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I am submitting herewith a thesis written by Camille C. Putman entitled "The Effects of Exercise Training and Mild Caloric Restriction on Metabolism and Fat Loss in Obese Women." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Human Performance and Sports Studies.

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THE EFFECTS OF EXERCISE TRAINING AND MILD CALORIC RESTRICTION ON METABOLISM AND FAT LOSS IN OBESE WOMEN

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Camille C. Putman

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DEDICATION

To my mother, father, sister, and brother, for their continual love and family support throughout my academic career. They instilled in me a belief that all goals are accomplished by believing and trusting in the Lord.

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ABSTRACT

Any difference in response to physical training and mild caloric restriction associated with body fat distribution would be important for the treatment of obesity. To address this issue, six lower body obese women (WHR $\leq$ 0.75) and five upper body obese women (WHR $\geq$ 0.85) were subjected to an eight week treatment period. The subjects were required to walk for 60 minutes five days a week at an intensity of 50-65% of their maximum VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$). In addition, a self-imposed diet of 1,200 to 1,500 kcal/day was utilized. Anthropometric and descriptive variables included waist to hip ratio (WHR), weight, body mass index (BMI), % fat, fat mass, fat free mass, VO_2 max, resting metabolic rate (RMR), triglycerides, total cholesterol, total cholesterol to HDL ratio, low density lipoprotein cholesterol (LDL), and high density lipoprotein cholesterol (HDL). For all measured variables, a 2 x 2 factorial ANOVA with repeated measures was used to test for significant group differences following the treatment period. Both groups experienced similar decreases in weight ($p=.01$), BMI (kg/m^2) ($p=.01$), percent fat ($p=.02$), and fat mass ($p=.002$). However, neither RMR or VO_2 max changed with the treatment in either group. The results indicate that the present program is a successful program for women with upper body and lower body obese women, whose goal is to lose fat and weight.

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CHAPTER I

INTRODUCTION

The prevalence of obesity in urbanized parts of the world continues to be associated with increased morbidity, as well as mortality. Obesity is due to a positive energy balance when energy intake exceeds energy expenditure. Traditionally, obesity has been defined as an excess of body fat, while there has been little regard to the distribution of adipose tissue. However, the importance of the distribution of adipose tissue has recently been related to the metabolic complications of obesity.

Upper body type obesity is characterized by a high waist to hip ratio (WHR), with fat being deposited in the abdominal region. Abdominal obesity is associated with hypertriglyceridemia, diabetes mellitus, hyperinsulinemia and hypertension (Kissebah et al., 1989, Peiris et al., 1989). Lower body obesity is characterized by a low WHR, with most fat being deposited on the buttocks, hips and thighs. This type of obesity has not been associated with negative health consequences.

Utilization of exercise as well as caloric restriction in the treatment of obesity has been shown to increase the amount of fat loss and preserve fat-free mass (Hill et al.,1987). However, rate of weight loss differs widely during treatment of obese subjects by caloric restriction as well as treatment by increased physical activity. After physical training, persons with abdominal obesity have exhibited a decrease in body fat, an increase in fat free mass, and a decrease in cholesterol and triglyceride levels (Krotkiewski and Björntorp, 1986). In contrast, in one study, persons with lower body fat obesity tended to show increased body fat after physical training (Krotkiewski and Björntorp, 1986). However, one investigation involving caloric restriction as well as physical training showed the opposite. Women with lower body obesity tended to lose more fat than did women with upper body obesity (Wadden et al., 1988). Thus, controversy exists between studies that have examined the differences in weight loss among individuals with different patterns of body fat distribution. The purpose of this study was to extend the work of previous studies by examining changes in body composition, fitness (VO_2 max), and serum lipid profile following a weight loss program which combined mild dietary restriction (-500 kcal/day) with regular endurance exercise (+300 kcal/day) (American College of Sports Medicine, 1986). Any difference in response to physical training associated with body fat distribution would be of obvious importance for obesity prevention and treatment of obesity.

CHAPTER II

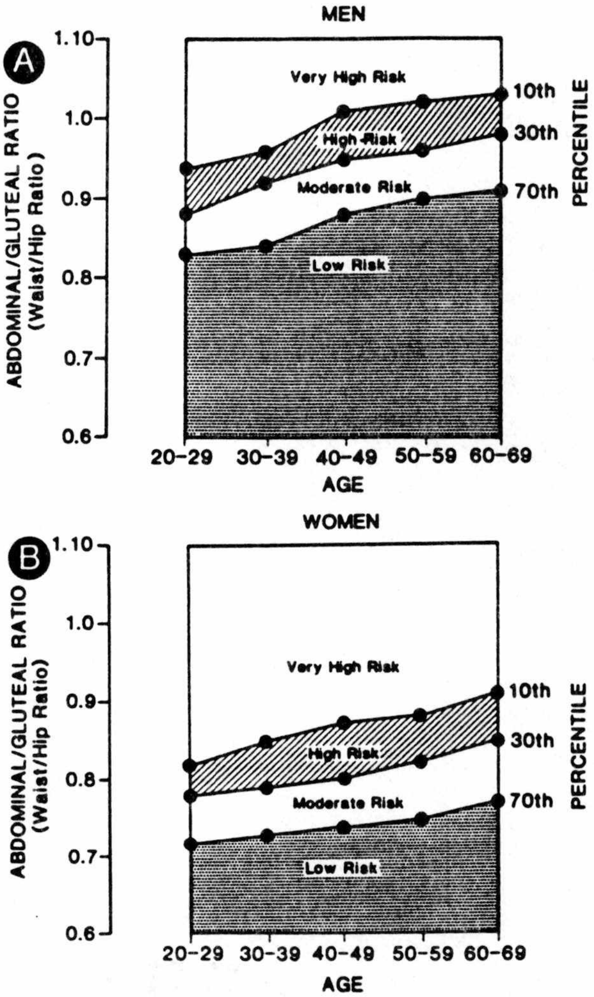
REVIEW OF LITERATURE

The association between obesity and morbidity is now widely accepted. Obesity results from a positive energy balance when less energy is expended than consumed. The result is an accumulation of adipose tissue. Past interest has focused primarily on the quantity of body fat rather than its pattern of distribution. However, recent research suggests that adipose tissue is heterogeneous rather than homogeneous, and more importantly, the functional anatomic location of the tissue is relevant (Vansant et al., 1988).

A classification system of obesity based on the site of body fat distribution was first suggested by Vague in 1956. Vague utilized skinfold ratios and fat-to-muscle areas to classify "male type" (upper) "android" fat distribution and "female type" (lower) "gynoid" obesity. Since then, Vague's findings have been confirmed by Kissebah et al., (1989).

A variety of methods have been used to assess body fat distribution. Anthropometric measurements have included various skinfold sites, circumference ratios, and computed tomography (Ashwell et al., 1985). Most investigators use either the subscapular skinfold thickness, determined by calipers, or the waist-to-hip ratio (WHR), determined by measurement with a tape (Kaplan 1989). However, the most widely used method has been the ratio of the circumference of the waist to the circumference of the hips (Bray 1989, Kaplan 1989, Campaigne 1990). The circumference of the waist is obtained by measuring the narrowest "natural waist" area above the umbilicus (Bray 1989). The hip circumference is measured at the maximal gluteal protrusion of the buttocks (Bray 1989). According to Bray (1989), women with a WHR of greater than 0.80 are at a "high risk" for adverse health complications, whereas men reach the "high risk" category if they have a WHR greater than 0.85 (see Figure 1). This preference for the WHR among investigators is primarily due to the convenience it provides in a routine clinical setting. In addition, the WHR is an accurate reflection of visceral fat deposition. Kaplan (1989) has used the WHR as a means of defining the two types of obesity. Android obesity has been associated with a WHR greater than 0.85, while gynoid obesity has been associated with a WHR less than 0.85.

Other investigators (Ashwell et al., 1978) have used photography as a means of assessing body fat distribution. Figure 2 shows three examples of body fat distribution: (a) android, or central body fat (b) gynoid, or peripheral body fat and (c) intermediate, somewhere between the two types (Ashwell 1978). Other terms used to describe android obesity include upper body, "apple", abdominal, central, and male-type obesity. Gynoid obesity has been described as lower body "pear", gluteal-femoral, peripheral, and female-type obesity.



