The effects of resistance training on resting metabolic rates in overweight adults

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ABSTRACT

The purpose of this study was to determine if resistance training (RT) aids in weight loss over time by increasing the fat free mass (FFM) and resting metabolic rate (RMR) in overweight subjects. This study included 6 sedentary, overweight male and female subjects between the ages of 19-33 years who participated in a 12-week intervention of RT or no exercise, and a 4-week post intervention of no exercise. Subjects were randomized into 1 of 2 groups: exercise (n = 2), control (n = 4). RMR, FFM, fat mass (FM), body fat percentage (BF), bone mineral density (BMD), one repetition maximum on the leg and chest press, waist circumference, height, and weight were all measured before the intervention (time 1), after the intervention (time 2), and after the post intervention (time 3). Oxygen consumption was measured through open-circuit spirometry to determine RMR. FFM was measured on a GE Lunar iDXA bone density scanner. A repeated measures analysis of variance (ANOVA) with post hoc tests was conducted to determine significant differences between groups over time analysis. Effect size (d) calculations determined the magnitude of change. The exercise group showed no significant changes, whereas the control group indicated significant increases in FFM between times 1 and 2 (p = .006), and between times 1 and 3 (p = .001). The data from this study indicate that RT does not significantly increase RMR. However, the ES revealed a large change from time 1 to time 2 in RMR (d = .87) and a small change in FFM (d = .10) in the exercise group; whereas the control group had small changes in both RMR (d = .26) and FFM (d = .36). The d suggests that RT may increase RMR without increasing FFM.

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TABLE OF CONTENTS

APPENDIX E

APPENDIX F

LIST OF TABLES AND FIGURES

TABLE

CHAPTER ONE

Introduction

Obesity is the condition of excess adipose tissue that has been linked to life threatening chronic diseases such as diabetes and heart disease (Skinner, 2005). The resting metabolic rate (RMR) is the rate at which the human body expends calories in order to maintain normal bodily processes in a resting state. RMR constitutes approximately 67% of the body's total daily caloric expenditure. The remainder of calories expended is through physical activity (23%) and the thermic effect of food (10%) (Nieman, 2007). Because RMR constitutes such a large proportion of the constant amount of energy expended, a potential long term increase could significantly help overweight adults lose fat mass (FM) and decrease the chance for developing chronic illnesses related to obesity. A strong correlation exists between RMR and a person's amount of fat free mass (Byrne & Wilmore, 2001b). Fat free mass (FFM) includes the compositions of the body that include muscle, bone, organ, and connective tissue. One of the most efficient ways of increasing FFM is through a progressive overload of resistance training. Two common modes of exercise prescribed to most subjects are resistance and aerobic/endurance training. Resistance training is a type of physical activity meant to increase muscular strength and endurance through the application of weight or resistance on a muscle group through its range of motion. Aerobic or endurance training is a mode of exercise that requires a person to continuously move their body at an elevated intensity for an extended period of time. Aerobic training is commonly prescribed to overweight adults because it substantially increases the immediate number of calories expended. However, studies show that resistance training raises RMR significantly more than aerobic training (Dolezal & Potteiger, 1998; Byrne & Wilmore, 2001b; Poehlman, et al., 2002; Bryner, et al., 1999). Therefore, it is hypothesized that resistance training can increase a person's RMR and improve the rate at which fat mass is lost during exercise and at rest.

Purpose

The purpose of this study was to examine the effects of resistance training on resting metabolic rate and how it is applicable for weight loss programming among obese adults. The long-term goal of this study was to discover a means to decrease fat mass through resistance training and increase the quality of life in obese subjects.

Limitations

1. This study did not include a personalized nutritional guideline to those subjects who were willing to participate. All subjects were given only nutritional guidelines set forth by the American Dietetic Association. The sole purpose was to educate the participants with what consists of a healthy diet.
2. The number of subjects in the beginning of the study was small; in addition, the number of subjects decreased as the research progressed.
3. The subjects' previous physical activity was not controlled. The researcher inquired each subject as to his or her physical activities, but had no way of actually knowing what type of physical activity the subjects were participating in prior to the study.
4. All of the subjects were recruited from a relatively small area around the University of Central Oklahoma. There were no subjects that participated in this study that were not from the university's surrounding community.

Delimitations

1. The subjects were overweight according to body mass index (BMI) standards. Each subject started the study with a BMI of greater than or equal to 25 kg/m^2 and with a waist circumference greater than or equal to 34.5 inches (female) or 40 inches (male).
2. All subjects were sedentary and had not been participating in any continuous exercise program. All subjects were screened before participation in the study and asked about his or her physical activity level. Those subjects who have participated in any type of systematic repetitive exercise one or more times per week were considered to be in a continuous exercise program.
3. The study was a relatively short time period of 12 weeks for exercise. Compared to a lifestyle change, this 12-week intervention is short in duration.

Significance of Study

The significance of this study lies within the possibility that resistance training will help increase resting metabolic rate. In overweight or obese people, an increase in resting metabolic rate along with the appropriate amount of aerobic or endurance exercise and diet will improve the ability to expend calories to more effectively lose weight. It is important for individuals to maintain a healthy weight in order to lower the risk of chronic diseases that are related to excess fat. In addition, resistance training will help maintain or increase fat free mass during a comprehensive weight loss program.

Assumptions

1. Participants in the exercise group performed their prescribed resistance exercises 8-12 times at an elevated intensity level for three sets, three times per week for 12 weeks.
2. Participants in the control group did not partake in any new physical activities throughout the study.
3. The participants were given nutritional handouts from the American Dietetic Association but did not make any significant changes to their diet.

Definition of Terms

1. Resting metabolic rate (RMR) is the minimum amount of calories a person expends per day due to the normal processes that are not related to his or her physical activity or thermic effect of food. This study will measure RMR by kilocalories per day.
2. Fat mass (FM) is the amount of adipose tissue a person has measured in pounds.
3. Fat free mass (FFM) is the amount of weight that a person has that is not fat mass measured in pounds. This mass is composed of mainly muscle, but also bone, organ tissue, and connective tissue.
4. Body fat percentage (BF %) is the proportion of a person's body that is made up of fat mass.
5. Resistance training is a form of exercise that involves moving a person's joint through its range of motion with an added weight for resistance.

Hypothesis

The hypothesis of this study was that progressive resistance exercise would significantly increase the resting metabolic rates in overweight subjects. This research sought to determine if progressive resistance training in overweight and sedentary subjects would increase fat free mass and resting metabolic rates in exercising subjects compared to similar subjects who did not perform any additional physical activities throughout the study.

CHAPTER TWO

Review of Literature

This review of literature was comprised of journal articles and textbook excerpts. The journal articles reviewed were found through the University of Central Oklahoma's library online databases. The study's main topic was how different types of exercise affected a person's resting metabolic rate (RMR). Some of the literature reviewed discusses the basal metabolic rate (BMR). BMR and RMR are essentially the same measurement with a different preparation. To measure a BMR, the subject must fast overnight for a period of 12-14 hours before the test is administered. RMR only requires a 4-5 hour fasting period that does not have to be completed overnight (Nieman, 2007). Other variations in study topics include resistance training versus aerobic training, intensity levels, and very low calorie diets. The purpose of this review of literature was to determine the effects of 12 weeks of progressive resistance training on resting metabolic rates among a group of overweight subjects.

Dolezal and Potteiger (1998) examined the changes on basal metabolic rate, body composition, VO_2max, muscular strength, and urinary urea nitrogen excretion through 10 weeks of concurrent resistance and aerobic training. The subjects included 30 active males, ages 20.1 ± 1.6 years who were randomized into a resistance only, endurance only, or a combined resistance and endurance training group. The results of the study indicated a significant increase in basal metabolic rate in the resistance only group from 7613.3 ± 968.7 to 8090.8 ± 951.2 kJ/day as well as a significant increase in the combined group from 7454.9 ± 964.2 to 7801.8 ± 980.6 kJ/day. Adversely, there was a significant decrease in basal metabolic rate in the endurance training group from 7231.2 ± 554.1 to

7029.7 ± 666.4 kJ/day. The changes in basal metabolic rate were consistent with the changes in FFM (Dolezal & Potteiger, 1998). The subjects did not include overweight participants or females. This study is more applicable for healthy males rather than an obese population.

A related study that emphasized the intensity of exercise also compared the RMR of aerobic and resistance training subjects. The 12-week study by Broeder, Burrhus, Svanevik, and Wilmore (1992b) compared the effects of a high intensity endurance program to a high intensity resistance training program on RMR. There were 47 male subjects randomly assigned to a control, resistance, or endurance training group. The results of the study indicated that neither intervention proved to create significant differences in RMR ($p < .05$). However, the post training data for fat free mass for the resistance training group (65.9 ± 2.6 kg) indicated significant differences from its pre treatment data (63.8 ± 2.4 kg) and from the post treatment value in the endurance training group (64.7 ± 2.2 kg) (Broeder, et al., 1992b). The study indicated that the resistance training group increased in fat free mass significantly over the control and the endurance groups. However, the results did not indicate a significant change in RMR for the resistance training group. Perhaps the study was not long enough in duration to effect caloric expenditure rates.

Byrne and Wilmore (2001a) focused not only on the intensity, but also different modes of exercise and their effects on RMR. The relationship between different levels of resistance and aerobic exercise intensities were studied. The study included 61 women between the ages of 18 and 46 years who were grouped as untrained, moderately trained, or highly trained in aerobic or resistance exercise. Subjects were grouped according to their VO_2max test values and a questionnaire directed towards the subjects' workout routines. The results of the study indicated that there were no differences in RMR between aerobically and resistance trained subjects ($p \leq .05$). There was a trend, however, for the subjects' RMR to increase as the intensity training levels increased (Byrne & Wilmore, 2001a). This characteristic is probably due to a higher amount of fat free mass in the highly trained group compared to both the moderately trained and untrained groups. As the groups' amount of fat free mass increased, a linear increase in RMR was observed ($p \leq .05$). The untrained group had a fat free mass of 44.5 ± 0.9 kg, the moderately trained group had 47.6 ± 0.9 kg, and the highly trained had had 49.8 ± 0.8 kg of fat free mass (Byrne & Wilmore, 2001a). Therefore, according to the statistics and the fact that resistance training has more bearing on fat free mass than endurance exercise, resistance training is the logical mode of exercise that may influence resting metabolic rates.

Hunter, Wetzstein, Fields, Brown, and Bamman (2000) observed resistance training as a means of increasing energy expenditure among men and women. The purpose of the study was to examine the effects of a 26-week resistance training program on resting energy expenditure among older adults. The subjects included 15 males and females whose ages ranged from 61-70 years. The results of the 26-week resistance training program concluded that resting energy expenditure significantly increased from 5388 ± 520 to 5753 ± 560 kJ/day with a concurrent significant increase in FFM from 50.0 ± 10.1 to 52.0 ± 10.7 kg (Hunter, et al., 2000). This study also suggests that an increase in FFM will increase a person's RMR. However, there are limitations of this study in regards to application in obese adults. The subjects in this study were of an older population of adults and of normal weight with a BMI of 24.8 ± 3.9 kg/m² (Hunter, et al., 2000) rather than that of an average population of obese adults.

