THE EFFECTS OF UPPER AND LOWER EXTREMITY RESISTANCE TRAINING ON RESTING METABOLIC RATE

By

ERIC CONCHOLA

Bachelor of Science in Sports and Exercise Sciences

West Texas A&M University

Canyon, Texas

2007

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 2010

RESTING METABOLIC RATE AND THE EFFECTS OF UPPER AND LOWER EXTREMITY RESISTANCE TRAINING

Thesis Approved:

Dr. Doug Smith

Thesis Adviser

Dr. Matthew O'Brien

Dr. Aric Warren

Dr. A. Gordon Emslie

Dean of the Graduate College

ACKNOWLEDGMENTS

I would like to offer a special thanks to my committee for the time and effort they have put forth in helping this endeavor come to fruition. I would like to sincerely thank Dr. Smith for allowing me to do research on this topic. Much appreciation is felt from the efforts of Dr. O'Brien and Dr. Warren for their help in critiquing my paper and willingness to cooperate with certain time constraints.

I would like to also thank my friends and co-workers for believing in my abilities and for keeping me motivated to write. A special thank you goes out to Robin Purdie, Mary Talley and Dave Thomas. Without your help this research project would not have been possible.

I would like to thank my parents for believing in me and for instilling values and morals that have enabled me to be the man that I am today. I hope to one day reciprocate the same to my kids what you all have done for me. I would like to wish an express of love thanking my fiancé' Gabrielle for her encouragement and dedication during this endeavor.

Lastly, I would like to thank my grandparents Leo and Lydia Conchola. Because of your trials and tribulations, you have enabled Hispanics to prosper and have given them hope for their dreams and aspirations. I will never give up and will always appreciate what you have done for me.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

CHAPTER I

THE EFFECTS OF UPPER AND LOWER EXTREMITY RESISTANC TRAINING ON RMR IN TRAINED AND UNTRAINED INDIVIDUALS

Introduction

With obesity being at an all-time high, there has been a significant increase in the amount of research that has been conducted in hopes of identifying strategies to help combat the growing obesity epidemic (Hill, 2009). Research suggests that obesity became a problem in 1970 and as the years continued, so did the trend (Utz, 2005). As of 2010, the United States is battling the highest rates of obesity and morbid obesity in its history (Utz, 2005). Incidences in weight gain typically increase in early adulthood (Wang, 2002). Because of this it is important for people to understand the consequences of what could happen if they deposit too much adipose or non-lean weight and resulting health consequences as a result of this weight gain.

Living a healthy lifestyle is extremely important; not only can a healthy body fight off common viruses and bacterial infections, but a healthier individual is less likely they are to acquire a condition that could have been prevented had they followed a healthier lifestyle (King, Mainous III, Carnemolla, Everett, 2009). Although weight gain may be a natural trend among people as they age, one's metabolism is a primary factor because it will dictate weight loss and weight gain and the rate-at which this occurs (Purnell, Cummings, Weigle, 2007). Adjustments in one's consumption of calories or increase in energy expenditure can help balance excess weight gain. People who are categorized as overweight or obese demonstrate an increased risk of certain problems that could occur because of their weight including hypertension, type 2 diabetes, stroke and heart failure (King, 2006). Due to these risks it is very important for people to make the proper adjustments in their caloric intake as well as energy expenditure to allow for a healthier life (Hill, 2009).

Currently, nearly 60% of American's are clinically defined as overweight (BMI > 25.9-29.9 kg) (Hajhosseini et al, 2006). From the research presented, there are no signs of this epidemic slowing down anytime soon. In fact, a recent study has shown that obesity is the second leading cause of preventable death in the U.S. (Blackwell, 2002). Studies show that there are nearly 365,000 fatalities annually for individuals who are obese (Manson et al, 2007). American children and early aged adolescents are significantly heavier compared to other nations (Wang, Wang, 2002). This is partly due to Americans having easier accessibility to highly processed foods; and having better access to fast food restaurants and because of this are at a greater risk for health problems at an earlier age (Davis, Carpenter (2009).

Environment plays an influential factor in obesity. Many Americans lack the accessibility to the gym or to fitness equipment which could prevent an active lifestyle. Areas of the Mid-west and the Northeast for instance, have severe weather periodically throughout the winter, which limits the opportunity to exercise outside and force many to find alternative methods to exercise. Lastly, a person's ethnic background can have a profound effect on a person's overall well-being (Cohen-Cole, Fletcher (2008). Family history of heart disease and diabetes can often predictably affect one's life as they are growing (MacKnight, 2003).The combination of genetic disposition and environment could make one more susceptible to common diseases and unhealthy weight gain.

Resting Metabolic Rate

Resting metabolic rate (RMR) is the rate of energy expenditure for an individual at rest (Wilmore, Costill, & Kenney, 2008). Resting metabolic rate is used to calculate how many calories one needs to consume daily to maintain their current weight. For most people their resting metabolic rate represents approximately 60%-75% of their total energy expenditure (Ryan, Pratley, Elahi, & Goldberg, 1995). Resting metabolic rate can be calculated in a laboratory setting by indirect calorimetry, or the measurement of respiratory gases (Wilmore, Costill, & Kenney, 2008). These gases are measured through the respiratory exchange ratio which factors the intake and actual use of oxygen and carbon dioxide produced.

Age plays a factor in one's metabolism; specifically RMR decreases by 1-2% per decade with aging (Ryan et al., 1995). It could be theorized that the younger a person is the higher their RMR if all other health factors remain constant. Age is not the only factor with effects on one's RMR; gender also plays an important role in the overall number of one's RMR. In fact RMR is lower in people with higher amounts of fat mass. Coincidentally, men usually have more fat-free mass compared to women because of the lack of testosterone that women display (Wilmore, 2008).

Anaerobic exercise and its' effects on fat free mass (FFM) and RMR vary amongst different training regiments. When calculating FFM and RMR in comparison with aerobic training/diet and diet group only, anaerobic training/diet produced positive results. Anaerobic training accompanied with a proper diet has shown to have positive results with weight loss and could be implemented into health or exercise regimens to increase weight loss (Geliebter, Maher, Gerace, Gutin, Haymsfield, & Hashmim 1997).

Obesity is a problem because it is affecting people's lives on a daily basis and has grown into a world epidemic. It is important for people to understand what types of exercises will help them effectively utilize more calories at a faster rate. Each individual presents a unique physiological composition which requires different eating patterns or training patterns to help them become healthy. It was theorized that as a person begins to lose weight, their FFM can stay relatively the same even when reducing caloric intake. This is important because their metabolism is not decreasing as fast when compared to people who only diet, or for people who only diet or train aerobically.

Statement of the Problem

Obesity is at an all-time high, because of this proper caloric consumption and exercise prescription is needed to off-set this pandemic. The problem of this study was to compare the effects of resistance training on upper and lower extremities in relation to resting metabolic rate. Isolating solely upper extremity and lower extremity groups will be able to give data if training these select groups does or does not have an effect on one's RMR.

.

Purpose of the Study

The purpose of the study was to identify changes in resting metabolic rate with upper and lower-extremity resistance training exercises.

Hypotheses

H_0^1: There will be a significant difference between the upper and lower extremity resistance training groups post-test.

H_o^2: There will be a significant increase in RMR seen in subjects who trained in the lower extremity group from initial and post RMR measurements.

Dependent and Independent Variables

Dependent Variable: Resting metabolic rate

Independent Variable: Length of the study, loads of weight lifted, both groups upper and lower extremity.

Delimitations of the Study

This study was delimited to the following:

- This study was conducted on male and female subjects ages 18 to 30.
- Test subjects were free of any physical impairments and recent or current injuries.

- Each subject exercised at a predetermined weight that was based on the percentage of his or hers 1-RM maximum strength test for each of the exercises performed.
- All subjects were limited to exercise at 50 percent of a 1-RM for weeks 1-2, 60% of a 1-RM for weeks 3-4, and 75 percent of a 1-RM for weeks 5-6.
- Total Testing time was 6 weeks, increasing in intensities every two weeks.

