# THE RELATIONSHIP BETWEEN MODES OF EXERCISE AND THE MEASURES IN VISCERAL ADIPOSE TISSUE

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Purpose: The increasing prevalence of obesity observed in the United States should be alarming to our nation, as it effects a large percentage of the population of the United States and is the cause of many thousands of deaths per year (NIH 2022). Obesity leads to many chronic disease states such as metabolic diseases, cardiovascular diseases, or fatty liver diseases. The most influential factor of obesity on chronic health conditions is the visceral adipose tissue (VAT). VAT is most influential due to these adipocytes being more metabolically active, and most VAT containing direct access to the hepatic portal which can lead to ectopic adipose storage. Physical activity and exercise have been shown to reduce VAT mass, however, it has been difficult to determine if resistance training (RT) or aerobic training (AT) are more influential in VAT differences. This study aims to better understand the effects of exercise training compared to a sedentary lifestyle and investigate the changes this will have on body composition. Subjects were separated into a “Highly Active” group and a “Sedentary” or control group. Both groups' body composition measurements were taken with DXA. The subject characteristics and adipose measurements were taken and compared through a 3x1 ANOVA. When comparing the measures of our Sedentary sample to both of the Highly Active groups, VO2 Max was significantly

different from the Control Group.  For Visceral Adipose Tissue Measures, the Resistance Training was significantly lower when compared to both the Control Group and the Aerobic Training group.

# THE RELATIONSHIP BETWEEN MODES OF EXERCISE AND THE MEASURES IN VISCERAL ADIPOSE TISSUE

A Thesis

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List of Abbreviations

AT- Aerobic Training

RT- Resistance Training

HA- Highly Active

SED- Sedentary

SAT- Subcutaneous Adipose Tissue

VAT- Visceral Adipose Tissue

FFA- Free Fatty Acids

ATP- Adenosine Triphosphate

CPET- Cardio-Pulmonary Exercise Test

DXA- Dual Energy X-ray Absorptiometry

DXA VAT- estimated VAT mass/volume/area

## Chapter 1: Introduction

The obesity epidemic in America is continuing to exacerbate. Obesity is personally experienced by over 35% of the public (NIH 2022). Obesity is the second largest preventable killer in the world, only behind smoking. Although physical activity has been known to reduce obesity and other chronic conditions for over 20 years now, many wonder why the obesity rates keep climbing with our increased knowledge and technological availability for nutrition and exercise.

Obesity is normally due to the continuous ratio of an excess of energy intake. Energy intake is the total amount of calories consumed during the day, and energy expenditure is the sum of the resting metabolic rate, thermogenic effect of eating, and physical activity. When the total energy intake is greater than total energy expenditure the body is forced to store the excess energy as body mass, which is mainly stored as fat tissue. One way to combat this excess energy storage is to increase our energy expenditure throughout our daily lives, or through planned exercise.

Although caloric intake and expenditure play a large role in the amount of adipose tissue stored, an increasing amount of research has been performed which concludes that there are specific genetic, racial, and gender differences in the body's metabolic fitness, fuel preference, and habits (Heymsfield et al. 2016). So, not all answers to obesity may be answered through physical activity and energy intake solely.

Within a healthy individual excess energy is stored as either visceral or subcutaneous adipose tissue. Visceral adipose tissue is located throughout the abdominal cavity, and subcutaneous adipose tissue is spread around the body located just under the skin. Visceral

adipose tissue is more metabolically and hormonally active than subcutaneous tissue (Ibrahim 2009). Due to this increased activity and location, the downstream effect of ectopic visceral adipose tissue is the biggest indicator of adverse health effects when dealing with obesity.

***The Problem***

Visceral adipose tissue has been the most correlated to the multitude of chronic conditions that come with obesity, in comparison with subcutaneous adipose tissue, total fat mass, or total body mass (Powell-Wiley 2021). So, when combating obesity and the negative health effects that come with obesity, visceral adipose tissue should be the focus.

Although a lot of research has been done on exercise and its health benefits, there is not lots of clear research articles specifically on the change in visceral adipose tissue concerning exercise. There is evidence illustrating that exercise has a direct relationship with both total body mass and total adipose mass, stating the increase in exercise time will cause a decrease in adipose tissue mass (Ismail et al. 2012). There are preliminary studies that showcase a loss of visceral adipose tissue due to physical activity, many of these studies conclude that the amount of time spent and the intensity of the exercise will have a greater impact on how the visceral adipose tissue changes (Vissers 2013). With an equal caloric intake the amount of adipose mass and body mass have a dose-response relationship with exercise.

However, this relationship is not completely known, and the modes of exercise are difficult to quantify when trying to equate intensity and expenditure. This study intends to further understand the effects that exercise will have on body composition. More specifically, how endurance or resistance-specific exercise will affect the change in mass of visceral adipose tissue and total adipose tissue.

The purpose of this study is to examine the relationship between modes of exercise and the effects on visceral adipose tissue and DXA VAT mass. Extended knowledge in this area can help combat the increasing obesity epidemic and lead to better exercise prescriptions, which will help lead to fewer morbidities, chronic diseases, and other quality-of-life issues due to obesity.

***Hypothesis***

It is expected that the exercise training groups will have a significant difference in body composition compared to the Sedentary group. The null hypothesis is long-term exercise training will cause no change in VAT or body composition. The main hypothesis is that both Highly-Active groups will have a significantly lower VAT mass than the control group. Resistance training individuals are hypothesized to have a lower body fat percentage compared to a Aerobic training individual. I hypothesize these findings because, normally, with highly-active individuals who mainly perform resistance training, they are more likely to do aerobic training as well. Compared to the amount of mainly aerobic exercisers who will also perform resistance training on the side.

# Chapter 2: Literature Review

## *Obesity*

The obesity epidemic in America is detrimental to over 35% of the public (NIDDK 2022). Obesity is the 2nd largest preventable killer in the world, only behind smoking. Physical activity has been known to reduce obesity and other chronic conditions for over 20 years now, so it is wondered by many why the obesity rates are climbing year after year.

Obesity of an individual is caused by the continuous ratio of increased energy intake compared to decreased energy expenditure. Energy intake is the total amount of calories consumed during the day, and energy expenditure is the sum of the resting metabolic rate, the thermogenic effect of eating, and physical activity & exercise. The resting metabolic rate is the minimum energy required to fuel the body at rest. Energy, even at rest, is required and expended to do basic bodily functions such as breathing or respiratory exchange, blood circulation, synthesizing and sending hormones, and cell repair. The thermogenic effect of food is the amount of energy that is required to digest, absorb, and then metabolize the food we eat. Physical activity is when we are performing work such as carrying and walking or any structured exercises.

When the total energy intake is greater than total energy expenditure the body is forced to store the excess energy as body mass. About 60-80% of the total amount of mass gained is stored as adipose tissue (Hill 2012). In an article by Hill, the importance of energy balance relating to obesity is highlighted. A constant state of increased energy uptake and decreased expenditure leads to a state of constant adipose gain, which in time leads to obesity. A chronic state of obesity leads to highly increased chances of mortality. In a separate article written by Hill, they describe how exercising is an important factor in maintaining an energy deficit to combat obesity. The article concludes that it is easier to increase energy expenditure combined with a

caloric deficit to create a greater difference in caloric output, instead of decreasing calorie intake only to create a deficit (Hill 2013). One way to combat this excess energy storage is to increase our energy expenditure throughout our daily lives.

