77	14.97	125.47	4.67	126.47	10.66
	2	134.26	7.70	132.34	7.98	124.07	6.67	127.34	12.90
	3	138.27	15.94	149.47	11.83	136.00	4.80	139.47	7.17
	4	145.00	11.11	144.77	15.87	126.07	12.32	134.47	10.38
Post DBP (mmHg)	1	74.80	6.81	80.47	11.82	74.40	3.86	82.00	5.66
	2	81.33	6.99	80.26	3.64	75.07	5.95	78.56	6.16
	3	81.80	8.08	86.27	5.48	82.47	3.66	77.13	6.71
	4	81.53	4.61	81.93	3.36	78.00	3.04	81.93	5.31
SBP_diff (mmHg)	1	4.00	6.74	0.90	1.63	2.86	2.69	1.20	1.54
	2	4.13	4.20	2.20	4.39	4.14	7.22	5.27	5.93
	3	14.07	5.84	16.87	10.53	13.80	8.82	10.47	4.05
	4	13.27	7.14	16.97	11.03	10.60	8.22	11.37	6.16
DBP_diff (mmHg)	1	0.93	1.38	0.13	1.08	0.27	0.65	0.60	0.97
	2	0.13	1.93	0.40	1.80	1.87	3.76	1.23	1.86
	3	1.20	1.40	1.67	1.51	4.20	5.01	0.53	1.85
	4	0.80	3.94	1.53	2.25	1.60	3.73	1.13	2.39
HR recovery (minutes:sec)	1	1:24	0:36	1:46	0:53	1:30	0:47	2:33	1:54
	2	2:01	1:50	2:40	3:12	2:05	1:41	2:35	1:22
	3	4:46	1:36	5:06	1:18	4:44	3:45	4:40	2:04
	4	5:07	3:38	2:46	1:31	4:12	2:30	4:18	3:24
VO_2_avg (ml/kg/min)	1	14.16	2.14	15.07	3.26	16.89	3.46	13.37	1.78
	2	14.98	2.03	15.74	2.52	16.21	2.48	16.03	1.91
	3	20.04	4.41	18.07	3.23	16.13	4.14	15.62	4.11
	4	18.21	3.05	18.31	2.65	18.81	2.66	14.88	1.92
METS	1	4.04	0.61	4.25	0.90	4.83	0.98	3.82	0.51
	2	4.28	0.58	4.50	0.72	4.63	0.71	4.53	0.53
	3	5.70	1.27	5.13	0.97	4.61	1.19	4.46	1.17
	4	5.20	0.87	5.22	0.76	5.38	0.76	4.25	0.55
EE (kcal/min)	1	5.97	1.52	6.57	1.61	5.14	1.09	5.17	1.43
	2	5.72	1.26	6.15	0.99	4.77	0.70	5.02	1.62
	3	7.30	2.23	7.62	1.45	5.40	1.56	5.76	1.76
	4	7.24	0.81	7.65	1.64	5.20	0.99	5.72	1.40
HR_avg (bpm)	1	96.02	10.47	106.51	15.47	118.22	8.41	115.10	20.24
	2	105.52	9.70	107.24	21.07	109.60	10.13	128.61	15.04
	3	134.56	10.83	134.83	11.81	135.58	8.44	132.78	3.55
	4	130.54	6.79	130.90	7.43	133.08	7.07	134.83	10.42
Final HR (bpm)	1	96.50	10.56	110.20	15.80	118.30	7.59	114.30	20.79
	2	106.60	9.09	107.40	21.50	110.90	8.40	129.20	15.99
	3	134.60	11.45	135.70	10.15	136.50	8.33	134.40	5.08
	4	132.20	6.88	131.20	7.48	133.50	7.89	136.80	8.64

%HRmax worked	1	52.00	6.80	57.87	8.57	64.49	6.15	60.88	8.65
	2	56.30	5.62	57.57	10.53	60.84	4.35	71.74	9.38
	3	72.04	4.24	73.10	3.85	74.17	4.58	73.91	4.97
	4	70.12	3.29	71.17	1.50	71.99	3.38	75.76	4.70

Values are presented as Means ± SD.
Condition : 1 = track at self selected speed, 2 = treadmill at self selected speed, 3 = track at prescribed speed, 4 = treadmill at prescribed speed.
SBP_diff = difference in systolic blood pressure from pre-exercise to post-exercise, DBP_diff = difference in diastolic blood pressure from pre-exercise to post-exercise, HR recovery = time for heart rate to return within 10 bpm of resting heart rate, VO2_avg = average oxygen consumption during exercise, METS = metabolic equivalents, EE = energy expenditure per minute, HR_avg = average heart rate during exercise.

Table A-7. Main effect of exercise pace on physiological responses to walking one mile.

	Pace	Mean	SD	Significance
Post_SBP (mmHg)	S.S.	128.94	10.33	p<0.001
	Pres.	139.19*	13.16	
Post_DBP (mmHg)	S.S.	78.36	7.12	p=0.004
	Pres.	81.38*	5.87	
SBP_diff (mmHg)	S.S.	3.08	4.78	p<0.001
	Pres.	13.43*	8.05	
DBP_diff (mmHg)	S.S.	0.66	1.92	p=0.024
	Pres.	1.58*	3.07	
HR recovery (min:sec)	S.S.	2:04	1:42	p<0.001
	Pres.	4:27*	2:37	
VO_2_avg (ml/kg/min)	S.S.	15.31	2.63	p<0.001
	Pres.	17.51*	3.63	
METS	S.S.	4.36	0.75	p<0.001
	Pres.	4.99*	1.04	
EE (kcal/min)	S.S.	5.56	1.38	p<0.001
	Pres.	6.48*	1.77	
HR_avg (bpm)	S.S.	110.85	16.67	p<0.001
	Pres.	133.36*	8.46	
Final HR (bpm)	S.S.	111.67	16.63	p<0.001
	Pres.	134.36*	8.27	
%HRmax worked	S.S.	60.21	9.28	p<0.001
	Pres.	72.78*	4.13	

Values are presented as Means ± SD. * significant difference between pace p<0.05
S.S. = self selected pace, Pres. = prescribed pace
Post SBP = post exercise systolic blood pressure, Post_DBP = post exercise diastolic blood pressure, SBP_diff = difference in systolic blood pressure from pre-exercise to post-exercise, DBP_diff = difference in diastolic blood pressure from pre-exercise to post-exercise, HR recovery = time for heart rate to return within 10 bpm of resting heart rate, VO2_avg = average oxygen consumption during exercise, METS = metabolic equivalents, EE = energy expenditure per minute, HR_avg = average heart rate during exercise.