Limitations

The study limitations included:

- There was no control group.
- MedGem device did not take into account for steady state, steady state measures RER and what energy substrate is being utilized.
- Subjects were college aged male and females aged 18-30.
- Subjects were not tested before or during the study for dietary supplements, or any type of muscle enhancing drugs. Subjects were informed to not take any supplements during the duration of the study.
- RMR collections were not corresponded with menstrual cycles accordingly.
- Groups were not analyzed between men and women due to the small sample size.
- The cadence of the study was set at a 4- 1 -4 (4 second eccentric, 1 second pause at the bottom and 4 second concentric).
- Use of both trained and untrained individuals.
- Seven subjects were used in the study.

Assumptions

The following assumptions were inherent during the study:

- All subjects answered the questionnaire accurately and honestly about past/present experience and drug/supplement use.
- Subjects participating in the study understood the questions and instructions of the assessment tool.
- Subjects fasted for 12 hours prior to RMR testing.
- All subjects made a maximum effort when attempting all resistance exercises.
- Subjects adhered to the program assigned to them, used proper from and exercise techniques when doing the exercises. Each exercise session was monitored by the primary investigator.
- Each group was asked to not participate in any activities beyond their normal routine.

Definitions

The following terms are used within this study:

- **Caloric Intake**: Amount of calories that one consumes per meal and in a complete day.
- **Exercise**: Exercise is physical activity that is planned, structured, and repetitive for the purpose of conditioning any part of the body. Exercise is utilized to improve

health, maintain fitness and is important as a means of physical rehabilitation (Medical-Dictionary, 2010).

- **Fat-free mass**: The mass (weight) of the body that is not fat, including muscle, bone, skin, and organs (Wilmore et al., 2008).
- **Hypertension**: Abnormally high blood pressure. In adults, hypertension is usually define as a systolic pressure of 140 mmHg or higher or a diastolic pressure of 90 mmHg or higher. (Wilmore et al., 2008).
- **Indirect Calorimetry**: Estimating the measurement of respiratory gases (Wilmore et al., 2008).
- **Obesity**: An excessive amount of body fat, generally defined as more than 25% in men and 35% in women; a body mass index of 30 or greater. (Wilmore et al., 2008).
- **One Repetition Maximum**: The maximum amount of weight a person can lift one time through a given full range of movement (Bond, 1997).
- **Overweigh**t: Body weight that exceeds the normal or standard weight for a particular individual based on sex, height, and frame size; a BMI of 25.0 to 29.9 (Hajhosseini et al, 2006).
- **Physical Activity Readiness Questionnaire (PAR-Q):** A questionnaire that has been designed to help qualify a person for low-to-moderate-to-high activity levels (Clark, Lucett, 2010)
- **Resting Metabolic Rate**: The body's metabolic rate in the morning (Wilmore et al., 2008).
- **Steady-state heart rate**: A heart rate that is maintained constant at sub-maximal levels of exercise when the rate of work is held constant (Wilmore et al., 2008).

CHAPTER II

REVIEW OF LITERATURE

Research suggests that obesity became a problem in 1970, and as the years continued so did the trend (Utz, 2005). In 2010 statistics indicate the highest rates of obesity and morbid obesity, because of this living a healthy lifestyle is extremely important, not only can a healthy body fight off common colds and viruses, but the healthier one is the less likely they are to be diagnosed with a condition that could have been eluded because of a healthier upkeep.

Social, environment, ethnicity are all factors that could lead to obesity. Statistics show that higher income families in higher socioeconomic status regions outside of the U.S. are less likely to have family members with higher percentages of body fat (McLaren, 2007). Comparatively, childhood and adolescent obesity in America is on the rise. Currently 25.5% of children are obese (Wang, Wang, 2002).

The following sections will review current research in various areas that may affect resting metabolic rate and obesity rates for people throughout the world. The review will focus on a general overview of resting metabolic rate and indirect calorimetry, different training protocols with measuring RMR; and different countries in the world and their obesity issues.

Resting Metabolic Rate and Indirect Calorimetry

Resting metabolic rate (RMR) is the rate of energy expenditure for an individual at rest (Wilmore, Costill, & Kenney, 2008). Rest in this case is when one is not physically or mentally active which could induce brain stimulation causing a similar increase in heart rate, and thus metabolic rate. RMR is useful because it calculates how many calories one needs to consume to maintain their current weight. For most people their resting metabolic rate represents approximately 60%-75% of their total energy expenditure (Ryan, Pratley, Elahi & Goldberg, 1995). Age plays a factor in metabolism, decreasing by 1-2% per decade with aging (Ryan, Alice, Pratley, Elahi, & Goldberg, 1995). This is important because it shows that as one ages their metabolism does slow down. The most common way to measure one's RMR is in a laboratory setting where they would be tested through indirect calorimetry "the measurement of respiratory gases between VO_2 and CO_2" (Wilmore, Costill, & Kenney, 2008). For one's RMR to be considered a valid measurement the subject must be tested in a calm environment free of internal or external stressors. The device used in the present study used an indirect calorimetry device to measure RMR called MedGem (MedGem by healthetech, USA). According to Van Loan (2007), "the MedGem instrument has provided more consistent results when compared to the Douglas bag method of measuring metabolic rate". Reliability of the MedGem is greater than 90% when compared to the Douglas bag method, and the ventilated hood system (Kearney, Murphy 2004).

Relationship of Training Protocols and Measuring RMR

Metabolism may be influenced by many factors such as caloric consumption, duration of exercise and mode of exercise. According to Geliebter, (1997), people who follow an anaerobic weight training program with proper diet have the most effective results in regard to development of fat-free mass (FFM) and higher levels of muscle mass ($p < 0.05$). In this study, three different groups underwent several conditions including group dieting only, aerobic activity and dieted, and performed anaerobic activity and dieted. After completing an eight week protocol the results from pre- and post-testing indicated that anaerobic activity with diet preserved muscle mass with increased levels of FFM. It was offered that individuals with higher levels of FFM can expend calories quicker compared to individuals with lower levels of FFM.

Dietz, et al (1994) found that RMR in obese girls is higher than non-obese girls aged 10.4 ± 1.1 years. This study lasted for one hour and recorded the girls RMR's during three randomly ordered conditions: 1) reading a favorite book, 2) viewing a videotaped situation comedy from "The Cosby Show", and 3) sitting quietly in a chair. The authors recorded RMR's from 27 subjects, of the 27 subjects, 18 subjects were non-obese and 9 were obese. The findings show that heavier individuals metabolisms have to work harder to perform the same tasks than non-obese individuals do ($P < 0.05$).

Baseline RMR was significantly lower in subjects who gained weight rather than those who did not gain weight (Buscemi, Verga, Caimi & Cerasola, 2005). This study lasted for 10 years, initial measurements consisted of measuring the subject's body fat and resting metabolic rate. A decade later post measurements were again taken. Subjects who gained weight over the 10 year span had lower RMR's compared to subjects who did not gain weight ($p < 0.01$). These researchers addressed the importance of exercise and proper levels of FFM. In this direct relationship; increased amounts of lean body mass result in increased levels of resting metabolic rate. Inversely, the lower the levels of FFM, the lower RMR one will have. Coincidentally lower the RMR, the higher the risk for weight gain.

Hajhosseini, et al. (2006) found that there is a significant correlation between changes in weight and RMR ($P < 0.02$). Twenty-seven college aged subjects participated in a 16-week study. Of the 27 subjects, 22 of the subjects were female and 5 subjects were male. Pre-tests were recorded the first week of the semester and post tests were taken the last week of the semester. All participants in the study arrived for pre- and post-measurements throughout the study period, there was no control group. Measurements included the subject's height, weight, RMR and body composition. Pre- to Post-measurements of each subject's RMR did not have any significance. There was a significant correlation between changes in weight and RMR ($p < 0.02$). Post tests resulted in an average weight gain of three pounds ($p < 0.001$). Pre and post measurements in RMR and body weight do support the mean of the three pound weight gain. This research lends support to the notion that a common college-aged student begins to adapt to a sedentary lifestyle, which allows for increases in body weight and a decrease in FFM.

According to Ryan et al., (1995), weight training and diet affected postmenopausal women's resting metabolic rate. This study identified two different groups that followed a precise protocol for 16 weeks. One group strictly performed resistance training, while the second group performed resistance training and dieted.