<u>Figure 1.</u> Values for WHR associated with risk for Coronary Heart Disease. Adapted from: Bray, G.A. (1989). Obesity:Basic considerations and clinical approaches. <u>Disease-A-Month</u> <u>18</u>(7), pg.466.

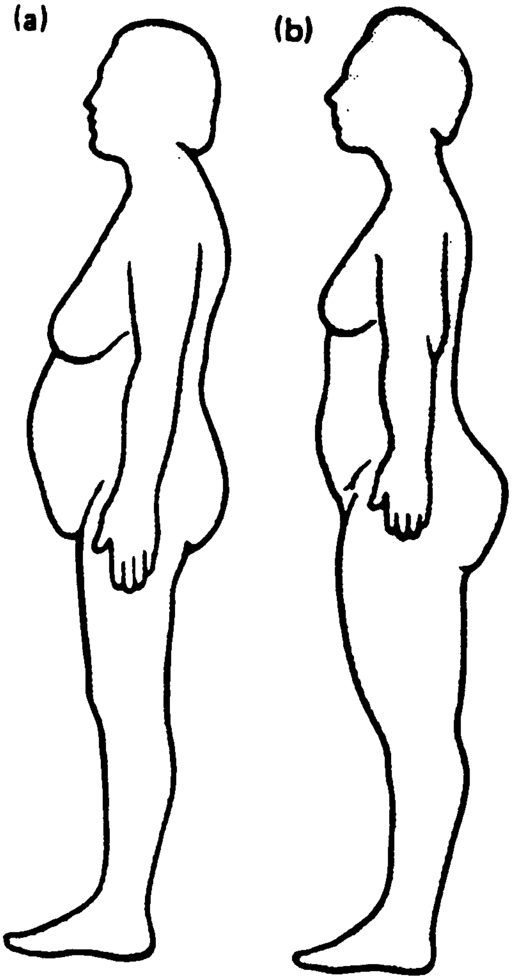


Figure 2. The guideline "outlines" used for subjective assessment. (a.) android, (b.) gynoid, (c.) intermediate. Adapted from: Ashwell, C.S., Chinn, S. Stalley and J.S. Garrow (1978).Female fat distribution-a photographic and cellularity study. International Journal of Obesity 2, pg.291.

It is apparent that adipocytes in various regions of the body differ metabolically. The ability to metabolize lipids is of special importance. Normally, in women, triglycerides accumulate more easily in gluteal-femoral adipocytes than in abdominal fat cells (Björntorp, 1985). Cells in the abdominal region are more metabolically active than those in the femoral region. In abdominal obesity fat cell size is enlarged, whereas in gluteal-femoral obesity the number of fat cells is increased (Vansant et al., 1988). Normally, men have typically enlarged abdominal tissue stores (Björntorp 1985). According to Campaigne (1990), cells from the abdominal region are associated with higher levels of free fatty acids. The blood leaving the abdominal area goes directly to the liver where some of the fats are converted into lipids associated with an increased risk of heart disease.

Recent advances in obesity research have suggested that obesity located in the abdominal area (android obesity) is strongly associated with adverse health effects. Risk factors typically connected with central adiposity include hyperinsulinemia, insulin resistance, hyperglycemia, hypertriglyceridemia, hypercholesterolemia, and hypertension (Kissebah et al., 1989, Peiris et al., 1989, Campaigne 1990).Krotkiewski et al., (1983) showed in a cross-sectional study of men and women that cardiovascular risk factors were more pronounced in subjects with a high waist to hip ratio. Another study concluded that the WHR was a risk factor for ischemic heart disease, stroke, and death, independent of total body fat mass (Lapidus et al., 1984). These studies indicate the extreme importance in recognizing this particular type of obesity.

Since Vague's original research in 1956, investigators have continued to confirm that obesity is more heterogeneous than homogeneous. More importantly, classifying the obese on the basis of fat distribution has direct clinical relevance for research as well as preventive medicine. Several studies have looked directly at the utilization of exercise as well as caloric restriction in the treatment of obesity. Three methods of weight reduction are typically employed: reducing caloric intake (diet), increasing caloric expenditure (exercise) or a combination of both. Body composition, maximal aerobic power (fitness), serum lipid profile, and resting metabolic rate are variables typically measured both before and following a training study of obese individuals (Hagen et al., 1985, Hill et al., 1987, Stern et al., 1987).

Previous investigations have found beneficial changes in these variables following an exercise and/or diet treatment (Hagen et al., 1985, Hill et al., 1987, Stern et al., 1987), although the rate of change varies considerably between individuals.

If fat/weight loss is especially desirable in abdominal-type obesity, it is beneficial to study how diet and/or exercise programs facilitate weight loss in the obese population. Few studies have looked at the effect of a diet and/or exercise program on body composition, resting metabolic rate (RMR), serum lipids, and fitness (VO_2 max) in individuals differing in fat distribution.

Body Composition

Wadden et al., (1988) found that weight loss by dieting alone produced a significant reduction in the WHR in upper body (UB) obesity (pre=0.905 vs. post=0.881). However, the lower body (LB) group lost more fat overall than the UB group (10.4 kg vs. 7.6 kg). Thus, subjects with LB obesity apparently lost large amounts of fat from both their lower and upper fat stores while subjects with upper body obesity lost fat primarily from their upper stores. Den Besten et al., (1988) also utilized the diet-only approach as a means of weight reduction. However, these authors concluded that both UB and LB groups experienced similar body weight and body fat-mass reductions. In yet another diet-only study, Vansant et al., (1988) found that body weight and body fat mass loss were slightly, but not significantly greater in the

UB obese group than in the LB obese group, 10.2 kg vs. 9.6 kg and 8.6 vs. 7.2 kg, respectively. WHR decreased significantly in the UB group, whereas, in the LB group, WHR did not change significantly. Thus, in this particular study, women with abdominal obesity displayed a more intermediate loss of adipose tissue. Although these studies are interesting, they are rather conflicting in nature. More importantly, they lacked exercise as part of the weight reduction treatment.

Exercise training has the potential to significantly alter the adiposity of obese as well as non-obese individuals. Tremblay et al., (1988) studied the effect of a 15 week cycle ergometer training program in young female and male adults (n=14). In men, significant decreases were noted in percent body fat ($p<.05$) and sum of seven skinfolds ($p<.01$). These variables were not significantly modified in women. Thus, men responded to the training stimulus in the "expected" manner. Krotkiewski and Björntorp (1986) found that an exercise program with no restriction on diet caused gynoid shaped women (WHR<0.82) to gain fat weight. In contrast, android shaped men and women (WHR>0.82) exhibited a decrease in body fat and an increase in muscle mass. The authors suggested that abdominal-type obesity is improved by physical training because of an adaptation to a negative energy balance. The failure of obese women with gynoid obesity to adapt to a negative energy balance was questioned (Krotkiewski and Björntorp 1986). Although both groups experienced normal circulatory adaptations to physical training, the authors concluded that "in pear-type obese women physical training induces an increase in body fat" (Krotkiewski and Björntorp 1985 p.263). Thus, controversy exists between the studies that have looked directly at the influence of body fat distribution on weight loss by either diet or exercise.

Resting Metabolic Rate

Resting Metabolic Rate (RMR) is defined specifically as the oxygen consumption of an individual while he/she is resting quietly several hours after a meal or physical activity (Danforth 1985). Obviously any variation in resting metabolic rate would significantly affect energy metabolism in the obese individual. Den Besten et al., (1988) found that weight loss by diet only caused a significant reduction in resting metabolic rate. Before weight loss the UB obese group had a slightly higher RMR than did the LB obese group. After weight loss, mean RMR decreased about 10% in the UB group and about 2.5% in the LB group, with no significant interaction (den Besten et al., 1988). RMR decreased to the same magnitude as did the fat free mass in response to the diet. Continued dietary restriction will disrupt the energy metabolism of the obese individual as well as limit further body weight loss. However, utilization of exercise as well as caloric restriction has been shown to increase the amount of fat loss and preserve fat-free mass (Hill et al., 1987). Thus, an exercise program may counteract the fall in RMR.