Table A-8. Descriptives of physiological responses to walking one mile with main effect of weight status.

		Male				Female			
		Non-obese		Obese		Non-obese		Obese	
Variable	**Cond.**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
VO_2_avg (ml/kg/min)	1	14.16	2.14	15.07	3.26	16.89	3.46	13.37	1.78
	2	14.98	2.03	15.74	2.52	16.21	2.48	16.03	1.91
	3	20.04	4.41	18.07	3.23	16.13	4.14	15.62	4.11
	4	18.21	3.05	18.31	2.65	18.81	2.66	14.88	1.92
METS	1	4.04	0.61	4.25	0.90	4.83	0.98	3.82	0.51
	2	4.28	0.58	4.50	0.72	4.63	0.71	4.53	0.53
	3	5.70	1.27	5.13	0.97	4.61	1.19	4.46	1.17
	4	5.20	0.87	5.22	0.76	5.38	0.76	4.25	0.55
Final HR (bpm)	1	96.50	10.56	110.20	15.80	118.30	7.59	114.30	20.79
	2	106.60	9.09	107.40	21.50	110.90	8.40	129.20	15.99
	3	134.60	11.45	135.70	10.15	136.50	8.33	134.40	5.08
	4	132.20	6.88	131.20	7.48	133.50	7.89	136.80	8.64
%HRmax worked	1	52.00	6.80	57.87	8.57	64.49	6.15	60.88	8.65
	2	56.30	5.62	57.57	10.53	60.84	4.35	71.74	9.38
	3	72.04	4.24	73.10	3.85	74.17	4.58	73.91	4.97
	4	70.12	3.29	71.17	1.50	71.99	3.38	75.76	4.70
Total EE (kcal)	1	111.85	22.38	103.66	30.88	83.90	13.23	112.15	43.45
	2	118.24	29.11	118.60	17.57	89.52	10.05	105.43	38.95
	3	105.32	29.99	130.46	30.03	102.98	45.81	101.16	49.78
	4	118.47	12.80	121.93	21.34	85.51	15.80	112.16	24.62

Values are presented as Means ± SD.
Condition : 1 = track at self selected speed, 2 = treadmill at self selected speed, 3 = track at prescribed speed, 4 = treadmill at prescribed speed.
VO2_avg = average oxygen consumption during exercise, METS = metabolic equivalents, Total EE = energy expenditure of exercise duration

Table A-9. Main effect of weight status on physiological responses during one mile walk.

	Weight status	Mean	SD	Significance
VO_2_avg (ml/kg/min)	NON	16.93*	3.55	p=0.037
	O	15.88	3.07	
METS	NON	4.83*	1.01	p=0.0.27
	O	4.52	0.88	
Final HR (bpm)	NON	121.14	16.66	p=0.049
	O	124.90*	17.91	
%HRmax worked	NON	65.24	9.04	p=0.016
	O	67.75*	9.92	
Total EE (kcal)	NON	101.97	27.40	p=0.019
	O	113.19*	33.56	

Values are presented as Means ± SD. * significant difference between weight status $p<0.05$
NON = non-overweight, O = overweight
VO2_avg = average oxygen consumption during exercise, METS = metabolic equivalents, Total EE = energy expenditure of exercise duration

Table A-10. Descriptives of perceptual responses to walking one mile with main effect of modality.

		Male				**Female**			
		Non-obese		Obese		Non-obese		Obese	
Variable	**Cond.**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
RPE average	1	6.36	0.62	6.32	0.43	6.43	0.61	6.21	0.37
	2	6.74	1.27	7.04	1.85	7.01	1.27	7.35	1.75
	3	8.52	2.07	7.99	1.51	6.49	0.51	7.14	1.27
	4	8.31	2.01	8.74	1.66	8.66	1.76	7.41	1.50
Final RPE	1	6.40	0.70	6.50	0.53	6.50	0.71	6.30	0.48
	2	6.90	0.99	7.10	1.91	7.40	1.71	7.10	0.74
	3	9.60	2.37	8.50	1.84	7.00	0.82	7.80	1.81
	4	9.10	2.23	9.40	2.01	9.30	1.89	7.90	1.97
CR-10 average	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.03	0.08	0.03	0.09	0.04	0.10	0.28	0.75
	3	0.27	0.34	0.06	0.12	0.18	0.35	0.06	0.20
	4	0.64	1.19	0.36	0.50	0.14	0.16	0.15	0.28

Values are presented as Means ± SD.

Condition : 1 = track at self selected speed, 2 = treadmill at self selected speed, 3 = track at prescribed speed, 4 = treadmill at prescribed speed.

RPE average = average rating of perceived exertion during exercise, Final RPE = rating of perceived exertion at cessation of exercise, CR-10 average = average category rating 0-10 pain intensity during exercise.

Table A-11. Main effect of modality on perceptual responses during one mile walk.

	Modality	Mean	SD	Significance
RPE average	Track	6.93	1.32	p=0.004
	Treadmill	7.66*	1.74	
Final RPE	Track	7.32	1.71	p=0.017
	Treadmill	8.03*	1.96	
CR-10 average	Track	0.07	0.20	p=0.038
	Treadmill	0.21*	0.55	

Values are presented as Means ± SD. * significant difference between modality $p<0.05$
RPE average = average rating of perceived exertion during exercise, Final RPE = rating of perceived exertion at cessation of exercise, CR-10 average = average category rating 0-10 pain intensity during exercise.