The effects of a 20-week exercise training program on RMR was observed in a group of 28 moderately obese women ages 38.0 ± 0.9 years (Byrne & Wilmore, 2001b). The purpose of the study was to discover the effects of a resistance training program on subjects without calorie restriction. The subjects were placed in a resistance, resistance plus walking, or a non-exercising control group. The results of the study revealed a significant increase in RMR in the resistance training group by 44 kcal/day (Byrne & Wilmore, 2001b). However, the resistance plus walking group indicated a significant decrease in RMR by 53 kcal/day. The researchers hypothesized that the decrease in RMR was due to an acclimation to the environmental temperature because the walking was done outdoors in a hot climate. The control group indicated no significant changes (Byrne & Wilmore, 2001b). One limitation to this study is that it was conducted among only females. This limits the sample to only about half of the appropriate population. Perhaps different changes in RMR could have been made in the resistance plus walking group if the subjects had performed endurance training indoors, rather than outdoors.

Poehlman, et al. (2002) examined the differences between energy expenditure of endurance and resistance training. The subjects included 48 non-obese sedentary women who were age 28.0 ± 4.0 years and randomized into a resistance, aerobic, or a non-exercise control group. The purpose of the study was to determine the effects of exercise on total energy expenditure (TEE). TEE includes energy expenditure through rest, physical activity, and the thermic effect of food throughout the day, whereas RMR is only the body’s essential caloric expenditure. After a 6-month intervention, the researchers concluded that neither endurance nor resistance trained subjects showed a significant change in TEE even though there were significant increases in FFM by 1.3 kg and RMR by 61 kcal/day in the resistance training group. The reason that TEE was not significantly different is unclear but the researchers speculate that it was due to the theory that as a subject increases their amount of exercise, the energy expenditure during non-exercising periods of the day decreases (Poehlman, et al., 2002). The limitations of this study were that it included non-obese subjects and that it did not include males. This study does, however, increase the awareness to future researchers of the subjects' non-exercising periods. Results could be less likely determined by this theory if subjects are educated and encouraged continuance with their normal daily activities.

Broeder, Burrhus, Svanevik, and Wilmore (1992a) determined the effects of aerobic fitness on RMR. The subjects included 69 males who were ages 18-35 years old. The purpose of this study was to find the relationship between RMR and aerobic fitness. Body composition, RMR, and a three-day dietary recall were collected from the subjects. The subjects were placed in low, moderate, or high fitness levels according to the results of their tests. The results of the study indicated that no differences existed between the three groups in RMR (Broeder, et al., 1992a). One statistic that also was not significantly different among the groups was the amount of FFM. FFM is normally positively associated with RMR. If the groups were graded on their level of strength, then there could possibly prove to be significant differences between groups. A limitation to this study was that it did not include females.

Potteiger, Kirk, Jacobsen, and Donnelly (2008) observed the effects of a 16-month aerobic exercise program among overweight females indicating an increase in

RMR. The study included 43 females and 31 males ages 17-35 that were all overweight or moderately obese. The purpose of the study was to determine whether 16 months of exercise training effects RMR and substrate oxidation. The results of this study indicated that RMR increased significantly for both males and females. Males increased RMR by 129 kcal/day and females increased by 132 kcal/day even though there were no differences in FFM before and after the 16-month intervention (Potteiger, et al., 2008). The results of this study indicated that an increase in RMR without an increase in FFM is possible in young overweight subjects.

Diet is an important factor in designing a weight loss exercise program. In order to expedite the decline of FM, a low calorie diet is often prescribed to obese patients. One study by Bryner, et al. (1999) studied the effects of resistance training versus aerobic training on the RMR and FFM on subjects undergoing a very low calorie diet for 12 weeks. The subjects included in this study were 17 females and 3 males who had a mean BMI of 35.2 ± 2.9 kg/m². The ages of the subjects were 36.7 ± 11.5 years. All subjects were restricted to a 800 kcal per day liquid diet. The subjects were randomized into a resistance plus diet or an endurance plus diet group. The results of the study indicated that the resistance group maintained FFM during the very low calorie diet whereas the endurance group significantly decreased FFM by 4.1 kg. Also, there was no significant change in RMR for the resistance group, but a significant decrease in RMR for the endurance group of 210.7 kcal/day (Bryner, et al., 1999). This study indicates that valuable FFM can be maintained even throughout a very low calorie diet and it is suggested to compliment a diet plan with resistance exercise in order to accomplish this preservation. Similar results were observed by Geliebter, et al. (1997) in a study whose purpose was also to determine the differences in the metabolic changes between dieting subjects undergoing either a resistance or aerobic training program. The study included 65 obese males and females who were all receiving a formula diet with an energy content of 70% of RMR and randomly placed in resistance training, aerobic training, or a control group for a period of 8 weeks. The results of the study indicated that resistance training prevented the loss of fat free mass during a significant loss in fat mass. The resistance training group lost only 1.1 ± 2.3 kg of fat free mass while losing 6.7 ± 2.8 kg of fat mass. All other groups significantly lost fat free mass along with fat mass. The aerobic training group decreased fat free mass by 2.3 ± 2.4 kg and fat mass by 7.2 ± 3.0 kg. The diet only group decreased fat free mass by 2.7 ± 2.1 and fat mass by 6.8 ± 2.6 kg (Geliebter, et al., 1997). This study indicates, again, that resistance training will decrease the amount of valuable muscle mass lost during a significant weight loss.

Whatley, et al. (1994) compared the effects on RMR and body composition of a 12-week program incorporating aerobic exercise among 23 obese females undergoing a very low energy diet. The subjects were placed in one of three groups, a high volume of aerobic exercise group that performed 400 minutes of endurance exercise per week plus resistance training 3 days per week, and moderate volume of aerobic exercise group that performed 200 minutes of endurance exercise per week plus 3 days of resistance training per week, or a control group that performed no exercise. All three groups were placed on the very low energy diet that consisted of an 800 kcal nutrient dense liquid formula. The two exercise groups also were prescribed a resistance training program in order to compliment the aerobic programs. The resistance exercises prescribed included the bench press, lateral pull-down, knee extension, and knee flexion. The resistance training progressed from two sets of six repetitions at 70% of the one repetition maximum (1RM) to three sets of eight repetitions at 80% of their 1RM. The results indicated that a large amount of aerobic exercise along with resistance training improved fat and weight loss compared to dieting alone. All three groups showed significant losses in body weight, fat mass, and fat free mass ($p < .05$). The high volume group decreased body weight by 19.8 ± 4.2 kg, fat mass by 15.7 ± 4.5 kg, and fat free mass by 3.9 ± 2.4 kg. The body weight and fat weight values from the high volume of exercise group were significantly different from those of the control group. The moderate volume group decreased body weight by 15.8 ± 4.2 kg, fat mass by 12.9 ± 3.8 kg, and fat free mass by 2.9 ± 1.3 kg. The control group decreased body weight by 13.1 ± 2.4 kg, fat mass by 9.3 ± 3.1 kg, and fat free mass by 3.8 ± 1.4 kg (Whatley, et al., 1994). The possible reduction in fat free mass in all groups regardless of the resistance training program might be due to the emphasis on the large or small volumes of aerobic training. In the previous studies, resistance training had been more emphasized. Suppose all of the exercise groups had been given a basic aerobic training program but emphasized either a moderate or high intensity resistance training program. Hypothetically, there would be no significant changes in fat free mass according the results of the previously reviewed studies.

Perhaps the amount of aerobic power that a subject is prescribed is not the determinant of the level of a subject's RMR, but it is the pre-existing level of aerobic capacity that can help determine a subject's resting caloric expenditure. Smith, et al., (1997) compared the level of aerobic capacity in 34 women to their RMR. The 34 women were divided in either a low or high aerobic capacity group determined by their VO_2 consumed. Body mass, VO_2, body fat percentage, and fat free mass were compared. The results of the study indicated that there was no significant relationship between VO_2max and RMR when fat free mass was partialed out ($p < .05$). Rather, the amount of fat free mass was positively correlated with RMR ($p = .0003$) (Smith, et al., 1997). Therefore, according to this study, it is logical to prescribe exercises that will significantly increase fat free mass. Exercises that prove to be the most efficient in doing so include resistance training.

In summary, the literature indicates the exercise intervention that has the most impact on fat free mass amounts is resistance training. Resting metabolic rate is strongly correlated with a person's amount of fat free mass (Byrne & Wilmore, 2001b). The more fat free mass a subject has, the greater his or her RMR. Resistance training has been the intervention shown to significantly increase fat free mass (Broeder, et al., 1992b; Byrne & Wilmore, 2001b; Dolezal & Potteiger, 1998; Hunter, et al., 2000; Poehlman, et al., 2002). Interventions that do not include resistance training have resulted in decreases or no significant differences in fat free mass amounts (Broeder, et al., 1992b; Dolezal & Potteiger, 1998; Geliebter, et al., 1997; Poehlman, et al., 2002; Potteiger, et al., 2008). The interventions that resulted in decreases in fat free mass also resulted in decreases in resting metabolic rate (Bryner, et al., 1999; Whatley, et al., 1994). According to Neiman, (2007) approximately 67% of a person's daily energy expenditure comes from his or her resting metabolic rate. If the daily RMR is increased, then the excess amount of calories expended will compound to greater numbers. Therefore, supplementing resistance training along with aerobic exercise and diet is a prudent decision when planning for an effective weight loss program. This study will determine the long term effect of resistance training on the resting metabolic rate and its validity in weight loss programming.

CHAPTER THREE

Methodology

Introduction

The purpose of this study was to examine the effects of resistance training on resting metabolic rate and how it is applicable for weight loss programming in obese adults. The long-term goal of this study was to discover a means to decrease fat mass through resistance training and increase the quality of life in obese subjects. All participants of this study underwent a series of tests on three separate occasions. Each group was introduced to a 12 week intervention. The control group was asked to only participate in the variable measurements. The exercise, or treatment, group participated in a progressive resistance exercise program. All of the subjects were tested after the 12 week intervention and once more after another 4-week period which neither group performed exercise. The results of this study will help exercise professionals understand how to practice efficient exercise programming to effectively increase the quality of life in overweight and obese subjects.

Participants

The subjects included both men and women between the ages 18-40. Subjects of any race or ethnicity were recruited from the University of Central Oklahoma, Edmond, OK and Oklahoma City communities. Recruitment of participants occurred through mass email and by word of mouth. All subjects were free of uncontrolled metabolic illnesses such as type 2 diabetes, hypertension, or any disabilities that may have inhibited participation in a regular exercise program. Subjects were previously sedentary by not participating in any continuous exercise programs for the past 6 months. Subjects considered to be in a continuous exercise program, are those who have participated in any type of systematic repetitive exercise one or more times per week. To be considered, male participants had a body mass index (BMI) of at least 25 kg/m² and a waist circumference of more than 40 inches. Female participants had a BMI of at least 25 kg/m² and a waist circumference of more than 34.5 inches (Armstrong, et al., 2006). Participants were screened during the first appointment with the primary investigator. During the appointment the participant had his or her height, weight, and waist circumference measured. The participant was given a medical history questionnaire. If the participant did not meet the criteria previously mentioned, he or she was disqualified from the study. The number of participants that could have been recruited for this study was small due to time constraints. The time for assessing variables was short because there was only one researcher and a twelve hour fasting period prior to the resting metabolic rate test. The primary investigator chose not to perform the two-hour set of measurements on any of the subjects in the afternoon because it would cause discomfort due to hunger.