Serum Lipid Profile

The serum lipid profile is a convenient indicator of whether a metabolic adaptation has occurred following either diet or exercise. After an eight week diet (1,000 kcal/day), Besten et al., found that an UB group showed a trend towards lower total serum cholesterol and lower serum triglycerides. In contrast, the LB group did not show a variation in either variable following the diet. In a similar study, in which diet was the method of weight loss, the LB group did not show any significant change in serum lipids, whereas the UB group exhibited a trend towards lower total cholesterol and triglyceride levels (Vansant et al., 1988). These authors concluded that the shift in body fat distribution, which was only exemplified in the UB group, may coincide with changes in serum triglycerides and total serum cholesterol.

Krotkiewski and Björntorp (1986) found that a physical training program of UB and LB obese groups produced similar variations in serum lipid profiles. Following a three month training program, these authors concluded that individuals with android obesity showed a decrease in cholesterol and triglycerides, whereas those with gynoid obesity did not. Again, the inability to change body weight or body fat in gynoid-type obesity may prevent the improvement in other variables (serum lipid profile) as well.

Fitness

Krotkiewski and Björntorp (1986) studied the adaptation to physical training in gynoid and android obese populations. Following a three month training period, these authors concluded that both the UB and LB obese groups significantly increased VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$). In addition, heart rate measured at rest and during submaximal work loads decreased significantly in both groups (Krotkiewski and Björntorp 1986). The authors concluded that regardless of body fat distribution, one can still improve fitness. Clinically speaking, this may be a high priority for the obese individual.

Summary

In conclusion, it should be recognized that adipose tissue is a heterogeneous entity that functions according to its distribution pattern. Most investigators agree that excess adipose tissue located in the abdominal area (android obesity) is the subgroup of obesity associated with adverse health complications. Therefore, if the goal is to reduce abdominal type obesity, the evaluation of weight-reducing therapies in obese populations is warranted. Previous studies have focused on the relation of body fat distribution (android and gynoid) to treatment by either diet or exercise. However, conflicting findings have surfaced regarding the efficacy of treatment in these two different types of obesity. In varying degrees of obesity, no effect, a decrease, or even an increase in body fat have been documented (Björntorp 1987). These controversial findings are due to a number of factors, including the type of obesity (android or gynoid), as well as the type of treatment (diet or exercise) utilized as a method of weight reduction. Little research has been done on the effects of a exercise-diet treatment on obese females of either android or gynoid obesity.

CHAPTER III

METHODS

This investigation sought to examine how females with either android or gynoid obesity responded to a program that combined endurance training with mild caloric restriction. Specifically, the study had three parts. Part one consisted of gaining consent of volunteers to utilize previously collected data from CRP #3350B (The Effects of Body Fat Distribution on Metabolism at Rest and During Exercise in Women). Blood lipid profiles, anthropometric data, including percent fat as well as circumference measures, maximal oxygen uptake, resting metabolic rate, and estimated yearly average caloric intakes were obtained for baseline measures. Part two consisted of engaging these subjects in an individualized, structured eight-week training program. Lastly, part three consisted of collecting post-training measures. This study was reviewed and approved by the Human Subjects Review Board of the University of Tennessee Committee on Research Participation, and all subjects gave written, informed consent prior to their participation in the study.

Description of Subjects

A questionnaire was circulated to subjects who had participated in a previous body fat distribution study (CRP

#3350B (Appendix A). Eleven women with no known health problems volunteered as subjects. Informed consent was obtained from each subject following an explanation of the measurements to be made, the risks involved and the time commitments required for the data collection (Appendix B). The participants in this investigation were representative of two groups of obese women of similar age and body size, but with significantly different regional fat distribution patterns. Subject groups, UB(WHR $\geq$0.85) and LB(WHR $\leq$0.75) were determined by the waist to hip ratio. (See Table 1 for physical characteristics of subjects pre and post treatment).

Description of Treatment

The treatment period, which lasted exactly eight weeks, was comprised of an aerobic exercise program and a mild restriction in caloric intake. For the physical training segment, subjects were required to walk for 60 minutes five days a week on Tom Black Track, which is located on the campus of The University of Tennessee. Subjects walked in Stokley Athletic Center on days of inclement weather. Subjects were instructed to walk at a pace that was equivalent to 50-65% of their maximum VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$).

Heart rate responses were measured with a Uniq CIC, Model 8799, Heart Watch Computer (Computer Instruments, Corp., Hemstead, NY) heart rate monitor. This device sensed electrical signals from the heart, and electronically

TABLE 1

PHYSICAL CHARACTERISTICS OF THE SUBJECTS
PRE AND POST TREATMENT

	UB (N=5) PRE	UB (N=5) POST	LB (N=6) PRE	LB (N=6) POST
AGE (yrs)	27.2 ± 1.6	27.8 ± 1.7	30.4 ± 1.8	31.0 ± 2.1
WT (kg)	92.2 ± 5.8	90.4 ± 6.4	80.6 ± 4.1	77.4 ± 4.9*
BMI (kg/m^2)	32.3 ± 2.1	31.7 ± 2.3	30.9 ± 1.4	29.6 ± 1.6*
WHR	.839 ± .01	.838 ± .01	.747 ± .01	.739 ± .01**
% FAT	39.0 ± 2.2	37.0 ± 2.5	40.4 ± 1.4	37.3 ± .93*
FFM (kg)	55.3 ± 2.7	58.5 ± .29	48.2 ± 2.0	48.3 ± 2.1
VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$)	26.0 ± .86	24.1 ± 1.8	29.2 ± 1.5	29.5 ± 2.6

* $p < 0.05$
** $p < 0.0001$

Values are Means ± Standard Error of Mean

WT=Weight; BMI=Body Mass Index; WHR=Waist/Hip Ratio; FFM=Fat Free Mass; VO_2 Max=Maximal Oxygen Consumption computed and digitally displayed the heart rate. Arterial blood pressure was measured twice weekly at rest before exercise by mercury sphygmomanometry. In addition, individual laps were recorded on an exercise log (1 lap=400m) (Appendix C). By the end of the study all subjects were comfortably walking three miles in the allotted time period. During a two week span in the treatment period, one subject experienced mild pain in the region surrounding the tibia. It is questionable whether she walked at a pace equal to 50-65% of maximum. Nevertheless, all subjects completed the study.

Restriction of caloric intake comprised the second component of the treatment period. The resting metabolic rate, expressed as kcals/day, and an estimated daily caloric intake was used to predict an individualized caloric intake for the treatment period (Appendix D). Subjects were asked to decrease caloric intake by no more than 500 kcal/day, and the average total caloric intake during the treatment period were 1,592 kcal/day for the LB subjects and 1,684 kcal/day for the UB subjects. Subjects were given examples of diets that consisted of the prescribed number of calories. Three-day dietary recalls were used as an indicator of adherence. On this record subjects were required to indicate time of eating, food eaten and amount eaten (Appendix E).

Anthropometric data were collected on four separate occasions (twice a month), as well as pre and post-training.

Data collected included body circumferences at six sites (Appendix F) and weight. Three-day dietary records were also collected on this day. The same individual made all the measurements. Measurements were made with the subject standing, wearing light-weight exercise shorts and top.

Methods of Procedure

Anthropometric Measures

Body weight was determined by a Health-o-Meter, Physician Balance Beam Scale, Series 400, and was measured to the nearest .25 pounds and converted to kilograms. Body Mass Index (BMI) was calculated as weight/height^2 (kg/m^2).

Standardized circumference measures were made with the subject standing erect and wearing light clothing (Lohman and Martorell 1988). Specifically, the waist was measured as the narrowest circumference at the "natural waist" as judged from the back of the subject. The measurement was taken with a measuring tape (Figure Finder) designed with a plastic "strain gauge" type device which enabled repeatable measures. The hip measure was identified as the largest circumference of the hip/buttocks as judged from the side of the subject. The waist to hip ratio (WHR) was calculated as waist(cm)/hip(cm).