Table A-12. Descriptives of perceptual responses to walking one mile with main effect of pace.

		Male				Female			
		Non-obese		Obese		Non-obese		Obese	
Variable	**Cond.**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
RPE average	1	6.36	0.62	6.32	0.43	6.43	0.61	6.21	0.37
	2	6.74	1.27	7.04	1.85	7.01	1.27	7.35	1.75
	3	8.52	2.07	7.99	1.51	6.49	0.51	7.14	1.27
	4	8.31	2.01	8.74	1.66	8.66	1.76	7.41	1.50
Final RPE	1	6.40	0.70	6.50	0.53	6.50	0.71	6.30	0.48
	2	6.90	0.99	7.10	1.91	7.40	1.71	7.10	0.74
	3	9.60	2.37	8.50	1.84	7.00	0.82	7.80	1.81
	4	9.10	2.23	9.40	2.01	9.30	1.89	7.90	1.97
CR-10 average	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.03	0.08	0.03	0.09	0.04	0.10	0.28	0.75
	3	0.27	0.34	0.06	0.12	0.18	0.35	0.06	0.20
	4	0.64	1.19	0.36	0.50	0.14	0.16	0.15	0.28
Final CR-10	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.05	0.16	0.05	0.16	0.10	0.21	0.15	0.24
	3	0.23	0.38	0.10	0.21	0.20	0.52	0.10	0.32
	4	0.90	1.56	0.45	0.64	0.30	0.35	0.25	0.42

Values are presented as Means ± SD.
Condition : 1 = track at self selected speed, 2 = treadmill at self selected speed, 3 = track at prescribed speed, 4 = treadmill at prescribed speed.
RPE average = average rating of perceived exertion during exercise, Final RPE = rating of perceived exertion at cessation of exercise, CR-10 average = average category rating 0-10 pain intensity during exercise.

Table A-13. Main effect of pace on perceptual responses during one mile walk.

	Pace	Mean	SD	Significance
RPE average	S.S.	6.68	1.17	p<0.001
	Pres.	7.91*	1.71	
Final RPE	S.S.	6.77	1.11	p<0.001
	Pres.	8.58*	2.03	
CR-10 average	S.S	0.05	0.27	p=0.005
	Pres.	0.23*	0.52	
Final CR-10	S.S.	0.04	0.14	p<0.001
	Pres.	0.37*	0.71	

Values are presented as Means ± SD. *****significant difference between pace p<0.05
S.S = self selected pace, Pres. = prescribed pace
RPE average = average rating of perceived exertion during exercise, Final RPE = rating of perceived exertion at cessation of exercise, CR-10 average = average category rating 0-10 pain intensity during exercise.

APPENDIX B

FIGURES

Figure B-1. Interaction of modality and pace for respiratory rate.

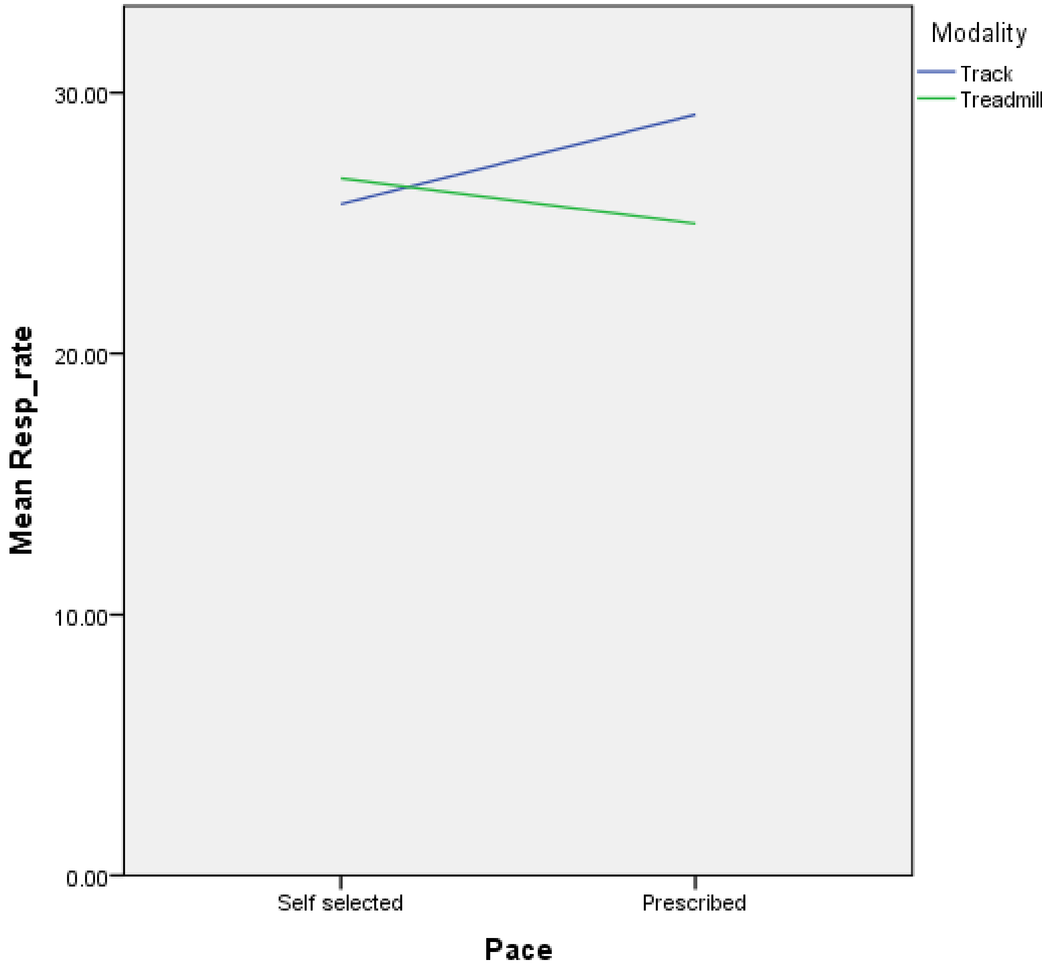


Figure B-2. Interaction effect of modality and pace on blood lactate difference from pre to post-exercise.