Instrumentation

Measurements in this study included height, weight, waist circumference, one repetition maximum on the bench press and leg press, body mass index (BMI), body fat percentage, fat free mass, bone density, and resting oxygen consumption. BMI was calculated using the subjects' individual weight, in kilograms (kg), divided by height, in meters squared (m²). The subject's weight and height were measured using a Detecto Physician's scale (Cardinal Scale Manufacturing Company, Webb City, MO). The subject removed his or her shoes and any other unnecessary garment that may substantially increase the weight of the subject. The subject then stepped onto the scale and remained still as the researcher slid the weighted measures to the nearest pound to indicate his or her approximate weight. The subject also stood on the scale while the researcher measured his or her height to the nearest inch by sliding the height measuring arm down slowly until the arm touched the very top of the head. Waist circumference was measured using a Gulick tape measure. Each subject was asked to remove any thick clothing, such as a coat or a sweater, which might interfere with an accurate measure. The measure was taken in a horizontal plane around the narrowest portion of subjects' torso between the umbilicus and the xiphoid process. The waist measurement was taken three times on each subject and then averaged.

The iDXA (GE Lunar, Madison, WI) measures individual's bone density, body fat percentage, and fat free mass. The subject's name, gender, height, weight, age, and race were entered in the computer before the test began. The subject was asked to remove his or her shoes and any metal objects. The subject laid supine on the scanning table within the parameters indicated on the table's surface. The researcher aided the subject in aligning each subject straight on the table and then used one or two straps the secure the subject's legs together. The straps helped ensure a minimal amount of movement during the test. The subject was instructed to shut his or her eyes when the test began and to remain very still throughout the test. Once the subject was ready to begin the test, the researcher began the scan. The iDXA scan lasted between seven and ten minutes. The subject's information was then saved on the computer and compared to the future tests.

The subjects' oxygen consumption was measured by using open-circuit spirometry to measure resting VO_2 (volume of oxygen consumed per minute) which determined his or her RMR. Before the subject arrived in the Kinesiology Lab, he or she was instructed to fast for a 12-hour period prior to the RMR test. Before testing RMR, the subject was asked to sit quietly for 15 minutes prior to beginning the test. While the subject was resting, his or her height, weight, age, gender, and name were entered into the metabolic cart's computer. Once 15 minutes passed, the researcher placed a hood over the subject's head. The hood was attached to the metabolic cart using a hose. The hood collected the carbon dioxide that was produced by the subject and was transported through the hose to the metabolic cart where the oxygen consumption was estimated. The researcher instructed each subject to remain very still and quiet throughout the test. Once the subject was ready, the researcher started the test. The RMR test lasted 30 minutes. Once 30 minutes was reached, the researcher ended the test and removed the hood from the subject.

The subjects' muscular strength was assessed using the one repetition maximum test. The equipment used to measure the strength of the subjects was a Cybex Eagle chest press and a Cybex Eagle leg press machines (Cybex, International Exercise Equipment, Owatonna, MN) that were located in the Wellness Center's resistance training area. The chest and leg press machines were used instead of the traditional barbell bench press and back squat methods of measuring the one repetition maximum. The measurement values from the chest and leg press machines were comparable to pounds, but not as accurate as the measurements that would have been obtained if the barbell bench press or the back squat had been used. Because the chest press and leg press machines are not calibrated laboratory equipment, the accuracy of the measurement is unreliable. However, the chest and leg press machines were a safer option to use as a measurement tool due to the subjects' inexperience with resistance training. The subjects were instructed to warm up before taking the one repetition maximum measurement. Warming up is crucial when performing any resistance training in order to decrease the chances of musculoskeletal injuries. Each subject was instructed on the proper technique when performing the chest and leg press. The subjects were shown proper foot placement on the leg press and hand placement on the chest press. The subjects were told to place the feet slightly wider than shoulder width and parallel with each other on the leg press foot platform. The subject was to grasp the handle bars on the chest press machine slightly wider than shoulder width. Each repetition was to descend until the subject had reached a 90° angle in the knees on the leg press, and 90° angle in the elbows on the chest press. Once the desired angle had been reached, the subject was instructed to exhale and press away from the body. The procedures for warming up were the same for both the chest press and leg press. The subjects performed three sets of increasing weight and decreasing repetitions on the chest and leg press. The first set of warm ups included 10 repetitions which were adjusted to an intensity of approximately 50% of the subject's estimated one repetition maximum. The second set was five repetitions at approximately 75%, and the final warm up was one repetition at approximately 90% of the subject's estimated one repetition maximum. Once the warm up sets were completed the subjects were instructed to continue performing subsequent, one repetition sets of increasing weight until he or she reached failure. Increases in weight on the leg press were by increments of 10 and by 5 on the chest press. The values that indicated the weight on the resistance training machines were comparable to pounds. Each subject was allotted 2 minute rest periods between all sets. The completed repetition prior to the failed repetition was considered to be the subject's one repetition maximum.

Procedures

Prior to any variables being measured, an informed consent form (Appendix C) was signed by each potential participant. Each potential subject was asked to fill out a short survey (Appendix B) that asked for his or her height, weight, and waist circumference in order to calculate the desired BMI to be considered for the study. The short survey also briefly asked about the candidate's current physical activity. If the subject fit the requirements for BMI and physical activity, the subjects were given a physical activity readiness questionnaire (Par-Q) (Appendix B) before being considered for the study. If the subject answered "yes" to one or more of the questions on the Par-Q, then he or she had to seek a physician's approval before engaging in physical activity. Once the subject passed the Par-Q or been given physician's approval for physical activity, the subject then completed a medical history questionnaire (Appendix B) followed by fitness testing.

A fitness assessment was conducted prior to the start of the intervention for each subject. The assessment variables were measured in this order: weight, height, waist circumference, resting energy expenditure through VO_2 after a 30 minute rest period and a 12-hour fasting period, iDXA bone density and body composition analysis, one repetition maximum (1RM) on the bench press, and 1RM on the leg press. Each fitness assessment variable was arranged in an order that would have the least effect on other tests. The fasting period was likely to affect the physical performance of the subjects. To decrease the effect on the physically active portions of the fitness assessment, including the 1RM bench and leg press, each subject was provided with the opportunity to consume a small amount of food and a bottle of water. Once all subjects underwent the fitness testing, each subject began his or her 16-week intervention.

All of the subjects were given nutritional guidelines set forth by the American Dietetic Association (ADA; Appendix D). The subjects were encouraged to follow the ADA's recommendations throughout the study.

The subjects were randomly assigned into either a control or treatment group. The control group was given nutritional guidelines and asked to continue with their normal daily activities for 16 weeks. The treatment group was given a resistance training regimen to follow for a continuous 12 weeks. After 12 weeks the treatment group ceased resistance training and continued with normal daily activities for the remaining four weeks of the 16-week intervention. The 4-week cease in exercise provided insight into the long-term effects of resistance training for previously untrained individuals.

The treatment group was prescribed a program that follows the American College of Sports Medicine's guidelines for resistance training (Armstrong, et al., 2000). Each subject was introduced to the resistance training program which was created by the primary investigator who was a certified personal trainer through the National Strength and Conditioning Association with a Bachelor's degree in Exercise and Fitness Management. Subjects performed resistance training exercises on each major muscle group three days per week. The subjects were not obligated to participate in supervised resistance training during specific times. However, the primary investigator was regularly available at the Wellness Center three nights per week. The program consisted of a whole body resistance training program to be performed three days per week that included chest, back, shoulders, core, and lower body exercises. The exercises that were prescribed included chest press, machine row, shoulder press, bicep curl, triceps extension, leg press, leg curl, and leg extension. The exercises were to be performed for 2-3 sets of 8-12 repetitions in order to increase muscular strength and hypertrophy. The exercise intensity prescribed for each subject was between 67-85% of his or her one repetition maximum (Earle & Baechle, 2004). For those exercises that the subject did not perform a maximum test, he or she was instructed to lift as much weight possible within 8-12 repetitions. The exercises prescribed were using machine weights rather than free weights to ensure safety and ease of use since most of the subjects were expected to be novice. In addition to performing machine weights, the subjects were prescribed abdominal crunches to train his or her core. In addition to being introduced to all of the resistance training machines, the primary investigator taught each treatment group subject how to set and use all of the machines required during intervention. All of the treatment group subjects started the intervention with a relatively moderate intensity according to his or her perceived exertion and later progressively increased the intensity of the exercises. All of the subjects were taught how to use a ratings of perceived exertion (RPE) scale (Appendix E) and encouraged to start at an intensity of three (Armstrong, et al., 2000). The treatment group subjects were encouraged to increase the intensity of the prescribed exercises throughout the study to at least a rating of seven on the RPE scale by the fourth week of intervention.

At 12 weeks and again at 16 weeks, the subjects from both groups underwent the same set of measurements that were completed prior to the intervention. The 4-week cease in resistance training between week 12 and week 16 provided more data on the long term effects of resistance training.

Research Design and Analysis

The study had an experimental pre- and post-test design. An independent samples t-test was conducted to determine if there were differences between the groups prior to the intervention. An analysis of variance (ANOVA) with repeated measures was used to determine the time, group, and group by time interaction effects. Post hoc tests were performed using the Bonferroni adjustment to determine any significantly different means (Berg & Latin, 2008). Due to the small sample size, effect sizes were calculated for each of the variables. Effect sizes were calculated by dividing the difference between the means of the treatment and control groups by the standard deviation of the control (Berg & Latin, 2008). Group assignments were random (treatment or control). Each dependent variable was measured at three different time points (pre-intervention, 12 weeks, and 16 weeks). The dependent variables included resting metabolic rate, fat mass, and fat free mass. The significance level for this study was set at $p < .05$.

CHAPTER FOUR

Results

There were three sets of measurements throughout this study. The first round of measurements occurred prior to the intervention. The initial measurements served as a source of baseline data and will be referred to in the statistical analyses as “time one.” The second round of measurements occurred after the 12-week intervention and will be referred to as “time two.” The treatment group was prescribed a resistance training program while the control group was expected to not partake in any extra physical activities during the 12-week intervention. The third round of measurements occurred four weeks after time two, in which both the treatment and control groups did not exercise. The third round of measurements is referred to “time three” in this report. Each subject was randomly assigned to either the treatment or the control group.

The total number of 14 participants that began the study included seven in the treatment group and seven in the control group. One member of the control group did not show up for the first round of measurements. Each round of measurements resulted in data consisting of resting metabolic rate, fat free mass, fat mass, body fat percentage, height, weight, waist circumference, bone mineral density, and one repetition maximum on the chest press and leg press machines. Each round of measurements took approximately two hours to complete for each subject. Once the first round of measurements was finished, the intervention began. Each subject was personally contacted by the primary investigator approximately once every two weeks in order to confirm that he or she kept with the direction of the study and to ensure an open channel of communication. One control subject dropped from the study during the intervention because it was indicated to the primary investigator that after seeing the results of the first round of measurements, he or she decided to start exercising to increase their fitness. Two members of the treatment group were dropped from the study after losing contact with the primary investigator. These two subjects were contacted several times, but did not return the primary investigator’s telephone messages or emails. One member of the treatment group dropped out because he or she became ill and was unable to finish the exercise intervention. Another member of the treatment group dropped out because of certain circumstances that forced him or her to move out of the state. One control group member dropped out because of extenuating circumstances that could not allow the subject to participate in the third round of measurements. One of the treatment group members finished the study but was unable to participate in four to five weeks of exercise training near the end of the intervention phase due to illness. Overall, two subjects from the treatment group and four from the control group finished the study.