Body Composition

Measurement of body density was made by standard hydrostatic weighing technique (Akers and Buskirk 1969). A submersion tank contained a submerged electronic "scale" that rested upon force cell transducers which were coupled to an integrated amplifier. The electronic output was fed into a chart recorder for a continuous record of the subject's underwater weight. Body composition was determined from no less than five hydrostatic weighing trials with the subject bent forward while she fully exhaled. Body density was determined by the equation of Buskirk (1961). Mass in water was determined as an average of the 3 heaviest weight trials. The percentage of body fat was calculated using an equation appropriate for this population (Lohman and Martorell 1988). Lung residual volume was determined in duplicate by the oxygen dilution technique immediately prior to hydrostatic weighing with the subject assuming the same position as required in the underwater tank (Wilmore 1969)

Resting Metabolic Rate

The conventional open circuit spirometry technique was used to measure resting metabolic rate. Subjects reported to the laboratory having refrained from food, drink, or exercise at least 4 hours prior to the test. The subject rested in a reclining chair for 20 minutes while breathing room air through a Daniels valve, with the nose occluded with a noseclip. The room temperature was kept between 25-27 °C to facilitate a comfortable resting environment. Following the acclimation period, expired air was collected in a Douglas bag for 20 minutes. The oxygen and carbon dioxide concentrations of the expired air were determined by an Applied Electro-Chemistry S-3A O_2 analyzer and a Beckman LB2 CO_2 analyzer. The analyzers were regularly calibrated using known gases whose compositions were determined by the Scholander method. The volume of expired air was determined by noting the displacement of a 120-liter Collins gasometer from the air in the Douglas bag. Temperature and barometric pressure were recorded prior to each test and ventilation was calculated in terms of standard temperature and pressure, dry conditions (STPD). Oxygen uptake was converted to caloric expenditure and expressed per kg body weight per hour.

Maximal Oxygen Uptake

The walking test for measuring maximal oxygen uptake followed a standard walking protocol. The initial treadmill speed was 80 m/min, and the grade was 0%. The subject was asked to continue walking with the grade increasing 2.5% every 2 minutes until volitional exhaustion. Treadmill speed and grade were reduced immediately following maximal exertion to facilitate a gradual walking cool-down and recovery.

Metabolic measures were made by standard open spirometry every minute. Values were considered maximal if the respiratory quotient was over 1.00. Heart rate (Heart Watch) and blood pressure were measured the last minute of each stage and every two minutes throughout recovery.

Blood Lipid Profile Assessment

All sterile procedures for blood collection were followed. Blood was drawn by a registered nurse after the subject had fasted for 12 hours. Two vacutainers containing 8 ml of the subjects' blood were collected. The samples were kept on ice and analyzed within four hours of collection. Analysis took place at The University of Tennessee Hospital laboratory.

Statistical Analysis

Descriptive statistics (mean and standard error of the mean) were computed on all anthropometric and descriptive variables used in the study. Variables included WHR, weight, BMI, % fat, fat mass, fat free mass, VO_2 max, RMR, triglycerides, total cholesterol, total cholesterol to HDL ratio, low density lipoprotein (LDL), and high density lipoprotein (HDL). For all measured variables, a 2 x 2 factorial ANOVA with repeated measures was used to test for significant group differences following treatment.

CHAPTER IV

RESULTS

The purpose of this study was to see if regular aerobic exercise combined with mild caloric restriction resulted in differences in weight/fat loss between UB and LB obese women. The primary question related to whether one group changed more than the other. Baseline measurements were collected and reevaluated following an eight week treatment period.

Body Composition

A significant treatment effect was seen for weight(kg) in both UB and LB groups ($p=.01$). However, there was no significant interaction in the way the two groups responded to treatment (See Figure 3). A significant treatment effect was seen for BMI(kg/m^2) in both UB and LB groups ($p=.01$). There was no significant interaction in the way the two different groups responded to treatment (See Figure 4). A significant treatment effect was seen for percent fat in both UB and LB groups ($p=.02$), with no significant interaction in the way the two groups responded. (See Figure 5). A significant treatment effect was also seen for fat mass in both groups following treatment ($p=.002$). However, there was no significant interaction in the way the two groups responded to treatment (See Figure 6).

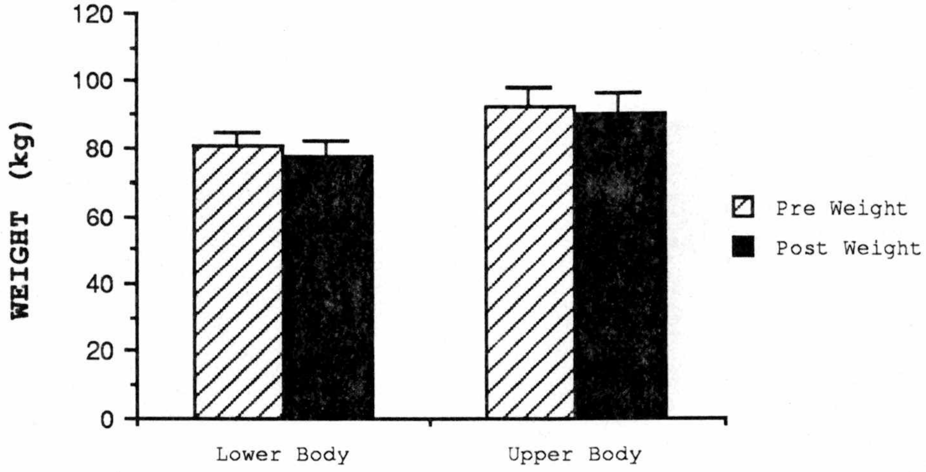


Figure 3. Pre and Post treatment values for weight (kg) between UB and LB obese groups.

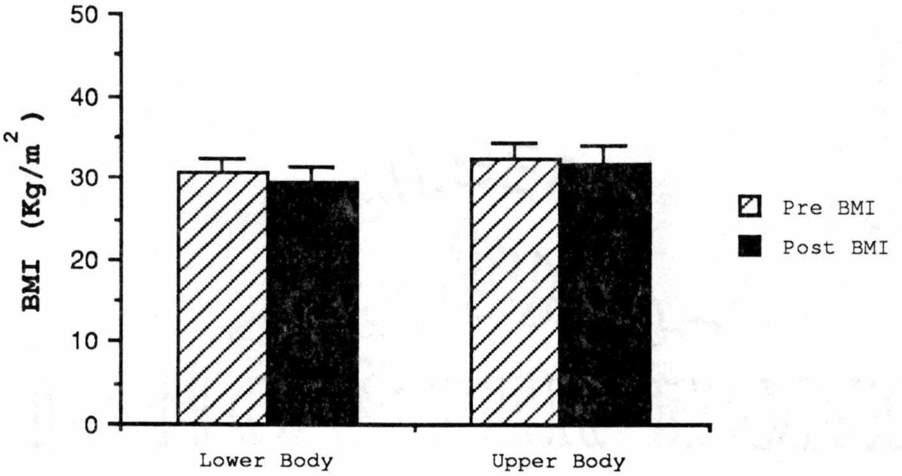


Figure 4. Pre and Post treatment values for BMI (kg/m^2) between UB and LB obese groups.

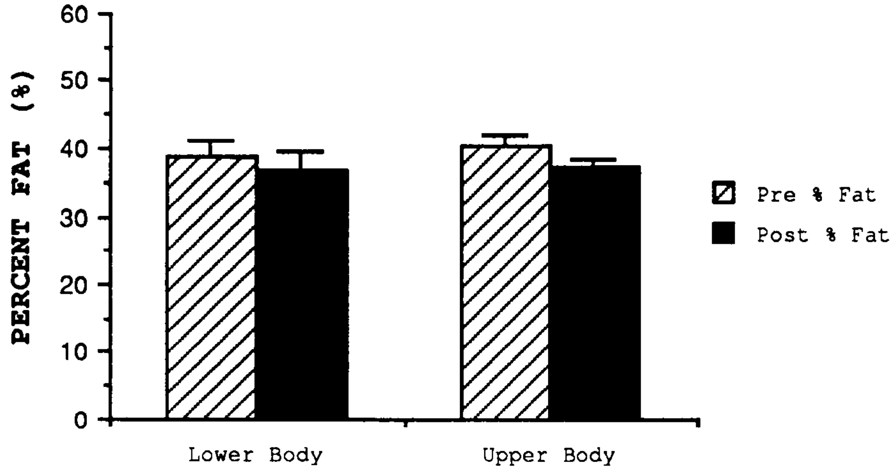


Figure 5. Pre and Post treatment values for percent body fat between UB and LB obese groups.

