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Association of Various Physiological and Fitness Markers to Body Fat Percentage in Physically inactive Adults

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Obesity can dramatically and negatively affect many aspects of normal physiological functioning. Obesity is defined as abnormal or excessive body fat accumulation that presents a risk to health. Body mass index (BMI) is a widely used approach to quantify body fat in large group settings; however, this method has significant shortcomings with accuracy and estimation. More direct measures such as bioelectrical impedance analysis (BIA) can provide a more reliable and accurate assessment of body fat mass and, therefore reduce the shortcomings of BMI when assessing possible associations with health- and performance-related variables. A plethora of research studies has been conducted on variables using BMI or other surrogate methods to estimate body fatness (i.e. waist-to-hip ratio); however, few have observed body fat percentage (%BF) as the independent variable and how particular physiological and fitness markers are affected. Physiological variables included resting heart rate (RHR), heart rate variability (HRV), and heart rate recovery (HRR). The fitness variables included exercise tolerance (TTE), and maximal oxygen uptake (VO$_2$Max). PURPOSE: The present study investigated possible associations between %BF and various physiological (RHR, HRV & RHR) and fitness markers (TTE & VO$_2$Max) in physically inactive adults. METHODS: Seventy-five total participants were recruited for the study. Of the total recruited for the study 36 were excluded for various reasons. Thus, the final analytical sample comprised 39 apparently healthy adults of both genders who
were identified as physically inactive. Participants undertook a collection of physiological and fitness measures that were conducted in a single visit to the Exercise Physiology Laboratory and took an average of 2h per participant. Basic anthropometric data was gathered prior to body composition assessments, which was measured using the InBody 520. HRV (ms) and RHR (bpm) were measured using a Polar Bluetooth heart rate monitor and a valid cell phone application (i.e., EliteHRV). Exercise tolerance was measured using a Woodway treadmill and the Bruce graded exercise protocol. The referred protocol takes into consideration both speed and grade and allowed for the collection of information pertaining to TTE and heart rate (HR). HR was recorded after 1 and 2 minutes and was used to determine HRR. All performance variables were used in an estimation equation for VO\textsubscript{2Max}. To accomplish the purpose of the study, data were analyzed using Pearson $r$ and Spearman $\rho$ correlation analysis, and correlation coefficients were interpreted as small (0.1), moderate (0.3), and large (0.5). Significance was set at $P < 0.05$. RESULTS: There was a small negative correlation observed between %BF and HRV, although not statistically significant ($P = 0.37$) ($r = -0.15$). Similar small negative correlation was seen in HRR\textsubscript{1} ($P = 0.50$), which was also not statistically significant ($r = -0.011$). Although a large positive correlation was seen between %BF and RHR, it was not statistically significant ($P = 0.76$) ($r = 0.05$). There was a large negative correlation seen between %BF and TTE ($r = -0.68$) and VO\textsubscript{2Max} ($r = -0.84$) where both correlations were statistically significant ($P = 0.00$) & $P = 0.00$ respectively). CONCLUSION: The findings of the present study demonstrated small-to-large correlations between %BF and various physiological and fitness markers. However only correlation between %BF and TEE and VO\textsubscript{2Max} were found to be statistically significant. Therefore, these findings suggest a potential small detrimental effect of
increased %BF on observed physiological (RHR, HRV & HRR) and fitness (TTE & VO2Max) variables.

*Keywords: body fat percentage, exercise tolerance, BIA, body composition*
ASSOCIATION OF VARIOUS PHYSIOLOGICAL AND FITNESS MARKERS TO BODY FAT PERCENTAGE IN PHYSICALLY INACTIVE ADULTS

BY

ANTHONY MCKEE

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Chapter 1

Introduction

Many factors of daily life are affected by obesity and are not restricted to solely economic factors. Obesity and undesirable/unhealthy body weight have been linked with increases in morbidity and mortality (Voelker, 2012), and decreased quality of life (QOL) (Salinsky & Scott, 2003). From the exercise science standpoint, obesity has been associated with physiological dysfunction and decreased performance (Salvadego, et al., 2010). Decreases in physiological function are seen, for example, with a decreased exercise tolerance due to dysfunctional gas exchange in submaximal exercise (Salvadego, et al., 2010). This observation of physiological dysfunction is only one example of how physiological function can be affected by obesity or an undesirable body composition. There are numerous determinants of physiological health and fitness. These variables include resting heart rate (RHR), heart rate variability (HRV), heart rate recovery (HRR), maximal oxygen uptake (VO$_{2\text{max}}$), and exercise tolerance until volitional fatigue, also referred to as time to exhaustion (TTE). Each of these variables have been indicated in previous research showing that abnormal values have an increase in mortality risk (Thayer, Yamamoto, & Brosschot, 2009). The most recent variable that has gained traction in research is evaluating how HRV and associated values indicate mortality risk (Thayer, Yamamoto, & Brosschot, 2009). A poorly controlled autonomic nervous system (ANS) can show a decrease in HRV, with improvements being seen with exercise (Thayer, Yamamoto, & Brosschot, 2009). The decreased values of HRV have been associated with increased mortality risk in men, regardless of fitness level (Thayer, Yamamoto, & Brosschot, 2009). Heart rate values are associated with health and physical activity (Jensen M. T.,
Suadicani, Hein, & Gyntelberg, 2013). There is a relationship between heart rate and the intensity of activity being performed. However, RHR values and ability to return to those baselines are also very valuable as they can indicate health and fitness. RHR can be indicative of fitness level and mortality risk. Research has demonstrated a correlation between a higher RHR and the risk of mortality in men (Jensen, Suadicani, Hein, & Gyntelberg, 2013). HRR is the body’s ability to return the heart rate back to a baseline value after exercise. Abnormal HRR and reduced tolerance to exercise has been shown to also increase the risk of mortality independent of other factors (Dhoble, Lahr, Allison, & Kopecky, 2014). Abnormal physiological cardiac values and performance markers that indicate a reduced exercise tolerance are major indicators of mortality and should be investigated further.

There are many methods available to assess percent of body fat (%BF) in individuals and they range from technologically complex to simple instruments and even surrogate measures. The most time efficient and widely used surrogate methods to assess body fatness include Body Mass Index (BMI), waist to hip ratio and skinfold measures. The advantages of these methods are the cost, practicality and the ability to assess many individuals in a short period and estimate body fatness. The major limitation, however, is there can be significant room for error when utilizing these methods as they use ratios that do not consist of a measure of %BF. Other, more time consuming and resource intensive methods include hydrostatic (underwater) weighing, dual-energy X-ray absorptiometry (DEXA) scans, air displacement plethysmography (ADP), and bioelectrical impedance analysis (BIA). Among the previous, the BIA (e.g., InBody Body Composition Analyzers) is a more time efficient measure of body composition (including %BF) that can provide consistent reliable results within a range of individuals quickly while benefiting
from being non-invasive, prompt and portable (Ricciardi & Talbot, 2007). The InBody 520 has also been shown to be accurate when compared to hydrostatic weighing, which is considered a gold standard method to assess %BF (Ling, et al., 2011).

Large contributions to research observing these variables have typically included generalized anthropometric characteristics such as the study by Dimkpa & Oji (2010) or the study conducted by Jensen, Suadicani, Hein, & Gyntelberg, (2013), both of which employed BMI as the primary classification for body fatness. Although using BMI as a primary clinical method for classifying individuals rapidly is common, this method leaves a large gap where lean mass is not considered. Additionally, studies such as the one conducted by Shafer, Siders, Johnson, & Lukaski, (2009) demonstrate that a high BMI classification in many individuals may not be an accurate assessment for total body fatness. Thus, the adoption of more accurate assessment methods of body composition is essential for determining body fatness accurately, especially when attempting to examining correlation between body fat levels and other variables.