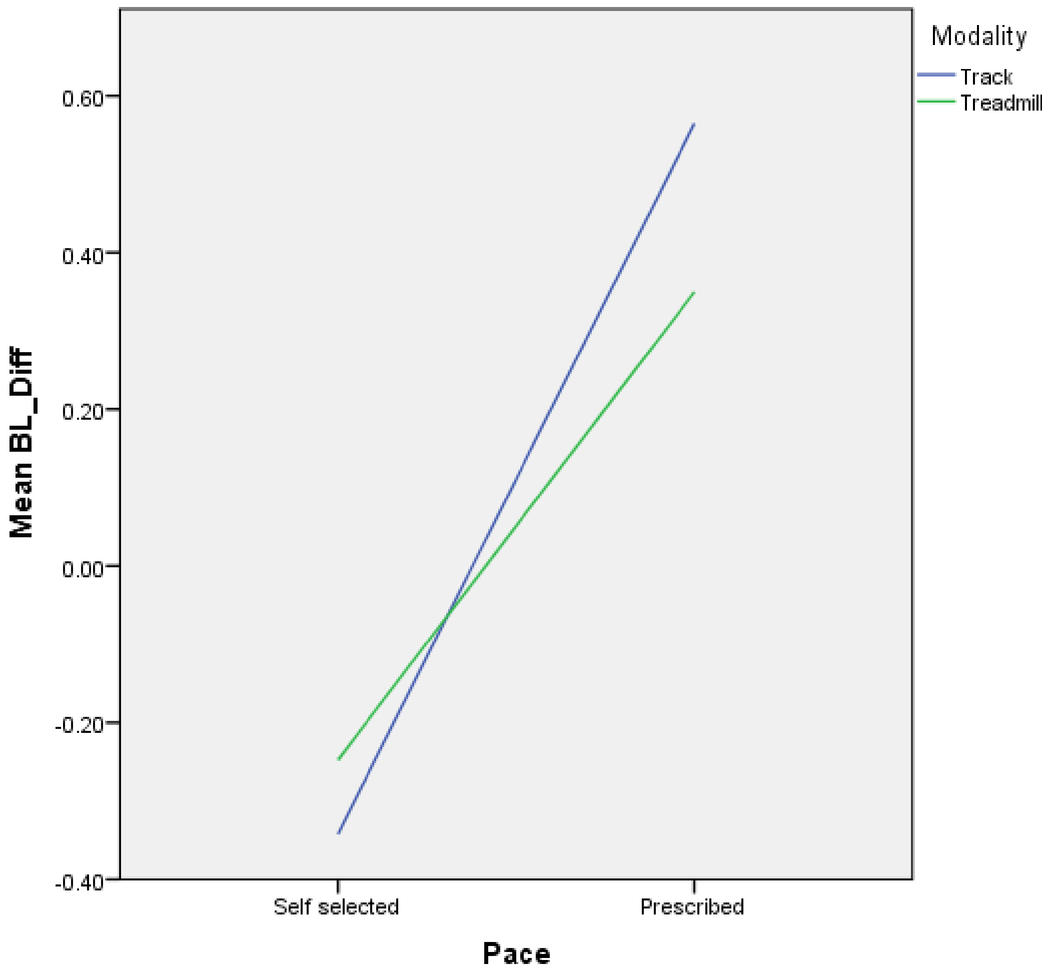
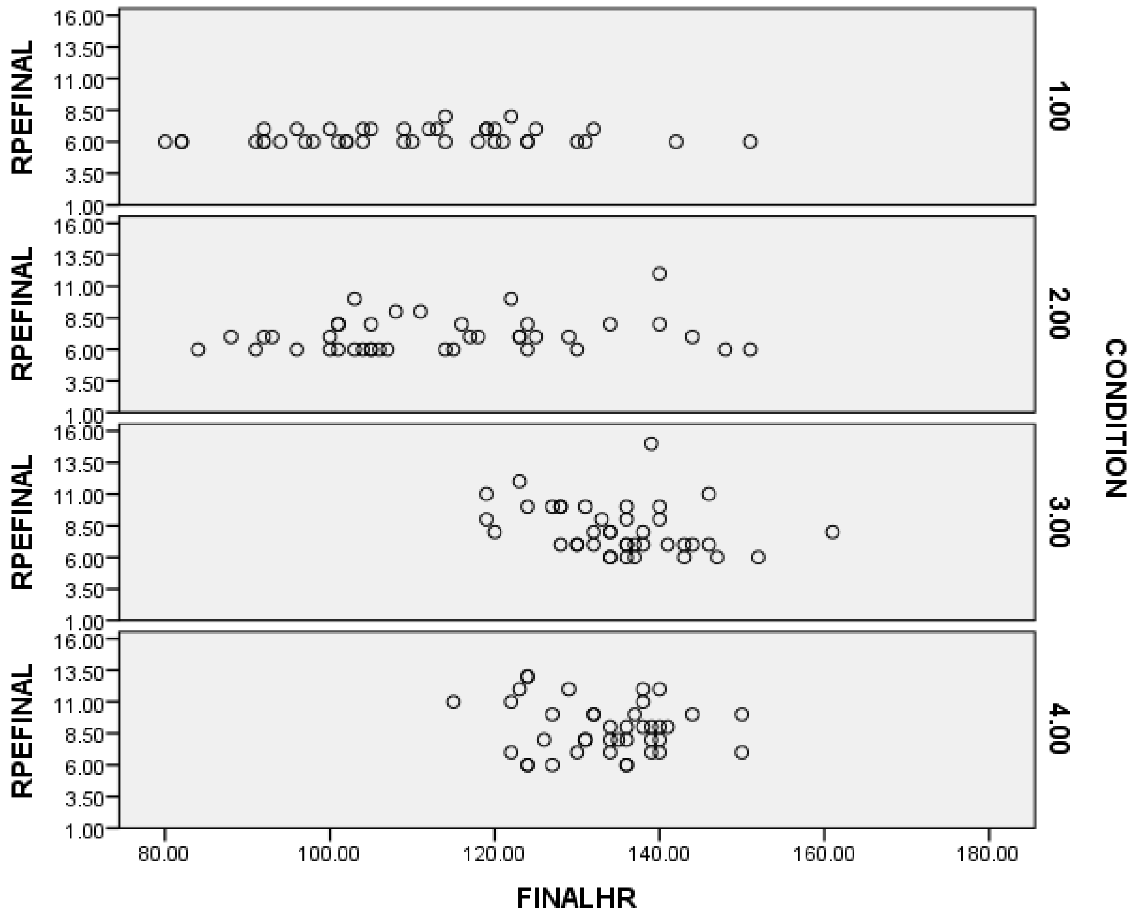