Due to medical reasons that arose during the 4-week post intervention period, one of the treatment group members participated in all of the fitness measurements except for the final round of chest and leg one repetition maximum tests. If the one repetition maximum data were to be included, then the treatment group’s number of subjects would be reduced to only one because of an incomplete data set. Therefore, all the results of this research study except for the one repetition maximum on the chest and leg press were reported after the preliminary data have been interpreted. Moreover, the one repetition maximum tests are not the most important variables to the research questions or the hypothesis of this study. In order to increase the meaningfulness associated with more important variables, the one repetition maximum tests were excluded from the results of the second and third tests. Overall, six subjects completed the study; however, complete data were collected from four control and only one treatment group member.

All of the statistics used in this study were determined using SPSS (statistical package for the social sciences, version 12.0). The statistical analyses used to interpret the results of this study include the descriptive statistics for each group, an independent t-test between the treatment and control groups, a repeated measures analysis of variance to determine group by time differences, test of sphericity to determine homogeneity of variance between the variables measured, post hoc tests on the significant univariate variables, and effect sizes to determine the magnitude of changes.

The descriptive statistics taken from the first round of measurements for the whole sample population can be found in Table 1. The differences between the treatment and control groups' initial descriptive statistics can be seen in Table 2. The control group had two female and two male participants, and the treatment group included two females. The subjects ranged from 19 to 33 years of age. The variable thought to have most impact on resting metabolic rate is fat free mass. The mean resting metabolic rate for the total sample was 2284.5 ± 248.9 kcal/day. The mean fat free mass for the total sample equaled 132.32 ± 12.3lb. The treatment group had a mean resting metabolic rate of 2304.5 ± 225.6 kcal/day. The control group had a resting metabolic rate at 2274.5 ±293.1 kcal/day. The fat free mass results from the first test for the treatment group were 126.8 ± 5.8 lb, and the controls measured 135.1 ± 14.4 lb. An independent samples t-test was conducted to determine if there were differences between the groups prior to the intervention. The alpha level for this statistic was set at $p < .05$ ($t = 2.776$). As shown in Table 3, there were no significant differences between the means of any of the variables prior to the intervention. Height, fat free mass, and the one repetition maximum on the chest press all significantly indicated that their equality of variance was not assumed using Lavene's Test for Equality Variances. However, height, fat free mass, and the one repetition maximum on the chest press still showed no significant differences between the exercise and control groups after adjusting for equality of variance.

All of the variable measurements' mean values, excluding the one repetition maximum tests and height, for time one, time two, and time three for the treatment group can be seen in Table 4, and Table 5 for the control group.

Repeated Measures ANOVA

A repeated measures analysis of variance was used to determine any significant changes over time in the data. The time points included in the analysis were before (time one), immediately after (time two), and four weeks after the intervention (time three). Group by time analyses were used to determine any significant differences between groups and over the three testing periods. If significance was found in the time or group by time analysis, then post hoc analyses were calculated to determine any further significance. The alpha level for the repeated measures analysis was set at $p < .05$. Finally, effect sizes were calculated to assess the magnitude of differences between variables and groups because of the small sample size. Effect sizes were calculated for each variable between time one and two, time two and three, and time one and three. Effect sizes for each testing variable were also calculated between the control and exercise groups between tests one, two, and three.

Mauchly's test of sphericity was used to determine the homogeneity of variance between the variables. The alpha level for this test was set at $p < .05$. The test of sphericity indicated no significance in any of the variables of the repeated measures except for body fat percentage. After using the Greenhouse-Geisser adjustment for body fat percentage, no significant differences were found between the body fat percentage variables.

Tables 6 through 14 show the results of the univariate tests. Analyzing time only, the univariate tests indicated significant differences in the resting metabolic rate data as indicated in Table 6. However, the pairwise comparisons between time one and two, time one and three, and time two and three for resting metabolic rate, shown in Table 15, indicated no significance between the groups. Table 7 indicates that the time, as well as the group by time, analysis for fat free mass was significantly different. Table 16 shows the post hoc analysis of fat free mass over time. The significant differences existed between time one and time two (p = .034), as well as between time one and time three (p = .006). No significance differences were found between the time two and time three set of measurements.

Effect Sizes Analyses

The sample size for this study was small. Therefore, effect sizes (d) were calculated to examine the magnitude of difference between the variable's three time points and between the group's variables. The estimated marginal means and the standard deviations from the univariate tests were used to calculate effect sizes. The estimated marginal means for both groups' resting metabolic rate and fat free mass are shown in Tables 17 and 18. An effect size of d = .20 and lower is considered to be small (Cohen, 1988). A small effect size means there is not a meaningful change or difference between the variables being measured. An effect size of d = .50 is moderate and $d \geq .80$ is considered to be a large change or difference (Cohen, 1988). After calculating the effect sizes, most meaningful changes were seen in the resting metabolic rate and fat free mass measurements. Table 19 shows the effect sizes of each group's resting metabolic rate measurements between times one and two, one and three, and two and three. The effect size between time one and two of the control group indicate only a small increase in resting metabolic rate (*d* = .26) whereas the exercise group measured a large increase (*d* = .87). Table 20 shows the effect sizes of each group's fat free mass measurements between times one and two, one and three, and two and three. The exercise group measured a small magnitude of change between time one and time two (*d* = .10) and actually decreased slightly throughout the study as indicated by the small decrease in effect size between times one and three (*d* = -.11). The trends for fat free mass and resting metabolic rate throughout the study for each group are shown in Figure 1. The only other variable that indicated more than a small magnitude of change between time points was the exercise group's waist circumference measurement. The effect size of the exercise group's waist circumference between times one and two was large at 2.12 and indicated a 0.79% increase. The magnitude of change moderately increased between times two and three. The effect size of the exercise group's waist circumferences between times one and three also indicated a large magnitude of change at 4.94 and a 1.82% increase in mean circumference. The control group's waist circumferences cited only a small magnitude of change between all tests. The effect size between times one and test three of the control group was 0.21.

Table 21 shows resting metabolic rate and fat free mass' mean, percent, and effect size differences between treatment and control for time points one, two, and three. It is indicated that that the resting metabolic rate of the treatment group was slightly greater (1.30%) than the control at the first time point (d = .10). At the same time point the treatment group had a moderately less fat free mass (-6.53%) than the control group (d = -.57). The second time point indicated that the treatment group's resting metabolic rate had risen up to 6.00% more than the control. Adversely, the treatment group's fat free mass had decreased to -10.11% less than the control group. The treatment group's amount of fat free mass continued to decrease by the third time point to -11.43% less than the control group. Also by the third time point, the treatment group's resting metabolic rate had decreased below that of the control group (-.84%). When comparing groups, it seems as though resistance training will increase the resting metabolic rates regardless of the amount of fat free mass.

Post Hoc Analysis

Post hoc analyses were calculated to discover where the significant changes occurred with body fat percentage since significant differences were indicated over time. Post hoc analyses were also calculated for fat free mass because a significant difference was indicated by the group by time univariate analysis ($p < .005$), shown in Table 7. A paired samples t-test was conducted on the fat free mass data to further examine differences between each of the groups' time periods. Tables 22 through 25 indicate the results of the paired samples t-tests on both the treatment and control groups' resting metabolic rate and fat free mass. The significance value of $p < .05$ was changed for the paired samples t-test because the test analyzed the differences between the three variables in each group. In order to prove differences, the significance value was divided by three to get a new significance value for the paired samples t-test of $p < .017$. Both the exercise and control groups' time points were divided to compare the first time point with the second, the second with the third, and the first with the third. The exercise group had no significant changes in fat free mass between any of the time points. The control group had significant increases in fat free mass from 135.1 ± 14.4 lb to 140.3 ± 13.8 lb between times one and two (*p = .006)*. The control group also had a significant increase fat free mass from 135.1 ± 14.4 lb to 141.1 ± 14.5 lb between times one and three (*p = .001)*. There was not a significant difference in fat free mass between the control group's second and third time points.

Results of Hypothesis

The primary research question for this study was to determine that progressive resistance exercise will significantly increase the resting metabolic rate in overweight subjects. The hypothesis for this study was not supported according to the data from this study. Progressive resistance exercise for 12 weeks did not significantly increase the resting metabolic rate in overweight subjects. The effect of resistance training on fat free mass was also a question of this research. Resistance training was hypothesized to increase fat free mass. According to the data presented in this research, 12 weeks of resistance training did not significantly change fat free mass.

CHAPTER FIVE

Conclusions

Though the hypothesis was not supported in this study, there may be some underlying factors that contributed to the conclusion. Some of the factors that possibly aided in disproving the hypothesis include the small sample size, high attrition rate, inconsistent pre-testing procedures by the subjects, inconsistencies of the exercise group, and the time of year. The sample size of any research study is an important factor when relaying significant or meaningful data. If a sample size is small, then the treatment given to the subjects in a study is less likely to represent how the target population would be effected. This study started out with a low sample size which did not provide a highly significant data set. In addition, the high attrition rate of the subjects added to a less meaningful outcome to the study towards the target population.

One aspect of the participants that was uncontrollable by the primary investigator was the physical activity prior to the tests. On some occasions during testing, subjects would indicate to the primary investigator that he or she had walked across campus to the testing lab. The resting metabolic rate data rely on the subject performing as little physical activity as possible prior to the measurement. The lengthy walk across campus could have affected the data by increasing the resting metabolic rate. Each subject was instructed to quietly rest for at least 15 minutes. The subjects who reported to the primary investigator his or her walking prior to the testing appointment were asked to sit quietly for another 10-15 minutes. Although the subjects were given additional time to slow his or her metabolism down to a resting rate, it is unknown how the extra physical activity affected the resting metabolic rate measurement.

Another factor that may have affected the data was the inconsistencies of the exercise group's resistance training program. The exercise group was inconsistent with their training program at times for reasons beyond the primary investigator's control. One exercise group participant was ill due to a virus during the last four to five weeks of the 12-week training program and was unable to perform the resistance exercises that were given. Another exercise group subject was also ill due to a virus for about two weeks close to the end of the 12-week intervention. This subject lost resistance training valuable time as well, though not to the same extent. These illnesses, particularly the four to five week one, were inconveniently timed toward the end of the intervention stage of the study. It is logical that the time lost to illness caused a detraining effect to the subjects. A study by LaForgia, et al. (1999) tested the effect of three weeks of detraining on the resting metabolic rates and body composition of 16 trained males. The study indicated a significant decrease of .7 kilograms of fat free mass (p = .05) in only three weeks. The illness the subjects experienced could have had a possible detraining effect that effectively reversed the muscular fitness gains back to the level at which they started. Also, the fact that the only two subjects who did not drop out of the resistance training group lost exercise time could have proven detrimental to the resistance training research data.