To this end, the raison d’être of the present thesis is to investigate the potential association between %BF, physiological and fitness markers. This will be accomplished by examining the association between body fat percent and RHR, HRV, HRR, VO\textsubscript{2max} and TTE on a graded exercise test. Body fat percentage will be objectively assessed using the bioelectrical impedance (i.e., InBody 520). RHR, HRR and HRV will be assessed using a mobile phone application alongside a heart monitor and exercise tolerance. VO\textsubscript{2max} will be assessed using a standardized, progressive treadmill walking protocol which was validated in a field setting using the same equipment (Perrotta, Jeklin, Hives, Meanwell, & Warburton, 2017). We hypothesized that, when controlling for physical fitness level, an increased level of body fat would negatively
affect physiological and fitness variables including RHR, HRV, HRR, VO$_{2\text{max}}$ and TTE on a graded exercise test. The use of a BIA approach to assess body fatness is important in order to address limitations of previous studies, as BIA is capable of accurate and rapid assessment necessary for our study design and criteria. The variables and the sample chosen for the study are necessary to address limitations of previous studies that have focused on BMI as their independent variable or the limitations of looking at only the physically active population (e.g. athletes).
Chapter 2

Review of the Literature

This study examined the association between body fat percent and RHR, HRV, HRR, VO$_{2\text{max}}$ and TTE on a graded exercise test in physically inactive adults. The present literature review is comprised of the following sections: (1) Obesity and Morbidity; (2) Heart Rate and HRV; (3) body composition; (4) Exercise Protocol, VO$_{2\text{max}}$ & TTE and (5) HRR.

2.1 Obesity and Morbidity

Obesity is a growing and very serious problem globally that increases all-cause mortality risk and is one of the largest draining preventable diseases on the global health care system (Spieker & Pyzocha, 2016). Defined as “a chronic, relapsing, multifactorial, neurobehavioral disease, wherein an increase in body fat promotes adipose tissue dysfunction and abnormal fat mass physical forces, resulting in adverse metabolic, biomechanical, and psychosocial health consequences” (OBESITY MEDICINE ASSOCIATION, 2019, www.https://obesitymedicine.org/definition-of-obesity), obesity poses a challenge to individuals and society. The trend of obesity and undesirable body composition has only gotten worse in the recent years, despite recognition of the problem (Apovian, 2009). Obesity has been observed throughout the human history; however, it was not until the 20$^{\text{th}}$ century that obesity became common and it was recognized as a global epidemic. Despite growing recognition of the problem, the obesity epidemic continues to be a challenge not only in the United States but also across the globe (Caballero, 2007). In the United States, data from the National Center for Health Statics show that the prevalence of obesity in 2015-2016 was 39.8% in adults and 18.5% in youth (Hales, Carroll, Fryar, & Ogden, 2017 (Report No. 288)).
Obesity and abnormal body composition have demonstrated not only a higher risk of mortality but also an increase in various health conditions including heart disease, diabetes, metabolic syndrome, and certain cancers (National Institutes of Health, 1998). More recent studies have also demonstrated that those with obesity and higher fat mass have decreased physical ability and functioning due to sarcopenic obesity (Jensen & Hsiao, 2010). Decreased physical functioning has the capability of negatively affecting job performance and ability to complete work tasks, in addition to causing difficulties performing ADL (Jensen & Hsiao, 2010) and an overall reduction in physical ability (Lipecki, Lic, & Kukla, 2015). Furthermore, researchers have also observed a reduction in the enjoyment of leisure time activity and other activities of daily living (ADL) (Jensen & Hsiao, 2010).

Considering the substantial risk in ability and mortality, there is also a detrimental impact on the health care system and financial burden associated with this preventable disease (Spieker & Pyzocha, 2016). It is estimated that the annual cost of treating medical complications directly related to obesity is around $200 billion, with an additional $66 billion in indirect costs associated with primary treatment (Spieker & Pyzocha, 2016). The observed upward trend in prevalence is anticipated to continue and could reach a staggering rate of 42% of adults over the next 15 years (Spieker & Pyzocha, 2016). Health care costs associated with those rates could reach an estimated $900 billion per year if the current trend continues (Spieker & Pyzocha, 2016). Most of the literature involving obesity and body composition use the body mass index (BMI) scale as a surrogate measure of body fatness. There are inherent problems with this assumption since BMI does not account for lean mass of an individual. Some studies have shown
that individuals can have a high BMI classification while having an ideal amount of lean mass (Shafer, Siders, Johnson, & Lukaski, 2009).

The reasons behind the increase of obesity incidence rate are multifactorial and very complex in nature. It is believed that genetic, environmental and behavioral factors play a role in the development of obesity (Apovian, 2009). Except for the genetics factor, environmental and obesity factors can be controlled through lifestyle modification. There is, however, a large group of researchers and professionals who believe the main reason behind the increase in obesity is the increase in energy intake, coupled with a decrease in energy expenditure (Salinsky & Scott, 2003). There are a lot of reasons why both parts of this equation have been altered over the years. For the increase in energy intake, the availability of food has increased, and manufacturing of food items has increased along with it (Salinsky & Scott, 2003). The decrease in energy expenditure is purportedly due to the increase in available technology. Notably, human environments are engineered to reduce the amount of physical activity. In fact, there is evidence suggesting that adults spend on average 6.4 hours per day in sedentary-related activities, which is an increase of 1 hour per day from 2007 (Yang, et al., 2019). A sharp association is seen between the increase of screen time (a proxy of physically inactive behavior) and the reduction of calories expended, in which some studies have shown daily screen time as much as 4 hours or more (Trivedi, et al., 2015). Increased screen time has been shown to be correlated with decreased physical activity which results in the decrease of caloric expenditure. Physical inactivity is different from sedentary behavior. Although commonly used interchangeably, sedentary behavior is a lifestyle where an individual spends a large amount of time in a sitting, reclining or lying posture with an energy expenditure of less than 1.5 metabolic equivalents (METs).
commonly observed with the use of electronic devices (Tremblay, et al., 2017). In contrast, physical inactivity is defined as not performing enough physical activity congruent with current guidelines, defined in adults as “150 minutes of moderate-to-vigorous-intensity physical activity per week or 75 minutes of vigorous-intensity physical activity per week or an equivalent combination of moderate- and vigorous-intensity activity” (Tremblay, et al., 2017). The large difference in these two definitions can be seen in total caloric expenditure where sedentary behavior can greatly reduce the daily caloric expenditure of an individual.

2.2 Body Composition

Body composition is observed in various models that include various compartment models ranging from 2-compartment to 4-compartment models (Heymsfield, Wang, Baumgartner, & Ross, 1997). The different models comprise of various observed levels and are broken down into atomic, molecular, cellular and tissue-system levels (Heymsfield, Wang, Baumgartner, & Ross, 1997). These models are relevant to the testing method employed when determining body composition. More detailed analyses can be accomplished dependent on the level of accuracy and supplementary information required. When determining something such as intracellular and extracellular water content, the cellular level is required. Comparatively, if bone density is required, a molecular scan would be the prime testing method to analyze mineral content (Heymsfield, Wang, Baumgartner, & Ross, 1997).

Most studies conducted in this area employed body mass index (BMI) to estimate body fatness. Although widely used, BMI is a ratio of body mass and height (Centers for Disease Control and Prevention, n.d.), which leaves some inherent issues when using this method for determining overall body fatness. While the BMI scale is useful for rapid determination of
whether an individual is overweight, or has an undesirable body composition in most adults, this calculation does not consider lean mass of the individual. This major limitation of the BMI scale renders it ineffective when determining if an individual can be classified as “overfat” or having an excess amount of stored bodyfat. To this end, the use of more direct and accurate measures is to be used when requiring an accurate determination of body fatness.

There are determinations when discussing body composition that need to be made aware and clarification is necessary in determining what variables are being discussed. Generally, obesity is defined as having an excessive amount of body fatness (Shea, King, Yi, Gulliver, & Sun, 2012). This broad definition provides no determination of what defines “excessive”, and there are other factors that need to be addressed such as healthy ranges of body fatness (Shafer, Siders, Johnson, & Lukaski, 2009). These ranges are defined in the 2008 guidelines by the American College of Sports Medicine (ACSM). The need for this distinction is apparent in the literature showing that a large portion of males and females who are categorized as obese using BMI, do not actually have a high percentage of body fat (%BF) and rather have a healthy amount of lean mass which is more dense (Shafer, Siders, Johnson, & Lukaski, 2009). This is likely since BMI is an index that accounts solely on body mass (i.e., weight) and height, and does not factor in lean mass or a true measure of body fatness of the individual (Shea, King, Yi, Gulliver, & Sun, 2012).