Figure B-3. Relationship between physiological and perceptual response across exercise conditions with apparent difference in variation within condition.



Condition 1 = Track at self selected pace, Condition 2 = Treadmill at self selected pace, Condition 3 = Track at prescribed pace, Condition 4 = Treadmill at prescribed pace.

APPENDIX C

SUPPORTING DOCUMENTS

DOCUMENT C-1

RECRUITMENT FLIER AND EMAIL

Recruiting males and females ages 18-44 years

Classified as untrained
(less than 2 aerobic exercise sessions per week for the last 6 months OR less than one hour of aerobic exercise per week)

Your voluntary participation is needed in a study evaluating the physiological and perceptual responses to walking one mile. We are interested in how the body responds and how you feel while walking on either a treadmill or an indoor track.

This study will consist of two sessions (1 hour each) separated by at least 48 hours:

> **Session 1**: Familiarization of equipment and protocol, DXA whole body scan for body composition, 70 foot walk test to determine normal walking speed, and an oxygen consumption test on a treadmill.
>
> **Session 2**: Exercise session consisting of a one mile walk either on a treadmill or an indoor track.
>
> **Both sessions will take place in the Turner Center at the University of Mississippi**.

Physiological exercise variables and perceived exertion scales will be measured during exercise. Blood lactate will be sampled via single finger prick on the inside of finger of non-dominant hand to get one drop of blood.

Following completion of Session 2, a copy of DXA whole body scan will be provided to you upon request.

If interested, please contact:

Riley Galloway	**Scott Owens**
Jrgallo1@olemiss.edu	sgowens@olemiss.edu
662-915-5158	662-915-5527

DOCUMENT C-2

RECRUITMENT SCRIPT FOR VERBAL RECRUITNG

Physiological versus perceptual responses to alternate modes of exercise at self-selected or prescribed intensity between normal and overweight individuals.

- Be male or female between the ages of 18 and 44 years
- Classified as untrained (less than 2 aerobic exercise sessions per week for the last 6 months). Which is approximately one hour of aerobic activity per week.
- Not have any history of lower body musculoskeletal system or central nervous system dysfunctions

The study will consist of two sessions (Applied Physiology lab of Turner Center and/or at the indoor track of the Turner Center) which could last about one hour each.

Description

This study is evaluating the physiological and perceptual responses to exercise while walking at alternate speeds. Different modes of exercise are offered such as walking on a track or treadmill, and we are interested in how both of these effect the body and how you feel during exercise.

You are being asked to participate in a research study that is investigating two different methods of exercise, track and treadmill, at your self-selected speed and a commonly prescribed speed. We will familiarize you with all exercise equipment , you will be required to complete a DEXA scan for body composition, and an oxygen consumption test in the Applied Exercise Physiology Laboratory. After a minimum of 72 hours rest following this first session, you will be completing a 1 mile walk under one of the four exercise conditions. Two conditions consist of walking one mile on the track while wearing a portable metabolic system. The other two conditions consist of walking one mile in the Applied Physiology Laboratory on the treadmill while wearing the portable metabolic system.

Your participation in this study is strictly voluntary. If you decide to participate in this research study, you will come to the Applied Exercise Physiology Laboratory on two separate occasions to complete the study. Each visit will last approximately 60 minutes.

Upon arrival to the lab for the one mile walk, the researchers will measure your body weight and height, along with resting heart rate, blood pressure, and blood lactate. Following this, the researcher and you will go over the exercise procedure. You will be asked to walk one mile at your self-selected or prescribed submaximal pace. Upon completion of the one mile, blood lactate and blood pressure will be sampled. A cool down period will be implemented consisting of a one lap walk around the track and stretching exercises will be instructed.

Blood lactate will be sampled via finger prick on the middle finger of your non-dominant hand. Your finger will be wiped clean and dry prior to sampling. The sampling procedure requires one drop of blood to be collected via blood lactate analyzer. The process requires a very minute amount of blood to record properly. Following blood sample, a cotton ball will be used to wipe away any capillary blood residue and a sterile band-aid will be provided to cover the sampling site. All equipment is properly sanitized according to manufacturer specifications.

DOCUMENT C-3

INFORMED CONSENT

Participant Consent

Consent to Participate in an Experimental Study:
Physiological versus perceptual responses to alternate modes of exercise at self-selected or prescribed intensity between normal and overweight individuals.

Investigator
Riley Galloway, M.S., NREMT
Department of Health, Exercise Science
and Recreation Management
244 Turner Center
The University of Mississippi
(662) 915-5158

Co-Investigator
Scott Owens, Ph.D.
Department Health, Exercise Science
and Recreation Management
220 Turner Center
The University of Mississippi
(662) 915-5527

Description
This study is evaluating the physiological and perceptual responses to exercise while walking at alternate speeds. Different modes of exercise are offered such as walking on a track or treadmill, and we are interested in how both of these effect the body and how you feel during exercise.