Increasing energy expenditure can be done by increasing physical activity time, or intensity, by either exercising or performing more active tasks instead of sedentary tasks. Physical activity is known to increase energy expenditure by the utilization of the metabolic pathways. Energy must be used for individuals to perform multiple, repeated, high-load contractions of muscle. This energy is created by the breakdown of substrates to create the ATP molecule (Ross 1994). ATP is synthesized using glucose and free fatty acids (FFA) through the mitochondria. This increase in the usage of FFA is what will cause the decrease in adipose mass, resulting in weight loss (Ross 1994).

***Combating Obesity***

It is shown that an increase in physical activity will have a linear increase in caloric expenditure or an increase in weight loss (Cox 2017). This systemic analysis had two main questions that they were aiming to answer. The main aim of this review was to investigate the role of physical activity on weight loss maintenance and to see if there was any compensation for caloric intake with an increase in exercise. This review took studies that had at least a 1-year follow-up and wanted to see which modality of exercise, diet restrictions, and lifestyle choices had on weight loss and weight maintenance. Exercise was a large determinant in an individual's ability to lose weight and then retain their weight at that level. If the subject was to perform the basic recommendations (ACSM PAG) then the subject is more likely to achieve weight loss and weight maintenance. Concluding that it was important to remember that dietary intake and exercise intensity are key contributing factors to weight loss and must be controlled accordingly

(Cox 2017). However, these are not the only key contributing factors to our weight management and health.

***Genetics & Age***

A caloric deficit is one of the most effective ways to decrease adipose storage, but some individuals may be predetermined to expend or store more calories. It has been studied that gender and age differences already play a key role in fat storage. As males are normally storing a bit more VAT than females, and it normally increases linearly with age (Ng et al. 2014). Certain genetic, racial, and lifestyle choices are also highly influential in individuals' metabolic fitness (Heymsfield 2016). In this particular study, they found discrepancies among both male and female percentages in body composition. While using DXA, they concluded that non-Hispanic blacks have the lowest percentage of fat, with non-Hispanic whites in the middle, and Hispanics having the highest body fat percentage (Heymsfield 2016). Certain individuals will experience different levels of caloric expenditure or storage based on certain genetic factors. Concluding that there are predetermined genetic differences among individuals which will affect weight loss and maintenance (Heymsfield 2016).

***Exercise***

Four main types of exercise can be performed to help improve health: endurance, strength, flexibility, or coordination. For the purpose of this study, the main groups that will be compared are endurance and strength training. These will be referred to as aerobic training (AT) and resistance training (RT), respectively. Aerobic training is a moderate-intensity exercise that will depend on the aerobic ATP pathway for energy usage (Johnson et al. 2009). These aerobic workouts are usually performed on a treadmill, stationary bike, or possibly an elliptical. Aerobic

training is known to increase fat utility and uptake during exercise, burning more adipose tissue due to the release of fatty triglycerides into the bloodstream (Thomas et al. 2000). While resistance training normally uses anaerobic pathways when performing work, it normally causes an increase in muscle mass and strength, with little to no changes in body mass or adipose tissue (Willis et al. 2012). The effects of exercise modes on VAT specifically are explained later on.

***Adipose Tissue***

The total amount of fat mass is important when determining an individual's health risks. More specifically, the ratio of adipose tissue to total body mass is usually a good indicator of health fitness (Powell-Wiley 2021). However, it is not the total amount of fat mass that determines the amount of risk, but rather the distribution and depots where the fat is stored (Ibrahim 2009). In an article by Ibrahim, the differences between subcutaneous adipose and visceral adipose tissues are stated. Ibrahim discusses the anatomical, cellular, molecular, physiological, clinical, and prognostic variations between these adipose stores. The most influential depot of fat mass is stored within the abdominal cavity. These are the fat cells that are present within the viscera mesentery and omentum, or what is known as visceral adipose tissue (VAT). The subcutaneous fat mass is increased through healthy fat storage due to a high caloric intake mixed with energy expenditure. If the storage capacity of the SAT adipocytes is exceeded, or, the ability for adipocytes to go through hyperplasia due to certain stressors and genetic predispositions may cause the free fatty acids to be stored as visceral adipose tissue (Ibrahim 2009). Through recent research, the visceral fat cells are found to be much different than the subcutaneous fat. The adipose stores differ in not only placement; but also the type of adipocyte, the endocrine function, hormone sensitivity, the lipolytic activity, and most importantly the inflammatory signaling differences (Ibrahim 2009).

***Visceral Adipose Tissue***

Visceral adipose tissue normally accounts for 10-20% of males, or 5-8% of females, out of the total adipose mass in a healthy individual, and the amount of VAT increases linearly with age (Ng et al. 2014). The positioning of the intra-abdominal adipocytes is one of the key contributions to the negative health effects of VAT. Because of the anatomical position of the VAT within the body, the secretion molecules of the adipocytes drain directly into the liver's portal vein (Hursting and Berger 2012). When the triglycerides are released from the adipocytes, this causes FFA to flow freely into the liver. After an extended time of FFA release into the hepatic portal vein, ectopic fat storage in the liver occurs. These secretion molecules are damaging to the liver, causing hepatic immune mechanisms to arise.

The VAT of an obese individual will contain many of hepatic triglycerides, which are independently linked with metabolic syndrome, insulin sensitivity, and cardiovascular disease (Johnson et al. 2019). In this article, they studied the effects of aerobic training on the hepatic and visceral adipocytes and triglycerides. 23 obese individuals volunteered for this study, and all participants had low alcohol consumption and no fatty liver disease. After a 4-week, progressive, supervised aerobic training program, the mean amount of hepatic triglycerides and lipids was shown to greatly decrease compared to the control, as well as VAT mass. This means that exercise greatly reduces the amount of FFA within the liver and after continued exercise, this will reduce VAT and health-associated risks. Without any liver disease or alcohol influence on the liver, visceral adipose tissue is one of the most influential factors when discussing liver function and health, because of the endocrine function of adipocytes.

The secretion molecules that make the intra-abdominal adipocytes so dangerous to an individual's health deal with the hepatic free fatty acids and adipokines. Adipokines are cell-signaling messengers synthesized and secreted by adipocytes which regulate energy homeostasis

by directing energy intake and energy expenditure (Gray and Vidal-Puig 2007). The adipokines act either centrally by regulating appetite or EE, or peripherally by reducing insulin responsiveness, oxidative capacity, and lipid uptake of cells (Gray and Vidal-Puig 2007). There is a difference in the amount and types of molecules that subcutaneous adipocytes secrete compared to visceral adipocytes. Some of the key factors expressed in the VAT are Cholesteryl-ester transfer protein (CETP), Angiotensinogen, Adiponectin, Interleukin-6, and Leptin (Gray and Vidal-Puig 2007, Wajchenberg 2000).

In Wajchenberg's article, the metabolic functions of adipose tissue are outlined in detail. They first describe the anthropometric indicators, imaging techniques, and measuring techniques to quantify obesity. As well as the implications and correlations that relate to abdominal fat. Both the metabolic function, adipocyte derivatives, SAT, and VAT are specifically compared and contrasted with the pathology of inflammatory, cardiovascular, and diabetes. This study helps solidify the fact that VAT is the most influential health factor dealing with body composition.