When analyzing body composition with the objective of measuring body fat mass, bioelectrical impedance analysis (BIA) is a fast and reliable method of analysis (Ling, et al., 2011). BIA uses electrical pulses to measure the resistance of electrical current within the body (Kyle, et al., 2004). BIA devices send electrical signals at specific frequencies to aid
determination of body fat mass; some BIA devices use multiple frequency signals to differentiate between different objectives such as measurement of water content in and out of the cells (Kyle, et al., 2004). Since body fat is anhydrous, it acts as a resistive insulator to electrical current and increased fat mass would result in a higher overall resistance (Kyle, et al., 2004).

Some studies have shown that using BIA devices is an expedient, non-invasive method of body composition analysis with minimal investigator or participant error (Ricciardi & Talbot, 2007). These benefits make BIA assessment very attractive to investigators who are working with either a large or busy population, which would make efficiency more crucial.

2.3 Heart Rate & Heart Rate Variability

It has been shown that a decreased RHR can indicate a healthier cardiopulmonary system, and decreased risk of mortality (Jensen, Suadicani, Hein, & Gyntelberg, 2013). Measures of RHR vary amongst individuals and fitness classifications, however in most cases, the more physically fit individual displays a lower RHR. Furthermore, it has been shown that increased BMI does correlate with a higher RHR (Jensen, Suadicani, Hein, & Gyntelberg, 2013). Most studies however use the BMI scale as the only variable in observing RHR. As mentioned previously, there is little regard for lean mass when using the BMI scale and muscle mass should be taken into consideration when determining if a higher body fat mass affects RHR. Other measures of cardiovascular health that has been more recently researched is HRV.

HRV is the measure of slight variations in the R-R interval between successive beats of the heart (Acharya, Joseph, Kannathal, Lim, & Suri, 2006). HRV represents the control of the autonomic nervous system (ANS) regarding both the sympathetic (SNS) and para-sympathetic
nervous systems (PNS) (Perrotta, Jeklin, Hives, Meanwell, & Warburton, 2017). Depending on where literature is viewed, there is some debate on whether the SNS or PNS have more control over rhythmic activity. It is regarded as a combination of both to varying degrees to comprise total rhythmic activity.

Research has shown that decreased HRV values correlate to increased mortality risk with both sudden and non-sudden cardiac events (Huikuri & Stein, 2013), while other research has demonstrated that a higher HRV shows decreased risk factors (Thayer, Yamamoto, & Brosschot, 2009). On the low end of the spectrum, heart failure patients have seen an HRV as low as the 20’s, where on the upper end of the spectrum, HRV has been high as the 90’s and into the 100’s (Acharya, Joseph, Kannathal, Lim, & Suri, 2006). Most research has been conducted on either the clinical population or the athletic population, leaving a gap of research on the healthy physically inactive populations. Of the research that has been conducted in the healthy non-athletic populations, BMI was used as the independent variable, rather than body fat percentage.

With the advancement of technology, assessing HRV can be completed using mobile phone applications. Paired with a heart rate monitor (HRM) such as the Polar H7, which is Bluetooth capable, applications can analyze and record data regarding cardiac activity (Perrotta, Jeklin, Hives, Meanwell, & Warburton, 2017). As demonstrated in the study by Perrotta et.al., there was a strong positive relationship between the HRV values measured with an ECG and analyzed using a computer-based software (Kubios) and using the EliteHRV phone application with a Polar H7 chest monitor (2017).
2.4 Exercise Protocol, VO$_{2\text{max}}$ & Time to Exhaustion

VO$_{2\text{max}}$ is a measure of how well the human body can deliver and utilize oxygen to the working muscles (Bassett & Howley, 2000). This value is often associated with physical fitness and general cardiorespiratory health (Dhoble, Lahr, Allison, & Kopecky, 2014). Cardiorespiratory exercise will strengthen the cardiac and pulmonary systems, while deconditioning from sedentary and physically inactive behavior will render these systems inefficient. Testing VO$_{2\text{max}}$ properly typically involves using a treadmill walking protocol while using a metabolic cart to assess and analyze respiratory gases while exercising. Some research has been conducted to create regression equations to estimate VO$_{2\text{max}}$ based on certain performance criteria (Koutilanos, et al., 2013).

Various estimation equations can use participant specific variables to estimate VO$_{2\text{max}}$ performance such as time to volitional fatigue, grade, BMI and age (Koutilanos, et al., 2013). This estimate did not differ from direct measurement values significantly and showed a moderate-to-strong positive correlation with the measurements taken directly with a metabolic gas analyzer (Koutilanos, et al., 2013). By taking specific anthropometric data and recording performance variables, we can accurately estimate cardiorespiratory performance quantified as VO$_{2\text{max}}$ (Koutilanos, et al., 2013). Most studies that investigate VO$_{2\text{max}}$ focus on using BMI as an independent variable or are performed in clinical populations. More research is needed to investigate the possible association with %BF as the independent variable.

The Bruce treadmill protocol is a graded exercise test (GXT) that increases in progressive intensities as the test continues. Graded exercise tests are primarily used in both performance and clinical settings for the purposes of testing either cardiac or pulmonary responses and efficiency
Graded protocols that increase intensity at specific increments are useful for predicting cardiorespiratory efficiency due to the “more uniform gas exchange and hemodynamic responses during the exercise test” (Kaminsky & Whaley, 1998). The Bruce ramp protocol has been established as a reasonable and valid treadmill protocol for use in the general population (Kaminsky & Whaley, 1998).

2.5 Heart Rate Recovery

HRR is defined as the body’s ability to lower heart rate immediately following maximal exercise and commonly indicates vagal tone (Cole, Blackstone, Pashkow, Snader, & Lauer, 1999). It has been established that a reduced vagal tone and lower HRR are risk factors of increased mortality (Cole, Blackstone, Pashkow, Snader, & Lauer, 1999). With the conclusion of the study by Cole et. al., it was established that a reduction of 12 beats per minute or less after 60 seconds ceasing maximal intensity exercise increased mortality risk by 14 percent (Cole, Blackstone, Pashkow, Snader, & Lauer, 1999). This component of physical fitness and physiological modulation is an extremely important variable in overall health. Studies have demonstrated that other factors can influence and reduce effective HRR. Some variables that can negatively affect HRR is BMI, waist circumference (WC), and waist-to-hip ratio (WHR) (Dimkpa & Oji, 2010). Although illuminating, this study focused on indices of obesity and general body fatness rather than direct measurement of body fatness.

This literature review briefly describes the current state of research regarding obesity and its relationship with morbidity as well as its influence on important physiological and fitness values. The current state of the literature regarding these relationships focuses on either clinical populations or individuals with categorical surrogate measures of body fatness such as BMI.
More research is needed to establish relationships between these variables discussed and how increased %BF can negatively influence them in untrained, non-clinical populations.
Chapter 3

Methodology

This chapter describes the research methodology that was employed in this study. It consists of a description of the research design, research measures, participant and site, data collection procedures, and data analysis. This research was approved by Northern Illinois University’s IRB and the approval notice can be viewed in appendix B.

3.1 Research Design

The aim of the present research study was to investigate the association between %BF, physiological and fitness markers. In doing so, we examined the association between %BF, RHR, HRV, HRR, VO$_{2\text{max}}$ and TTE on a graded exercise test. To this end, a correlational research design was employed. This type of study is adopted to analyze the relationships between two or more variables and to predict correlation (Thomas, Nelson, & Silverman, 2015). This method was chosen since the study was searching for potential relationships (i.e., correlations) between a dependent variable (i.e., PBF and other independent variables, namely RHR, HRV, HRR, VO$_{2\text{max}}$ and TTE.

