THE EFFECT OF RESISTIVE EXERCISE ON RESTING METABOLIC RATE, LEAN BODY WEIGHT, AND PERCENT FAT DURING CALORIC RESTRICTION IN OBESE FEMALES

by

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(ABSTRACT)

Only a small number of the subjects who enter treatment for obesity maintain their target weight. Explanations for this include increased food efficiency and alterations in resting metabolic rate (RMR). The RMR has been shown to be reduced after weight reduction and it is believed that a benefit of exercise training is an adaptive increase in lean body weight (LBW) with a concurrent decrease in excess body fat. Since caloric restriction is essential for weight reduction, an increase or preservation of LBW is desirable. The purpose of this study was to assess the effect of caloric restriction (DO group; n = 6) and caloric restriction plus weight training (DWT group; n = 8) on total weight (TW), percent fat (% fat), lean body weight (LBW), and RMR during an 8 week study. Both groups met 3 days/week for 30-45 min/day to perform a specific exercise or flexibility routine. The DWT group performed three sets of ten lifts on seven resistive exercises, under supervision, while the DO group performed a set routine designed to increase flexibility but result in no appreciable exercise. Subjects met weekly with a Registered Dietitian to provide information regarding nutritional and caloric content of food, as well as behavior modification techniques. Results revealed non-significant treatment effects between the groups on the variables RMR, % fat, and LBW. A treatment effect was observed for TW, with the DO group significantly losing more weight. Total weight and % fat significantly decreased in both groups from pre to posttest. A significant difference was noted for the DWT group from 4 weeks - 8 weeks in RMR, although there was no effect from baseline - 8 weeks. Thus, resistive exercise when added to caloric restriction, increases strength, but results in slower weight loss when compared to diet only subjects while resulting in similiar losses in % fat and total weight.

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CHAPTER I

Introduction

Lifestyles differ between generations and cultures, with some generations and cultures being active, others less active or sedentary. In many tribal cultures, men are physically active either hunting for food or in conflict with other tribes. While in a few societies women have physically active roles, in the United States women have historically engaged in homemaking activities. Prior to the Industrial Revolution homemaking tasks were physically demanding. However, technological advances and automation have significantly decreased the total energy expenditure of homemakers.

Traditionally, women have been discouraged from exercising vigorously or participating in most sport activities. The resultant lack of regular physical activity by women in the United States has contributed to an increased incidence of obesity, with estimates of obesity high as 40 percent of the adult female population (Bray, 1976).

Over the last decade increased social pressure to be thin has led to the increased popularity of radical forms of dieting. These diets range from total fasting to eating only a single food. The major problems with these diets, nutrition and health risks aside, are the poor adherence to the dietary regimen and maintaining weight after resumption of a "normal" caloric intake. Recently women have become more active, and the social forces that have discouraged women from exercise may be diminishing. Exercise is just gaining broader acceptance as an important component of successful weight management. Exercise may help both during the dietary phase and after the desired weight has been reached, by a variety of proposed mechanisms.

Weight training and other activities for women are becoming more popular as many women shed the traditional image of homemaker. This changing of the traditional role of women and the increased public awareness of the benefits of physical activity may eventually lead to a reduction in the prevalence of obesity.

Statement of the Problem

Only a small number of the subjects who enter treatment for obesity maintain their target weight (Wing & Jeffery, 1979). Possible physiological explanations include increased food efficiency and alterations in metabolic rate. An increased food efficiency after weight loss has been shown in animals (Brownell et al., 1987), with the possible mechanism for this increased metabolic efficiency the decline in basal, or resting metabolic rate (RMR). After weight reduction the RMR has been shown to be decreased (Bray, 1969).

It is believed that a benefit of exercise training is an adaptive increase in lean body weight (LBW) with a concurrent decrease in excess body fat. An increase or preservation of LBW was shown in 52 of the 59 exercise training studies that were reviewed by Wilmore (1983). Significant decreases in LBW are found when dietary caloric restriction is used alone in treatment of obesity (Zuti & Golding, 1976, Hill et al., 1987, Walberg 1989, & Yang et al, 1976).