In the Gray & Vidal-Puig study, they focused on a number of adipocytes and adipocytokines, mainly focusing on Leptin, the adipocyte-derived factor. Leptin reduces appetite and inhibits/prevents the uptake of lipids in non-adipocyte cells to prevent lipotoxic accumulation. This study highlights the examples of disease states and transgenic animal models with altered adipose tissue function to support their hypothesis. Normally, in a healthy individual, Leptin does not cause an increase in fat storage. However, in an obese condition, or a state of repeated excess caloric intake, the continuous release of leptin causes a resistance to leptin signaling and leptin uptake. This resistance causes metabolic disturbances, and this disturbance leads to preventing the reduction of energy intake as well as preventing adipose loss (Gray and Vidal-Puig 2007). With a compromised adipose system with no adipose uptake and

resistance to leptin release, ectopic adipose storage takes place. Ectopic adipose storage will lead to cells functioning abnormally therefore hindering the tissue or organ's ability of their functions.

In order to reliably measure the adipose tissue found intraabdominally, expensive and special equipment's must be used. A study performed by Bosch et al. in 2015 investigated the correlation between DXA and, at the time, the gold-standard for body composition, computed topography. A total of 329 participants aged 6-18 went through both a DXA scan and CT scan. They concluded with a multiple regression analysis that both estimates of VAT were significantly associated with lipids and insulin sensitivity, measured by euglycaemic-hyperinsulinaemic clamp. Additionally, DXA-VAT was associated with diastolic blood pressure, homeostasis model of insulin resistance and fasting insulin, but CT-VAT was not. With a significant correlation between the two modes of measurement suggests that DXA is a useful and valid method for estimation of VAT in children.

***Exercise Affects***

All these secreted factors and changes in metabolic functions can be improved by daily lifestyle changes or exercise. The ACSM recommends 150 minutes of moderate aerobic exercise with two times of resistance training per week for achieving the most optimal health benefits for the average population. There are two primary modes of exercise that are studied frequently, both aerobic and resistance training, comparing their effects on body composition and health.

One study by Yan et al. that studied the effects of long-term exercising on 105 older adults wanted to compare the results of resistance training to aerobic training. Yan required the subjects to be prediabetic and sedentary to be included in the study. The participants were required to do 3 sessions a week of moderate-intensity resistance training of 13 different exercises with a bungee cord. The exercises were a mixture of unilateral and bilateral upper

body, lower body, core, and back exercises performed at 60% of their 1RM for 10-15 repetitions. The exercise intervention took place over 12 months, measuring VAT and SAT with computed tomography before and after the intervention, as well as blood lipid levels and other blood factors. This study concluded that there was a significant difference in VAT and SAT reduction when comparing both exercise groups to the control group. However, comparing AT and RT to each other showed no distinct difference between one another. Both exercise groups experienced decreased fasting plasma glucose compared to the control. RT greatly increased muscle mass compared to AT. Also, with both exercise groups, the incidence of diabetes was four times lower than the control group. Helping conclude the positive effects of both AT and RT on adiposity and metabolic fitness (Yan et al. 2019).

Another study that examined the effect of both aerobic and resistance exercise on body composition was conducted by Willis et al. This study took 119 overweight, sedentary, adults and placed them into RT, AT, or a mixture of both AT and RT to be performed for eight months. They stated that RT should be performed if an increase in muscle mass is desired. AT and AT+RT groups had the most adipose tissue loss, with little to no change between the two. This study concludes that AT is the most influential mode of exercise associated with adipose loss in young adults with pre-diabetes (Willis et al. 2012).

Another study that outlined the effects of aerobic training on adipose tissue was performed by Thomas et al. However, this study only pertained to non-obese females and only used aerobic exercise. This study found very little changes in total body mass over 6 months but still found significant differences in VAT and high-density lipoprotein cholesterol

A study by Ohkawara et al. was conducted to help illustrate if aerobic training has a dose-response relationship to the reduction in visceral adipose tissue. With nine RCT and seven non-

RCT designs and a total of 582 subjects, they concluded that AT is a favorable means to VAT reduction and 80 percent of the groups experienced significant VAT reduction, however, in all the groups there was no seen dose-response relationship to the amount of METs/h/w of aerobic training and percentage of VAT reduction. So, AT is an important factor in VAT reduction however it is not exactly known how the VAT responds to the exercise exactly (Ohkawara et al 2007).

An article written by Ismail et al. studies RT and AT as well as a combination of the two and differentiates the impact these have on VAT volume. This systematic review and meta-analysis was done on a total of 35 studies that followed the criteria set a priori. These studies must be randomized controlled designs that examine the effects of aerobic training, resistance training, or the combination of both over 4 weeks and must compare VAT measures pre and post-intervention with either CT or MRI. Ismail found that the combination exercise led to more favorable body composition outcomes, with increased muscle mass and decreased adipose volume. Aerobic training had a more significant impact on VAT volume loss compared to resistance training directly. The study also concluded that even less than the recommended amounts of AT may help with adipose reduction (Ismail). However, the intensity of the resistance groups in this study were not measured very similarly which made it hard to make distinct conclusions.

Another meta-analysis that highlights the effects of exercise interventions is a study conducted by Vissers et al. This review declared a priori that studies require a mean age above 18 and a mean BMI, at baseline, above 25. Any RCT, non-RCT, or clinical trials are allowed that follow other specified criteria, with any physical activity that is aerobic or resistance at low, moderate, or high intensities with an 8-week program. This review concluded similarly to Ismail,

stating that AT is of high importance to the reduction of VAT, however high intensity of AT was the most beneficial, even compared to low intensity-high amount of AT or RT. However, within this study, there were only a handful of studies that included resistance exercises within their exercise programming, and only one or two were resistance only. One of the resistance groups measured their exercise intensity by using the individuals' VO2 peak and reaching 75 percent of that. This can be hard to quantify resistance exercise depending if the individual is not breathing properly during exercise, such as incorrectly performing the Valsalva maneuver or hyperventilating during the lift. This makes tracking the resistance training intensity difficult, and hard to equate the VAT loss to that of aerobic training.

In conclusion, visceral adipose tissue is an important factor in determining the long-term health of an individual. This study aims to better understand the difference between endurance aerobic training and resistance anaerobic training and the effects these will have on visceral adipose tissue. The goal is to find or determine a relationship between individuals who are Highly Active and those who are Sedentary and the modes of exercise and VAT measures with a DXA machine

# Chapter 3: Methods

## *MoTrPAC*

The goal for the entire MoTrPAC study is to measure both sedentary and active participants, which were recruited and allocated into about 300 highly active and 1,980 sedentary adults. However, for this study, only data gathered from subjects tested in Greenville, North Carolina at East Carolina University will be used. The adults went through medical screening and health history questionnaires to be determined healthy. After answering a questionnaire provided by the research recruiter, subjects were then categorized as Highly Active, or Sedentary. Participants underwent anthropometric measurements and tests to assess subject characteristics. We tested isometric knee strength test, hand grip strength test, and a cycle ergometer CPET. Participants then had their body composition measured by DXA analysis. For this study, the DXA procedure is used to measure visceral adipose tissue.