3.1.1 Instruments for Data Collection

Body Composition (Body Fat Percent)

Body composition was assessed using an InBody 520 bioelectrical impedance scale. Using BIA devices, and specifically the InBody 520 has been validated as an accurate testing method in previous studies compared to other standard testing measures (Ling, et al., 2011). During body composition assessment, the electrodes on the feet and hand holds of the InBody
were cleaned immediately prior to each participant being assessed. The participant was instructed to hold the hand sensors and properly stand on the foot sensors per manufacture’s protocol. The placement of the participants’ hands and feet were checked for correct positioning by the principal investigator (PI). The participant was then instructed to stand straight up, holding the hand sensors firm, but not too tightly, and to hold as still as possible while the scan is being conducted (about 90 seconds).

All participants were informed via email of pre-test guidelines prior to arriving for testing. These guidelines included a) no eating three hours prior to the test b) drink adequate fluids for 12 hours prior to the test c) avoid intense exercise for 12 hours prior d) avoid caffeine intake for three hours prior and e) empty bladder within 30 minutes of the test.

*Heart Rate (HR) & Heart Rate Variability (HRV)*

HR and HRV were taken from the participant using a Polar H7 Bluetooth chest strap and a cell phone application called EliteHRV (version 4.7.0) which was validated against ECG measurements in a field-based setting (Perrotta, Jeklin, Hives, Meanwell, & Warburton, 2017). The polar HR monitor was moistened with tap water and placed on the participant’s skin so that the transmitter is centered at the base of the sternum over the xiphoid process. The participant was instructed to remain seated for a period of 5 minutes in a quiet room prior to data being collected. The PI informed the participant that this measurement was to be recorded via the cellphone application. Once the subject was seated for the required amount of time, we started the EliteHRV application, which ran with a 1-minute test to determine heart rate and HRV (Esco, Flatt, & Nakamura, 2017).
VO$_{2\text{max}}$ and Exercise Heart Rate

VO$_{2\text{max}}$ was estimated using a submaximal treadmill protocol, namely the Bruce protocol. Although the Bruce protocol is intended for submaximal testing, ending at 85% maximum heart rate, the participants performed a maximal effort test past that threshold in order to measure TTE. This treadmill test was conducted using a Woodway treadmill (Woodway, Waukesha, Wisconsin) and all testing was conducted in the exercise physiology laboratory of Anderson Hall, Northern Illinois University. This graded exercise test (GXT) increased in incline and speed at standardized stages and intensities. Each stage of the test lasted for three minutes and the protocol began with the participant walking at a 1.7 mph speed and a 10% grade. The speed and grade both increased with subsequent stages at standard increments. See appendix D for the specific increases per stage. Participants were instructed to perform the test until volitional fatigue, defined as when the participant felt they could not continue the test. The participant was instructed at the termination of the test to place their hands on the support rails of the treadmill and straddle the belt of the treadmill to signal termination of the test. Time and stage of the termination was recorded in the data sheet. VO$_{2\text{max}}$ was estimated using an equation 

\[ 58.443 - (0.215 \times \text{Age}) - (0.632 \times \text{BMI}) - (68.639 \times \text{Grade}) + (1.579 \times \text{Time}) \]

that factors in age, BMI, time at completion and time of completion. This equation has been validated in a study comparing the equation against a direct measure of VO$_{2\text{max}}$ (Koutilanos, et al., 2013).

Time to 85% MHR & Heart Rate Recovery (HRR)

During the incremental exercise protocol, participant’s HR was monitored using a Polar H7 Bluetooth chest monitor. As the participant reached 85% of age-predicted max heart rate, the time was recorded indicating the time it took for the participants HR to reach that value. The
participants continued the test until volitional fatigue. After the exercise protocol was completed, a 3-minute recovery session was conducted. This involved the participant walking at 2.5 mph at a 0.0% grade. HR was recorded after one minute and two minutes of recovery and recorded on the data sheet. Absolute HRR in beats per minute were calculated from HR at time of test termination using the following equations: $HRR1 = HR @ \text{Quit} - HR @ 1 \text{Minute}$ and $HRR2 = HR @ \text{Quit} - HR @ 2 \text{Minutes}$.

**Age Predicted Max Heart Rate & 85% of Age Predicted Max Heart Rate**

Age predicted max heart rate (MHR) and 85% of the age predicted max heart rate (85MHR) was determined mathematically based on participant’s age. The formula for determining a participants MHR is $MHR = 208 - (Age \times 0.7)$ and the formula for determining the participants 85MHR is $85\%MHR = MHR \times 0.85$ (Tanaka, Monahan, & Seals, 2001).

**Additional assessments**

Blood pressure was taken from each participant prior to beginning any testing to ensure they met the inclusion criteria. Each participant was instructed to remain seated for a period of five minutes in a quiet room to allow blood pressure to stabilize. The participants’ arms were to be rested on a table at heart level, while seated in a chair that supported their backs; following guidelines proposed by the American Heart Association (American Heart Association, n.d.). Blood pressure was taken by the PI, manually using a Mabis Legacy Sprague Rapport stethoscope and a Mabis MatchMates Aneroid sphygmomanometer.

Height was gathered using a wall mounted stadiometer rounded to the nearest centimeter. The height taken was converted to meters using the equation $Height \ (m) = \frac{Height \ (cm)}{100}$. Weight was
gathered for each participant when they stood on the InBody 520 for body composition analysis. The weight of each participant was gathered in pounds and converted to kilograms with the equation \( Mass \ (kg) = \frac{Weight \ (lbs)}{2.2046} \). The metric converted values were used to calculate BMI using the equation \( BMI = \frac{Mass \ (kg)}{Height \ (m)^2} \) (Keys, Fidanza, Karvonen, Kimura, & Taylor, 1972).

3.2 Participants & Study Site

We recruited and scheduled a total of 75 participants who were apparently healthy individuals between the ages of 18 and 30 years old, with a mean age of 22 years. Of the 75 participants, 39 were able to participate after exclusion. There were 15 males and 24 females. Recruitment comprised of various methods including word of mouth, posted flyers and personal visits to different classes to explain and invite prospective participants to volunteer for the study. Detailed recruitment materials can be seen in appendix A.

3.2.1 Inclusion and Exclusion Criteria

Inclusion criteria included: a) between 18 and 30 years old; b) being physically inactive according to the American College of Sports Medicine (ACSM) and c) no history of cardiopulmonary diseases, or any medical conditions that prevent them from participating in physical activity or exercise. The established age was employed to limit the body fat ranges of individuals to two categories (low and high fat). All participants were deemed to be physically inactive and physically inactive according to the ACSM, if individuals performed less than 150 minutes of moderate physical activity, less than 75 minutes of vigorous activity or a combination of the two per week.
Participants were excluded from the study if they answered ‘yes’ to any of the questions on the health history questionnaire (HHQ) or on the ParQ. The only exception to this will be if the participant had a letter from their primary care physician clearing them for physical activity. Other exclusion criteria include falling outside of the designated age or %BF ranges. Lastly, during the initial intake meeting, each participant’s blood pressure was taken by the primary investigator (PI) and if the reading for blood pressure is at hypertension stage I or greater, the participant will be excluded from the study. AHA guidelines set hypertension stage I as having a systolic blood pressure of 120-130 or a diastolic blood pressure of 80-89.

3.3 Data Collection

Participants meeting the inclusion criteria were scheduled a one single time visit to the Exercise Physiology Laboratory in the Department of Kinesiology and Physical Education for assessments. Upon arrival, participants were given time to read and sign the informed consent. Following, participants completed a series of questionnaires, which included physical activity levels, and health history questionnaire. Participant intake forms are detailed in appendix C. After completion participants underwent anthropometric measures of height and weight, and resting blood pressure. After completion of this part of the assessments, participants had their percent body fat (PBF) quantified. The footpads and hand grips on the InBody were cleaned with a cleaning solution prior to running the scan. The participants information was entered into the InBody and the participant was instructed to stand up straight and look straight ahead, ensuring that their hands and feet were placed properly on the electrodes of the InBody. The scan took about 90 seconds to be complete and results were printed for the records of both the PI and the participant. Data that was taken from the InBody results include the PBF and weight in pounds.
The weight was converted to kilograms \(\text{Weight (kg)} = \frac{\text{Weight (lbs)}}{2.2046}\) and recorded on the data sheet along with the \%BF.