After 16 weeks the group that conducted a resistance training program and dieted lost significant amounts of body fat, fat mass, FFM ad BMI ($p < 0.05$). When analyzing both groups collectively, resting metabolism increased after resistance training ($p < 0.05$). According to their findings, the authors suggest resistance training and dieting can offset a decline in RMR because of their FFM stabilization.

Ravussin et al., (1982) studied twenty-four-hour energy expenditure and resting metabolic rates in obese, moderately obese, and control subjects. Each subject lived in a respiratory chamber for 24 hours. Within those 24 hours they were fed three standardized meals and one snack. While in the respiratory chamber the subjects were allowed to perform everyday living tasks such as: watching television, reading, talking on the phone and listening to music. No bouts of strenuous exercise were allowed to be performed. After the 24 hour observation period commenced, a RMR measurement was immediately taken. The subjects in the obese group had significantly higher RMR than the control group ($p <0.01$). Also the 24 hour energy expenditure was higher in the obese subjects compared to the control group. The control groups mean value was an average of 8439 kj/day while the severe obese group average was 10043 kj/day. This measured to a 383.03 calorie difference between the control group and the severe obese group. These findings support data that heavier individuals have to expend more caloric energy to allow them to do the same tasks that a healthier individual can do.

Weiss et al., (2007), conducted a yearlong investigation studying the effects of weight loss on muscle size, strength and aerobic capacity. Group 1 followed caloric restriction guidelines only, while group 2 focused on exercise intervention only. Both groups lost an average of 8.0 kg of body weight ($p < 0.58$). Pertaining to thigh muscle volume, thigh muscle cross-sectional-area decreased significantly in the caloric restriction group compared to the exercise group. The caloric restriction group had an average decrease in size of 13.8 cm compared to the exercise group which gained .99 cm in size ($P < 0.0001$). Subjects in group 1 lost significant amounts of FFM in their lower extremities, because of this they are more at risk for weight gain because the lower the levels of FFM, the lower RMR one will have.

Albu et al., (1997), studied the differences in resting metabolic rate between white and black premenopausal women. The investigators measured the women's RMR three separate times in one week (Day one, three and four). Subjects consumed the same composition of diet; 40%-45% carbohydrates, 35%-40% fat and 15% protein. Review of the findings indicate black women have lower resting metabolic rates compared to white women ($p < 0.08$). These findings lend support that black women are more susceptible to obesity than white women. Previous literature supports fat free mass (FFM) as a factor in how it can effect resting metabolic rate (RMR). The investigators from this study showed the significance on ethnicity and reasons why certain races may be heavier than others.

Dulloo et al., (1998) studied the differences in basal metabolic rate (BMR) in response to food deprivation in humans. The study lasted 36 weeks and measured BMR both at the beginning of the investigation period and end. Over the 36 week study each man lost an average of 25% of their initial body weight. Results from the study indicate a positive relation between the reduction in thermogenesis and the degree of fat mass depletion ($p < 0.01$). This study provided evidence that as the subjects lost weight their BMR decreased. It is theorized that once fat storage is depleted a suppression in thermogenesis results.

Melby et al., (1993) studied the differences of resistance training on post-exercise energy expenditure and RMR. The two groups of subjects were identified over the two day period. Group 1 performed six sets of eight-twelve reps for each exercise throughout ten different exercises, totaling 60 total sets. Three minutes of rest were allowed between each of the sets. Resistance weight was calculated at 70% of their 1 repetition maximum. Group 2 lifted five sets of each exercise and underwent a four minute rest period between sets. Post-exercise metabolic rate was measured for two consecutive hours post workout. The following morning, subjects were re-measured resulting in the RMR. Exercise group 1 had a significantly elevated RMR 9.4% increase ($p < 0.01$) and group 2 had a 4.7% increase ($p < 0.01$). Strenuous resistive exercise may elevate post exercise metabolic rate for a prolonged period.

Obesity Pandemic

Currently in America, nearly 60% of American's are clinically defined as overweight (BMI > 25.9-29.9 kg) (Hajhosseini et al, 2006). From the research presented, there are no signs of this epidemic slowing down anytime soon. To show the severity of overeating, a recent study has shown that obesity is the second leading cause of preventable death in the U.S. (Blackwell, 2002). Studies show that nearly 365,000 fatalities occur annually for obesity related issues (Manson et al, 2007).

Public health and socioeconomic status amongst genders in developing countries can impact weight gain in third world countries. According to Monteiro et al., (2004), "obesity can no longer be associated with people who have higher levels of income" all economic classes have opportunities for weight gain. Obesity rates for lower socioeconomic population grow more when the gross national profit (GNP) increases. Reason being is healthier foods come more. So lower class citizens have to purchase the cheapest things. Montiero et al., (2004) also found higher rates of obesity with young women compared to men in lower socioeconomic status. Because obesity rates are at an all-time high (Hill, 2009) the authors urge proper education of health and wellness to these developing countries in hopes of slowing the chances of weight gain and health problems.

According to Uauy et al (2001) as a South American's family income increases, so does the chance of obesity. Potential rationale for the increase in obesity is because of the type of food that could be purchased. During poverty, families are limited to grains, vegetables, and fruits as primary sources of nutrients consumed. With a higher level of income, families begin to bypass the essentials of grains and veggies, and either focus their intake on highly saturated meats of high carbohydrate dense foods. Because of this, the higher levels of income population are more at risk for obesity and health concerns due to an inadequate intake of foods that should be consumed in less moderation. A person's childhood and socioeconomic class up-bringing can have a direct effect on a person's chances for obesity later on in life (Case, Menendez (2009). Data from Case et. al., (2009) suggest that obesity rates in South Africa are significantly higher in women compared to men. Also, they suggest that women who were deprived of food as a child and women that are of higher socioeconomic status as an adult are more likely to be obese than a male of the same circumstances.

A person's ethnic background can have a profound effect on a person's overall well being. Family history of heart disease and diabetes can negatively affect someone's life as they are growing up (MacKnight, 2003). That person could be susceptible to common diseases than another person whose family background is healthy.

Summary

After examining the research on resting metabolic rate and socioeconomic status, it is evident that women have lower RMR’s than men and that race is a factor in RMR. It is also suggested that weight loss can lower one’s metabolic rate, especially if that person losing weight was not active with weight training or aerobic exercise. Future research needs to examine the effects of different relative intensities and training regiments, including a higher intensity (one that is commonly used by weight lifters, i.e, > 70% 1 RM). These variables need to be evaluated on a more extensive region of the upper and lower extremity muscles, to give future researchers a better understanding of the effects of this type of training.

CHAPTER III

METHODS

The purpose of the study was to identify changes in resting metabolic rate with upper and lower-extremity resistance training exercises. The hypotheses addressed will be: H_0^1: There will be a significant difference between the upper and lower extremity resistance training groups post-test. H_o^2: There will be a significant increase in RMR seen in subjects who trained in the lower extremity group from initial and post RMR measurements.

Study Design

This study utilized quantitative measures to provide descriptive research. Through quantitative research the information acquired will proved data addressing individual as well as group information throughout the study. The dependent variable being measured is pre- and post- RMR measurements, independent variables include the duration of the study, amount of weights lifted, upper and lower extremity groups.

Subjects Selection

Seven subjects, five females and two males between the ages of 19-26 were selected based on their freedom from injures, drug use, supplementation, and availability for testing. Each subject selected was assigned to one of two groups, Upper-Extremity group (UE) (Lat pull-down, bicep curl, shoulder press, chest press, tricep extension) or Lower-Extremity group (LE) (leg extension, leg curl leg press, modified squat and lunges). Subject population was selected by using volunteers who were currently enrolled at the university. Recruitment of subjects was achieved through flyers posted at various buildings throughout a mid-western university. Participants were screened using a physical activity readiness questionnaire (PAR-Q) to rule out any pre-existing health contraindications and risk factors to exercise. None of the participants had any lower or upper extremity injures during the previous year. Each participant signed an informed consent prior to participating in the study, which was approved by the institutional review board at Oklahoma State University.