For our study, sedentary is defined as self-reporting no more than 1 day per week, lasting no more than 60 minutes, of regular, or structured endurance exercise, or activity that results in feelings of increased heart rate, rapid breathing, or sweating, or performing any resistance exercise that results in muscle fatigue in the past year. Persons bicycling as a mode of transportation to and from work will not be considered sedentary. Leisure walkers are included unless they meet the heart rate, breathing, and sweating criteria noted above. And no Resistance Exercise resulting in muscular fatigue within the past year.

For our study, a Highly Active Endurance Participant is defined as >240 minutes/week of Aerobic Training for >1 year; this can include running, walking, cycling, elliptical, etc. which (at a minimum) results in increased heart rate, rapid breathing and sweating. Must include cycling at least 2 days per week. RT in the past year must be limited to ≤2 days/week of upper body RE and ≤2 muscle groups of upper body RE and ≤1 day/week of lower body RE. While a Highly

Active Resistance Participant is defined as Resistance Training of ≥3 upper and ≥3 lower body muscle groups ≥2 times/week for >1 year; using a prescription sufficient to increase strength and muscle mass.

***Exclusion Criteria***

If any of the following criteria are met by the participant, then they were excluded from the study; diabetes, coagulopathy, thyroid disease, chronic obstructive pulmonary disease, metabolic bone disease, estrogen therapy (or replacement), pregnancy, elevated blood pressure, cardiovascular disease, abnormal blood lipid, Cancer, chronic infections, abnormal liver enzyme, chronic renal insufficiency, hematocrit, blood donation, autoimmune disorders, night shift workers, cognitive status, major weight change, lidocaine allergy, or exceeding limits of alcohol/tobacco/marijuana consumption. The use of certain medications such as cardiovascular, psychiatric, muscle relaxants, pulmonary inflammation, genitourinary, hormonal, or pain medication are all included in the exclusion criteria.

***Body Composition***

The body composition of the participants were measured using Dual-Energy X-ray Absorptiometry (DXA). This machine measures body composition by comparing the total mass and density of measured adipose tissue, bone tissue, and muscle tissue. The DXA methodology is determined by the analysis of the DXA operator and technician. The analysis begins with the alignment of the android and gynoid regions. A 5 cm wide region is placed across the abdomen directly above the iliac crest, usually coinciding with the fourth lumbar vertebrae. This abdominal region is measured, then the scanned region and the measured composition of mass was used to create the estimation for the VAT. The technician must align the outer and inner

margins of the abdominal wall on both sides of the measured image based on the fat and lean mass profiles across the abdomen at the level of the fourth lumbar vertebrae. The DXA computing software then measures the total adipose tissue within that abdominal region, which is the visceral adipose of the abdominal cavity as well as the anterior abdominal subcutaneous and oblique subcutaneous adipose tissue. Then, the VAT mass, VAT area, and VAT volume were estimated based on the measurement of subcutaneous fat subtracted by the abdominal region adipose mass to help calculate the true adipose tissue within the abdominal cavity. This estimated adipose tissue within the abdominal region is defined as DXA VAT.

***Statistical Analysis***

This study was conducted as a 3x1 analysis. An ANOVA is performed to find the interaction effect between the three groups (Sedentary, RT, AT)

## Chapter 4: Results

Anthropometric data and other recorded subject characteristics are shown in data tables, these were compared with a 3x1 ANOVA. Table 1A represents all subjects used within the study broken down into their respective groups; Sedentary (n=38), Resistance Exercise (n=10), and Endurance Exercise (n=6). The minutes per week that the Sedentary group measured had a significant difference compared to both the Resistance ($RT_{p\text{-}val}$=.0031) and Endurance ($AT_{p\text{-}val}$=.0044) groups. There was no significant difference in the amount of time between RT compared to AT. When comparing the VO2 max measured in all subjects, there was a high statistical difference (p-val<.0001) found between all groups, SED vs RT, SED vs AT, and RT vs AT. Isokinetic torque was also significantly different for both groups compared to Sedentary, ($AT_{p\text{-}val}$<.0001, $RT_{p\text{-}val}$<.0001). Age was also found significantly different from the AT group to the Sedentary group and the RT group, ($SED_{p\text{-}val}$=.046, ($RT_{p\text{-}val}$=.003). No other statistically significant differences were found between the anthropometric variables compared.

These three groups were then compared through their adiposity measures. Table 1B breaks down the measures for all the groups' VAT mass, volume, and area. Figure 1 illustrates these groups in a bar graph, with Graph A, B, and C, respectively. When looking at VAT mass there are statistical differences from the Resistance group to both the Sedentary ($SED_{p\text{-}val}$<.0001), and the Aerobic ($AT_{p\text{-}val}$<.01). However, there was no difference between the Endurance and the Sedentary. Following the pattern, when observing the VAT volume, the RE was found significantly different than both Sedentary ($SED_{p\text{-}val}$<.0001) and Aerobic ($AT_{p\text{-}val}$=.007). With none found between AT and the Sedentary.

The next section shows the 3 exercise groups separated by gender, and focused on the males since there were no AT females. Table 2A, containing males only, again shows

anthropometric data and other subject characteristics of Sedentary (n=19), Resistance (n=4), and Endurance (n=6). The activity level of the groups was found significantly different than the Sedentary, ($RT_{p\text{-}val}$=.001), and ($AT_{p\text{-}val}$=.001). Next, the VO2 Max was also highly significant from the Sedentary group to both Highly Active groups, ($RT_{p\text{-}val}$<.0001), and ($AT_{p\text{-}val}$<.0001). There was also a significance found between the RT and AT groups (p-val=.01). Isokinetic torque was also significantly different for both male groups compared to Sedentary, ($AT_{p\text{-}val}$<.0001, $RT_{p\text{-}val}$=.0003). Age was also found significantly different from the AT group to the Sedentary group and the RT group, ($SED_{p\text{-}val}$=.0027, ($RT_{p\text{-}val}$=.0081).

Table 2B represents the adiposity measures in males; VAT mass, volume, and area. Figure 2 illustrates these in bar form, with Graph A, B, and C, respectively. When looking at these three groups of males only, the adiposity measures follow almost the same pattern as before. VAT mass has a significant difference between the RT group and the Sedentary ($RT_{p\text{-}val}$ =.01), with no other difference found between groups. The VAT volume also has significance between the RT group and the Sedentary ($RT_{p\text{-}val}$ =.01). While no other significances were found.

## Chapter 5 Discussion:

An individual's change in fat mass often cannot be explained by one singular variable, and the change in body composition is due to a multitude of factors both internal and external. However, a clear explanation of one variable may help the overall understanding of all variables affecting tissue composition and fat mass. This study aimed to help better understand an external variable, exercise, on body composition. Directly comparing the effects of Resistance Exercise and Aerobic Exercise on visceral adipose tissue. This comparison is important because of the increasing United States health epidemic, and a better knowledge of the effects of exercise can directly translate to the health and weight management solutions people need.