Once the body composition analysis was completed, the participant was fitted for a Polar H7 heart rate monitor to be worn on the chest. The monitor was moistened with water and proper placement was ensured by the PI. The participant was instructed to take a seat and remain relaxed for a time of two minutes to allow for heart rate to stabilize from any previous standing and walking. After the allotted time was used for heart rate stabilization, the PI analyzed HRV and RHR using a cellphone application called EliteHRV. This application records a 1-minute time frame of HRV and RHR. These values that were recorded are HRV (ms) and rMSSD. Both values were recorded in the data table.

The participants performed the exercise protocol after the other variables were taken and collected. The participants were provided verbal instructions on what the test would entail, and the specific protocol for terminating the test. The participants were to perform the graded exercise test (GXT) until volitional fatigue which was described as the point where the participant felt they could not continue the test protocol. The PI monitored the participant’s heart rate using the Polar H7 strap that was applied earlier in the session. The protocol for the GXT was the Bruce protocol and uses gradually increasing difficulty in both incline grade and speed every three minutes. During the GXT the PI monitored heart rate as the intensity of the test increased. The PI recorded the time it took for the participants heart rate to reach 85% of their age predicted maximum (85%MHR). The equations used to estimate this value was \(MHR = 208 - (Age \times 0.7)\) and \(85\%MHR = MHR \times 0.85\). This time variable was recorded in the data sheet.
The participant continued the test uninterrupted until volitional fatigue. The time was recorded when the participant stopped the test, as well as the heart rate at the time of completion. The PI immediately lowered the grade of the treadmill to zero and the speed of the treadmill to 2.5 mph to start the cool-down walk. The heart rate after one minute and two minutes of recovery was recorded on the data table. The participant was instructed to continue walking until a five-minute recovery walk was completed.

### 3.4 Statistical Analysis

Data was analyzed using SPSS version 25 (IBM Corporation, Armory, N.Y) and significance was set at $P < .05$. Descriptive statistics (mean, standard deviation and percentage) were used to describe sociodemographic and health-related data. Shapiro-Wilk test was used to test the normality of the data for the variables of interest (i.e., %BF, RHR, HRV (rMSSD), HRR in beats per minute, VO$_{2\text{max}}$, TTE). Normality of the data was confirmed for all variables, except RHR. Despite RHR data not showing to be normally distributed, Pearson $r$ and Spearman $\rho$ were used to examine and report the association between %BF and all variables of interest. Further, 95% confidence intervals (95%CI) was calculated for all correlation analyses. The magnitude of the correlation of 0.1, 0.3, and 0.5 was interpreted as representative of small, moderate and large, respectively, based on Cohen’s guidelines (Cohen, 1988).
Chapter 4

Results

The purpose of this study was to investigate the association between %BF and various physiological and fitness markers in physically inactive adults. This chapter is organized into a) general participant characteristics and demographics, b) Physiological and Performance Data and, c) Correlational Analysis.

4.1 Participant Demographic and Anthropometric Data

Of the total 75 participants recruited for screening to participate in the study, 36 were excluded from testing for various reasons. Twenty-six were excluded for being too active, six from having medical conditions, two because of %BF not falling within accepted ranges and two because of age. One individual in the medical category was disqualified due to having an HRV value (27ms) that was deemed to be too low, and risky to include in the rest of the testing. This determination to exclude the individual from the study was in line with researching showing low HRV values having a high risk of adverse events, even in normal individuals (Vanderlei, Pastre, Hoshi, Carvalho, & Godoy, 2009). The individual excluded was advised to follow up with their primary care physician with a detailed email of our findings and concerns.

Following the excluded individuals, a total of 39 participants were included and enrolled in the present study to continue with the remainder of the testing. Detailed characteristics of the participants are shown in table 1. Briefly, the average age of the participants was 22 years old and nearly 62% (n = 24) were females. In addition, most of the participants in this study self-reported as Caucasian (n = 20) with average BMI values in the category of overweight.
Table 1. Demographic and anthropometric characteristics of college age students.

<table>
<thead>
<tr>
<th>Demographics</th>
<th>N=39</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, Years</td>
<td>22 (2.2)</td>
</tr>
<tr>
<td><strong>Sex, n(%)</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15 (38)</td>
</tr>
<tr>
<td>Female</td>
<td>24 (62)</td>
</tr>
<tr>
<td><strong>Ethnicity, n(%)</strong></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>20 (51)</td>
</tr>
<tr>
<td>Asian</td>
<td>6 (15)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>5 (13)</td>
</tr>
<tr>
<td>African American</td>
<td>8 (21)</td>
</tr>
<tr>
<td><strong>Anthropometrics</strong></td>
<td></td>
</tr>
<tr>
<td>Height, m</td>
<td>1.7 (0.1)</td>
</tr>
<tr>
<td>Body Mass, kg</td>
<td>75.5 (16.9)</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>26.4 (5.4)</td>
</tr>
</tbody>
</table>

Note: Values are mean and standard deviation unless otherwise noted.
BMI: Body Mass Index

4.2 Physiological and Performance Data

Mean and standard deviation values for the analyzed physiological and performance variables employed in this study can be seen in table 2. Briefly, the participants overall had a mean %BF of 27% with the low %BF group averaging 15% and the high %BF group averaging nearly 33%. Other notable differences include VO₂max with overall values close to 42 mL·kg⁻¹·min⁻¹ while the mean for the low %BF group of 47 mL·kg⁻¹·min⁻¹ and the high %BF group of 40.0 mL·kg⁻¹·min⁻¹.
Table 2. Mean (SD) values of physiological and performance variables for college age students

<table>
<thead>
<tr>
<th>%BF Categories</th>
<th>Overall (n=39)</th>
<th>Low (n=10)</th>
<th>High (n=29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>%BF</td>
<td>27.2 (10.1)</td>
<td>15.0 (1.9)</td>
<td>33.3 (6.8)</td>
</tr>
<tr>
<td>RHR, bpm</td>
<td>79.5 (13.9)</td>
<td>77.3 (19.3)</td>
<td>80.3 (11.4)</td>
</tr>
<tr>
<td>HRV, ms</td>
<td>55.8 (7.8)</td>
<td>58.8 (6.5)</td>
<td>54.8 (8.0)</td>
</tr>
<tr>
<td>TTE, Decimal</td>
<td>9.87 (1.63)</td>
<td>11.1 (1.1)</td>
<td>9.5 (1.6)</td>
</tr>
<tr>
<td>HRR1, bpm</td>
<td>20.7 (6.5)</td>
<td>22.0 (7.3)</td>
<td>20.3 (6.1)</td>
</tr>
<tr>
<td>(VO_{2\text{max}}), mL·kg(^{-1})·min(^{-1})</td>
<td>41.7 (4.9)</td>
<td>47.1 (1.8)</td>
<td>40.0 (4.3)</td>
</tr>
</tbody>
</table>

Note:
- %BF: Percent Body Fat
- RHR: Resting Heart Rate
- HRV: Heart Rate Variability
- TTE: Time to Exhaustion
- HRR1: Heart Rate Recovery at 1 Minute
- \(VO_{2\text{max}}\): Maximal Oxygen Uptake

4.3 Correlation Analysis

Pearson \((r)\) correlational analysis showed a small negative correlation between %BF and HRV \((r = -0.15)\) and HRR1 \((r = -0.11)\). There was a large positive correlation between %BF and RHR \((r = 0.52)\) although not statistically significant. There are also large negative correlations between %BF and TTE \((r = -0.68)\) and \(VO_{2\text{max}}\) \((r = -0.84)\). The correlation between %BF and TTE and \(VO_{2\text{max}}\) was statistically significant \((p < 0.01)\). Spearman \((\rho)\) analysis demonstrated no correlation between %BF and HRR1 \((\rho = -0.1)\), however there was a small negative correlation between %BF and HRV \((\rho = -0.13)\). Analysis further revealed a small positive correlation with %BF and RHR \((\rho = 0.18)\). Large negative correlations were observed between %BF and TTE \((\rho = -0.67)\) and \(VO_{2\text{max}}\) \((\rho = -0.87)\). Detailed results from the correlation analysis can be seen in table 3 and figures 1 and 2.
Table 3. Correlational analysis between percent body fat and physiological and performance variables in college age students.