Cunningham (1980) established that LBW was most predictive of RMR, accounting for 70% of the variability in RMR. Thus, any appreciable change in lean tissue would alter the body's RMR, providing one possible explanation for the decrease in RMR associated with caloric restriction. However, RMR has also been shown to decrease independent of changes due to LBW (Shah, 1988). Since caloric restriction is essential for weight reduction, an increase or preservation of LBW is desirable. Enhanced LBW should increase caloric expenditure through a concurrent maintenance of RMR. It has been thought that aerobic exercise might have the dual effect of increasing caloric expenditure and preserving LBW during caloric restriction, Hagan et al. (1986) and Bogardus et al. (1984) reported a decrease in fat-free mass for women consuming a low calorie diet and exercising 3 times per week. This decrease in fat-free mass in the Bogardus study is the same as the diet only group, while in the Hagan study the exercise group actually tended to lose more fat-free mass when compared to the diet only group. Goldberg et al. (1975) has observed muscle hypertrophy in rats losing body weight during fasting while weight-training. Ballor et al. (1988) reported an increase in arm muscle area over 8 weeks, as measured by radiograph, in obese women consuming 1000 calories below maintenance energy and weight-training 3 times per week. The purpose of this study was to assess the effect of weight training on total weight (TW), percent fat (% fat), lean body weight (LBW), and RMR during 8 weeks of caloric restriction.

The present program was administered to obese women (>30% fat) aged 18-23. Emphasis was placed on the difference between diet only (DO) and the diet plus weight training (DWT) groups on the following variables: 1) % fat, 2) LBW, 3) RMR, and 4) TW.

<u>Research Hypothesis</u>

Ho: There will be no difference in resting metabolic rate, total body weight, lean body weight, and percent fat in obese females following 8 weeks of moderate caloric restriction between the following two groups: 1) Diet only (DO) and 2) Diet plus weight training (DWT).

<u>Significance of the Study</u>

Obesity is associated with a number of health hazards. It may impair both cardiac and pulmonary function and over the longterm, and obesity is also considered by some to be an independent risk factor for atherosclerotic heart disease (Van Itallie, 1985). A decrease in RMR has been shown in response to caloric restriction (Bray, 1969 & Donahoe, 1984). In the obese, this decline in RMR results in a decreasing rate of weight loss during periods of low-calorie dieting (Bray, 1969). Presently, there is a lack of information in the literature on the effect of weight training on RMR, LBW, and % fat during caloric restriction in obese females. It has been postulated that weight training will minimize the loss of LBW seen after caloric restriction and thus prevent the decline in RMR, since LBW has been shown to account for up to 70% of the RMR (Ravussin et al., 1985). Ballor et al. (1988) and Goldberg et al. (1975) found that resistive training increased regional muscle area after caloric restriction in humans and animals respectively, but Donnelly (1989) found a decrease in LBW after resistive training during a very low calorie diet. Sohar and Sneh (1973) found that only approximately 10% of the obese patients that lost weight successfully kept that weight off after 10 years. Thus, the maintenance of RMR should increase the likelihood that the subject will successfully keep off the weight that has been lost.

Delimitations

The following delimitations were imposed by the investigator:

1) Subjects were 14 nonsmoking obese (>30% fat) female volunteers aged 18-23 and presently attending VPI & SU.
2) Subjects were prescribed a daily dietary deficit of 1000 kcal, resulting in a 1200 - 1400 kcal diet.
3) The training program was conducted 3 days per week for 8 weeks.
4) Subjects had not been involved in a weight training program for at least six months.
5) The weight training program was performed using free weights.
6) Resting metabolic rate was measured between 6:00-8:00 AM after a 12 hour fast in the laboratory.
7) Percent fat and lean body weight were determined by hydrostatic weighing technique (Brozek & Keys, 1951).

Limitations

The following limitations affect the generalizability of the findings:

1) Application of results is limited to diet and weight training involving the specific diet and exercises used in this study.

2) Adherence to dietary and exercise protocol was voluntary so variation may have occured.

Basic Assumptions

1) The subjects adhered to their respective exercise prescription and did not engage in any other weight lifting activities in addition to the treatment program.
2) Subjects adhered to their reduced calorie diets.
3) Measurement of TW, RMR, LBW, and % fat were accurate within error of the various instruments.