Each test subject was categorized as having being trained (two males, one female) or not being trained (four females). To be considered trained, subjects had to be exercising for the past eight months, at least two times per week, with weight lifting exercises. To be considered untrained; subjects had to be free from any weight lifting programs for the last eight months, despite any prior weight lifting experience before this time. Participants were instructed keep with the same exercise regimen that they were performing pre participation with the present study. Reason being was to make sure the subjects did not change their daily routines because of their participation in the present study. However they were restricted from resistance training the same day prior to a testing session. All testing sessions were performed at a standard exercise facility.

Methodology

Subjects were administered a one repetition maximum (1 –RM) on the initial visit, each individuals maximums were used for computing percentage of load to be lifted for conditions. All exercises proceeded as follows: first warm-up set of 5-10 repetitions were performed at 40-60% of the perceived maximum. Participants were allowed to rest for 1 –min and perform light stretching. The next stage included 3 to 5 repetitions were performed at 60-80% of the perceived maximum. Resistance was then increased to the same level or a level that was 5-10 pounds higher than the perceived maximum, at which point a maximal repetition was attempted. If the repetition was successful, 5-10 more pounds were added, following a 5 minute rest another maximal repetition was attempted. This process was repeated until a failed attempt occurred, a failed attempt was defined as the subject's inability to complete the lift through the entire range of motion (ROM).The 1 –RM was recorded as the last successfully completed attempt. Once a maximal lift was performed their 1 –RM was recorded for that specific exercise. This protocol continued until all exercises 1 –RM were found excluding modified squat and modified lunge.

The equipment used for the exercise tests listed above were as follows:

- Chest Press: Cybex stationary machine, cable loaded with high capacity load ability.
- Shoulder Press: Cybex stationary machine, cable loaded with high capacity load ability.
- Bicep Curl: Cybex stationary machine, cable loaded with high capacity ability.

- Tricep Extension: Cybex stationary machine, cable loaded with high capacity ability.
- Latissiumus Pull-Down- Cybex Cable machine loaded with high capacity ability.
- Leg Press: Cybex stationary machine, cable loaded with high capacity load ability.
- Leg Extensions: Cybex stationary machine, cable loaded with high capacity load ability.
- Leg Curl: Cybex stationary machine, cable loaded with high capacity load ability.
- Body Weight: Standard floor scale with beam and moveable balance weights.

Procedures

The initial session consisted of data collection including a subject's health PAR-Q, informed consent, height, weight and resting metabolic rate via indirect Calorimetry by MedGem (HealtheTech, Inc, Golden CO). Subjects were asked to reframe from: consuming food or caffeine, exercising, and use of nicotine previous to 12 hours prior to resting metabolic rate collection. Consumption of water was allowed. Following these collections, a maximal strength test for their assigned training group were completed.

All participants engaged in a 6-week exercise regimen. Participants attended two training sessions per week for the first three weeks, and three sessions per week for the last three weeks. Individual sessions occurred no less than forty-eight hours apart for appropriate resting purposes. During weeks 1-2, participants performed one set of 8-12 repetitions on each exercise that they were assigned to lifting at 50% of 1 RM. In weeks 3-4, participants performed one set of 8-12 repetitions on each exercise that they were assigned to lifting 60% of 1 RM. Weeks 5-6, participants performed one set of 8-12 repetitions on each exercise that they were assigned to lifting 75% of 1 RM. As a safety precaution, all testing sessions took place using stationary equipment (besides modified squat) in which proper placement of the bar or leg positions were set appropriately in the range of motion for each movement. The primary investigator and one certified personal trainer was present for each testing session.

During each set the subjects lifting cadence was controlled by a verbal count given to the subject while performing each repetition by the primary investigator using a stop watch. The cadence was set at a constant 5 second to lower the weight and 5 second to raise the weight. Each participant completed the study as originally prescribed and none of the participants failed to meet the requirements of the aforementioned protocols.

Recording Device

Resting metabolic rate was calculated by measurements of respiratory gases. The device being used to measure the subjects RMR's for this given study is the MedGem (healthetech, Inc. Golden, CO). According to (Kearney,and Murphy (2004), the MedGem device has repeatedly demonstrated it's ability to measure oxygen consumption and calculate resting metabolic as accurately and reliably as reference systems. Reliability scores of the MedGem vs. other indirect calorimetry devices was greater than 90% success rate. Before the RMR testing began, subjects were instructed to lie on a flat table in a supine position for 30 minutes to allow their body to rest and become relaxed. Using the MedGem (HealtheTech, Inc. Golden, CO), subjects breathed into the device until their resting metabolism were completely recorded. Measurements lasted 5 to 10 minutes in duration.

Statistical Analysis

The data of each resting metabolic rate assessed was compared between pre- and post- testing using a paired T-Test. A 2 X 2 mixed factorial analysis of variance (ANOVA) was used to measure a between group (upper-extremity and lower extremity) and a within group (the effects of time on pre and post testing) effect. Significance of effects was based on an alpha level of $p < 0.05$. All statistical comparisons were made using SPSS version 15.0 (SPSS Inc., Chicago, IL).

CHAPTER IV

Findings

Introduction

The purpose of the study was to identify changes in resting metabolic rate with upper and lower-extremity resistance training exercises. Seven test subjects consisting of 2 males (ages 20-26) and five females (ages 19-22) participated in the study. Experienced subjects ranged from having one month to 10 years of experience, while the inexperienced subjects ranged from not working out for the past eight, months, to never having lifted weights before. There were two males and two females that were experienced and zero men and three females that were inexperienced. The upper extremity group (n= 4) and lower extremity group (n=3) performed three different exercises at different intensities over the six week study. 1 –RM were measured on the initial visit (chest press, 46.71 ± 26.2 kg; shoulder press, 39.92 ± 20.29kg; tricep extension, 25.83 ± 14.37 kg; bicep curl, 27.27 ±14.04 kg; lateral pull-down, 45.46 ± 17.97 kg; seated leg press, 96.97 ± 65.76; leg extension, 56.06 ±44.1; leg curl 39.02 ± 15.51) each individual's 1 -RM were used to computing percentage of load to be lifted for the conditions. Both groups lifted 50 percent, 60 percent, and 75 percent of their 1 repetition maximum.

Following six weeks of resistance training, the RMR for the upper extremity resistance training group's RMR changed from (1945 ± 427.51 – 2060 ± 632.72 kcal day $P = 0.66$) resulting in no significance. Also the lower extremity resistance training group (2190 ± 790.31 – 2266.67 ± 810.51 kcal day ($p < 0.28$) resulted in no significance on their RMR. Through ANOVA the interaction phase of the duration of the study and the effects of the RMR resulted in ($p < 0.89$) and no significance for the overall effect for upper extremity versus lower extremity ($P = 0.60$). This suggests that a six week study with three different progressive intensities of resistance training does not have a significant effect on one's RMR. Both groups trained the same amount of weeks and made progressions throughout the six-week study (Tables 1 & 2).

Table 1

Pre-training and descriptive characteristics of subjects (N = 7)

	Upper Extremity (n = 4)	**Lower Extremity** (n = 3)
Age years	21 ± 1	23.25 ± 2.22
Height cm	170.17 ± 11.01	171.03 ± 13.2
Weight kg	79.43 ± 24.65	122.04 ± 33.19
Shoulder Press kg	38.92 ± 20.29	N/A
Lateral-Pulldown kg	45.46 ± 17.97	N/A
Bicep Curl kg	27.27 ± 14.04	N/A
Seated Leg Extension kg	N/A	56.06 ± 44.1
Seated Leg Curl kg	N/A	39.02 ± 15.51
Modified Squat kg	N/A	122.04 ± 33.19
Total RMR kcal	2190 ±797.31	1945 ±427.51

* significant at $p < .05$ level

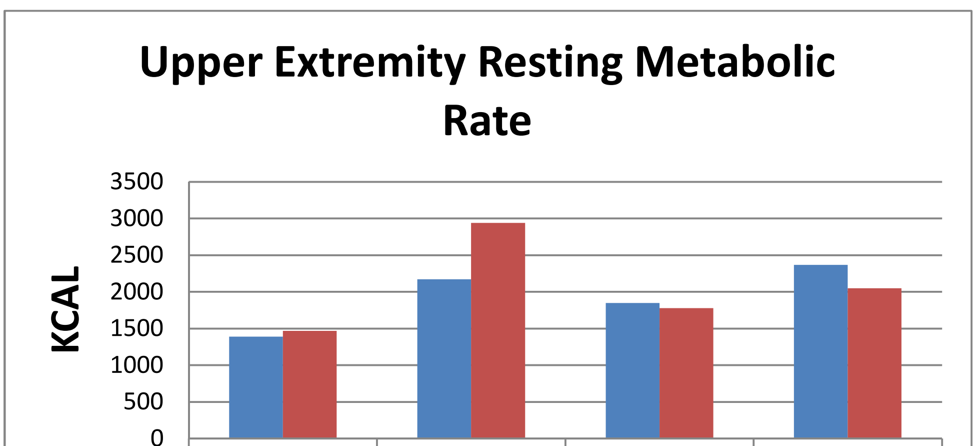
Table 2
Summary of anaerobic training program for each group including resistance intensities and repetitions performed.