<table>
<thead>
<tr>
<th>%BF</th>
<th>%BF</th>
</tr>
</thead>
<tbody>
<tr>
<td>RHR, bpm</td>
<td>0.52</td>
</tr>
<tr>
<td>HRV, ms</td>
<td>-0.15</td>
</tr>
<tr>
<td>TTE, decimal</td>
<td>-0.68*</td>
</tr>
<tr>
<td>HRR1, bpm</td>
<td>-0.11</td>
</tr>
<tr>
<td>VO₂max, mL·kg⁻¹·min⁻¹</td>
<td>-0.84*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>%BF</th>
<th>95% CI</th>
<th>%BF</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>RHR, bpm</td>
<td>0.52</td>
<td>0.24; 0.71</td>
<td>0.18</td>
<td>-0.14 – 0.47</td>
</tr>
<tr>
<td>HRV, ms</td>
<td>-0.15</td>
<td>-0.44; 0.17</td>
<td>-0.13</td>
<td>-0.43 – 0.18</td>
</tr>
<tr>
<td>TTE, decimal</td>
<td>-0.68*</td>
<td>-0.82; -0.46</td>
<td>-0.67*</td>
<td>-0.81 - -0.45</td>
</tr>
<tr>
<td>HRR1, bpm</td>
<td>-0.11</td>
<td>-0.41; 0.21</td>
<td>-0.09</td>
<td>-0.39 – 0.23</td>
</tr>
<tr>
<td>VO₂max, mL·kg⁻¹·min⁻¹</td>
<td>-0.84*</td>
<td>-0.91; -0.72</td>
<td>-0.85*</td>
<td>-0.93 - -0.69</td>
</tr>
</tbody>
</table>

Note: *P<0.01
Figure 1. Scatterplots for the association between percentage of body fat and physiological variables: resting heart rate (top left), heart rate variability (top right), and heart rate recovery after 1 minute (bottom center) (right).

Figure 2. Scatterplots for the association between body fat percent and performance variables: time to exhaustion (left) and aerobic fitness (right).
Chapter 5

Discussion

5.1 Discussion

The present study sought to investigate the potential associations between %BF and physiological and fitness markers in physically inactive adults. More specifically, we examined the association between %BF, RHR, HRV, and HRR1 and fitness markers (i.e. TTE and VO_{2max}). We hypothesized that %BF would be moderate-to-strong associated with all physiological and performance variables assessed. The main findings were a) a small negative correlation between %BF and HRV and HRR1, none of which were statistically significant b) large positive correlation between %BF and RHR which was not significant c) large negative correlations between %BF and TTE and VO_{2max} that were both statistically significant. Although not all expectations of a moderate-to-strong correlation between %BF and observed variables were met, most showed at least a small correlation.

Based on the results of the study in the sample size and demographics observed, we can infer that an increased %BF can be detrimental to health and performance. Since the fitness level of individuals was controlled, the increased %BF appears to have at least a small adverse correlation between the observed variables. With increased levels of %BF adverse correlation was observed in both physiological markers such as HRV, HHR1 and RHR, and fitness markers which included TTE and VO_{2max}. With adverse correlations seen in all observed variables, discussion is necessary to evaluate the possible causes and importance of the findings.
The statistical analysis also demonstrated a small negative correlation (-0.15) when comparing HRV to %BF. As previously mentioned, heart rate is controlled by the ANS, with contributions from both the sympathetic and parasympathetic branches to varying degrees. Increased resting values of HRV have been shown to have a link with potential cardiac events (Malik & Camm, 1990). The link between HRV and diseases have also led to investigations in those that affect the ANS such as diabetes (Malik & Camm, 1990). It is possible that the correlation seen between %BF and HRV have similar physiological causes that are seen in reduced HRV values and diabetic individuals (Kudat, et al., 2006). As stated by Kudat et al. (2006), further decreased HRV values were observed in those with chronic complications compared to those without. Therefore, the small correlation observed in the present study could indicate the start of a metabolic syndrome or disease and provide a warning to those with increased levels of %BF.

The ability for the body to control, and specifically reduce, heart rate after ceasing exercise has been shown to be an important indicator of health and mortality risk in previous studies (Dhoble, Lahr, Allison, & Kopecky, 2014). The correlational analysis demonstrated a small negative correlation (-0.15) when comparing HRR1 to %BF. The reduction in heart rate after exercise is controlled by the autonomic nervous system (ANS), specifically by the vagal innervation of the heart. Impaired ability to reduce heart rate after exercise can indicate inefficiencies in the ANS via vagal innervation and indicate that the body’s energy requirement is still elevated post exercise. The assumption of an increased energy requirement is because heart rate and workload, the energy requirement of activity, have a positive linear relationship (Garet, et al., 2005). The ability to reduce heart rate after exercise can be bolstered as an
adaptation to training, specifically endurance training (Daanen, Lamberts, Kallen, Jin, & Meeteren, 2012). Subsequently, fitness levels were controlled in this study, so there was minimal training adaptation if any when observing HRR1 values. Due to the control for training adaptation, the decreased HRR1 values indicate an elevated metabolic state after exercise, possibly due to increased adipose tissue.

We further observed a strong positive correlation shown between RHR and %BF. This suggests that the higher level of adipose tissue is associated with a greater RHR value. It has been established that lower RHR values can be a surrogate measure of cardiorespiratory fitness and efficiency along with disease factors (Jensen M. T., Suadicani, Hein, & Gyntelberg, 2013). Those who display lower RHR values are considered more physically fit individuals due to their cardiovascular system not having to work as hard at a given workload or intensity of activity, including when at rest. Since fitness levels were controlled for in the present study, it may be possible that the increases in RHR values were caused by an increased level of adipose tissue. This would indicate that the heart must work harder at every level of intensity to sufficiently supply the body with oxygen, even when at rest. Studies have shown that increased RHR can lead to increased mortality and a decreased lifespan (Jensen M. T., Suadicani, Hein, & Gyntelberg, 2013) which would illuminate the importance of controlling RHR values. Furthermore, Jensen et al. (2013) demonstrated that this increased risk of mortality was independent of training status and physical fitness. This study was conducted over the course of more than a decade to track individuals and their mortality risk, which included RHR and fitness (VO₂max).
The reduced exercise tolerance, noted by the decreased performance markers with higher %BF is in line with similar research demonstrating the same result when comparing exercise tolerance to BMI (Prabha, Padamanabha, & Doddamani, 2014; Pataky, Armand, Muiller-Pinger, Golay, & Aller, 2014; O. Ozcelik, 2004). The study conducted by Pataky et. al. (2014) demonstrated abnormal behavior regarding gait speed and efficiency as well as reduced endurance in obese women. Reduced TTE and VO2max values generally are used to compare fitness levels between individuals and within fitness classification categories. Since the physical activity level for participants was controlled, we can inference that the increased %BF values independently played a role in reduced exercise tolerance. The increase in adipose tissue may have played a direct role by limiting mechanical efficiency of ventilation, as well as increasing the workload during a given stage compared to individuals who had a lower %BF. It is shown that those with higher BMI classifications also run into mechanical inefficiencies when performing exercise related to joint biomechanics and ventilatory mechanics (Chlif, Keochkerian, Choquet, Vaidie, & Ahmaidi, 2009).