The time of year may have also been a factor with the changes seen in the body composition and resting metabolic rate of the control group. The intervention started one week prior to the beginning of the fall semester. It is apparent the 11 of the 12-week intervention period occurred coinciding with the first 11 weeks of the normal fall semester of classes. A study by Buchowski, et al. (2009) indicated that the physical activity levels during the summer were higher than fall or spring in 57 women ($p = .027$). A decrease in physical activity from the summer to the fall could have produced the non-significant increase in the fat mass seen in the control group. Consequently, the increase in fat mass could have triggered a response in the bodies of the control group subjects to increase the amount fat free mass in order to help the subjects physically bear the extra weight. It is a possibility that the increases in resting metabolic rates in the control group may have been partly due to the increase in fat free mass. If all of the subjects were to write about physical activities and nutritional habits in a diary, then the researcher may be able to better understand the reasons for many of the unexpected events that happened during this study. A mandatory diary or ledger for the subjects may also create more accountability to the study.

Although there were no significant data that supported the hypothesis, the effect size calculations provided some data that may support the theory of prescribing resistance training exercises for weight loss. The effect size measurements for fat free mass in the control group indicated a moderate increase (4.26%) in fat free mass from time one to time three while the exercise group produced a small decrease (-0.14%). There were no other effect sizes that registered more than small between any of the time periods for either group. The effect size value for fat free mass between the exercise and control group indicated a moderate difference of -.57. This value means that the control group started with a moderately higher amount of fat free mass compared to the exercise group. After the intervention the effect size between the exercise and control group's fat free mass grew to -.93. After the four-week post intervention period, the effect size grew again to -1.00. This means that the magnitude of difference between the exercise and control group was large. Overall, the control group showed increases in fat free mass during the study whereas the exercise group did not.

At the same time, the control group's effect size for resting metabolic rate measured only a small increase (*d* = .26) while the exercise group registered a large magnitude of change (*d* = .87) immediately after the intervention. In addition, there was only a slightly higher magnitude of difference (*d* = .10) between the exercise group's measurement of resting metabolic rate and the control. After the 12-week intervention the magnitude of difference was moderate with an effect size of .39. This means that the exercise group started with a slightly higher resting metabolic rate and increased to a moderate difference over the control group after the intervention. However, the effect size between the exercise and control group reverted back to a small magnitude of difference between the post intervention tests (*d* = -.04). This may indicate the importance of a continuous resistance training program in terms of maintaining an elevated resting metabolic rate and managing weight.

Overall, the effect size calculations indicated that there were large increases in resting metabolic rate for both the exercise and control groups. Furthermore, there were moderate increases in fat free mass observed in the control group and small decreases in the exercise group. It may be apparent that the control group experienced increases in resting metabolic rate due to concurrent increases in fat free mass. The exercise group experienced increases in resting metabolic rate while slight decreases of fat free mass were observed. The effect sizes may suggest that resistance exercise may increase a person's resting metabolic rate even if there is no apparent increase in fat free mass. It is possible that increasing the number of metabolically active muscle fibers, also known as neuromuscular facilitation, may increase resting metabolic rate without having to increase the size of the muscle.

One possibility that explains why the treatment group did not show increases its fat free mass but did with resting metabolic rate, is because the group was composed of only female subjects. Females do not produce as much testosterone as males. Testosterone is a hormone that augments the release of human growth hormone and is much more prevalent in males (McArdle, Katch, & Katch, 2000). Testosterone and human growth hormone tend to stimulate growth processes when resistance training (Earle & Baechle, 2004).

Recommendations for Future Studies

Perhaps the most valuable improvement for future studies to consider is to obtain a larger sample size. Even at the same attrition rate as the present study, the meaningfulness of the data would increase with a larger sample size. A larger sample would also compliment a larger portion of the population that the study was trying to serve. By adding more subjects under the same guidelines that this study imposed, the study would become applicable to a more diverse population. Also with a larger sample, the data will be less affected by those subjects who become unable to participate in exercise.

In order to create a sense of accountability to the research study, it is suggested to require mandatory exercise sessions throughout the intervention. The present study did not require the exercise group to participate in a regimented program. The subjects were only required to exercise three times per week. All of the subjects had memberships to the fitness facility because they were students. Each subject was given the privilege of exercising around his or her schedule. The primary investigator dedicated a schedule of three nights per week during the intervention when he would be available at the fitness facility for accountability. However, most of the exercise group subjects were unable to meet the primary investigator during the specified times. Perhaps if the study had more than one researcher and could dedicate more time toward being available in the fitness center or individualized personal training, then the subjects would have a higher sense of accountability.

Another way the primary investigator could possibly increase the accountability and decrease the attrition rate would be contributing more time for communication with the subjects. All subjects were called or emailed approximately once every two weeks throughout the study. The communication was intended on keeping the subjects informed about the study or to inquire about his or her physical activity. More frequent or persistent communication would possibly increase subject accountability and motivation to participate in the study.

Further dividing the sample population to males and females would also provide some insight on how resistance training could influence resting metabolic rate. Results of resistance training may differ between genders; therefore, comparisons should be made in future studies.

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Appendix A

Recruiting tool

Exercise Research Study

Be a part of a University of Central Oklahoma research study that teaches you the benefits of exercising.

What are the Benefits if I participate?

- Learn your *bone density*
  - *Early detection of low bone density may help prevent osteoporosis!*
- Learn your *resting metabolic rate*
  - *The number of calories your body burns at rest.*
- Learn your *body fat percentage*
- Learn your *muscular strength*

Who qualifies?

- *Males and females*
- *Ages 18-40*
- *Must be Overweight*
- *Cannot be, or possibly be pregnant*

Where will the study take place, how long will it last?

- The UCO Wellness Center
- The study will last 16 weeks

What are the Risks?

- Certain exposure to small amounts of radiation during body composition measurements.
- Possible risk of muscle soreness, strain, pull, & other injuries associated with lifting weights.

Contact: Brian Phillips – bphillips6@uco.edu – (405) 476-0987

Appendix B

Screening tools

BMI & PHYSICAL ACTIVITY SURVEY

1. What is your height? ________________________
2. What is your weight? ________________________
3. What is your waist circumference (your waist is the horizontal measurement around your trunk located between the bottom of your ribs and above your belly button)? ______________________
4. Are you currently participating in any type of regular exercise routine?
   - ☐ Y ☐ N
5. Do you regularly participate in any of the following? If so, please check and describe how often?
   - ☐ Weight lifting? How often? ______________________________
   - ☐ Running? How often? ______________________________
   - ☐ Bicycling? How often? ______________________________
   - ☐ Walking? How often? ______________________________
   - ☐ Recreational sport? How often? ______________________________
   - ☐ Other? How often? ______________________________
6. When was the last time you participated in a regular exercise routine?
   - ☐ 1 – 6 months
   - ☐ 7 – 12 months
   - ☐ More than 1 year
   - ☐ Never
7. Has your physician suggested that you refrain from physical activity?
   - ☐ Y ☐ N

PAR-Q & You

(A Questionnaire for People Aged 15-69)

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

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

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

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

If You Answered

YES to one or more questions

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

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

NO to all questions

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

- Start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- Take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.

DELAY BECOMING MUCH MORE ACTIVE:

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

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

Informed Use of the PAR-Q: The Canadian Society or Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

You are encouraged to copy the PAR-Q but only if you use the entire form

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

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

NAME ____

SIGNATURE ____ DATE __________________________

SIGNATURE OF PARENT ____ WITNESS ______________________

Or GUARDIAN (for participants under the age of majority)

© *Canadian Society for Exercise Physiology* *Supported by: Health Canada*

From *ACSM's Guidelines for Exercise Testing and Prescription* by Armstrong, et al, 2000

Health/Medical Questionnaire

Date: _________________

Name: __________________________________ Date of Birth: ___________________

Address: ____

Street City State Zip

Phone (H): _______________ Work: _______________ Email: ___________________

In case of an emergency, whom may we contact?

Name: __________________________ Relationship: __________________________

Phone (H): _________________ (W): __________________

Personal Physician

Name: __________________________ Phone: _______________ Fax: ____________

Present/Past History

Have you had OR do you presently have any of the following conditions? (Check if yes)

- ☐ Rheumatic fever
- ☐ Recent operation
- ☐ Edema (swelling of the ankles)
- ☐ High blood pressure
- ☐ Injury to back or knees
- ☐ Low blood pressure
- ☐ Seizures
- ☐ Lung disease
- ☐ Heart attack
- ☐ Fainting or dizziness
- ☐ Diabetes
- ☐ High cholesterol
- ☐ Orthopnea (the need to sit up to breath comfortably) or paroxysmal (sudden, unexpected attack) nocturnal dyspnea (shortness of breath at night)
- ☐ Shortness of breath at rest or with mild exertion
- ☐ Chest pains
- ☐ Palpitations or tachycardia (unusually strong or rapid heartbeat)
- ☐ Intermittent claudication (calf cramping)
- ☐ Pain, discomfort in the chest, neck, jaw, arms, or other areas
- ☐ Known heart murmur
- ☐ Unusual fatigue or shortness of breath with usual activities
- ☐ Temporary loss of visual acuity or speech, or short-term numbness or weakness in one side, arm, or leg of your body
- ☐ Other

Family History

Have any of your first-degree relatives (parent, sibling, or child) experienced the following conditions? (Check if yes) In addition, please identify at what age the condition occurred.

- ☐ Heart attack who: ________________________ age: _________
- ☐ Heart operation who: ________________________ age: _________
- ☐ High blood pressure who: ________________________ age: _________
- ☐ High cholesterol who: ________________________ age: _________
- ☐ Diabetes who: ________________________ age: _________
- ☐ Other major illness ____

Activity History

1. How were you referred to this program? (Please be specific)

____

____

2. Have you ever worked with a personal trainer before? Yes___ No___

3. Date of your last physical examination performed by a physician: _________________

4. Do you participate in a regular exercise program at this time? Yes___ No___ If yes, briefly describe: ____

____

5. Can you currently walk 4 miles briskly without fatigue? Yes___ No___

6. Have you ever performed resistance training exercises in the past? Yes___ No___

7. Do you have injuries (bone or muscle disabilities) that may interfere with exercising? Yes___ No___ If yes, briefly describe: ____

____

____

8. Do you smoke? Yes___ No___ If yes, how much per day and what was your age when you started? Amount per day ___________ Age _____

9. Do you follow or have you recently followed any specific dietary intake play, and in general how do you feel about your nutritional habits? ____________________________

____

10. List any medications you may be taking. ________________________________

____

____

____

____

____

From *NSCA's Essentials of Personal Training* by Roger W. Earle and Thomas R. Baechle, 2004, Champaign, IL: Human Kinetics.

Medical Clearance Form

Dear Doctor:

Your patient ____ wishes to take part in an exercise program and/or fitness assessment. The exercise program may include progressive resistance training, flexibility exercises, and a cardiovascular program; increasing in duration and intensity over time. The fitness assessment may include a sub-maximal cardiovascular fitness test and measurements of body composition, flexibility, and muscular strength and endurance.

After completing a readiness questionnaire and discussing their medical condition(s) we agreed to seek your advice in setting limitations to their program. By completing this form, you are not assuming any responsibility for our exercise and assessment program. Please identify any recommendations or restrictions for your patient's fitness program below (Physician's Recommendations).