The data collected from this study almost supported my hypothesis. The data refuted the first point that both Highly-Active groups would have a significantly different VAT mass, area, and volume than the Sedentary group. However, the data supported the hypothesis that RT would have a lower adipose tissue amount compared to the AT

When looking into the past research of VAT differences with both modes of exercise, there has been many of the same conclusions. However, our study saw an uncommon outcome. We found decreased VAT measures in Resistance training over the Aerobic training individuals. A study performed by Lee et al. also uncovered increased VAT reduction in Resistance Training individuals, although the Aerobic was significantly less compared to control as well. This study also uncovered that the Resistance group had a significantly increased insulin sensitivity compared to before the intervention, as the AT did not. These insulin changes were very apparent in the obese population and not as much as the healthy individuals, as their beta-cell function is impaired compared to the healthy individuals (Lee et al. 2012). This increased insulin sensitivity taking place over a long enough period of time, like our Resistance Training group,

may explain our differences found within our groups and why RT was the only group with significantly lower VAT. Insulin sensitivity is also seen to highly correlate with T2D or prediabetes, so the more improvements seen with the general population's exercise habits then the more positive health outcomes are expected.

Another study which illustrates the benefits of long-term resistance exercise was conducted by Schmitz et al. This study's resistance intervention was conducted for over 2 years. They found that a long-term resistance intervention was significantly different than the control group in experiencing full body fat loss as well as intraabdominal fat loss, or VAT. This study included a large variety of races. However, this study was done with females exclusively and a sedentary and overweight/obese only population. Through this study it is shown that long-term resistance exercise can progress VAT amount and activity to a healthier level, especially within an overweight population (Schmitz et al. 2007)

Yan et al. also studied the effects of long-term resistance exercise in overweight individuals with prediabetes. This study followed 35 RT and 35 AT exercisers for 12 months, and a control group who continued their primary lifestyle. Both exercising groups lost VAT compared to the Control Group, AT seemed to have a higher significance, while RT was slightly less but still significant. The RT training was shown to increase muscle mass compared to both AT and CG. Both exercising groups had a far less fasting plasma glucose compared to the CG, and the RT group had a higher impact on this change. No significant differences were observed in lipid, waist-to-hip ratio, body mass index, fasting insulin, 2-hour postprandial glucose (2hPG), glycosylated hemoglobin (HbA1c), HOMA-IR, and HOMA-$\beta$ across groups (Yan et al. 2019). The key difference in this study is that Aerobic Training also had similar results to the Resistance

Training with VAT and fasting plasma glucose, as was expected. AT did not have the same affects for our Highly-Active group.

The limitations within the study are very important to mention in the conclusion of these results. The inclusion of the wide range of age in sample did not allow for a matched age mean which may have influence the VAT of the groups, since VAT is highly correlated with age. Through recruitment in the immediate region, mainly white males were available after screening. The estimation of VAT by DXA must also be mentioned, as this is not an exact measure of the real amount of adipose tissue within an individual. The main delimitation is the compliance or inclusion criteria of "Highly-Active".

The next steps in studies should try to involve a larger population of North Carolina, or the East Coast. As well as the inclusion of more female participants. Then we may want to observe which types of Resistance modes are best for VAT adaptations, such as HIIT, cross-fit, heavy eccentrics, etc. As well as comparing types of Aerobic modes of exercise to one another to find the best adaptations.

***Conclusion***

Visceral adipose tissue is highly associated with cardiovascular diseases, metabolic diseases, and other obesity-related mortalities. Because of this, and the exponentially growing obesity epidemic among the United States, it is imperative to continue to study the effects of both long and short-term exercise on the body. This study observed the differences between a long-term exercising person and a sedentary person. Through CPET, isokinetic knee strength, and grip strength tests, the subject characteristics were compared. As well as body mass, and VAT by the Dual-Energy X-ray Absorptiometry.

This study hypothesized that when comparing a group of sedentary adults living in eastern North Carolina to a group of Highly-Active adults, resistance and aerobic, both the exercise groups would have decreased VAT measures compared to the Sedentary group. It is known that exercise will increase energy expenditure therefore burning more calories, and with a maintained diet this may translate to fat tissue loss. However, within our study we found that only our RT group had a significantly lower VAT mass compared to sedentary. There was no statistical difference in the AT and the sedentary group with any VAT data. This may be due to the small sample size that we were able to work with. Another reason that may lead to no difference in VAT, is the high age difference between both groups. Since the amount of VAT increases linearly with age (Ng et al. 2014), and our AT group's age in years was 53.5 ± 16.5, while the sedentary group's age was 40 ± 12.1, while our RT had the lowest age of all groups, 31 ± 12. With more than 10 years between the groups' average ages and the small sample size, these may explain why there is a big difference for Resistance Training and not the Aerobic Training group. Both exercise groups did have a statistically difference VO2 Max compared to the sedentary group, which follows common conclusions in research.

A better understanding of the effects of exercise will progress our knowledge with exercise prescription for health benefits. This progression may assist health professionals in the care of the overweight and obese populations. All general population care may also have the additional benefits of this knowledge to help specify training to help meet the individual's goals.

## Chapter 6: References


Abe, T., Song, J.S., Bell, Z.W., Wong, V., Spitz, R.W., Yamada, Y., Loenneke, J.. Comparisons of calorie restriction and structured exercise on reductions in visceral and abdominal subcutaneous adipose tissue: a systematic review. *Eur J Clin Nutr* 76, 184–195 (2022). https://doi.org/10.1038/s41430-021-00942-1

American College of Sports Medicine. (n.d.). *Physical activity guidelines resources*. https://www.acsm.org/education-resources/trending-topics-resources/physical-activity-guidelines

Apovian C. M. (2016). Obesity: definition, comorbidities, causes, and burden. *The American Journal of managed care*, *22*(7 Suppl), s176–s185. https://www.ajmc.com/view/obesity-definition-comorbidities-causes-burden

Bosch, T.A., Dengel, D.R., Kelly, A.S., Sinaiko, A.R., Moran, A. and Steinberger, J. (2015), DXA vs. CT for quantification of VAT in children. Pediatric Obesity, 10: 172-179. https://doi.org/10.1111/ijpo.249

Cox C. E. (2017). Role of Physical Activity for Weight Loss and Weight Maintenance. *Diabetes spectrum: a publication of the American Diabetes Association*, *30*(3), 157–160. https://doi.org/10.2337/ds17-0013

Gray, S., & Vidal-Puig, A. J. (2007). Adipose Tissue Expandability in the Maintenance of Metabolic Homeostasis. *Nutrition Reviews*, *65*(s1), S7–S12. https://doi.org/10.1111/j.1753-4887.2007.tb00331.x

Harvard School of Public Health. (2022, September 16). *Obesity trends*. Obesity Prevention Source. https://www.hsph.harvard.edu/obesity-prevention-source/obesity-trends/

Hill, J. O., Wyatt, H. R., & Peters, J. C. (2012). Energy balance and obesity. *Circulation*, *126*(1), 126–132. https://doi.org/10.1161/CIRCULATIONAHA.111.087213

Hill, J. O., Wyatt, H. R., & Peters, J. C. (2013). The Importance of Energy Balance. *European endocrinology*, *9*(2), 111–115. https://doi.org/10.17925/EE.2013.09.02.111

Hursting, S. D., & Berger, N. A. (2010). Energy balance, host-related factors, and cancer progression. *Journal of clinical oncology: official journal of the American Society of Clinical Oncology*, *28*(26), 4058–4065. https://doi.org/10.1200/JCO.2010.27.9935