5.2 Implications for Practice

The results of the present study provide practical implications for both general health and performance. For the general public, overall health and wellbeing can be affected by increased levels of %BF based on the correlations observed in the study. Health professionals can use this information to better inform their patients of the potential risks involved in not achieving and maintaining a more ideal body composition. The variables observed in this study should bolster the large volume of information regarding general body composition and health risks such as BMI, physical activity level and nutritional intake. It is also the researchers’ hope that medical
professionals will start to investigate %BF in junction with BMI to assess health risk, rather than using BMI alone. Practitioners in the athletic performance professions could also benefit from the results of this study. A large negative correlation was observed between %BF and exercise tolerance in the present study. Coaches and athletes, for example, can use the information on reduced exercise tolerance to motivate change in attained body composition to enhance peak performance. Due to the control for physical fitness level, it appears that an increased %BF can be a detriment to exercise performance and athletic ability in healthy adults.

5.3 Strengths and Limitations

There are some strengths of the study. The use of the same assessor for data collection ensured uniformity and concise operation when collecting data. Another strength of the study was the use of a more reliable body composition testing method (BIA) compared to previous studies that used a surrogate method of body composition (BMI).

The results of the present study should be interpreted with caution due to some limitations. The primary limitation is that of participant number for statistical strength. Our target population 60 inactive college age individuals, and we were only able to test 39 due to disqualifications for various reasons stated previously. The disqualification of some subjects compromises the generalizability of the study since we are unsure if using a different sample would yield different results. Another limitation of the study was not using a balanced number of individuals for anthropometric data such as sex and ethnicity. The anthropometric characteristics were unbalanced and may have had different results were the participants more balanced. Another limitation of the study was the use of an equation to estimate physical fitness level (VO₂max). This was done due to laboratory scheduling limitations of the study, and total time
investment of the participants. Additionally, using a mobile phone application and a Bluetooth heart rate monitor was a limitation. Although the use of the application was validated in a study against an ECG (Perrotta, Jeklin, Hives, Meanwell, & Warburton, 2017), there is room for error when dealing with wireless technology.

5.4 Suggested Future Research

Future research should attempt to address some of the limitations of this study that were presented earlier. For example, future research should primarily focus on recruiting a larger sample of individuals, attempting to recruit a more heterogeneous sample. Ideally, a more balanced population of subjects (low %BF and high %BF) would add additional strength to any future research study conducted with such purpose. Additionally, future studies should investigate and compare physically inactive to physically active adults and observe whether the pattern of associations are similar between these two subgroups. It is possible that with increased physical activity, most of the adverse correlations observed in the present study would be affected with physical activity regardless of %BF.

5.5 Conclusion

The purpose of the present study was to examine potential associations between %BF and physiological and fitness markers in physically inactive adults. Our findings suggest that %BF is positively and negatively associated with different physiological and performance variables. The most notable correlation was observed between %BF and exercise tolerance. This association was found to be negative and strong in magnitude. Other variables had small to moderate
correlations; however, all the results hold an importance for both general health and athletic ability.

Body composition continues to be an important variable for health and performance purposes. Studies of this nature are crucial in identifying where major influencers are regarding physiological and fitness variables to better guide health and fitness professional’s decisions and actions. The importance of maintaining and ideal body composition should be a top priority for general health and athletic purposes.


APPENDIX A

RECRUITMENT MATERIALS
Recruitment Flyer

Association of Various Physiological and Fitness Markers to Body Fat Percentage in Sedentary Adults

Overview
The purpose of the study is to determine if there is an association between an increased level of body fat and lower fitness markers, or an undesirable effect on physiological variables. Our hypothesis is that an increased level of body fat, regardless of fitness level, will alter the variables we are observing.

We will be testing the following variables:
- **Physiological**: Resting blood pressure, resting heart rate, heart rate variability, body fat percentage
- **Fitness**: Estimated VO2Max, time to volitional fatigue during treadmill walking, heart rate recovery

Testing is happening now! Contact the following individuals if you are interested!
- Anthony McKee at 717677338@students.niu.edu
- Emerson Sebastian at Esebastian@niu.edu

Who can participate?
Anyone who meets the following criteria:
- Between the ages of 18 and 30 years old
- Does not have a medical condition preventing them from physical activity
- Resting blood pressure that is not classified as hypertension stage 1 or higher
- Exercise less than 75 minutes of vigorous activity per week
  - Vigorous activity is defined as not being able to hold a conversation while performing the activity
- Not on any medications that control heart rate or blood pressure

Who will not be allowed to participate?
Anyone who meets the following criteria:
- Anyone who has a history of cardiovascular or lung disease
- Anyone who is taking medications to control heart rate or blood pressure
- Anyone who has blood pressure readings that correlate to hypertension stage 1 or higher
- Anyone who falls out of the specified age, activity or body fat ranges

Are there any risks to participating?
There are some inherent risks, although unlikely, and are as follows:
- Slips, trips and falls
- Musculoskeletal injury during testing
- Unforeseen cardiac events
  - An EKG will NOT be monitored during fitness testing
- Breach of confidentiality with identifiable information
  - All data will be secured in locked rooms and password protected documents
Recruitment Script

Hello everyone,

My name is Anthony McKee and I would like a few minutes of your time to explain a research study I am conducting for my master’s thesis. I am a graduate student here at NIU, and I am pursuing my master’s degree in exercise physiology. I am a graduate teaching assistant and I teach the laboratory sessions for KNPE 452 - Applied Exercise Physiology.

The research I am conducting is titled “Association of Various Physiological and Fitness Markers to Body Fat Percentage in Sedentary Adults.” The purpose of the study is to determine if there is an association between an increased level of body fat and lower fitness markers, or an undesirable effect on physiological variables. Our hypothesis is that an increased level of body fat, regardless of fitness level, will alter the variables we are observing.

There is a set standard of inclusion and exclusion criteria to be included in the study. To be included you must be physically healthy with no cardiac or pulmonary diseases, blood pressure must fall within either the normal or elevated categories, and your total time of vigorous exercise should not exceed 75 minutes per week. Vigorous activity is defined as not being able to hold a conversation with someone else while performing the activity. Body fat ranges should also be met and are set as less than 17.5 or more than 22.4 for males, and less than 23.7 or more than 27.7 for females.

Exclusion criteria of the study include; any medical condition that excludes the participant from conducting exercise, any history of cardiopulmonary disease, the use of medications that regulate heart rate or blood pressure, body fat levels that do not fall within the given range, or a blood pressure that is classified as hypertension stage 1 or higher.

The testing will include taking resting values of blood pressure, heart rate, and heart rate variability. Body fat will be tested using the InBody 520 which uses bioelectrical impedance analysis. The exercise protocol will include a graded exercise test walking on the treadmill. The test will continue until you decide to stop the test when you reach fatigue. There will not be any monitoring of an EKG while conducting this test. I will record heart rate values at the end of the test and 2 minutes following the end of the test.
The total time of the test will be about 60 minutes and will be completed in one or two sessions. Variations in the time to complete and number of sessions vary based on scheduling, and equipment issues that may arise. All testing will be conducted in the exercise physiology laboratory in Anderson Hall 206.

There are some risks involved with the study. Injury risks such as slips, trips, falls and muscular injury while conducting the tests are possible, however unlikely. Unforeseen cardiac events are also a possibility since an EKG will not be monitored during the treadmill test. Cardiac events are unlikely given the screening process to exclude those who would be at risk.

If you are interested in participating, or have any questions, please feel free to contact me at Z1760733@students.niu.edu to schedule a time for screening and testing. Alternatively, you can contact my thesis chair Emerson Sebastiao at esebastiao@niu.edu.
APPENDIX B

IRB APPROVAL FORM
09-Oct-2019
Emerson Sebastiao (01839181)
Kinesiology and Physical Education

RE: Protocol # HS20-0065 “Association of various physiological and fitness markers to body fat percentage in sedentary adults”

Dear Emerson Sebastiao,

Your Initial Review submission, which was reviewed under Member Review procedures by the Institutional Review Board on 11-Sep-2019 has now been approved. Please note the following information about your approved research protocol:

Protocol Approval period: 11-Sep-2019 - 10-Sep-2020
Please remember to use your protocol number (HS20-0065) on any documents or correspondence with the IRB concerning your research protocol.