There was no significant treatment effect for fat free mass in either group following treatment (See Figure 7). Lastly, there was no significant treatment effect for WHR in either group following treatment. (See Figure 8).

Resting Metabolic Rate

There was no significant treatment effect for resting metabolic rate in either group following treatment (See Figure 9). Incidentally, 4 out of the 5 UB subjects exhibited an increase in RMR following the treatment period.

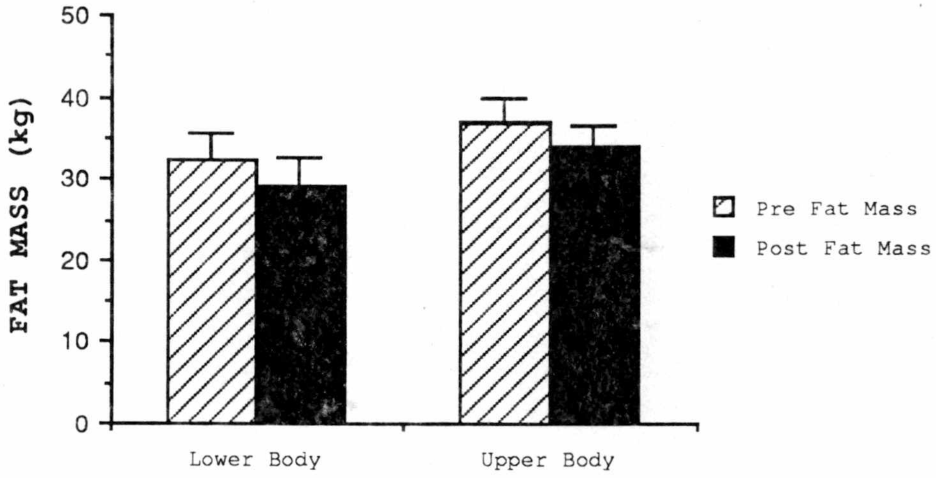


Figure 6. Pre and Post treatment values for fat mass (kg) between UB and LB obese groups.

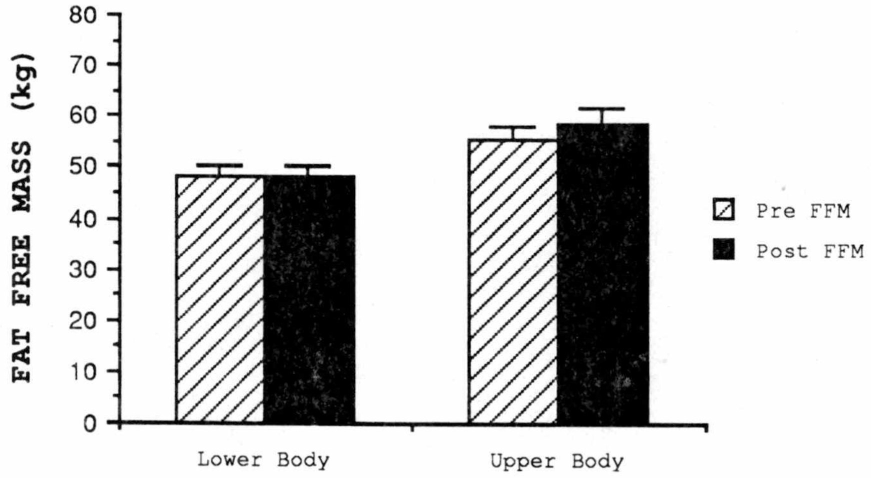


Figure 7. Pre and Post treatment values for fat free mass (Kg) between UB and LB obese groups.

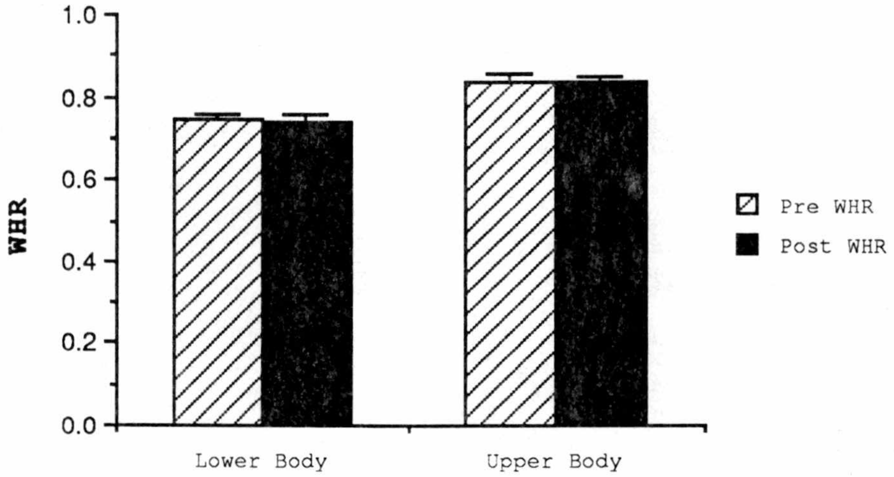


Figure 8. Pre and Post treatment values for WHR between UB and LB obese groups.

Maximal Aerobic Power

There was no significant treatment effect for maximal aerobic power in either group following treatment (See Figure 10).

Blood Lipid Profile Characteristics

One UB subject did not have a post treatment blood lipid assessment. A borderline treatment effect was seen for triglycerides in both groups following treatment (p=.06) (See Figure 11). More importantly, a significant interaction existed in the way the two groups responded to training (p=.008). The UB group increased triglycerides over the treatment period while the LB group decreased triglycerides.

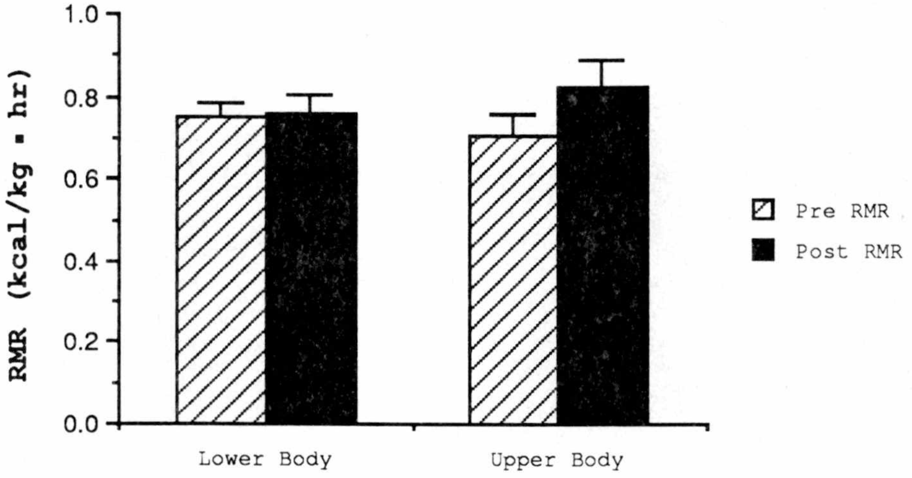


Figure 9. Pre and Post treatment values for resting metabolic rate (kcal/kg·hr) between UB and LB obese groups.

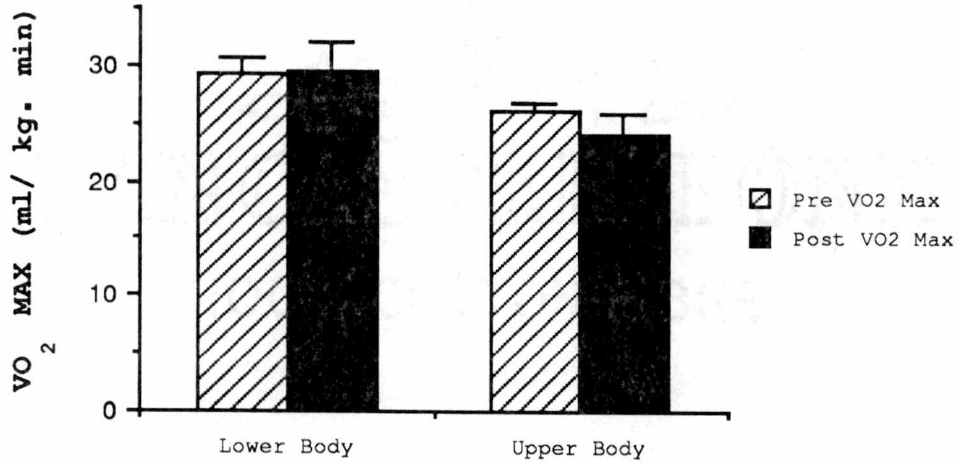


Figure 10. Pre and Post treatment values of maximal aerobic power (ml/kg·min) between UB and LB obese groups.