Group	Weeks	Intensity	Repetitions
Upper Extremity	1-2	50% 1-RM	8-12
	3-4	60% 1-RM	8-12
	5-6	75% 1-RM	8-12
Lower Extremity	1-2	50% 1-RM	8-12
	3-4	60% 1-RM	8-12
	5-6	75% 1-RM	8-12

Table 2 shows that both groups followed the same protocol for the six week study. Every two weeks, weight training intensities increase until week five where both groups reached 75% of their pre-determined 1 RM. Tables 3 & 4 display the results in Kcal changes from pre to post test measurements of each groups resting metabolic rate (RMR).

Table 3.

Resting Metabolic Rate Changes in Upper-Extremity Group.



	Subj. # 2	Subj. # 3	Subj. # 5	Subj. # 7
Pre	1390	2170	1850	2370
Post	1470	2940	1780	2050

Table 4.

Resting Metabolic Rate Changes in Lower-Extremity Group.

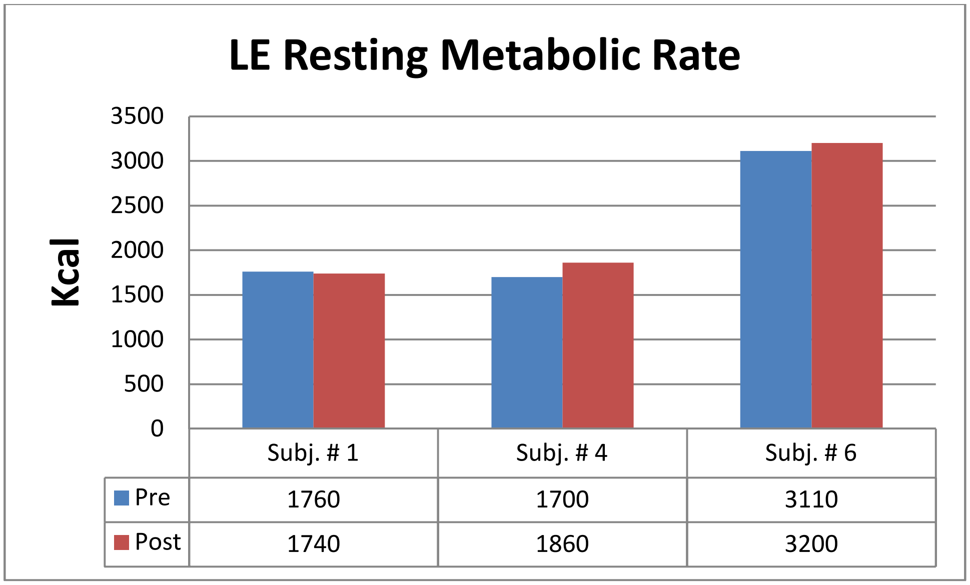
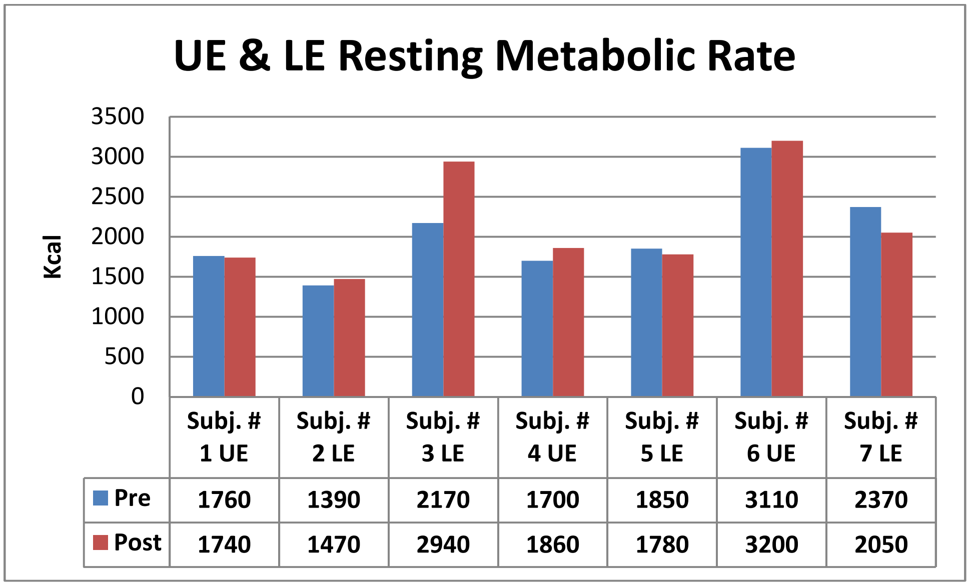


Table 5.

Resting Metabolic Rate Changes in Upper Extremity and Lower Extremity Groups.



	Subj. # 1 UE	Subj. # 2 LE	Subj. # 3 LE	Subj. # 4 UE	Subj. # 5 LE	Subj. # 6 UE	Subj. # 7 LE
Pre	1760	1390	2170	1700	1850	3110	2370
Post	1740	1470	2940	1860	1780	3200	2050

Hypothesis

Two hypotheses were tested to determine if there were significant differences between the two groups and with each group over time. A mixed factorial *ANOVA* was used to analyze the treatment effects. A T-Test dependent was used to see pre- and post-resting metabolic rate measurements.

The following null hypotheses were tested at the .05 level of significance. Investigation of each hypothesis was made on comparison of resistance training and the duration of the study, and the interaction between the upper and lower extremity group.

Results of Hypothesis 1

H_0^1: There will be a significant difference in RMR between the upper and lower extremity resistance training groups over a six week resistance training period. The results are shown in table six.

ANOVA results demonstrate that no significance was found for the main effect of time (p = 0.52). There was no significance at the p < .05 between the groups (p = 0.89) or any difference between the groups over time (p = 0.66), thus rejecting the overall null hypothesis (Table 6).

Table 6.

2 X 2 Mixed Factorial ANOVA

Source	SS	Df	MS	F	Sig.
Time	31488.095	1	31488.095	.470	0.524
Group X Time	1259.524	1	1259.524	.019	0.896
Group	174859.524	1	174859.524	.219	.660

* significant at p < .05 level

Results of Hypothesis 2

H_o^2: There will be a significant increase in RMR seen in subjects who trained in the lower extremity group from initial and post RMR measurements. The Results are seen in table seven.

Results of the T-Test show that no significant differences were found for pre- to post- resting metabolic rate measurements of the lower extremity group ($p = 0.281$). The overall null hypothesis was rejected (Table 7).

Table 7

SPSS version 15.0 Paired T-Test

Source	Paired dif. Pre	Paired dif Post	T	df	Sig. (2 Tailed)
Pre lower – Post lower	-302.07165	148.73832	-1.463	2	0.281

*significant at p < .05 level

.

CHAPTER V

DISCUSSION

The hypotheses of this study was that resistance training at different levels of intensity would elicit greater resting metabolic rate (RMR) results from pre- to post-measurements. Several studies have demonstrated effects of resistance training and the effects of RMR within different age groups and genders. Because 60% of American's are clinically defined as overweight (Hajhosseini, 2006), researchers findings are vital in hopes of finding interventions to attenuate the potential decline in RMR and loss of fat-free mass (FFM) (Ryan et al., 1995). The hypothesis were supported in some cases and rejected in others.