This approval is effective for one year from the original approval date. If you have not waived the signature of informed consent, I have attached a date-stamped copy of the approved consent form for your use. NIU policy requires that informed consent documents given to subjects participating in non-exempt research bear the approval stamp of the NIU IRB. The stamped document is the only consent form that may be photocopied for distribution to study participants. If you intend to make modifications to the study, you will need additional approval and should contact the Office of Research Compliance, Integrity, and Safety for assistance. Annual review of the project will be necessary until you no longer retain any identifiers that could link the subject to the data collected.

It is important for you to note that as a research investigator involved with human subjects, you are responsible for ensuring that the project has current IRB approval at all times, and for retaining the signed consent forms obtained from your subjects for a minimum of three years after the study is concluded. If consent for the study is being given by proxy (guardian, etc.), it is your responsibility to document the authority of that person to consent for the subject. In addition, you are required to promptly report to the IRB any injuries or unanticipated problems involving risks to the subjects or others.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact the Office of Research Compliance, Integrity, and Safety at (815) 753-8588.
APPENDIX C
SUBJECT INTAKE PACKET
Consent Form

Northern Illinois University
Consent to Participate in a Research Study

Title of Study: **Association of Various Physiological and Fitness Markers to Body Fat Percentage in Sedentary Adults**

Investigators

Name: Anthony McKee

Dept: KNPE

Phone: (847)924-1977

Key Information

- This is a voluntary research study on the effects of body fat percentage on different fitness and body markers on low activity adults.
- This study involves taking basic body data such as resting blood pressure, heart rate, and heart rate variability. Fitness testing includes time to fatigue and heart rate recovery after exercise.
- The benefits include knowing what resting body values are and knowing your fitness limitations; the risks include slips, trips, falls, muscular injury, and cardiac events when conducting fitness testing.

Description of the Study

The purpose of the study is to examine if the level of body fat has an impact on fitness and vital measurements regardless of fitness level. If you agree to be in this study, you will be asked to do the following things: Sit quietly in a room while the researcher takes vitals and other measurements, perform a fitness test to fatigue while the researcher collects data. Fatigue is defined in this context as when you feel you cannot continue the test. An EKG will NOT be used during the treadmill activity; therefore, the researchers will not be monitoring the participant’s physiological state during testing. The tests will be done in one (1) or two (2) session with a total invested time of about 90 minutes. Differences in session number may be due to time or equipment limitations.

Risks and Benefits

The study has the following risks. First, risk of slips, trips and falls are unlikely but possible when conducting fitness testing. Precautions will be taken to ensure the risk of these events occurring is minimal. Other muscular injuries are possible while performing the testing and are unlikely. Unforeseen cardiac events are also possible but unlikely.

The benefits of participation are knowing and understanding your vital information and knowing how fit you are during the fitness tests.

Confidentiality

- This study is confidential.
- The records of this study will be kept strictly confidential. Research records will be kept in a locked file, and all electronic information will be coded and secured using a password protected file. We will not include any information in any report we may publish that would make it possible to identify you.

Your Rights
Northern Illinois University
Consent to Participate in a Research Study

The decision to participate in this study is entirely up to you. You may refuse to take part in the study at any time. Your decision will not result in any loss of benefits to which you are otherwise entitled. You have the right to skip any question or research activity, as well as to withdraw completely from participation at any point during the process.

You have the right to ask questions about this research study and to have those questions answered before, during, or after the research. If you have any further questions about the study, at any time feel free to contact the researcher, Anthony McKee at Z1760733@students.niu.edu or by telephone at (847)924-1977. Alternatively, you can contact Emerson Sebastiao at e.sebastiao@niu.edu or by telephone at (815)753-3656. If you have any questions about your rights as a research participant that have not been answered by the investigators or if you have any problems or concerns that occur as a result of your participation, you may contact the Office of Research Compliance, Integrity, and Safety at (815)753-8588.

Northern Illinois University policy does not provide medical treatment or compensation for treatment of injuries that may occur as a result of participation in research activities. The preceding information shall not be construed as a waiver of any legal rights or redress which the participants may have.

Future Use of the Research Data
Your information collected as a part of this research will not be used or distributed for future research, even if all identifiers are removed.

Your signature below indicates that you have decided to volunteer as a research participant for this study, and that you have read and understood the information provided above. You will be given a signed and dated copy of this form to keep, along with any other printed materials deemed necessary by the study investigators.

Participant’s Signature __________________________ Date ____________

Northern Illinois University

9/11/2019
Approved by NIU IRB
Void one year from above date
Health History Questionnaire

This form asks several questions regarding your health. Please answer every question to the best of your ability. If you have any questions, please ask. Your information will be confidential and secure.

Personal Information

Last Name: ___________________________ First Name: ___________________________ Gender: M F
Email: _______________________________ Ethnicity: ______________________________
Date of Birth: __/__/_________ Age: ______ Height: ______ Weight: ______
Emergency Contact: ________________________________

Health Screen

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
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</thead>
<tbody>
<tr>
<td>Do you have any personal history of heart disease?</td>
<td></td>
<td></td>
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<tr>
<td>Any personal history of diabetes or other metabolic diseases?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any personal history of pulmonary disease, asthma, interstitial lung disease or cystic fibrosis?</td>
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<tr>
<td>Have you experienced pain or discomfort in your chest?</td>
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<tr>
<td>Any unaccustomed shortness of breath walking distances or up a short flight of stairs?</td>
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<tr>
<td>Have you had any problems with dizziness or confusion?</td>
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<tr>
<td>Have you had any unexplained fainting?</td>
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<td></td>
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<tr>
<td>Do you have any difficulty with breathing while standing or sudden breathing problems at night?</td>
<td></td>
<td></td>
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<tr>
<td>Do you suffer from ankle edema (Swelling)?</td>
<td></td>
<td></td>
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<tr>
<td>Have you experienced any fluttering or rapid heartbeat?</td>
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<td></td>
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<tr>
<td>Have you had any severe pain in the leg while walking?</td>
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<tr>
<td>Do you have a known heart murmur?</td>
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<tr>
<td>Do you have a family history of cardiovascular disease?</td>
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<td></td>
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<tr>
<td>Do you have any other medical conditions that would prevent you from performing intense exercise?</td>
<td></td>
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</tbody>
</table>

I have carefully read and understand the questions above. Any questions have been answered by research staff and all questions have been answered to the best of my knowledge. I am satisfied with the answers I have provided.

Signature: ___________________________ Date: ___________________________
ParQ

Physical Activity Readiness Questionnaire (PAR-Q)
(revised 2000)

PAR-Q & YOU
(A Questionnaire for People Aged 15 to 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 their doctor before they start becoming much more physically active.

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

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: 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?

2. Do you feel pain in your chest when you do physical activity?

3. In the past month, have you had chest pain when you were not doing physical activity?

4. Do you lose your balance because of dizziness or do you ever lose consciousness?

5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?

6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart conditions?

7. Do you know of any other reason why you should not do physical activity?

If you answered YES to one or more questions

Talk with your doctor by phone or in person before you start becoming much more physically active, or before you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.

- Find out which community programs are safe and helpful for you.

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 be active. 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 as a cold or a fever — wait until you feel better; or
- If you are or may be pregnant — talk to your doctor before you start becoming more active.

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

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

Note: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

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

Name:

Signature:

Signature of Parent or Guardian (for participants under the age of majority):

Date:

Witness:
APPENDIX D
DATA COLLECTION SHEET
### BRUCE SUBMAXIMAL TEST PROTOCOL

**Assessor Initials:**

**Subject ID:**

**Date:**

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<th>(meters)</th>
<th>Weight (lb.)</th>
<th>(kg)</th>
</tr>
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<tr>
<td><strong>Sex:</strong> ( ) M ( ) F</td>
<td>85% of MHR:</td>
<td>RHR:</td>
<td><strong>T_{start}</strong>: ____ <strong>T_{end}</strong>: ____</td>
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### BRUCE SUBMAXIMAL TEST PROTOCOL

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**Time to 85%**

**VO2max (ml.kg⁻¹.min⁻¹)**

**Comments**