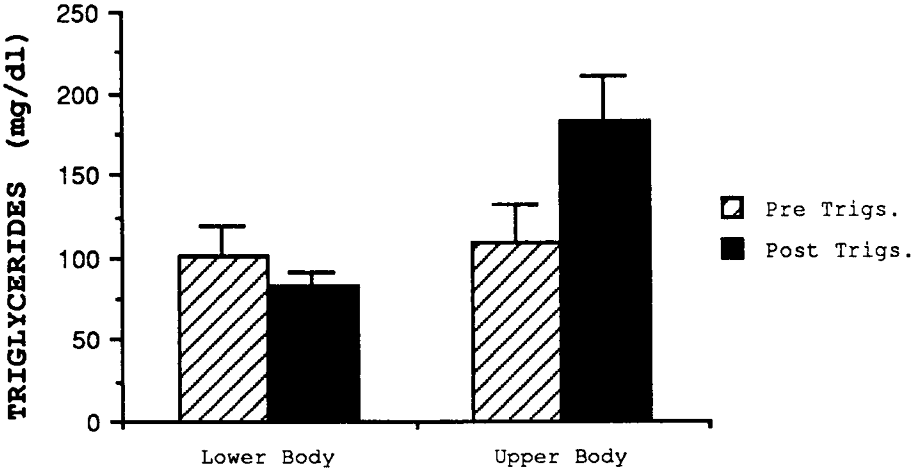


Figure 11. Pre and Post treatment values for triglycerides (mg/dl) between UB and LB obese groups.

There was no significant treatment effect for total cholesterol in either group following treatment. However, a borderline significant ($p=.09$) interaction existed in the way the two groups responded to treatment (See Figure 12). A significant treatment effect was seen for total cholesterol to HDL ratio in both groups ($p=.05$). However, there was no significant interaction in the way the two groups responded to training (See Figure 13). Although LDL cholesterol decreased in both groups following training, there was no significant treatment effect for LDL or HDL cholesterol. Thus no interaction existed between groups (See Figure 14 and 15).

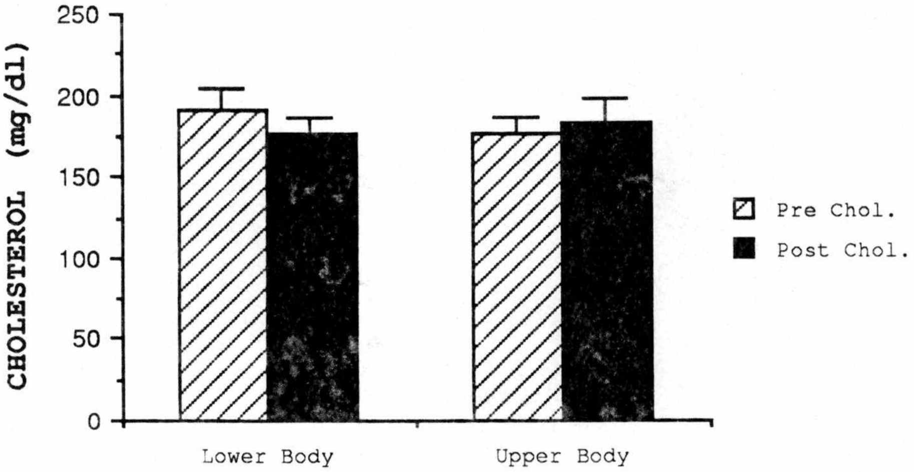


Figure 12. Pre and Post treatment values for total cholesterol (mg/dl) between UB and LB obese groups.

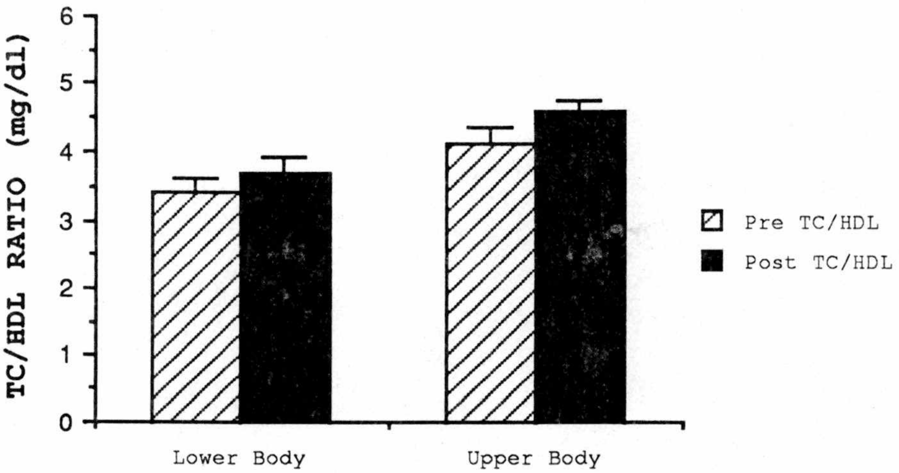


Figure 13. Pre and Post treatment values for total cholesterol to HDL ratio (mg/dl) between UB and LB Obese groups.

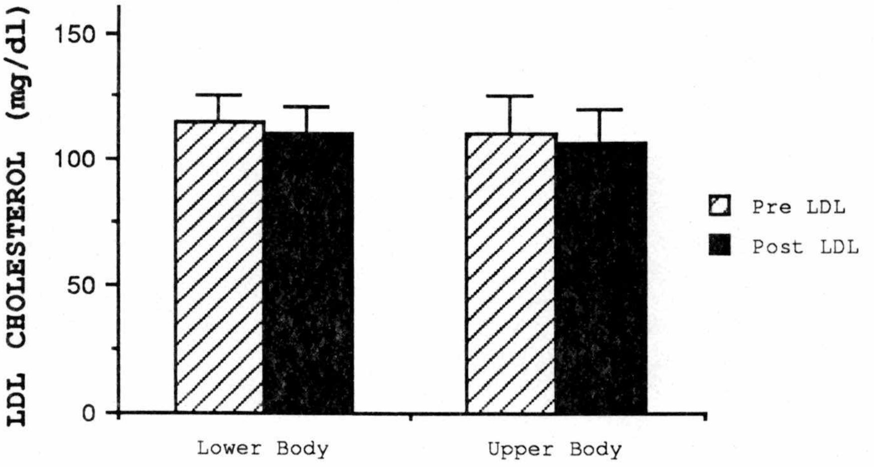


Figure 14. Pre and Post Treatment Values for LDL cholesterol (mg/dl) between UB and LB obese groups.

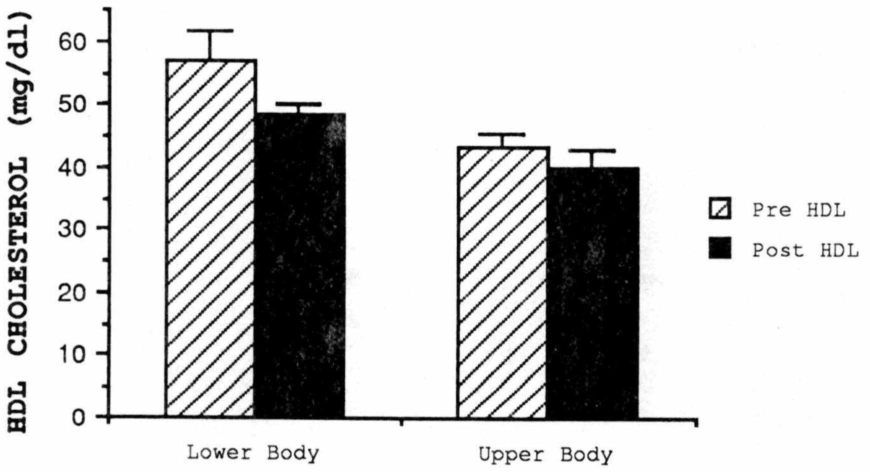


Figure 15. Pre and Post treatment values for HDL cholesterol (mg/dl) between UB and LB obese groups.