Definitions and Symbols

Terms and symbols requiring clarification for use in this study are as follows:

Caloric Restriction. 1200-1400 calorie diet based on the diabetic exchange list diet. The diet was designed to result in weight loss of approximately 1kg/week (American Diabetes Association, 1976).

Lean Body Weight. (LBW) The total body weight of an individual minus their fat weight.

Obesity. Any subject whose percentage of body fat was 30% or greater of total body weight, as determined by underwater weighing.

One Repetition Maximum (1RM) Subjects lifted increasingly heavier weight until reaching a weight they were unable to raise. After 5 minutes rest, subjects again tried the failed weight. The last successfully lifted weight was taken as the 1RM.

Percent Fat (% fat) Percent of total body weight that is made up of adipose tissue.

Resting Metabolic Rate (RMR) The energy expenditure, as determined by indirect calorimetry, at rest several hours following meals or physical activity.

Weight Training. Consisted of a 3 days per week supervised routine including the following exercises: bench press, leg extensions, biceps curl, triceps extension, calf raise, and military press as described in the Gold's Gym book of bodybuilding (Spraque & Reynolds, 1983). Ten repetitions (60 - 70% of 1RM) of each exercise were completed in the first two sets and as many repetitions as the subject could perform in the third set. Three sets of 50 sit-ups were also performed at each exercise session.

Summary

The incidence of obesity in the United States has increased dramatically this century. Up to 40% of adult women are considered to be obese. With such a high incidence of obesity and the serious health hazards associated with obesity, it is important to determine the most efficient method for losing and maintaining weight loss. It is postulated that adding a weight training exercise to caloric restriction will not only help in losing weight by direct caloric expenditure but reverse the decline in RMR seen with caloric restriction alone. Thus, an enhanced RMR after dieting would maintain energy balance, making it easier to avoid gaining back the weight that was lost (Ravussin et al., 1985).

CHAPTER II

REVIEW OF THE LITERATURE

To present the reported knowledge pertinent to each topic under investigation in this study, the review of literature is divided into three sections: Health Implications of Obesity, Weight Reduction, and Exercise and Resting Metabolic Rate.

Health Implications of Obesity

Adipose tissue is a normal component of the human body that serves the important function of storing energy as fat for mobilization in response to metabolic demands. Obesity is an excess of body weight (>20% above desirable weight, midpoint of the range for medium-frame individuals as shown in the 1983 Metropolitan Height and Weight Tables, 1984,) but more specifically excess body fat (> 30% of total weight in females) frequently resulting in a significant impairment of health. The excess fat accumulation is associated with increased fat cell size; however, in individuals with extreme obesity, fat cell numbers are also increased (McArdle, Katch & Katch, 1981). Both genetic and environmental factors are likely to be involved in the pathogenesis of obesity. These include excess caloric intake, decreased physical activity, and metabolic abnormalities (NIHCDCS, 1985).

According to the National Institute of Health Consensus Development Conference Statement (NIHCDCS)(1985) clinical observations have demonstrated a connection between obesity and a variety of illnesses. The NIH statement indicates that obesity creates an enormous psychological burden, and in terms of suffering, this burden may be the greatest adverse effect of obesity. There is a strong association between the prevalence of obesity and cardiovascular disease (CVD) risk factors (Ashley et al. 1974). The relationship of obesity to the incidence of coronary artery heart disease (CAD) has been studied in a large number of cohort studies. Widely divergent results have been reported for the relationship of obesity to the incidence of CAD (Ashley et al, 1974). However, when the data from these same studies were combined, there was a positive relationship of obesity to the risk of CAD. Possible explanations for the discrepant findings include differences in health status of the industrial workers in contrast with health status of the total population, varying duration of follow up among the studies, and inadequate sample sizes. The Framingham study, a large general population based study of long duration, found a direct association of degree of obesity with CAD, independent of other risk factors (Hubert et al, 1983). Hypertension (blood pressure >160/95) in the obese is 2.9 times higher than for the nonobese. The prevelance is 5.6

times higher for the young (20 through 44 years old) obese than for the non overweight subjects in this age group. Hypercholesterolemia (blood cholesterol over 250mg/dl) in the young (20-40 years old) obese is 2.1 times more frequent than the nonobese, but obese and nonobese subjects show similiar prevalences for hypercholesterolemia after age 45 (Van Itallie, 1985). The level of blood pressure and serum cholesterol vary with levels of obesity in a continuous manner. Intervention studies confirm that levels of blood pressure and serum cholesterol can be reduced by weight reduction (Dustan, 1985).