Heymsfield, S. B., Peterson, C. M., Thomas, D. M., Heo, M., & Schuna Jr., J. M. (2016). Why are there race/ethnic differences in adult body mass index–adiposity relationships? A quantitative critical review. *Obesity Reviews, 17*(3), 262-275. https://doi.org/10.1111/obr.12358

Ibrahim, M. M. (2009). Subcutaneous and visceral adipose tissue: structural and functional differences. *World Obesity, Obesity Reviews. Vol. 11 Iss. 1*. https://doi.org/10.1111/j.1467-789X.2009.00623.x

Ismail, I., Keating, S. E., Baker, M. K., & Johnson, N. A. (2012). A systematic review and meta-analysis of the effect of aerobic vs. resistance exercise training on visceral fat. *Obesity reviews: an official journal of the International Association for the Study of Obesity, 13*(1), 68–91. https://doi.org/10.1111/j.1467-789X.2011.00931.x

Johnson, N.A., Sachinwalla, T., Walton, D., Smith, K., Armstrong, A., Thompson, A., George, J. (2009), Aerobic exercise training reduces hepatic and visceral lipids in obese individuals without weight loss. Hepatology, 50: 1105-1112. https://doi.org/10.1002/hep.23129

Kolnes K.J., Petersen M.H., Lien-Iversen T., Højlund K., Jensen J. (2021) Effect of Exercise Training on Fat Loss—Energetic Perspectives and the Role of Improved Adipose Tissue Function and Body Fat Distribution. *Frontiers Physiology* 12:737709. doi: 10.3389/fphys.2021.737709 https://www.frontiersin.org/articles/10.3389/fphys.2021.737709/full

Mendham, A.E., Larsen, S., George, C. Adams, K., Hauksson, J., Olsson, T., Smidt, M., Nankam, P., Hakim, O., Goff, L. Pheiffer, C., Goedecke, J. Exercise training results in depot-specific adaptations to adipose tissue mitochondrial function. *Scientific Reports* 10, 3785 (2020). https://doi.org/10.1038/s41598-020-60286-x

Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., Mullany, E. C., Biryukov, S., Abbafati, C., Abera, S. F., Abraham, J. P., Abu-Rmeileh, N. M. E., Achoki, T., AlBuhairan, F. S., Alemu, Z. A., Alfonso, R., Ali, M. K., Ali, R., Guzman, N. A., … Gakidou, E. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: A systematic analysis for the Global Burden of Disease Study 2013. *The Lancet*, *384*(9945), 766–781. https://doi.org/10.1016/S0140-6736(14)60460-8

Nunes, P., Martins, F., Souza, A., Carneiro, M., Orsatti, C., Michelin, M., Murta, E., Oliveira, E., Orsatti, F. Effect of high-intensity interval training on body composition and inflammatory markers in obese postmenopausal women: a randomized controlled trial. *Menopause*: March 2019 - Volume 26 - Issue 3 doi:10.1097/GME.0000000000001207

Ohkawara, K., Tanaka, S., Miyachi, M., Ishikawa-Takata, K., Tabata, I. (2007). A dose-response relation between aerobic exercise and visceral fat reduction: systematic review of clinical trials. *International journal of obesity (2005)*, *31*(12), 1786–1797. https://doi.org/10.1038/sj.ijo.0803683

Powell-Wiley. American Heart Association Council on Lifestyle and Cardiometabolic Health; Council on Cardiovascular and Stroke Nursing; Council on Clinical Cardiology; Council on Epidemiology and Prevention; and Stroke Council (2021). Obesity and Cardiovascular Disease: A Scientific Statement From the American Heart Association. *Circulation*, *143*(21), e984–e1010. https://doi.org/10.1161/CIR.0000000000000973

Romieu, I., Dossus, L., Barquera, S., Blottière, H. M., Franks, P. W., Gunter, M., Hwalla, N., Hursting, S. D., Leitzmann, M., Margetts, B., Nishida, C., Potischman, N., Seidell, J., Stepien, M., Wang, Y., Westerterp, K., Winichagoon, P., Wiseman, M., Willett, W. C., & IARC working group on Energy Balance and Obesity (2017). Energy balance and obesity: what are the main drivers? *Cancer causes & control: CCC*, *28*(3), 247–258. https://doi.org/10.1007/s10552-017-0869-z

Ross, R., Rissanen, J., Pedwell, H., Clifford, J., Shragge, P. Influence of diet and exercise on skeletal muscle and visceral adipose tissue in men. 1996. Journal of Applied Physiology. 81:6, 2445-2455. https://doi.org/10.1152/jappl.1996.81.6.2445

Ross, R., Rissanen, J. Mobilization of visceral and subcutaneous adipose tissue in response to energy restriction and exercise, The American Journal of Clinical Nutrition, Volume 60, Issue 5, November 1994, Pages 695–703, https://doi.org/10.1093/ajcn/60.5.695

Schmitz K.H, Hannan P, Stovitz S.D, Bryan C.J , Warren M, Jensen M.D, Strength training and adiposity in premenopausal women: Strong, Healthy, and Empowered study, The American Journal of Clinical Nutrition, Volume 86, Issue 3, 2007, 566-572, https://doi.org/10.1093/ajcn/86.3.566.

Stinkens, R. Brouwers, B., Jocken, J., Blaak, E., Teunissen-Beekman, K., Hesselink, M., Baak, M., Schrauwen, P., Goossens, G. (2018) Exercise training-induced effects on the abdominal subcutaneous adipose tissue phenotype in humans with obesity. 26 Nov. 2018. https://doi.org/10.1152/japplphysiol.00496.2018

Lee SoJung, Bacha F, Hannon T, Kuk J.L, Boesch C., Arslanian S,; Effects of Aerobic Versus Resistance Exercise Without Caloric Restriction on Abdominal Fat, Intrahepatic Lipid, and Insulin Sensitivity in Obese Adolescent Boys: A Randomized, Controlled Trial. *Diabetes* 1 November 2012; 61 (11): 2787–2795. https://doi.org/10.2337/db12-0214

Thomas, E. L., Brynes, A. E., McCarthy, J., Goldstone, A. P., Hajnal, J. V., Saeed, N., Frost, G., Bell, J. D. (2000). Preferential loss of visceral fat following aerobic exercise, measured by magnetic resonance imaging. *AOCS Lipids*, *35*(7), 769–776. https://doi.org/10.1007/s11745-000-0584-0

Thorogood, A. Salvatore Mottillo, Avi Shimony, Kristian B. Filion, Lawrence Joseph, Jacques Genest, Louise Pilote, Paul Poirier, Ernesto L. Schiffrin, Mark J. Eisenberg,
Isolated Aerobic Exercise and Weight Loss: A Systematic Review and Meta-Analysis of Randomized Controlled Trials, The American Journal of Medicine, Volume 124, Issue 8, 2011, Pages 747-755, ISSN 0002-9343, https://doi.org/10.1016/j.amjmed.2011.02.037.