CHAPTER V

DISCUSSION

The recognition of abdominal obesity as a clinically important factor associated with increased risk of disease is a recent advance in the field of obesity research. Previous research involving weight loss and body fat distribution focused primarily on treatment by either diet or exercise. Very little research has been done on the effects of both physical training and diet in females with android or gynoid obesity. However, for those interested in the prevention of chronic disease, the ability to alter adipose tissue by diet and exercise is worthy of investigation. This study addressed the effect of mild caloric restriction combined with regular endurance exercise in women with either upper or lower body fat distribution patterns.

It has been suggested that exercise conducted a minimum of 5 days per week for 15 to 60 minutes in duration, with a intensity of 50%, and an expenditure of at least 350 kcal per exercise session is the threshold stimuli for body and fat weight reduction (American College of Sports Medicine, 1986). The treatment period, which lasted exactly eight weeks required the subjects to walk for 60 minutes, 5 days a week at a pace equivalent to 50-65% of their VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$). In addition, subjects were asked to adhere to a self-imposed diet of 1,200 to 1,500 kcal per day.

However, three day dietary recalls indicated that subjects consumed an average of 1,500 to 1,700 kcal per day. In addition, this research was based on the assumption that the subjects recorded accurate and honest food records.

Body Composition

The adaptation to a diet-exercise treatment was evaluated in females with android (n=5) and gynoid (n=6) obesity. The data from the present investigation did not show group differences in body composition following treatment by diet and exercise. Rather, both groups experienced similar decreases in weight ($p=.01$), BMI (kg/m^2) ($p=.01$), and percent fat ($p=.02$) following treatment. Thus, the distribution of fat was not correlated with the ability to adapt to a diet-exercise program in these subjects. Fat free mass, which is dominated by muscle mass, was higher in UB subjects both before and after treatment. However, both groups responded to treatment with a increase in fat free mass ($p=.002$). This particular finding suggests that LB obese women, in particular, have the ability to favorably increase fat free mass following eight weeks of walking for 60 minutes at 50 to 65% of maximum.

These results are in accordance with den Besten et al., (1988), but are in contrast to the findings of Krotkiewski and Björntorp (1986). In diet-only therapy involving females with android and gynoid obesity, den Besten et al., (1988) found that both groups experienced similar body weight and body fat mass reductions. However, Krotkiewski and Björntorp (1986) found that obese women with gynoid obesity showed an increase in body fat and no metabolic improvements after physical training. In contrast, physical training in the android obese subjects resulted in a decrease in body fat and an increase in fat free mass. These authors concluded that women with gynoid obesity increased energy intake disproportionally during the treatment period, resulting in positive energy balance.

In conclusion, the results obtained from this study regarding changes in body composition are two-fold. First, this study does not support the hypothesis that LB obese women are more resistant to weight or percent fat loss than UB obese subjects. More importantly, there does not appear to be sufficient data to say that the distribution of body fat has an effect on weight loss or the ability to increase fat free mass. Second, variation in reductions of body weight and percent fat reduction was quite large, indicating individual differences in diet as well as exercise compliance.

Resting Metabolic Rate

In the current investigation, mean RMR values were very similar between groups before training. There was no significant treatment effect for RMR in either group following training. Den Besten's group observed a slightly greater RMR in the UB group before weight loss. After weight loss mean RMR decreased about 10% in the UB group and about 2.5% in the LB group. Reduction in RMR in obese women after weight loss is generally attributed to a comparable loss in fat free mass (FFM) (den Besten et al., 1988). However, these authors failed to demonstrate a correlation between decreases in RMR and decreases in FFM. Several other studies have demonstrated an association between caloric restriction and a decrease in RMR (Bray, 1969, Vansant et al., 1989).

Data from the present investigation indicate a significant increase occurred for FFM, while there was no significant increase in RMR. This particular finding suggests that exercise may counteract the dietary-induced fall in RMR by increasing the amount of FFM. It should be noted that the UB group increased their RMR to a greater degree than the LB group. This phenomenon may be explained by the rather large increase in FFM that also occurred in the UB group. It can be stated that UB obese women may be more likely to improve RMR, if FFM is increased, following a diet-exercise program.

Maximal Aerobic Power

Because of the extremely high attrition rate in training studies involving obese subjects, very little research has been done on the effects of physical training on VO_2 max in obese females differing in fat distribution. Krotkiewski and Björntorp (1986) found that VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$) increased after 3 months of physical training at a intensity of 10 to

15 beats below maximum to the same extent in both android and gynoid obese women. Although beneficial changes in body composition occurred, the present study did not see significant improvements in maximal oxygen uptake following treatment. The inability to draw conclusions between this study and Krotkiewski and Björntorp (1986) in regards to maximal oxygen uptake is due to the lack of similarity in the utilization of training intensities. According to Lennon et al., (1985), "improvement in VO_2 max is directly related to aerobic training intensity " (p.44). Although improvement in VO_2 max is not usually a concern for the obese individual, a training intensity of 50-65% of maximum, 5 days a week for an 8 week period may not be adequate to elicit an increase in VO_2 max in certain obese subjects.

Blood Lipid Profile Characteristics

The hypothesis that after physical training cholesterol and triglycerides would decrease in android shaped women and not in gynoid shaped women (Krotkiewski and Björntorp, 1986) was not supported by this study. Extreme interindividual variation and a small subject number may have influenced the results. After an eight week diet (1,000 kcal/day), den Besten et al., found that the UB group showed a trend towards lower total serum cholesterol and lower total serum triglycerides, while the LB group did not show a variation in either variable following the diet. The results of the present study indicate that serum triglycerides increased for the UB group, while they decreased in the LB group following treatment. This occurrence is quite disturbing, and can best be attributed to the low UB subject number (n=4) as well as wide interindividual variation in diet compliance throughout the treatment period. Also, it is assumed that the subjects fasted prior to the collection for the entire 12 hours. Data from the present study indicate that a significant increase occurred for total cholesterol to HDL ratio in both groups. The inability for either group to decrease total cholesterol or LDL cholesterol, and increase HDL cholesterol following training may be due to the relatively short period of training (8 weeks). The changes reported by Krotkwieski and Björntorp (1986) took place following a 3 month training period.

Summary and Implications

The overall findings of this study suggest that despite obvious differences in fat distribution, obese females have similar adaptations to a diet-exercise treatment. The results from this study suggest that a self-imposed diet (1,500-1,700 kcal/day) as well as aerobic training 5 days per week at 50-65% of maximum for an eight week period is a successful program for both android and gynoid obese subjects, whose goal is to lose weight and fat. In addition, favorable increases in FFM were shown.

Further investigations might include the use of a metabolic ward to guarantee a low-fat reduced calorie diet in combination with a physical training program. Although the results of the present study will be useful for developing intervention guidelines for the obese, there is still a need to conduct a study involving 10 to 15 subjects in each group as well as extending the treatment period to a minimum of 3 months.

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APPENDICES

Appendix A

THE UNIVERSITY OF TENNESSEE
HUMAN PERFORMANCE AND SPORTS STUDIES

Let's dump our plump!!

Many of you expressed interest in taking part in a weight loss through exercise program. Immediately following Pam's metabolism study, another study will offer you such a program. This type of research will be based on the completion of the exercise program. A considerable amount of commitment will be required from the individual. This type of exercise and weight maintenance program would cost approximately $300.00 at a clinic. I am offering it to you **FREE** of charge!!

The program will be comprised of 8 weeks of exercising and 1 week of post-testing where you will need to come in for 3 separate sessions lasting approximately 1 hour. The exercise session will require you to report to the designated area on campus at a designated time Monday through Friday (5 days a week). Child care will be provided. Exercise will be conducted in a professional manner and heart rate and blood pressure will be monitored. Skinfold, and waist-to-hip ratio measurements will be collected on a pre-selected day once every other week. In order to facilitate weight loss, you will also be asked to restrict your diet to an individualized range of calories per day. Dietary recalls will be collected every other week.