You are being asked to participate in a research study that is investigating two different methods of exercise, track and treadmill, at your self-selected speed and a commonly prescribed speed. Following familiarization of all the equipment and completion of the ACSM health history questionnaire, you will be required to complete a DEXA scan, short self-selected pace determination test, and a VO2max test in the Applied Exercise Physiology Laboratory at the University of Mississippi. After a minimum of 72 hours rest following VO2max testing, you will be completing a 1 mile walk under one of the four exercise conditions randomly assigned. Two conditions consist of walking one mile on the track while wearing a breathing mask and the portable metabolic system for the duration of the testing session. Two separate conditions consist of walking one mile in the Applied Exercise Physiology Laboratory on the treadmill while wearing a mouth-piece styled mask for the duration of the testing session.

Your participation in this study is strictly voluntary. If you decide to participate in this research study, you will come to the Applied Exercise Physiology Laboratory on two separate occasions to complete the study. Each visit will last approximately 60 minutes.

☐ ***By checking this box I certify that I am 18 years of age or older.***

Description of Procedures
This study will take place at the University of Mississippi, in the Applied Exercise Physiology Laboratory located in the Turner Center and at the indoor track in the Turner Center.

You will be asked to come to the lab on two separate occasions, separated by a minimum of 72 hours. On day one, anthropometrics will be taken and familiarization will take place where you will be introduced to all equipment used for research purposes. Following equipment familiarization, you will be asked to complete a DEXA scan for body composition. If female, you must complete a urine pregnancy analysis and conclusive negative results must be observed to be considered for participation. During this session you will also be asked to complete a self-selected walking pace determination test and VO2max test. The remaining session will consist of a one mile walk either on a treadmill or track and at your pre-determined self-selected pace or a commonly prescribed submaximal walking pace.

To be eligible, you must be a healthy, untrained trained male or female, 18-44 years old. Untrained is classified as less than 2 aerobic exercise sessions per week for the previous 6 months.
Exclusion criteria include:

- Any lower body musculoskeletal injuries or central nervous system injuries within the last year.
- Classified as high risk according to ACSM risk stratification and health history questionnaire.

Day 1: Consists of your familiarization day.
Upon completion of informed consent document and health history questionnaire, your anthropometrics will be measured, via stadiometer and weighing scale. Body composition will be determined via DEXA scan, and blood pressure along with resting heart rate will be assessed. You will then be familiarized with all equipment and fitted for a heart rate monitor, the stationary metabolic unit mouth-piece and the portable breathing mask. If female, prior to DEXA scan a urine pregnancy analysis must be completed with conclusive negative results. If positive or inconclusive results are found, individuals will be not be allowed to complete the DEXA body scan and recommended to check with her physician for confirmation. Also during this session you will be required to complete six repetitions of a 70 foot walk at a self-selected pace followed by a VO2max test.

Listed below are the remaining four sessions which you will be asked to complete one.

Day 2: Consists of walking one mile at self-selected pace on the indoor track.
Upon arrival to the lab, the researchers will measure your body weight and height, along with resting heart rate, blood pressure, and blood lactate in a seated position. Following this, the researcher and you will walk to the indoor track. Once there, you will put on the breathing mask and portable metabolic system. Once fitted with the equipment you will be asked to walk one mile at your self-selected submaximal pace. Upon completion of the one mile, blood lactate will be sampled. A cool down period will be implemented consisting of a one lap walk around the track and stretching exercises will be instructed.

Day 3: Consists of walking one mile at self-selected pace on the treadmill.
Upon arrival to the lab, your body weight and height will be measured, along with seated resting heart rate, blood pressure, and blood lactate. Following this, the researcher will fit you to the appropriate mouth-piece for testing. The metabolic system used on this day will be stationary and is connected to the computer. Once equipment is fitted, you will be asked to follow the same procedures as day three; walk one mile at the self-selected pace determined from your first session. Upon completion of the one

mile, blood lactate will be sampled. A cool-down period of walking at self-selected submaximal pace will be implemented followed by a stretching routine.

Day 4: Consists of walking one mile at a prescribed pace on the indoor track.
Upon arrival to the lab, your body weight and height will be measured, along with seated resting heart rate, blood pressure, and blood lactate. Following this, the research will fit you to the portable metabolic device and walk you to the indoor track. Once there, you will put on the breathing mask and straps will be connected on the device. You will be asked to walk one mile at the prescribed pace. Researchers will monitor your pace and ask you to speed up or slow down to maintain the proper intensity. Upon completion of the one mile, blood lactate will be sampled. A cool down period will be implemented consisting of a one lap walk around the track and stretching exercises will also be instructed.

Day 5: Consists of walking one mile at a prescribed pace on the treadmill
Upon arrival to the lab, your body weight and height will be measured, along with seated resting heart rate, blood pressure, and blood lactate. Following this, the researcher will fit you to the appropriate mouth-piece for testing. You will be asked to walk one mile at the prescribed pace on the treadmill. Upon completion of the one mile, blood lactate will be sampled. A cool-down period of walking at your preferred submaximal pace will be implemented followed by a stretching routine.

Blood lactate measurement

Blood lactate will be sampled via finger prick on the middle finger of your non-dominant hand. Your finger will be wiped clean and dry prior to sampling. The sampling procedure requires a small lancet and one drop of blood to be collected via blood lactate analyzer. The process requires a very minute amount of blood to record properly. Following blood sample, a cotton ball will be used to wipe away any capillary blood residue and a sterile band-aid will be provided to cover the sampling site. All equipment is properly sanitized according to manufacturer specifications.