Upper-Extremity and Resting Metabolic Rate

The results from the present study demonstrated no significance from pre- to post-test measurements. Subjects performed resistance training twice a week for the first three weeks, and three times a week for the last three weeks, each subject performed eight to twelve repetitions per assigned exercise. Lifters began lifting at 50 percent of their single repetition maximum lift (1 –RM) and progressed to lifting 75 percent of their 1 –RM by the end of the study.

These results differ from those of Ryan et al 1995. who found that exercising did have a significant effect on the subject's RMR ($p < 0.05$). Fifteen subjects exercises for the duration of the study. All fifteen subject's RMR's were higher post- measurement ($p < 0.05$).These conflicting results could be due to the fact that subjects in the study were sedentary individuals (had not lifted a weight for more than 6 months). Also this study alternated upper-extremity and lower extremity exercises instead of primarily lifting within one region of the body. Subjects in this study lifted 90% of a three repetition maximum (3 –RM), with sets of 15 repetitions. Increases in weight were recommended when the subject was easily able to perform all repetitions. The lowest resistance in the present study was 50% 1 –RM compared to 90% of 3 –RM of Ryan et al. It is plausible that resistance training with sedentary individuals can significantly increase one's RMR over time. This may be due to the increase in FFM (Ryan, et al., 1995).

Bosy-Westphal, Eichhorn, Kutzner, Illner, Heller, & Muller conclude that "age-related decline in resting energy expenditure is not caused be a decreasing organ metabolic rate but is fully accounted for by a reduction in FFM and proportional changes in its metabolically active components." These findings support Ryan et al., because the higher the amount of FFM the higher one's metabolism is and vice-versa.

Bryner, Ulrich, Sauers, Donley, Hornsby, Kolar & Yeater (1999) found that resistance training plus diet has an increase ($p < 0.05$) on one's RMR. It is likely that the differences observed between Bryner et al 1999, and the present study is contributed to the duration, amount of sets, and repetitions performed. Bryner et al increased sets and decreased repetitions as the study continued. Weeks one consisted of 15 repetitions per exercise, by week twelve, subjects were lifting 8-12 repetitions per exercise. Also sets increased from one set during week one to four sets by week nine. Because the present study did not include multiple sets of the same exercise in the training, the results are not directly comparable.

Broeder, Burrhus, Svanevik, & Wilmore (1992) found that resistance training may help to prevent an attenuation in RMR normally observed during extended periods of negative energy balance by either preserving or increasing a person's fat-free weight. Broeder et al., incorporated a 12-week study lifting 4 d/wk with eleven different exercises. Exercises were set for upper-body and lower-body, upper-body exercises were performed on Monday and Thursday and lower-body exercises were performed on Tuesday and Friday. Weeks 1-2 implemented three sets of 10-12 repetitions. Weeks 3-12 implemented one set of 10-12 repetitions, one set of 8-10 repetitions, and one set of 6-8 repetitions. Each of the three sets increased weight. These results differ from the present study, the conflicting results may be due to the study alternating upper and lower-body exercises, the duration of the study, and the numerous sets altering repetition ranges.

Melby, et al. found that acute resistance training created higher RMR measurements the following morning post exercise ($p < 0.01$). It is likely that the differences observed between Melby et al., and the present study are due to differences in the amount of sets, repetitions, and differences in load intensities. The absolute loads used by Melby et al., study were larger than those used for the present study. The lowest load condition for the present study was 50% 1 –RM whereas Melby et al used 70% 1 –RM. In their study, subjects performed six sets of eight to twelve repetitions with ten different exercises. Because the present study did not include multiple sets of the same exercise in the training, the results are not directly comparable.

Lower-Extremity and Resting Metabolic Rate

The results from the present study demonstrated no significance for lower extremity weight resistance training from pre- to post test RMR. Subjects performed resistance training twice a week for the first three weeks, and three times a week for the last three weeks, and each subject performed eight to twelve repetitions per assigned exercise. Lifters began lifting at 50 percent of their single repetition maximum lift (1 – RM) and progressed to lifting 75 percent of their 1 –RM by the end of the study. According to Dionne et al., 2003 women aged 18-35 who incorporate a resistance training program three times a week for six months increase FFM ($p < 0.05$) and increase RMR ($p < 0.0001$). Given that RMR is related largely to the amount of FFM, strength training would help preserve both FFM and RMR during dieting (Geliebter, Maher, Gerace, Gutin, Heymsfield & Hashim 1997). It is likely that the differences observed between the present study and Dionne et al., 2003 are due to differences in the amount of sets and repetitions that were performed. Also Dionne et al., 2003 performed their resistance training protocol with nine different exercises involving three lower-extremity exercises and six upper-extremity exercises. More research is warranted in evaluating various resistances to help achieve a greater understanding of the effects of load increments and the effects on RMR.

Another difference between the previous studies was that the present study had a mixture of sedentary subjects, and subjects that were currently active in exercise. For

Dionne and associates 2003, their subjects were non-regular exercisers whose weights did not adjust ± 2.2 kg over the previous six months of data collection.

The results of this study indicate that for overall RMR increases there is a significant benefit performing upper and lower extremity training in the same sessions.

Future Research

More research is warranted on the effects of load intensity and the effects of RMR within each extremity. This study tested as high as 75% 1 –RM with one set for each exercise. There are however, many other methods of training that involve a different physiological response. The results of this study are only limited to stationary machines and must not be assumed as the primary modes of resistance training. There are however, other modes of resistance training while using stationary equipment (i.e., isometric, negatives which slow down the repetition count on eccentric movements, high intensity training (HIT) etc.). Likewise, the results of each movement performed are only limited to that movement.

Future research may use RMR to evaluate the effects of exercise training methods and how pre- and post- measurements compare. Using a broader population can allow researchers to understand which age groups and genders are benefiting the most from certain modes of training, and if further analysis needs to be implemented to allow for a positive result. Postmenopausal females are at higher risk for lower RMR due to lowered testosterone levels. Because of this future research can adjust the loads of training to see if that could or could not have an effect on one's RMR.

Select literature reviews from the present study had positive effects with resistance training and weight loss, of those studies with positive results, both upper and lower extremity exercises were implemented in the protocol. Future research can elaborate on these findings and see if certain intensities of each exercise can affect post RMR measurements.

Research has shown that lean body mass (LBM) effects RMR (Ryan et al., 1995). Future research with a nutritional department and certified weight lifting professionals can elaborate findings on pre- and post- RMR after supervised bouts of eating and exercises over a prolonged period of time.

Environment plays a factor on citizens accessibility to perform physical activity outside (i.e., harsh weather) future research can be conducted at select regions of the country. Gathering data from these areas can allow researchers to understand not only current levels of fitness via FFM and body compositions, but data about one's exercise fitness and overall wellbeing.

Summary

The purpose of the study was to identify changes in resting metabolic rate with upper and lower-extremity resistance training exercises. The dual purpose was to examine the effects of resistance training and the effects of upper and lower-extremities effects on one's RMR. The dependent variable was each subject's RMR, while the independent variables were the level of load intensities, rep ranges and duration of the study. Seven healthy, college aged males and females were used as participants. Participants were divided into the upper or the lower extremity weight training groups.

Maximal strength testing was performed to predict weights to be lifted for each subject on each condition and exercise. The three conditions were: (a) 50% 1 –RM, (b) 60% 1 –RM and, (c) 75% 1 –RM. Each condition was performed by both the upper-extremity group, the upper-extremity group performed (shoulder press, chest press, tricep extension, bicep curl and lateral pull-down) exercises while the lower-extremity group performed (leg press, leg extension, leg curl, standing lunges and a modified squat) exercises. Results for the upper-extremity group from pre- to post- RMR measurements indicate there was no significance with one's RMR after the 6-week training protocol. Likewise, pre- to post- RMR measurements for the lower-extremity group also resulted in no significance with one's RMR after a 6-week training protocol. From the results of the present study it appears that a progressive load resistance training program did not have an effect on one's RMR. This study evaluated a basic element of an effect of resistance training on RMR, other studies are needed to further this study to find significance.

Conclusions

With obesity at an all-time high it is imperative that researchers help combat this growing trend with significant research allowing for precise exercise prescription to be prescribed for people needing to lose weight and increase their RMR. Because of this, future research is needed on the effects of resistance training on RMR. The present study was not able to provide significant findings from pre- to post RMR measurements with a 6-week resistance training program varying in intensities from 50 percent to 75 percent of a previously determined 1 –RM.