Please answer the following questions as honestly and thoughtfully as possible.

1. I will be in the Knoxville area from March 25 until approximately May 31......
   YES **NO**

2. I would ______________ to walk for 60 minutes five times a week.
   A. Be very willing **B. Not be willing**

3. I would ______________ to monitor my food intake during the 8 week exercise program.
   A. Be very willing **B. Not be willing**

4. I would ______________ to exercise at 7:00 AM Monday through Friday;
   A. Be very willing **B.Be somewhat willing** **C. Not be willing**

5. I would ______________ to exercise at 7:00 P.M. Monday through Friday.
   A. Be very willing **B. Be somewhat willing** **C. Not be willing**

6. I am______________ about improving my health, and losing weight through this type of exercise program.
   A. Very excited **B. Somewhat excited** **C. Not excited**

*** If you would like to make any comments or suggestions regarding this program, or if child care is needed, please indicate on back.***

Appendix B

INFORMATION TO PARTICIPANTS

Description of the project:

This training study is designed to study the effects of exercise training on metabolism and fat loss in women with "apple" or "pear" shaped-bodies. Exercise training, combined with mild caloric restriction, has the potential to reverse cardiovascular health risks, associated with obesity. Of interest are the possible effects that training may have on women with different types of body fat distribution. The study is divided into three main segments.

Segment One:

Consent form
Circumference and Skinfold Measurements
Explanation of individualized exercise and caloric restriction protocols
Begin Exercise

Segment Two:

The exercise training study will last exactly eight weeks. During the training study, you will be motivated and monitored in a professional manner. You will be required to walk for 60 minutes, five days a week from 7:00 - 8:00 PM, unless otherwise arranged. Exercise will take place either on Tom Black Track or in Stokley Athletic Center, if the weather is not suitable to be outside. Child care for the hour you are exercising will be provided. During the exercise sessions, you will be taught various "walking stretches" that will facilitate proper warm-up and cool-down. You will also be taught how to calculate your heart rate during exercise. This will enable us to validate your training intensity. Heart watches will be worn on subsequent days. Blood pressure will be monitored before and after each exercise session. Your exercise sessions will be charted on an exercise log (see attached). Every other Friday will be used as "data collection day." On this day the following data will be collected: skinfold and circumference measures, weight, and three day dietary records. Approximately four weeks into the study a Resting Metabolic Rate will be collected. The procedures for the RMR are the same as you have experienced before. In addition to exercising, you will also be required to limit your caloric intake by no more than 500 kcal/day. This caloric intake will be pre-determined for each subject. You will be asked to bring in a 3 day dietary recall every two weeks so that we can make sure you are consuming the specified number of calories.

Recommended clothing:

YOU SHOULD WEAR LOOSE FITTING EXERCISE CLOTHING SUCH AS A T-SHIRT, SWEAT PANTS, COMFORTABLE TENNIS SHOES AND SOCKS SO THAT YOUR COMFORT AND SAFETY CAN BE ASSURED.

Post-Study: (After 8-week training session)

The post-testing measurements are almost identical to those you have done previously. The following data collections will be made:

A.) A health history questionnaire

B.) Assessment of blood lipids

C.) Resting Metabolic Rate (RMR):

You will come into the lab having had no physical exercise nor any food or liquid except water for at least 4 hours previously. You will recline on a lounge chair as motionless as possible, without sleeping, for a total of 40 minutes. During the last 20 minute period you will be asked to put a mouthpeice in your mouth and breathe through a valve attached to hose and collecting bag so that your expired air can be collected and analyzed.

D.) Body Composition:

This test consists of measuring your body weight while you are submerged underwater. First the amount of air trapped in your lungs following full exhalation is measured. Next you will climb into a tank of warm water. You will sit on a scale on the bottom of the tank. You will be asked to blow out your air and exhale fully as you completely submerge your head and body underwater (about 10 seconds) so a measurement of your weight underwater can be made.

E.) Maximal Exercise Capacity Test:

You will complete a maximal treadmill test. This will require that you complete a graded exercise test by walking on a treadmill. Exercise will begin at low levels and be advanced gradually in stages to the point of voluntary exhaustion, which you alone will determine. You may stop the test at any time due to feelings of fatigue, discomfort or for any other personal reason.

Possible Risks and Discomforts:

You will probably feel localized muscular fatigue in your legs at the onset of the exercise program, This soreness should subside within several days, or when your body becomes accustomed to exercising. The risks involved with exercise include the possibility of abnormal heart beats, abnormal blood pressure response, and a heart attack, although these risks are rare for someone with no known heart disease. Selection and supervision of the exercise test and exercise program are matters of professional judgement.

Benefits:

You will be given a complete analysis of the results that occurred following the training session. The services and benefits provided to you in this study are those sought by and recommended to overweight people intending to lose weight. By participating in this exercise/weight loss program you will understand the steps required to reach your goal of lowering your weight.

CONSENT FORM

I have read the above information carefully. I understand my role in the the experiment and the risks involved. The procedures have been explained to me and my questions have been answered to my satisfaction. In addition, I am aware that:

1) My participation is entirely voluntary. No coercion of any kind has been used to obtain my cooperation.

2) Data collected may be used in research presentations or publications but that my identity will remain completely confidential.

3) I am entitled to have further inquiries answered regarding the experiment.

4) I may withdraw from this study at any time for any reason without penalty or prejudice toward me.

5) In the event of injury because of my participation in this study, financial compensation is not available and medical treatment is not provided free of charge

I wish to give my voluntary cooperation as a participant.

____
Date

____
Signature

____
Date

____
Witness

Project Directors:

Dr. Wendy Bubb (faculty advisor)
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Appendix C

EXERCISE LOG

****

TRACK- 4 LAPS=1 MILE

STOKLEY- 5 1/3 LAPS=1 MILE

Name_____________

Target Heart Rate_____

DAY	TRACK/ STOKLEY	DISTANCE (MILES)	ELAPSED TIME(MINS)	RESTING H.R.	POST-EXERCISE H.R.	R.P.E. (1-10)
MON.						
TUES.						
WED.						
THURS.						
FRI.						
MON.						
TUES.						
WED.						
THURS.						
FRI.						

Appendix D

EXERCISE PERSCRIPTION & CALORIC INTAKE PROTOCOLS

NAME____________________

MAX WALKING TREADMILL TEST: (EXERCISE PROTOCOL)

Max Vo2 __________

65% of Max Vo2= ________

Max Heart Rate __________

(CALORIC INTAKE PROTOCOL)

RESTING METABOLIC RATE:

kcals/ day: ____________

AVERAGE DAILY CALORIC INTAKE: ___________

AVERAGE DAILY CALORIC INTAKE FOR THIS TRAINING STUDY: _____

Appendix E

Food Record DAY # ______ ID# ______

A Date: ______ Item #	Time	Place	B Foods & Beverages	# Units oz	gr	TB	tsp	cup	C "Other" units (eg 5"x3"x1")	D Complete Description

Appendix F

Body Fat Distribution Study

ID# ________

Circumference Measures

Name: ______________________________ Date: ________

Age: ________ Height: ________ Weight: ________

==

	left / right
Arm	________/________
Chest	________________
Waist	________________
Abdomen	________________
Buttocks (hips)	________________
Thigh	________/________
Calf	________/________

Waist to Hip Ratio: ________ Description: Apple Pear

VITA

Camille C. Putman was born in Iowa City, Iowa, on January 9, 1968. She lived in Texas, California, and Connecticut before settling in Chapel Hill, N.C. in 1977. She graduated from Chapel Hill High School in June of 1986.

Camille entered The University of North Carolina, Chapel Hill the following August of 1986. She received a Bachelor of Science degree in Education, majoring in Health and Physical Education in May, 1990.

Following graduation, she entered The University of Tennessee, Knoxville where she was employed in the Department of Human Performance and Sport Studies as a graduate research assistant and a graduate teaching associate. She subsequently completed the requirements for the Master of Science degree in Human Performance and Sport Studies, with a concentration in exercise physiology. She plans to pursue a career in cardiac rehabilitation.