Risks and Benefits
You may experience slight muscular discomfort due to soreness following exercise. This can be minimized through stretching routines instructed by researchers. The intensity of a maximal oxygen consumption (VO2max) test presents a possible risk of cardiac event or muscular discomfort. The risks of this test will be minimized due to the experience of researchers and certification of emergency medical technician of primary investigator. Minimal exposure to x-ray radiation is present during DEXA scan. This minimal exposure has been established through previous research to cause no harm unless pregnant. Possible benefits include improved physical fitness and increased knowledge of superior exercise modalities for core strength and stability.
Cost and Payments
The tests will take approximately one hour per session for a total of five sessions. There are no other costs for helping us with this study.

Confidentiality
We will not put your name on any of your tests. The only information that will be on your test materials will be your gender (whether you are male or female) and your age. Therefore, we do not believe that you can be identified from any of your tests.

Right to Withdraw
Participation in this study is strictly voluntary. Participant has the right to withdraw from the current study with no penalty. Please notify one of the investigators upon desire to withdraw. Whether or not you choose to participate or to withdraw will not affect your standing with the Department of Health, Exercise Science, and Recreation Management, or with the University of Mississippi. The researchers may terminate your participation in the study without regard to your consent and for any reason, such as protecting your safety and protecting the integrity of the research data. If the researcher terminates your participation, any inducements to participate will be prorated based on the amount of time you spent in the study.

Student Participants in Investigators' Classes
Special human research subject protections apply where there is any possibility of undue influence or coercion – such as for students in classes of investigators. Investigators can recruit from their classes but only by providing information on availability of studies. They can encourage you to participate, but they cannot exert any pressure for you to do so. Therefore, if you experience any undue influence or coercion from your instructor, you should contact the IRB via phone (662-915-7482) or email (irb@olemiss.edu) and report the specific form. You will remain anonymous in an investigation.

Compensation for Illness or Injury
"I understand that I am not waiving any legal rights or releasing the institution or their agents from liability from negligence. I understand that in the event of physical injury resulting from the research procedures, The University of Mississippi does not have funds budgeted for compensation for 1) lost wages, 2) medical treatment, or 3) reimbursement for such injuries. The University will help, however, obtain medical attention which I may require while involved in the study by securing transportation to the nearest medical facility."

IRB Approval
This study has been reviewed by The University of Mississippi's Institutional Review Board (IRB). The IRB has determined that this study fulfills the human research subject protections obligations required by state and federal law and University policies. If you have any questions, concerns, or reports regarding your rights as a participant of research, please contact the IRB at (662) 915-7482

Statement of Consent
I have read the above information. I have been given a copy of this form. I have had an opportunity to ask questions, and I have received answers. I consent to participate in the study.

____
Signature of Participant Date

____
Signature of Investigator Date

NOTE TO PARTICIPANTS: DO NOT SIGN THIS FORM
IF THE IRB APPROVAL STAMP ON THE FIRST PAGE HAS EXPIRED.

DOCUMENT C-4

HEALTH HISTORY QUESTIONNAIRE

University of Mississippi
Dept of Health, Exercise Science, and Recreation Management

PRE-EXERCISE HEALTH HISTORY QUESTIONNAIRE

Directions: Please answer all the questions to the best of your ability. All information is **CONFIDENTIAL**.

Name____ Age_____ Male___Female___
First Last

Address____
Street City State Zip

Current height: ________ft _______in Current weight: ______lb

Telephone __________________________

Part 1. Known cardiovascular, pulmonary, or metabolic disease

Please mark if a physician has told you that you have:

___ cardiac disease
___ peripheral vascular disease
___ cerebrovascular disease
___ chronic obstructive pulmonary disease (COPD)
___ asthma
___ interstitial lung disease
___ cystic fibrosis
___ type I diabetes
___ type 2 diabetes
___ kidney disease

Part 2. Signs or symptoms suggestive of cardiovascular, pulmonary, or metabolic disease

Please mark all *true* statements

___You have pain or discomfort in the chest during exercise
___You have shortness of breath at rest or with mild exertion
___You experience dizziness or fainting
___You have difficulty breathing at rest while lying down that is relieved promptly by sitting up
___You have difficulty breathing 2-5 hrs after falling asleep
___You experience ankle swelling
___You experience heart palpitations or a rapid heart beat
___You experience muscle pain in the legs when walking, but not when standing or sitting
___You have been told by a doctor that you have a heart murmur
___You have unusual fatigue or shortness of breath with usual activities

Part 3. Cardiovascular disease risk factors

Please mark all *true* statements

Age

____You are a man 45 years of age or older
___ You are a woman 55 years of age or older

Family history

___ Your father or brother suffered a heart attack, sudden death, or cardiovascular revascularization before age 55
___ Your mother or sister suffered a heart attack, sudden death, or cardiovascular revascularization before age 65

Cigarette Smoking

___ You currently smoke or have quit within the last 6 months

Sedentary lifestyle

___ You have participated in less than 30 minutes of moderate intensity physical activity at least 3 days per week for the last 3 months

Obesity

___ Your BMI is ≥ 30 or your waist circumference is > 40 in for men or > 35 in for women

Hypertension

___ You have systolic blood pressure ≥ 140 mm Hg or diastolic pressure ≥ 90mm Hg, confirmed on two separate occasions, or you are have been prescribed anti-hypertensive medication

___You don't know your blood pressure values

Blood lipids

___ Your LDL cholesterol is ≥ 130 mg/dL, or your HDL is < 40 mg/dL, or you have been prescribed lipid-lowering medication. (If total cholesterol is all that is known, use ≥ 200 mg/dL)

___ You don't know your blood lipid values

Prediabetes

___ Your fasting blood glucose is ≥ 100 mg/dL but < 126 mg/dL, or your 2-hr oral glucose tolerance test was ≥ 140 mg/dL but < 200 mg/dL, confirmed on two separate occasions

___ You don't know your blood glucose values

Negative risk factor

___ Your HDL cholesterol is ≥ 60 mg/dL

(Based on Figure 2.2 & Table 2.2, *ACSM's Guidelines for Exercise Testing & Prescription*, 9th ed., 2014)