Obese subjects have a 2.9 times higher prevalence of diabetes than non-overweight (Van Itallie, 1985). In type II diabetes (maturity onset or noninsulin-dependent mellitus-NIDDM), studies show that weight reduction can reverse the abnormal biochemical characteristics of NIDDM (West, 1973).

Obese males, regardless of smoking habits, had a higher mortality rate from cancer of the colon, rectum, and prostate than the nonobese, while obese females had a higher mortality rate from cancer of the gallbladder, biliary passages, breast (postmenopausal), uterus (including both cervix and endometrium), and ovaries than the nonobese (Garfinkel, 1985).

Clearly, obesity has many adverse health effects, both physical and psychological. There is an increased in both morbidity and mortality with increase degrees of obesity. When measured by relative weight (actual weight as percentage of average or desirable weight for given height/age group) obesity has an adverse effect on longevity. The greater the degree of obesity, the higher the mortality ratio or excess death rate (Feinleib, 1985).

Weight Reduction

The minimum recommended features of a professional weight-control program are diet, behavioral therapy, and exercise (Weinsier, 1984). Dietary recommendations should be individualized to meet the patients needs. The diet should have the following characteristics: 1) a sound scientific rationale, 2) safety and satisfaction of all nutrient needs except energy, 3) practicality and long-term effectiveness, and 4) gradual changes in lifestyle behavior such as eating habits (Atkinson et al., 1984).

Numerous dietary regimens have been devised in an attempt to achieve progressive weight loss in obese individuals, including fasting, very low-energy diets, and balanced low-energy diets. Weight loss occurs only when energy expenditure exceeds intake (Council on Scientific Affairs, 1988).

Fasting as a treatment for obesity, particularly morbid obesity (>50% above desirable weight for females and >30% above desirable weight for males), has been used for more than 70 years, with those fasting programs conducted under medical supervision having produced variable and sometimes contradictory results (Drenick & Johnson, 1980). Prolonged fasting may produce a number of adverse effects, including severe ketosis, hyperuricemia, excessive loss of lean body mass, hypokalemia, hypoglycemia, and increased renal loss of phosphate and magnesium (Newmark & Williamson, 1983). Along with these adverse effects the weight is regained by a majority of patients and, in some cases, the former weight is exceeded (Drenick & Johnson, 1980).

The adverse effects associated with total fasting led to the development of the very low-energy diet (less than 600 kcal/day) (Drenick & Johnson, 1980). These diets are also prescribed for severly or morbidly obese adults. The purpose of these diets is to produce a rapid weight loss while preserving lean body mass by providing dietary protein or protein with carbohydrate. There are two types of commonly used very low-energy diets: 1) protein sparing modified fast (PSMF) that provides approximately 1.5g of protein per kilogram of desirable body weight daily and 2) a liquid formula diet that provides approximately 33 to 70g of protein daily. Comparable results have been achieved with both types of diets (Wadden et al., 1985).

The formula diet may be further broken down into chemically-defined formula diets and liquid protein diets. The chemically-defined formula diets include a variety of preparations containing a source of protein, carbohydrate, vitamins, minerals, electrolytes, and essential fatty acids. Theoretically, with proper formulation optimal nutritional status may be maintained. However, chemically-defined formulas do have possible shortcomings. First, there is no guarantee that defined formula diets will meet the nutritional requirements of all patients following this diet. The recommended dietary allowances (RDA) are not meant to fulfill nutrient requirements for all members of the population. Second, rigid plans do not teach the obese person beneficial eating habits. Thus, when placed on a normal dietary pattern, patients may quickly regain their weight because they are unaware of how to manage typical food intake to maintain weight loss.