U.S. Department of Health and Human Services. (2019, August 5). *Molecular transducers of Physical Activity Consortium*. National Institute of Arthritis and Musculoskeletal and Skin Diseases. https://www.niams.nih.gov/grants-funding/clinical-trials-spotlight/molecular-transduc

Vissers, D., Hens, W., Taeymans J., Baeyens, J., Poortmans, J. Gaal, L.V., (2013). The effect of exercise on visceral adipose tissue in overweight adults: a systematic review and meta-analysis. *PloS one*, *8*(2), e56415. https://doi.org/10.1371/journal.pone.0056415

Wajchenberg Bernardo Léo, "Subcutaneous and Visceral Adipose Tissue: Their Relation to the Metabolic Syndrome", *Endocrine Reviews*, Volume 21, Issue 6, 1 December 2000, Pages 697–738, https://doi.org/10.1210/edrv.21.6.0415

Willis, L., Slentz, C., Bateman, L., Shields, A., Piner, L., Bales, C., Houmard, J., Kraus, W. Effects of aerobic and/or resistance training on body mass and fat mass in overweight or obese adults. Journal of Applied Physiology 2012 113:12, 1831-1837. https://doi.org/10.1152/japplphysiol.01370.2011

Yan, J., Dai, X., Feng, J., Yuan, X., Li, J., Yang, L., Zuo, P., Fang, Z., Liu, C., Hsue, C., Zhu, J., Lou, Q., "Effect of 12-Month Resistance Training on Changes in Abdominal Adipose Tissue and Metabolic Variables in Patients with Prediabetes." 05 May, 2019. Hindawi, *Journal of Diabetes Research*. Article ID 8469739, 10 pages, 2019. https://doi.org/10.1155/2019/8469739

Yarizadeh, H., Eftekhar, R., Anjom-Shoae, J., Speakman J.R, Djafarian, K., The Effect of Aerobic and Resistance Training and Combined Exercise Modalities on Subcutaneous Abdominal Fat: A Systematic Review and Meta-analysis of Randomized Clinical Trials, January 2021 *Advances in Nutrition*, Volume 12, Issue 1,https://doi.org/10.1093/advances/nmaa090

# Chapter 7: Tables and Figures

SUBJECT CHARACTERISTICS OF ALL PARTICIPANTS

| TABLE A | Sample Size | Age | BMI | Waist Circumference (cm) | Activity (Minutes/week) | VO2 Max (ml/min) | Isokinetic Torque (N) |
|---|---|---|---|---|---|---|---|
| Sedentary | 38 | 40 ± 12.1 | 27.4 ± 4.3 | 89.6 ± 15.3 | 0 | 2100 ± 687 | 212.5 ± 73.7 |
| Resistance | 10 | 31 ± 12 | 25 ± 2 | 81.4 ± 5 | 294 ± 58 * | 2732 ± 645 * ^ | 413 ± 49 * |
| Endurance | 6 | 53.5 ± 16.3 * ^ | 25.5 ± 4.5 | 88 ± 11.1 | 351.7 ± 157 * | 3730 ± 689 * | 428 ± 38.2 * |

Results are expressed as mean ± stand. dev.
* Significantly Different (p>.05) from Control
^ Significantly Different (p>.05) from Highly-Active

REGIONAL ADIPOSITY OF ALL PARTICIPANTS

| TABLE B | Sample Size | VAT Mass (grams) | VAT Volume ($g/cm^3$) | VAT Area ($g/cm^2$) |
|---|---|---|---|---|
| Sedentary | 38 | 513.3 ± 221.8 | 554.9 ± 239.7 | 106.4 ± 46 |
| Resistance | 10 | 274 ± 66.6 * ^ | 296 ± 72 * ^ | 56.9 ± 13.8 |
| Endurance | 6 | 495.7 ± 172.6 | 535.8 ± 186.5 | 102.9 ± 35.8 |

Results are expressed as mean ± stand. dev.
* Significantly Different (p>.05) from Control
^ Significantly Different (p>.05) from Highly-Active

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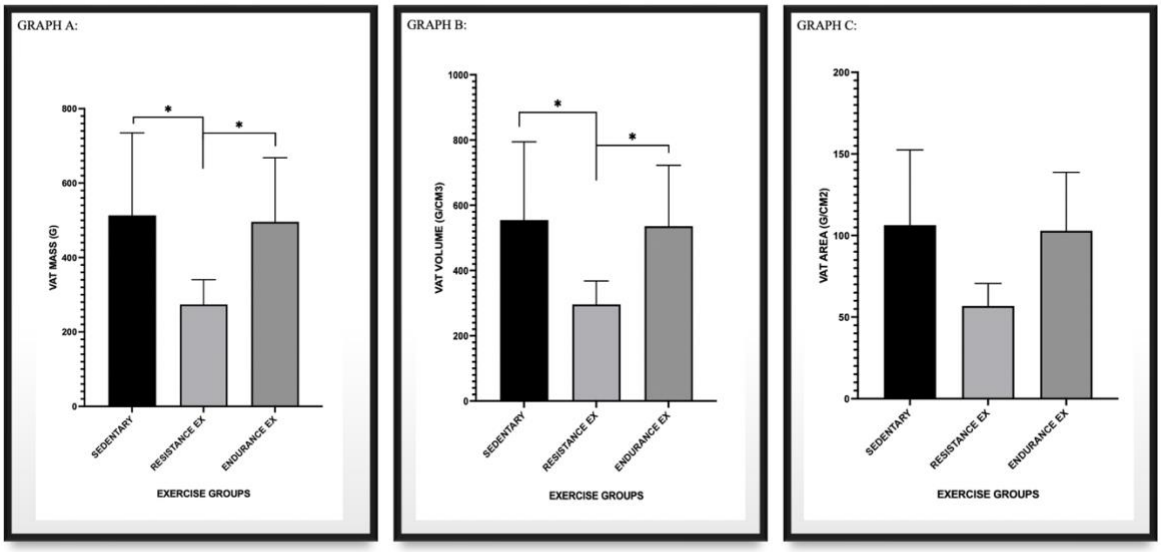
Endurance and Resistance Group Activity and VO2 max significantly different (p<.05) than CG
Resistance Group VAT Mass and VAT Volume significantly different (p<.05) than CG

1.

REGIONAL ADIPOSITY OF ALL PARTICIPANTS




Groups compared by a 3x1 ANOVA
* (p < .005)
Results are expressed as mean ± stand. dev.

---

VAT Mass and VAT Volume significantly different (p<.05) than Resistance Group

SUBJECT CHARACTERISTICS OF MALE PARTICIPANTS

| TABLE A | Sample Size | Age | BMI | Waist Circumference (cm) | Activity (Minutes/week) | VO2 Max (ml/min) | Isokinetic Torque (N) |
|---|---|---|---|---|---|---|---|
| Sedentary | 19 | 33.3 ± 10.5 | 28.3 ± 4.7 | 92.8 ± 19.7 | 0 | 2630 ± 510.7 | 262.6 ± 66 |
| Resistance | 4 | 29 ± 7.6 | 24.9 ± 2 | 80.6 ± 3.6 | 337.5 ± 68.5 * | 3365 ± 351.1 * ^ | 413 ± 49 * |
| Endurance | 6 | 53.5 ± 16.3 * ^ | 25.5 ± 4.5 | 88 ± 11.1 | 351.7 ± 156.9 * | 3730 ± 689 * | 428 ± 38.2 * |

Results are expressed as mean ± stand. dev.
* Significantly Different (p>.05) from Control
^ Significantly Different (p>.05) from Highly-Active