Patient's Consent and Authorization

I consent to and authorize ____ to release to ____ , health information concerning my ability to participate in an exercise program and/or fitness assessment. I understand this consent is revocable except to the extent action has already been taken. Authorization is not valid beyond one year from date of signature. Further disclosure or release of my health information is prohibited without specific written consent of person to whom it pertains.

Member's signature	Date
Trainer's signature	

Physician's Recommendations

	I am not aware of any contraindications toward participation in a fitness program.
	I believe the applicant can participate, but urge caution because:
	The applicant should not engage in the following activities:
	I recommend the applicant **not** participate in the above fitness program.

Physician's signature		Date
Physician's name (print)	Phone	Fax
Address	City	State & Zip

From http://www.exrx.net/Testing/PhysicianLetter.html, 2008.

Appendix C

Informed Consent Form

INFORMED CONSENT

Title: The effects of resistance training on resting metabolic rates in overweight adults.

Investigator(s): Brian Phillips, Graduate Student, Kinesiology & Health Studies
University of Central Oklahoma, 100 N. University Drive, Edmond, OK 73034, bphillips6@uco.edu

Purpose of this research: The purpose of this study is to examine the effects of resistance training on resting metabolic rate and how it is applicable for weight loss programming in obese adults. The long-term goal of this study is to discover a means to decrease fat mass through resistance training and increase the quality of life in obese subjects.

Procedures/treatments involved: After you have signed this form and agreed to participate in this study, you will be asked to complete several physical tests and surveys. You will be asked to fill out a medical history questionnaire before you participate in the physical tests. There will be three sets of fitness tests during your participation in this study. Each set of fitness tests will include the measurement of resting metabolic rate, resting heart rate, height, weight, waist circumference, fat free mass, fat mass, bone density, and the one repetition maximum on the bench press and the leg press.

All consenting will be done individually and in private to assure the confidentiality of your information. You will be asked to fast for no less than 12 hours before your first appointment and keep all physical activity during that time to a minimum. Upon your arrival to the lab, you will be asked to sit comfortably in a room for 15 minutes in order to try to attain your resting metabolic rate. Then, you will be fitted with a hood designed to seal completely around your head creating an air tight seal to measure the amount of air you inspire and expire. You will continue sit comfortably for 30 more minutes and breathe into the hood. You may bring a snack to eat once the resting metabolic rate measurement is finished. Your heart rate will be measured after this test by counting the number of times your heart beats in one minute. The researcher will place his/her fingers on your wrist to feel your heart beat. Then we will measure your height, weight, and the distance around your waist. Then we will measure your fat free mass, fat mass, and bone density using dual-energy x-ray absorptiometry (DXA). For this test, you will lie quietly on a flat table, while the machine scans over your body. This test uses a very weak x-ray to determine how much fat is in your body. It takes about 7 minutes to complete and exposures you to less radiation than 10 minutes in a tanning bed. If you are pregnant or could be pregnant (unprotected sex within the past month), please tell the researcher now. You will not be allowed to have an iDXA scan or participate in the study if there is a chance of pregnancy. Next you will be asked to participate in a test of your maximal upper body strength. You will perform a chest press exercise several times until you have lifted the most the most weight you can possibly lift only one time. After the upper body weight lifting test, you will be asked to participate in a test of your maximal lower body strength. You will perform a leg press exercise several times until you have lifted the most the most weight you can possibly lift only one time. We will let you practice this test before you actually start to make sure you can correctly perform the exercise.

After the first testing phase you will be randomly assigned to one of two groups. One group will be introduced to a 12-week long, supervised weight lifting program. The other group will continue with their normal daily activities during the same 12-week period. After the 12-week period is finished, you will be asked to complete the same fitness tests that were completed before 12-week period, and again after an additional four weeks.

Expected length of participation: Including all three testing phases, the 12-week intervention, and the four-week post intervention period, you will be asked to participate in this program for approximately 18 weeks.

If you complete all tests, your participation should take no longer than two hours. Most physical tests will be conducted during the appointment time, while the survey may be taken home and returned within a few days.

Potential Benefits: The benefit of participation in this study is that you will learn about your level of physical fitness and specific resistance training techniques that will increase your quality of life. You will benefit from knowing your bone density. Testing bone density at an early age is beneficial in determining any increased risk of developing osteoporosis. The effects of osteoporosis can be minimized with exercise, diet, and/or medication if early detection is possible. Also, having an early record of bone density will be beneficial if you ever have your bone density tested in the future. An early bone density record will show any changes compared to future tests. You will also benefit from knowing your resting metabolic rate (RMR). Since weight loss is determined by the amount of calories you burn compared to the amount you consumed, knowing your RMR will help if you decide to plan for weight loss through dieting. If you know how many calories you are burning, then planning for weight loss through dieting will be a simple mathematical equation consisting of "calories in" verses "calories out". You will also benefit from knowing your body fat percentage. You will learn the risks of developing certain chronic conditions, such as diabetes, high blood pressure, high cholesterol, and osteoarthritis, which are associated with excess amounts of fat mass. You will learn methods of exercise that will increase your chances of decreasing fat mass and increasing your quality of life. You will learn how resistance training is beneficial for increasing fat free mass. You will learn that resistance training not only increases muscle mass, but also helps increase bone density and strengthens tendons and ligaments.

Potential Risks or discomforts: In order to measure bone density, fat free mass, and fat mass, you will be exposed to a small amount of radiation. This is the equivalent to the amount acquired in the natural environment in an 8-hour period or 10 minutes in a tanning bed. There is no way possible to perform the test without this exposure, but certain precautions will be made to ensure the participant is safe from undue harm. Anyone that is currently pregnant or may be pregnant (unprotected sex within the last 60 days) will be turned away from participating at that time. There is always a risk of physical injury due to one's exposure to radiation. However, the amount of radiation that is produced by each iDXA scan is at least 120,000 to 6,000,000-fold less than the necessary amount needed to cause physical harm. However, there is still a slight risk to the ovaries in terms of delay in menstration, genetic mutations, temporary sterility, and permanent sterility. There is a slight risk to the testicles in terms of a decrease in the number of sperm, temporary sterility, and permanent sterility. There is a slight risk of reddening of the skin. Each iDXA scan will expose you to a small amount of radiation. The radiation from the three iDXA scans that you will be exposed to is approximately 120,000 to 6,000,000-fold less that the amount of radiation needed to cause physical harm. Some of the participants of this study will be exposed to normal fitness facility conditions. There is a small risk of musculoskeletal injuries such as muscle soreness, strains, pulls, tears, and broken bones. There is also an inherent risk of injury while using the weight lifting equipment in the facility. However, you will be monitored and coached during the testing phases and instructed how to use all of the equipment safely so the risk of musculoskeletal injury is minimized.

Medical/mental health contact information: If for any reason you receive an injury as a result from testing, the Student Health Center is located in close proximity to the Kinesiology Laboratory and the Principal Investigator (PI) will escort you to the office and ensure you are seen by a staff member on duty. If for any reason you feel you need medical attention after testing, please visit the Student Health Center or call 405-974-2317. Also the Student Counseling Center (SCC) is located in Nigh University Center (room 402). Contact SCC if you feel like you need counseling as a result of testing procedures or results (405-974-2215).

Contact information for researchers and UCO IRB:
Please feel free to contact the Principal Investigator (PI) or the Institutional Review Board (IRB) at any time for any question or concern, either before or after testing.

PI: Brian Phillips, Graduate student
bphillips6@uco.edu
(405) 476-0987

IRB: Dr. Jill Devenport
Office of Research and Grants
216 ADMN
405-974-2526
405-974-5479

Explanation of confidentiality and privacy: You will be assigned a code number that will be used throughout data collection and analysis. Your name will never be associated with your results. Your results will not be reported individually, only as part of a group (averages). All data is kept in a locked file cabinet in a secure room.

Assurance of Voluntary Participation: Your participation in the research is completely voluntary. There are no payments for participating. You are free to refuse to participate in the research and to withdraw from this study at any time. Your decision to withdraw will bring no negative consequences or penalty to you.

Affirmation by research subject: I hereby voluntarily agree to participate in the above listed research project and further understand the above listed explanations and descriptions of the research project. I also understand that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty. I have read and fully understand this Informed Consent Form. I sign it freely and voluntarily. I acknowledge that a copy of this Informed Consent Form as been give to me to keep.

Research Participant’s Printed Name ____

Signature____________________________________ Date_____________________

Appendix D

American Dietetic Association Nutritional Information

Healthier Eating:
Getting Where You Need to Be

The Dietary Guidelines for Americans recommends these food groups within ***MyPyramid*** *as a good source of important nutrients that help provide the foundation for a healthy diet.**

Whole Grains

Vegetables

Fruits

Milk and Milk Products
Low-fat and Fat-free

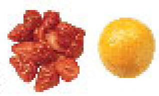
Increased intakes of fruits, vegetables, whole grains and fat-free or low-fat milk and milk products are likely to have important health benefits for most Americans, according to the Dietary Guidelines. They are encouraged for a healthful diet and are sources for specific nutrients of which many Americans are not getting enough – calcium, potassium, fiber, magnesium, vitamins A, C and E.

Be sure to include the recommended amounts every day:

Whole Grains ✓ ✓ ✓
3 (1 oz.) equivalents
(at least 1/2 of all the grains eaten should be whole grains)
One ounce serving equals 1 slice whole-wheat bread, 1/2 cup brown rice, 5 whole-wheat crackers, 1/2 cup oatmeal

Vegetables ✓ ✓ ✓
2-1/2 cups
One serving equals 1 cup chopped or florets of raw/cooked broccoli, 2 medium carrots, 2 cups of raw, leafy greens – 1 cup cooked, leafy greens

Fruits ✓ ✓
2 cups
One serving equals 1 cup sliced, chopped or cut-up fruit, about 8 large strawberries, 1 large orange, 32 seedless grapes



Dairy Foods ✓ ✓ ✓
3 cups of low-fat or fat-free milk or milk equivalents
One serving equals 1 cup milk, 1 container (8 oz.) yogurt, 1-1/2 oz. cheese

Source: Dietary Guidelines for Americans, 2005 (6th Edition). www.healthierus.gov/dietaryguidelines.
*The foods listed here are part of the MyPyramid food groups, which also include meat & beans and oils. Please visit **www.mypyramid.gov** for more information.

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eat right. American Dietetic Association

Nutrition Fact Sheet

A Positive Approach: Choose Nutrient-Rich Foods for the Most Nutrition

What to eat or what not to eat? That's the question many of us struggle with every day. For decades nutrition advice has told us how to answer the question by telling us what foods and nutrients to avoid. As a result, most Americans are overweight yet undernourished.

It's time for a change in the way we think about food. By choosing nutrient-rich foods that provide the most nutrients per calorie, we can build healthier diets and start down a path of health and wellness.

The nutrient-rich foods way of eating emphasizes choosing foods based on their total nutrient package, including vitamins and minerals, instead of choosing foods based only on what they don't contain—saturated fat, sugar and salt. It offers a positive foundation to help you build overall healthier eating habits and meet personal nutrition needs over a lifetime.

Choosing nutrient-rich foods first is a positive and realistic way to think about eating and focuses on enjoying food instead of avoiding it. Because nutrient-rich foods are familiar, easy to find and represent the five basic food groups, achieving balance and building a healthier diet is simple and stress-free.