REFERENCES

Albu, J., Shur, M., Curi, M., Murphy, L., Heymsfield, S., B, Pi-Sunyer, F., X. (1997). Resting metabolic rate in obese, premenopausal black women. *American Journal of Clinical Nutrition,* 66; 531-538.

Blackwell, J., (2002). Identification, Evaluation, and Treatment of Overweight and Obese. Adults. *Journal of the American Academy of Nurse Practitioners*. 14, (5), 196-198.

Bosy-Westphal, A., Eichhorn, C., Kutzner, D., Illner, K., Heller, M., & Muller, J, M., (2003). The Age-Related Decline in Resting Energy Expenditure in Humans Is Due to the Loss of Fat-Free Mass and to Alterations in Its Metabolically Active Components. *American Society for Nutritional Sciences.* 2356-2362.

Broader, E, C., Burrhus, A, K. Svanenik, S, L., & Wilmore, H, J., (1992). The effects of either high-intensity resistance or endurance training on resting metabolic rate. *American Journal of Clinical Nutrition,* 55; 802-810.

Bryner, W, R., Ullich, H, I., Sauers, J., Donley, D., Hornsby, G., Kolar, M., & Yeater, R., (1999). Effects of Resistance vs. Aerobic Training Combined with an 800 Calorie Liquid Diet on Lean Body Mass and Resting Metabolic Rate. *Journal of the American College of Nutrition.* 18, (2), 115-121.

Buscemi, S., Verga, S., Caimi, G., Cerasola, G., (2005). Low relative restingmetabolic rate and body weight gain in adult Caucasian Italians. *International Journal of Obesity,* 29, 287-291.

Case, A., & Menendez, A., (2009). Sex differences in obesity rates in poor countries. *Journal of Economics and Human Biology*, 7, (3), 271-282.

Cohen-Cole, E., & Fletcher, M. J., (2008). Is obesity contagious? Social networks vs. environmental factors in the obesity epidemic. *Journal of Health Economics* 27, 1382-1387.

Davis, B., & Carpenter, C., (2009). Proximity of Fast-Food Restaurants to Schools and Adolescent Obesity. *American Journal of Public Health.* 3, 505-510.

Dietz, W. H., Bandini, L. G., Morelli, J. A., Peers, K, F., & Ching, P. LYH. (1994). Effect of sedentary activities on resting metabolic rate. *American Society for Clinical Nutrition* 59, 556-559.

Dionne, J, I., Melancon, O M., Brochu, M., Ades, A, P., & Poelhman, T, E., (2003). Age related differences in metabolic adaptations following resistance training in women. *Experimental Gerontology* (39), 133-138.

Dulloo, G, A., & Jacquet J., (1998). Adaptive reduction in basal metabolic rate in response to food deprivation in humans: a role for feedback signals from fat stores. *American Journal Clinical Nutrition* 68, 599-606.

Geleibter, A., Maher, M. M., Gerace, L., Gutin, Be., Heymsfield, S. B., & Hashim, S, A., (1997). Effects of strength or aerobic training on body composition, resting metabolic rate, and peak oxygen consumption in obese dieting subjects. *American Journal of Clinical Nutrition*. 66, 557-563.

Hajhosseini, L., Holmes, T., Mohamadi, P., Goudarzi, V., McProud, L., & Hollenbeck, C. B., (2006). Changes in Body Weight, Body Composition and Resting Metabolic Rate (RMR) in First-Year University Freshman Students. *Journal of the American College of Nutrition*. 25, (2), 123-127.

Hill, O, J., (2009). Can a small-changes approach help address the obesity epidemic? A report of the Joint Task Force of the American Society for Nutrition, Institute of Food Technologists, and International Food Information Council. *American Journal of Clinical Nutrition*, 89, 477-484.

Kearney, T, J., & Murphy, W., (2004). The MedGem is a Valid and Reliable Indirect Calorimeter. *HealtheTech*, 1-5.

King, E, D., Mainous III, G, A., Carnemolla, M., & Everett, J, C., (2009). Adherence to Healthy Lifestyle Habits in US Adults, 1988-2006. *The American Journal of Medicine*, 122, (6) 528-534

King, E, J., (2006). *What is metabolic syndrome?* Nursing 2010, 36(6):31, June 2006.

MacKnight, J, M., (2003). Exercise considerations in obesity, hypertension and dyslipidemia. *Journal of Clinics in Sports Medicine,* 22, (1), 101-121.

Manson, J, E., Bassuk, S, S., Hu, F, B., Stampfer, M, J., Colditz, G, A., & Willett, W, C., (2007). Estimating the Number of Deaths due to Obesity: Can the Divergent Findings be Reconciled*? Journal of Women's Health*, 16, (2), 168-176.

McLaren, L., (2007). Socioeconomic Status and Obesity. *Epidemiology Review*, 29, 29 48.

Melby, C., Scholl, C., Edwards, G., & Bullough R., (1993). Effect of acute resistance exercise on postexercise energy expenditure and resting metabolic rate. *The American Physiological Society*, 1847-1853.

Monteiro, C. A., Moura, M. C., Conde, W. L., & Popkin, B. M.,(2004) Reviews Socioeconomic status and obesity in adult populations of developing countries: a review. *Public health* 82, (12), 940-946.

Nadar, P. R., O'Brien, M., Houts, R., Bradley, R., Belsky, J., Crosnoe, R., Friedman, S., Mei, Z., & Susman, E. J., (2009). Identifying Risk for Obesity in Early Childhood. *American Journal of Pediatrics*. 118, (3), 594-601.

Poehlman, T, E., Tremblay, A., Nadeau, A., Dussault, J., Theriault, G., & Bouchard, C., (1986). Heredity and changes in hormones and metabolic rates with short-term training. *The American Physiological Society*, E711-E717.

Poehlman, E, T., Goran, M, I., Gardner, A, W., Ades, P, A., Arciero, P, J., Katzma, Rooks, S, M., Montgomery, S, M., Toth, M, J., & Sutherland, P, T., (1993). Determinants of decline in resting metabolic rate in aging females. *The American Physiological Society*, E450-E455.

Purnell, JQ., Cummings, D., & Weigle, DS., (2007). Changes in 24-h area-under-the curve ghrelin values following diet-induced weight loss are associated with loss of fat-free mass, but not with changes in fat mass, insulin levels or insulin sensitivity. *International Journal of Obesity*, 31, 385-389.

Ravussin, E., Burnand, B., Schutz, Y., & Jequier, E., (1982). Twenty-four-hour energy expenditure and resting metabolic rate in obese, moderately obese, and control subjects. *The American Journal of Clinical Nutrition*, 35, 566-573.

Ryan, A., S, Pratley, E., R, Elahi, D., & Goldberg, A., P. (1995). Resistive training increases fat-free mass and maintains RMR despite weight loss in postmenopausal women. *Journal of Applied Physiology*, 79, (3) 818-823.

Uauy, R., Albala, C., & Kain, J., (2001). Obesity Trends in Latin America: Transiting from Under- to Overweight. *The Journal of Nutrition*, 893-899.

Utz, R., (2005). Obesity in America, 1960-2000: Is it an Age Period, or Cohort Phenomenon? 1-4.

Van Loan, D, M., (2007). Do Hand-Held Calorimeters Provide Reliable and Accurate Estimates of Resting Metabolic Rate? *Journal of the American College of Nutrition*, 26 (6), 625-629.

Wang, Y., & Wang JQ., (2002). A comparison of international references for the assessment of child and adolescent overweight and obesity in different populations. *European Journal of Clinical Nutrition*, 56, 973-982.

Weiss, E., P, Racette, S., B, Villareal, D., T, Fontana, L., Steger-May, K., Schechtman, K., B, Ehsani, A., A, Holloszy, J., O, and Washing University School of Medicine Calorie Group. (2007). Lower extremity muscle size and strength and aerobic capacity decrease with caloric restriction but not with exercise-induced weight loss. *Journal of Applied Physiology*, 102, 634-640

Wilmore, H. J., Costill, L.D. & Kenney, W.L. (2008). *Physiology of Sport and Exercise (*3rd ed.). Champaige, IL: Human Kinetics.