REGIONAL ADIPOSITY OF MALE PARTICIPANTS

| TABLE B | Sample Size | VAT Mass (grams) | VAT Volume ($g/cm^3$) | VAT Area ($g/cm^2$) |
|---|---|---|---|---|
| Sedentary | 19 | 542.8 ± 238.4 | 586.8 ± 257.7 | 112.5 ± 49.5 |
| Resistance | 4 | 301 ± 13.3 * | 325.5 ± 14.6 * | 62.5 ± 2.8 |
| Endurance | 6 | 495.7 ± 172.6 | 535.8 ± 186.5 | 102.9 ± 35.8 |

Results are expressed as mean ± stand. dev.
* Significantly Different (p>.05) from Control
^ Significantly Different (p>.05) from Highly-Active

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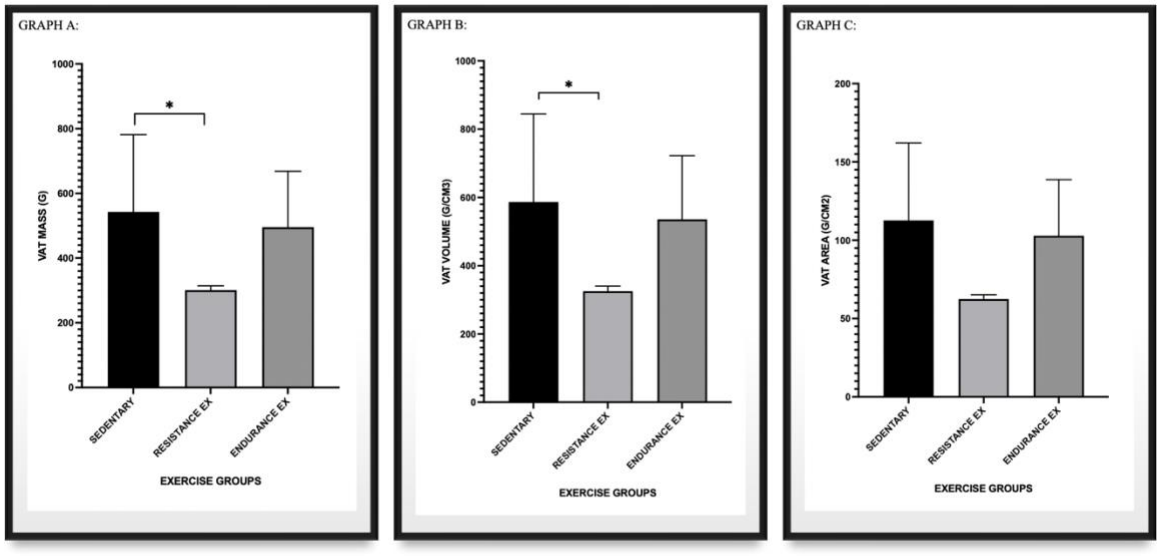
Activity and VO2 max significantly different than (p<.05) Endurance and Resistance Group
VAT Mass and VAT Volume significantly different than (p<.05) Resistance Group

2.

REGIONAL ADIPOSITY OF MALE PARTICIPANTS




Groups compared by a 3x1 ANOVA
* (p < .005)
Results are expressed as mean ± stand. dev.

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VAT Mass and VAT Volume significantly different (p<.05) than Resistance Group.

# Appendix A – IRB memo

WAKE FOREST
UNIVERSITY
HEALTH SCIENCES

Office of Research
INSTITUTIONAL REVIEW BOARD

**MEMORANDUM**

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To: Michael Miller
Public Health Sciences

From: Jeannie Sekits, Senior Protocol Analyst, Institutional Review Board

Date: 11/30/2023

Subject: Human Protocol: IRB00097219
Molecular Transducers of Physical Activity Consortium (MoTrPAC) Coordinating Center
Amendment 15 for IRB Study #IRB00097219

Study Documents:
Protocol Version: MoTrPAC_Adult Protocol_v3.0_2023-08-22_clean.docx; Informed Consent Version: AdventHlth Orlando[REDCap LC PI Survey]FINAL_Kohrt_IRB00097219_MoTrPAC_Consent_Addendum_v2.1_2023.08.21_AH TRI.docx (approved), AdventHlth OrlandoREDCap LC PI Survey_IRB00097219_MoTrPAC_Site Specific Consent_Adult Sedentary_v2.2_2023.10.02_clean.docx (approved), AdventHlth OrlandoREDCap LC PI Survey_IRB00097219_MoTrPAC_Site Specific Consent_Highly Active_v2.3_2023.11.01_clean.docx (approved), Ball Stat Univ[REDCap LC PI Survey]FINAL_Trappe_BSU_IRB00097219_MoTrPAC_Consent_Addendum_v2.1_2023.08.21_BSU.docx (approved), Ball Stat Univ[REDCap LC PI Survey]FINAL_Trappe_BSU_IRB00097219_MoTrPAC_Master Site Specific Consent_Adult Sedentary_v2.1_2023.08.21_BSU.docx (approved), Ball Stat Univ[REDCap LC PI Survey]FINAL_Trappe_BSU_IRB00097219_MoTrPAC_Master Site Specific Consent_Highly Active_v2.1_2023.08.21_BSU.docx (approved), Cedars Sinai[REDCap LC PI Survey]Musi_MoTrPAC_Consent_Addendum_v2.1_2023.08.21.docx (approved), Cedars Sinai[REDCap LC PI Survey]Musi_MoTrPAC_CSMC Site Specific HIPAA.docx (approved), Cedars SinaiREDCap LC PI SurveyMusi_MoTrPAC_CSMC Site Specific Consent_Adult Sedentary_v2.2_2023.10.2_clean.docx (approved), Cedars SinaiREDCap LC PI SurveyMusi_MoTrPAC_CSMC Site Specific Consent_Highly Active_v2.2_2023.10.2_clean.docx (approved), Colorado_Kohrt_IRB00097219_MoTrPAC_Site Specific Consent_Adult Sedentary_v2.2_2023.10.02_clean.docx (approved), Colorado_Kohrt_IRB00097219_MoTrPAC_Site Specific Consent_Highly Active_v2.2_2023.10.02_clean.docx (approved), Duke Univ[REDCap LC PI Survey]MoTrPAC_Highly Active ICF_Part 2_v2.3_01.NOV.2023_DUKE_clean.docx (approved), Duke Univ[REDCap LC PI Survey]MoTrPAC_ICF Addendum_v2.1_21.AUG.2023_DUKE.docx (approved), Duke Univ[REDCap LC PI Survey]MoTrPAC_Sedentary ICF_Part 2_v2.2_02.OCT.2023_DUKE_clean.docx (approved), East Caro Univ[REDCap LC PI Survey]FINAL_Houmard_IRB00097219_MoTrPAC_Consent_Addendum_v2.1_2023.08.21.docx (approved), East Caro UnivREDCap LC PI SurveyFINAL_Houmard_IRB00097219_MoTrPAC_Master Site Specific Consent_Highly Active_v2.2_2023.10.2_clean.docx (approved), East Caro UnivREDCap LC PI SurveyFINAL_Houmard_IRB00097219_MoTrPAC_Site Specific Consent_Adult Sedentary_v2.2_2023.10.2_clean.docx (approved), FINAL_Kohrt_IRB00097219_MoTrPAC_Consent_Addendum_v2.1_2023.08.21.docx (approved), FINAL_Kohrt_IRB00097219_MoTrPAC_Master Site Specific Consent_Adult