DOCUMENT C-5

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

PAR-Q & YOU

(A questionnaire for People Aged 15-69)

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

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

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

YES ☐	NO☐	**1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
YES ☐	NO☐	**2. Do you feel pain in your chest when you do physical activity?**
YES ☐	NO☐	**3. In the past month, have you had chest pain when you were not doing physical activity?**
YES ☐	NO☐	**4. Do you lose your balance because of dizziness or do you ever lose consciousness?**
YES ☐	NO☐	**5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
YES ☐	NO☐	**6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
YES ☐	NO☐	**7. Do you have a diabetes or thyroid condition?**
YES ☐	NO☐	**8. Do you know of any other reason why you should not do physical activity?**

If you answered "Yes":

YES to one or more questions

A medical clearance form is required of all participants who answer 'yes' to any of the eight PAR-Q questions.
Note: Personal training staff reserve the right to require medical clearance from any client they feel may be at risk.

- Discuss with your personal doctor any conditions that may affect your exercise program.
- All precautions must be documented on the medical clearance form by your personal doctor.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active - begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal - this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- If you are not feeling well because of a temporary illness such a cold or a fever - wait until you feel better; or
- If you are or may be pregnant - talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professionals.
Ask whether you should change your physical activity plan.

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

NAME____

SIGNATURE____ **DATE**_______________

CURRICULUM VITAE

VITA

James *Riley* Galloway, M.S., NREMT, Ph.D.(c).
Department of Health, Exercise Science, and Recreation Management
School of Applied Sciences
University of Mississippi
244 Turner Center
University, MS 38677

ACADEMIC RECORD

August, 2016	Doctor of Philosophy	*Department of Health, Exercise Science, and Recreation Management* School of Applied Sciences University of Mississippi **Major Area:** Exercise Physiology and Metabolism **Cognate Area**: Statistics and Neuromechanics **Dissertation**: *Physiological and perceptual responses to alternate modes of exercise at self-selected or prescribed intensity between normal and overweight individuals.*
2012	Master of Science	*Department of Kinesiology* College of Education Mississippi State University **Major:** Clinical Exercise Physiology **Thesis**: *The evaluation of driver selection on measures of golf performance.* Through Research Graduate Assistant of the Institute of Golf.
2011	Bachelor of Science	*Department of Sports Medicine and Exercise Science* Belhaven University **Concentration**: Exercise Physiology

ACADEMIC POSITIONS

2016	**Dissertation Fellow**	*University of Mississippi*
2013 – Present	**Graduate Teaching Instructor** • Instructor of record for courses listed below	*Department of Health, Exercise Science, and Recreation Management* School of Applied Sciences University of Mississippi
2013 – Present	**Graduate Research Assistant** • Research Design and Implementation • Data Collection and Analysis	Kevser Ermin Applied Physiology Laboratory *Department of Health, Exercise Science, and Recreation Management* School of Applied Sciences University of Mississippi
2012	**Instructor** • Instructor of record for courses listed below	*Department of Sports Medicine and Exercise Science* Belhaven University
2011-2012	**Graduate Research Assistant**	*Department of Kinesiology* College of Education Mississippi State University
2010 – 2011	**Academic Mentor/Advisor**	*Department of Sports Medicine and Exercise Science* Belhaven University

TEACHING EXPERIENCE

University of Mississippi 2013 - Present	• ES 456	• Exercise Testing and Prescription Lecture	Spring 2014
	• ES 457	• Exercise Testing and Prescription Lab	Spring 2014, Fall 2013
	• ES 351	• Measurement and Statistics in Exercise Science	Spring 2016, Fall 2015
	• ES 348	• Physiology of Exercise Lecture	Fall 2014, Summer 2015
	• ES 349	• Physiology of Exercise Lab	Fall 2014, Summer 2015
	• ES 346	• Kinesiology	Summer 2014
	• HP 312	• Behavioral Aspects of Weight Management	Spring 2015
	• HP 203	• First Aid and CPR	Fall 2013, Spring 2014, Summer 2014, Fall 2014, Spring 2015, Fall 2015
	• EL 153	• Sports Conditioning	Spring 2015
Belhaven University 2012	• SME 380	• Exercise Physiology	Spring 2013
	• SME 302	• Adaptations to Aerobic Conditioning	Spring 2013
Mississippi State University *Instructor Assistant* 2012	• EP 4703	• Neural Control of Human Movement	Fall 2012
Belhaven University *Instructor Assistant* 2010-2011	• BIO 230	• Human Anatomy and Physiology	Fall 2010, Spring 2011
	• BIO 231	• Human Anatomy and Physiology Lab	Fall 2010, Spring 2011
	• 420	• Advanced Exercise Physiology	Spring 2011

RELEVANT GRADUATE COURSEWORK

Mississippi State University (2011-2012)

EP 8203	Advanced Exercise Physiology
EP 8243	Cardiorespiratory Exercise Physiology
EP 8263	Exercise Biochemistry
KI 8303	Research in Kinesiology
KI 8313	Interpretation of Data in Kinesiology
EP 8283	Environmental Exercise Physiology
EP 8423	Graded Exercise Testing and EKG Interpretation
EP 8443	Neuromuscular Mechanisms in Exercise
EP 8503	Occupational Physiology
KI 8000	Thesis

University of Mississippi (2013-Present)

ES 608	Methods and Procedures in Graded Exercise Testing
ES 618	Advanced Muscle Physiology
ES 615	Physiology of Aging
ES 614	Cardiovascular Physiology
ES 613	Health Aspects of Physical Activity
ES 612	Instrumentation and Analysis in Biomechanics
NHM 619	Sports Nutrition
ES 651	Advanced Individual Study
ES 653	Independent Research
Phad 688	Research Methodology and Techniques
Phad 780	General Linear Models
Phad 781	Applied Multivariate Analysis
ES 652	Advanced Individual Study
Phad 795	Longitudinal Data Analysis (Auditing)
ESPR 797	Dissertation