.

APPPENDICES

Appendix A

Informed Consent

Research Participant Consent Form

"Resting Metabolic Rate in Comparison with Upper and Lower Extremities"

Principle Investigators

Eric Conchola, BS and Douglas Smith, PhD

Oklahoma State University
Department of Health, Leisure, and Human Performance

The present study will examine pre and post-exercise resting metabolic rates on college males and females aged 18-30.

Purpose of Research
The purpose of this study is to determine if there is a difference in resting metabolic rate (RMR) following upper and lower extremity resistance training. An increase in RMR allows for calories to be burned at a faster rate, allowing people to adjust their exercises and caloric intake to meet the weight loss/gains they are hoping to achieve. You are being selected as a participant for this study because you are a college-aged female/male.

Procedures
You understand that the tasks required are as follows:

1. Complete a Health History Questionnaire and Informed Consent Forms. The Health History Questionnaire must be completed and if a medical clearance is required, one must be obtained by a physician before participating.
2. Complete an indirect calorimetry test (test to measure Resting Metabolic Rate). This test requires no eating prior to 12 hours of the test, on test day you are to remain sedentary (non-active), and that no nicotine or caffeine is ingested.
3. You will be randomly assigned to either the upper-extremity (back, shoulders, biceps) group or the lower-extremity (hamstrings, quadriceps, calves and gluteal muscles). group.
4. Subjects will begin exercises at 50% of their 1 repetition max (1RM) during the first two weeks, and will gradually increase their intensities until week six where they will be lifting 75% of their 1RM. Repetition max means the maximum amount of weight one can lift during one single repetition. Subjects will exercise twice a week for the first four weeks with 8-12 repetitions, and by week 5 subjects will be exercising three times a week for 8-12 repetitions.
5. You understand the differences between pain and discomfort when exercising, and if you experience pain at any time, you will discontinue exercise and withdraw from the study.

Compensation
No additional incentive is being offered; however, results of the study can be assessed by all participants following analysis.

Risks of Participation
Risks associated with the study are minimal and with about the same physical demands as a typical hard workout. It is possible that you will experience muscle fatigue and muscle soreness during and following the testing. Furthermore, it is possible that certain changes may occur. These changes include fainting, irregularities in heartbeat, and heart attack. Every effort is made to minimize these occurrences. CPR certified personal will be present at all test times, as well as a certified personal trainer. If further care is needed emergency OSU procedures will be followed. You understand the risks associated with this study and voluntarily choose to participate. You understand that in case of injury or illness resulting from this study, emergency medical treatment will be available. You understand that no funds have been set aside by Oklahoma State University to compensate you in the event of illness or injury.

Confidentiality

Participants will be assigned an ID number when they arrive to the testing lab. The list of corresponding names and ID numbers will be stored in a locked file cabinet in the Applied Musculoskeletal and Human Physiology Laboratory, which only the advisor and primary investigator will access to at any given time. After all the data is collected, the form containing names and numbers will be shredded. Medical clearance and Informed Consent Forms will contain names, but no ID numbers. These forms will be kept in a second locked file cabinet in the Applied Musculoskeletal and Human Physiology Laboratory which only the advisor will have access to at any given time. They will be shredded one year after the research is completed (Spring 2010). Data will be reported as groups (upper-extremity/lower-extremity) and will not be linked to participants.

Contacts

If you should have questions about your rights as a research volunteer, you may contact Dr. Shelia Kennison, IRB Chair, 219 Cordell North, Oklahoma State University, Stillwater, OK 74078, 405-744-1676 or irb@okstate.edu. If you need any additional information concerning the study contact Doug Smith 197 CRC, Oklahoma State University, Stillwater, OK 74078, 405-744-5500, doug.smith@okstate.edu, or Eric Conchola 001 Seretean Wellness Center, Oklahoma State University, Stillwater OK 74078, 405-744-6962, eric.conchola@okstate.edu.

"I have read and fully understand the consent form. I sign it freely and voluntarily. A copy of this form has been given to me."

__________________________ __________________________

Participants Signature Date

__________________________ __________________________

Investigator's Signature Date

Appendix B

Health Questionnaire

OKLAHOMA STATE UNIVERSITY
APPLIED MUSCULOSKELETAL HUMAN PERFORMANCE LABORATORY

Personal Medical history Survey

Complete the front and back of this form.

Subject ID #:_______________________ Date:_______________

Age: _______ Sex:_______ Weight: _______ Height:_______

1. Have you ever been diagnosed as having: (check all that apply)

	Never	In the past	Presently
A. Heart disease	_____	_____	_____
B. High blood pressure	_____	_____	_____
C. Other vascular disorders	_____	_____	_____
D. Diabetes	_____	_____	_____
E. Asthma	_____	_____	_____
F. Chronic bronchitis	_____	_____	_____
G. Other respiratory illness	_____	_____	_____
H. Heart Murmur	_____	_____	_____

2. Please indicate any surgery that you have undergone and the approximate date(s).

____

____

3. Please indicate recent illnesses or major injuries that you have had. Also list approximate dates.

____

____

4. Please list all medications or supplements (prescription and non-prescription) that you are presently taking.

Medication	Dosage	Duration

5. Have you ever performed endurance training? Yes____ No____

6. On a scale from 1-10 (1 being novice, 10 being expert) rate your experience with using resistance training. ___________

7. Describe exercise or activity program during the last 6 months. (Please include: the activity, amount per day, days per week, and length of time you have been exercising at this level).

Activity Of exercise	minutes/day	days/week	weeks/months

Eric Christopher Conchola

Candidate for the Degree of

Master of Science

Thesis: THE EFFECTS OF UPPER AND LOWER EXTREMITY RESISTANCE TRAINING ON RESTING METABOLIC RATE

Major Field: Health and Human Performance

Biographical: Born in Mesquite, TX. Raised in Austin, TX until I was 19. Attended West Texas A&M University in Canyon, TX for my undergraduate degree in Sports and Exercise Sciences. Currently attend Oklahoma State University for my Master's degree in Applied Exercise Science

Personal Data:

Education:

Completed the requirements for the Master of Science at Oklahoma State University, Stillwater, Oklahoma in May, 2010.
Major: Applied Exercise Sciences

Completed the requirements for the Bachelor of Science in Sports and Exercise Sciences at West Texas A&M University, Canyon, TX/2007.

Experience:
Graduate Assistant for Seretean Wellness Center at Oklahoma State University. Assisted with blood pressure, cholesterol, height, weight, and body composition.

Professional Memberships:
Certified personal trainer through American Council on Exercise

Name: Eric Conchola Date of Degree: May, 2010

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: THE EFFECTS OF UPPER AND LOWER EXTREMITY RESISTANCE TRAINING ON RMR IN TRAINED AND UNTRAINED INDIVIDUALS

Pages in Study: 56 Candidate for the Degree of Master of Science

Major Field: Health and Human Performance Applied Exercise Science

Scope and Method of Study: The purpose of the study was to identify changes in resting metabolic rate with upper and lower-extremity resistance training exercises. Seven test subjects consisting of 2 males (ages 20-26) and five females (ages 19-22) participated in the study. Both males were trained, and one of the females was trained. Subjects were assigned into either the upper extremity (lat pull-down, bicep curl, tricep extension, chest press, shoulder press) group or the lower extremity (modified squat, modified lunge, leg press, leg extension, leg curl) group. Participants performed each movement under three different conditions, 50%, 60%, and 75% 1 –RM. Subjects lifted at 50% 1 –RM for weeks 1-2, 60% weeks 3-4, and 75% 1 –RM weeks 5-6. Subjects exercised 2 times a week for the first 3 weeks and 3 times a week for the last 3 weeks.

Findings and Conclusions: Following 6-weeks of resistance training, the upper-extremity resistance training which consisted of four subjects had no significance ($p<0.66$) on post RMR measurements. The lower-extremity resistance training group consisting of three subjects as well had no significance ($p<0.28$) on post RMR measurements. The present study was not able to provide significant differences from pre- to post RMR measurements with a 6-week resistance training program varying in intensities from 50 percent to 75 percent of a previously determined 1 –RM.

ADVISER'S APPROVAL: Dr. Douglas Smith