Selecting nutrient-rich foods and beverages first is a way to make better choices within your daily eating plan. Choose first among the basic food groups:

- Brightly-colored fruits and 100% fruit juice
- Vibrantly-colored vegetables and potatoes
- Whole, fortified and fiber-rich grain foods
- Low-fat and fat-free milk, cheese and yogurt
- Lean meats, poultry, fish, eggs, beans and nuts

The contents of this fact sheet have been reviewed by the American Dietetic Association's Fact Sheet Review Board. The appearance of this information does not constitute an endorsement by ADA of the sponsor's products or services. This fact sheet was prepared for the general public. Questions regarding its content and use should be directed to a registered dietitian.

Appendix E

Ratings of perceived exertion (RPE)

Ratings of Perceived Exertion

The RPE (rating of perceived exertion) scale is a method of measuring an individual's exercise tolerance that closely correlates with his or her exercising heart rates and work rates. There are two types of RPE scales: a category scale (6-20) and a category-ratio scale (0-10). (Balady, et al. 2000.)

To use the RPE scale, the exerciser must quantify the stress of the exercise in terms of numbered intensity. Basically, an RPE is not just a measure of how fast the heart is beating but is meant to include exertion, respiration, and emotional response to the exercise. (Earle, Baechle. 2004)

Category-ratio scale (0-10)

0	– Nothing at all	"No Intensity"
0.3		
0.5	– Extremely weak	Just noticeable
1	– Very weak	
1.5		
2	– Weak	Light
2.5		
3	– Moderate	
4		
5	– Strong	Heavy
6		
7	– Very Strong	
8		
9		
10	– Extremely Strong	"Max Intensity"
11		
•	- Absolute Maximum	

Category scale (6-20)

6 – No exertion at all
7 – Very very light
8
9 – Very light
10
11 – Fairly light
12
13 – Somewhat hard
14
15 – Hard
16
17 – Very hard
18
19 – Very very hard
20 – Maximal exertion

(RPE scales: Earl, Baechle. 2004 & Balady, et al. 2000)

The 0-10 scale is more appropriate for use with clients whose maximum heart rate is significantly lower than 200 bpm. The 0-10 scale ratings are not associated with a particular heart rate; rather they indicate how stressful an exercise is above resting level. (Earl, Baechle. 2004)

The 6-20 scale was developed primarily for graded exercise and is best used on subjects whose maximum heart rate is around 200 bpm. Each number on the scale is associated with an approximate heart rate.

Balady, Berra, Golding, Gordon, Mahler, Myers, Sheldahl. ACSM's Guidelines for Exercise Testing and Prescription, Sixth Edition. Lippincott Williams & Wilkins. 2000.
Earl, Roger W., Baechle, Thomas R. NSCA's Essentials of Personal Training. Human Kinetics. 2004.

Appendix F

Internal Review Board permission letter

IRB wrote:

Mr. Brain Phillips
Dr. Michelle Gray
College of Education and Professional Studies
Campus Box 189
University of Central Oklahoma
Edmond, OK, 73034

Dear Mr. Phillips and Dr. Gray:

Re: Application for IRB Review of Research Involving Human Subjects

We have received and reviewed your revised application (UCO IRB# 09069) entitled, The effects or resistance training on resting metabolic rates in overweight adults, and find all stipulations in order. The UCO Institutional Review Board is pleased to inform you that your IRB application has been approved. A stamped, approved copy of the ICF will be sent to you in campus mail.

Caveat: Please send a copy of the protocol that the DXA technician will use including the questions regarding possible pregnancy to be asked before each scan.

This project is approved for a one year period but please note that any modification to the procedures and/or consent form must be approved prior to its incorporation into the study. A written request is needed to initiate the amendment process. You will be notified in writing prior to the expiration of this approval to determine if a continuing review is needed.

On behalf of the Office of Research & Grants and UCO IRB, I wish you the best of luck with your research project. If our office can be of any further assistance in your pursuit of research, creative & scholarly activities, please do not hesitate to contact us.

Sincerely,

Jill A. Devenport, Ph.D.
Chair, Institutional Review Board
Office of Research & Grants, Academic Affairs
Campus Box 159
University of Central Oklahoma
Edmond, OK 73034
405-974-5479 405-974-2526
JAD/

Tables and Figures

Table 1

Descriptive statistics for the sample population prior to the intervention

Variable	Mean	SD	Min	Max
Age	26.67	4.68	19.00	33.00
HT	67.42	2.32	65.25	71.00
WT	264.42	38.74	221.00	331.00
WC	45.75	4.01	40.00	51.25
RMR	2284.50	248.95	1976.00	2642.00
FFM	132.32	12.25	119.82	150.19
FM	124.13	35.80	85.46	180.21
BF	47.70	6.87	40.30	55.80
BMD	1.31	0.11	1.19	1.51
RMC	170.00	63.95	115.00	250.00
RML	420.83	59.03	340.00	505.00

Note. SD = standard deviation. Min = minimum score. Max = maximum score. Age = age in years. HT = height in inches. WT = weight in pounds. WC = waist circumference in inches. RMR = resting metabolic rate in kilocalories per day. FFM = fat free mass in pounds. FM = fat mass in pounds. BF = body fat percentage. BMD = bone mineral density in grams per centimeter squared. RMC = one repetition maximum on the chest press. RML = one repetition maximum one the leg press.

Table 2

Descriptive statistics by group for the sample population

Variable	Group	N	Mean	SD
HT	Exercise	2	66.50	.707
	Control	4	67.88	2.817
WT	Exercise	2	267.75	22.274
	Control	4	262.75	48.210
WC	Exercise	2	47.13	.177
	Control	4	45.06	4.989
RMR	Exercise	2	2304.50	225.567
	Control	4	2274.50	293.138
FFM	Exercise	2	126.80	5.848
	Control	4	135.08	14.434
FM	Exercise	2	133.93	29.211
	Control	4	119.23	41.899
BF	Exercise	2	51.10	6.65
	Control	4	46.00	7.24
BMD	Exercise	2	1.242	.069
	Control	4	1.339	.122
RMC	Exercise	2	140.00	28.284
	Control	4	185.00	75.166
RML	Exercise	2	425.00	49.497
	Control	4	418.75	70.519

Note. SD = standard deviation. HT = height in inches. WT = weight in pounds. WC = waist circumference in inches. RMR = resting metabolic rate in kilocalories per day. FFM = fat free mass in pounds. FM = fat mass in pounds. BF = body fat percentage. BMD = bone mineral density in grams per centimeter squared. RMC = one repetition maximum on the chest press. RML = one repetition maximum one the leg press.

Table 3

Independent Samples Test to Determine Differences in Pre Intervention Means

	Lavene's Test for Equality of Variances		t-test for Equality of Means	
Variable	F	*p*	df	*p*
HT	15.000	.018*	3.631	.415
WT	.778	.428	4.000	.900
WC	6.125	.069	4.000	.611
RMR	.536	.505	4.000	.907
FFM	9.024	.040*	4.000	.376
FM	.334	.595	4.000	.687
BF	.162	.708	4.000	.453
BMD	.487	.524	4.000	.368
RMC	216.000	.000*	3.982	.350
RML	.558	.497	4.000	.918

Note. HT = height. WT = weight. WC = waist circumference. RMR = resting metabolic rate. FFM = fat free mass. FM = fat mass. BF = body fat percentage. BMD = bone mineral density. RMC = one repetition maximum on the chest press. RML = one repetition maximum one the leg press. F= F ratio. df = Degrees of freedom. *$p < .05$.

Table 4

Means for Times One, Two, and Three for the Treatment Group

Variable	Time 1	SD	Time 2	SD	Time 3	SD
WT	262.75	22.27	269.25	12.37	269.75	10.25
WC	47.13	.18	47.50	1.06	48.00	1.41
RMR	2304.50	225.57	2501.00	90.51	2669.00	202.23
FFM	126.80	5.85	127.39	7.37	126.62	6.27
FM	133.93	29.21	133.70	18.35	135.75	15.45
BF	51.10	6.65	51.15	4.88	51.70	4.10
BMD	1.291	.122	1.286	.118	1.286	.123

Note. SD = standard deviation. WT = weight in pounds. WC = waist circumference in inches. RMR = resting metabolic rate in kilocalories per day. FFM = fat free mass in pounds. FM = fat mass in pounds. BF = body fat percentage. BMD = bone mineral density in grams per centimeter squared.

Table 5

Means for Times One, Two, and Three for the Control Group

Variable	Time 1	SD	Time 2	SD	Time 3	SD
WT	262.75	48.21	269.25	44.27	270.63	48.61
WC	45.06	4.99	45.72	4.43	46.38	5.04
RMR	2274.50	293.14	2351.00	358.07	2691.50	500.26
FFM	135.08	14.43	140.27	13.84	141.09	14.47
FM	119.22	41.90	121.14	38.30	120.54	39.55
BF	46.00	7.24	45.65	6.88	45.33	6.70
BMD	1.339	.061	1.351	.059	1.352	.061

Note. SD = standard deviation. WT = weight in pounds. WC = waist circumference in inches. RMR = resting metabolic rate in kilocalories per day. FFM = fat free mass in pounds. FM = fat mass in pounds. BF = body fat percentage. BMD = bone mineral density in grams per centimeter squared.

Table 6

Univariate Test of Within-Subject Effects for Resting Metabolic Rate

Source	SS	df	MS	F	*p*
Time	419486.000	2	127608.867	5.085	.038*
Time * Group	20850.000	2	10425.000	.253	.783

Note. RMR = resting metabolic rate. SS = type III sum of squares. df = degrees of freedom. MS = mean square. $*p < .05$.

Table 7

Univariate Test of Within-Subject Effects for Fat Free Mass

Source	SS	df	MS	F	*p*
Time	29.968	2	14.984	12.382	.004*
Time * Group	27.537	2	13.769	11.378	.005*

Note. FFM = fat free mass. SS = type III sum of squares. df = degrees of freedom. MS = mean square. $*p < .05$.

Table 8

Univariate Test of Within-Subject Effects for Fat Mass

Source	SS	df	MS	F	*p*
Time	6.554	2	3.277	.196	.826
Time * Group	5.286	2	2.643	.158	.856

Note. FM = fat mass. SS = type III sum of squares. df = degrees of freedom. MS = mean square. $^{*}p < .05$.

Table 9

Univariate Test of Within-Subject Effects for Body Fat Percentage

Source	SS	df	MS	F	*p*
Time	.065	1.048	.062	.063	.825
Time * Group	1.134	1.048	1.080	1.094	.357

Note. BF = body fat percentage. SS = type III sum of squares. df = degrees of freedom. MS = mean square. The Greenhouse-Geisser adjustment to test sphericity was used. *$p < .01$.

Table 10

Univariate Test of Within-Subject Effects for Weight

Source	SS	df	MS	F	*p*
Time	73.347	2	36.674	2.086	.187
Time * Group	26.792	2	13.396	.762	.498

Note. WT = weight. SS = type III sum of squares. df = degrees of freedom. MS = mean square. $*p < .05$.

Table 11

Univariate Test of Within-Subject Effects for One Repetition Maximum on the Chest Press

Source	SS	df	MS	F	*p*
Time	.67.500	2	33.750	1.034	.411
Time * Group	60.833	2	30.417	.932	.444

Note. RMC = one repetition maximum on the chest press. SS = type III sum of squares. df = degrees of freedom. MS = mean square. $*p < .05$.

Table 12

Univariate Test of Within-Subject Effects for One Repetition Maximum on the Leg Press

Source	SS	df	MS	F	*p*
Time	663.333	2	331.667	.320	.738
Time * Group	1623.333	2	811.667	.783	.499

Note. RML = one repetition maximum on the leg press. SS = type III sum of squares. df = degrees of freedom. MS = mean square. $*p < .05$.

Table 13

Univariate Test of Within-Subject Effects for Waist Circumference

Source	SS	df	MS	F	*p*
Time	3.193	2	1.597	3.313	.089
Time * Group	.131	2	.066	.136	.875

Note. WC = waist circumference. SS = type III sum of squares. df = degrees of freedom. MS = mean square. $*p < .05$.

Table 14

Univariate Test of Within-Subject Effects for Bone Mineral Density

Source	SS	df	MS	F	*p*
Time	.001	2	.000	1.194	.343
Time * Group	.000	2	.000	.868	.456

Note. BMD = bone mineral density. SS = type III sum of squares. df = degrees of freedom. MS = mean square. $^*p < .05$.

Table 15

Post Hoc Analysis of Resting Metabolic Rate Over Time

Time Points		Mean Difference	Standard Error	*p*
1	2	-136.500	145.584	1.000
1	3	-390.750	131.510	.123
2	3	-254.250	88.959	.138

Note. Time point 1 = pre-intervention measurements. Time point 2 = post intervention, week 12 measurements. Time point 3 = post 4-week detraining period, week 16 measurements. *$p < .05$. Mean difference measured in kilocalories per day.

Table 16

Post Hoc Analysis of Fat Free Mass Over Time

Time Points		Mean Difference	Standard Error	*p*
1	2	-2.891	.650	.034*
1	3	-2.915	.402	.006*
2	3	-.024	.882	1.000

Note. Time point 1 = pre-intervention measurements. Time point 2 = post intervention, week 12 measurements. Time point 3 = post 4-week detraining period, week 16 measurements. $*p < .05$. Mean difference measured in pounds.

Table 17

Estimated Marginal Means of Resting Metabolic Rate Between Time Points by Group

Group	Time Point	Mean	Standard Deviation	Standard Error Mean
Control	1	2274.50	293.138	146.569
	2	2351.00	385.074	192.537
	3	2691.50	500.264	250.132
Exercise	1	2304.50	225.567	159.500
	2	2501.00	90.510	64.000
	3	2669.00	202.233	143.000

Note. Time point 1 = pre-intervention measurements. Time point 2 = post intervention, week 12 measurements. Time point 3 = post 4-week detraining period, week 16 measurements. Means are measured in kilocalories per day.

Table 18

Estimated Marginal Means of Fat Free Mass Between Time Points by Group

Group	Time Point	Mean	Standard Deviation	Standard Error Mean
Control	1	135.078	14.434	7.217
	2	140.265	13.842	6.921
	3	141.088	14.466	7.233
Exercise	1	126.795	5.848	4.135
	2	127.390	7.368	5.210
	3	126.615	6.272	4.435

Note. Time point 1 = pre-intervention measurements. Time point 2 = post intervention, week 12 measurements. Time point 3 = post 4-week detraining period, week 16 measurements. Means are measured in pounds.

Table 19

Effect Sizes Between Time Points for Resting Metabolic Rate

Group	Between Time Points	Mean Difference	Percent Change	Effect Size	Magnitude of Change
Control	1, 2	76.50	3.25%	.26	Small
	1, 3	417.00	15.49%	1.42	Large
	2, 3	340.50	12.65%	.88	Large
Exercise	1, 2	196.50	7.86%	.87	Large
	1, 3	364.50	13.66%	1.62	Large
	2, 3	168.00	6.29%	1.86	Large

Note. Time point 1 = pre-intervention measurements. Time point 2 = post intervention, week 12 measurements. Time point 3 = post 4-week detraining period, week 16 measurements. Mean difference measured in kilocalories per day. Effect size magnitude of change measurement: .20 = small. .50 = moderate. .80 = large

Table 20

Effect Sizes Between Time Points for Fat Free Mass

Group	Between Time Points	Mean Difference	Percent Change	Effect Size	Magnitude of Change
Control	1, 2	5.19	3.70%	.36	Small
	1, 3	6.01	4.26%	.42	Moderate
	2, 3	.823	.58%	.06	Small
Exercise	1, 2	.60	0.47%	.10	Small
	1, 3	-.18	-0.14%	-.03	Small
	2, 3	-.78	-0.61%	-.11	Small

Note. Time point 1 = pre-intervention measurements. Time point 2 = post intervention, week 12 measurements. Time point 3 = post 4-week detraining period, week 16 measurements. Mean difference measured in pounds. Effect size magnitude of change measurement: .20 = small. .50 = moderate. .80 = large

Table 21

The Treatment Group Compared to the Control at Each Time Point for RMR and FFM

Variable	Time Point	Mean Difference (T – C)	Percent Difference	Effect Size	Magnitude of Difference
RMR	1	30.00	1.30%	0.10	Small
	2	150.00	6.00%	0.39	Moderate
	3	-22.50	-.01%	-.04	Small
FFM	1	-8.28	-6.53%	-.57	Moderate
	2	-12.88	-10.11%	-.93	Large
	3	-14.47	-.11%	-1.00	Large

Note. Positive mean differences, percent differences, and effect sizes indicate higher values for the treatment group. Negative mean differences, percent differences, and effect sizes indicate higher values for the control group. RMR = resting metabolic rate. FFM = fat free mass. Time point 1 = pre-intervention measurements. Time point 2 = post intervention, week 12 measurements. Time point 3 = post 4-week detraining period, week 16 measurements. Mean difference of RMR measured in kilocalories per day. Mean difference of FFM measured in pounds. Effect size magnitude of change measurement: .20 = small. .50 = moderate. .80 = large

Table 22

Paired Samples T-Test using Resting Metabolic Rate for the Control Group

Time Points		Mean Difference	Standard Deviation	Standard Error Mean	t	df	*p*
1	2	-76.500	380.313	190.157	-.402	3	.714
1	3	-417.000	350.435	175.217	-2.380	3	.098
2	3	-340.500	228.287	114.144	-2.983	3	.058

Note. Time point 1 = pre-intervention measurements. Time point 2 = post intervention, week 12 measurements. Time point 3 = post 4-week detraining period, week 16 measurements. The alpha level was lowered to $*p < .017$. Mean difference measured in kilocalories per day.

Table 23

Paired Samples T-Test using Resting Metabolic Rate for the Exercise Group

Time Points		Mean Difference	Standard Deviation	Standard Error Mean	t	df	*p*
1	2	-196.500	135.057	95.500	-2.058	1	.288
1	3	-364.500	23.335	16.500	-22.091	1	.029
2	3	-168.000	111.723	79.000	-2.127	1	.280

Note. Time point 1 = pre-intervention measurements. Time point 2 = post intervention, week 12 measurements. Time point 3 = post 4-week detraining period, week 16 measurements. The alpha level was lowered to $*p < .017$. Mean difference measured in kilocalories per day.

Table 24

Paired Samples T-Test using Fat Free Mass for the Control Group

Time Points		Mean Difference	Standard Deviation	Standard Error Mean	t	df	*p*
1	2	-5.188	1.493	.747	-6.948	3	.006*
1	3	-6.010	1.043	.522	-11.514	3	.001*
2	3	-.823	2.265	1.133	-.726	3	.520

Note. Time point 1 = pre-intervention measurements. Time point 2 = post intervention, week 12 measurements. Time point 3 = post 4-week detraining period, week 16 measurements. The alpha level was lowered to $*p < .017$. Mean difference measured in pounds.

Table 25

Paired Samples T-Test using Fat Free Mass for the Exercise Group

Time Points		Mean Difference	Standard Deviation	Standard Error Mean	t	df	*p*
1	2	-.595	1.520	1.075	-.553	1	.678
1	3	.180	.424	.300	.600	1	.656
2	3	.775	1.096	.775	1.000	1	.500

Note. Time point 1 = pre-intervention measurements. Time point 2 = post intervention, week 12 measurements. Time point 3 = post 4-week detraining period, week 16 measurements. *$p < .017$. Mean difference measured in pounds.

Comparison of the Changes in Fat Free Mass and Resting Metabolic Rate in Both the Control and Exercise Groups

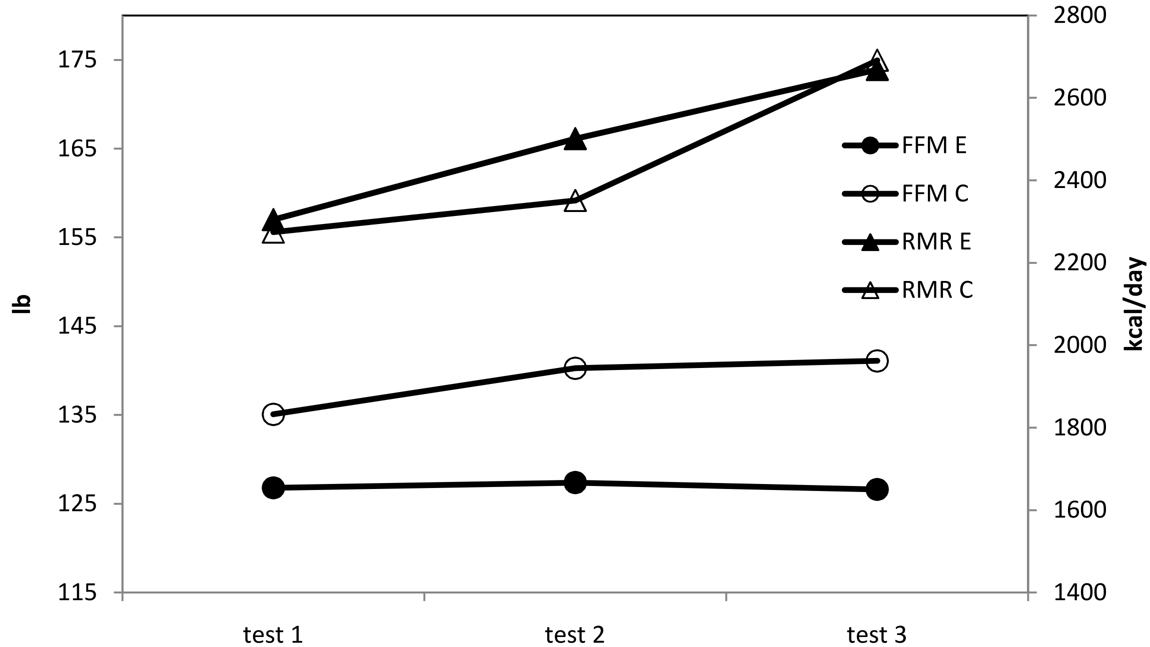

Figure 1. FFM E = fat free mass in the exercise group. FFM C = fat free mass in the control group. RMR C = resting metabolic rate in the control group. RMR E = resting metabolic rate in the exercise group.