Liquid protein diets contain a protein hydrolysate or free amino acids with vitamins, minerals, and artificial flavoring. The protein is of low biologic value, lacking the full complement of essential amino acids. By the end of 1977, approximately 60 deaths had been attributed to liquid protein diets (Felig, 1984).

Treatment with very low-energy diets produce large weight losses which are directly proportional to the duration of treatment (Wadden et al., 1983). Very low-energy diets should be supervised by physicians and limited to persons with severe obesity (Felig, 1984). Sours et al. (1981) concluded that the use of any very-low calorie weight reduction regimen should be eliminated until further studies can be performed to determine what modifications, if any, can insure subject safety. This conclusion was based on case reports of 17 subjects who died secondary to ventricular arrythmias following prolonged use of very-low-calorie, high-protein diet formulas (Inser et al, 1979). The postmortem myocardial examination disclosed muscle atrophy consistent with protein calorie malnutrition, unrelated to biologic value of the protein consumed, potassium supplementation, or the presence of medical supervision. Pregnant women, children, patients with renal or hepatic disease, and patients with a recent history of transient ischemic attacks or myocardial infarction should not be candidates for a PSMF very low-calorie diet (Bistrian, 1978). Gotto et al. (1980) also recommends that individuals who are responsible for the safety of others, for example bus drivers, not be prescribed a PSMF diet.

The appeal of the large amount of weight loss achieved with the very low-energy diet is severely limited by the seeming inability of patients to sustain their weight loss (Council on Scientific Affairs, 1988). Therefore, attention must be directed to maintanence programs after the desired weight loss is achieved (Coucil on Scientific Affairs, 1988). Non-formula very low-energy diets providing higher quality protein, when compared to formula diets, along with vitamin and mineral supplements appear to be safe when administered under careful supervision (Wadden, 1983). Cardiac performance with the non-formula very low-energy diets using high quality protein is not adversely affected, in fact it may be actually improved (Fisler et al, 1982).

The nutritionally balanced low-energy diet provides a conventional distribution of carbohydrates (>50% of total energy intake), protein (15-20%), and fat (<30%). The usual range of energy intake for such diets are 1000 to 1200 kcal/day. When energy intake falls below these levels it is very difficult to obtain the recommended levels of certain nutrients, such as iron, calcium, zinc, vitamin B6, and copper (Dwyer, 1985). Therefore, vitamin and mineral supplementation is usually necessary under these circumstances (Council on Scientific Affairs, 1987). Since the ultimate goal of any weight-reduction program is to lose weight and maintain the desired weight, it would appear that a nutritionally balanced low-energy diet composed of conventional foods that are easily obtained and economically feasible would help meet the objective (Council on Scientific Affairs, 1988). Unbalanced low energy diets place emphasis on one or more specific macronutrients while restricting others. Low-carbohydrate diets predominate in this category. The physiological responses to such diets vary widely among individuals and depends on initial nutritional status of the individual and energy content of the diet (Van Itallie, 1980). The initial rates of weight loss and fluid balance can be affected by the relative proportions of the energy-producing nutrients. Diets low in energy value and carbohydrate (<100 grams/day) tend to result in diuresis, which may be mistaken as loss in body fat during the beginning stages of a weight loss regimen. Low-carbohydrate diets may be effective in the short term, but the weight is regained once carbohydrate intake is increased to normal levels. These diets are also associated with a number of physical problems such as nausea, fatigue, dehydration, and electrolyte imbalance (Council on Scientific Affairs, 1988).

Novelty diets are very popular and are promoted as "revolutionary" or "guaranteed 100% successful" in weight loss. A majority of these diets rely on the consumption of a specific food to promote weight loss (eg, the grapefruit diet or the banana and skim milk diet). The diets are usually deficient in providing important nutrients (Newmark et al., 1983). The implication from these diets is that a specific food group can selectively oxidize body fat, increase metabolic rate, or inhibit food intake (Newmark, 1983). Weight is usually lost if the individual follows the prescribed diet protocol, but not for the reasons stated. Instead, weight is lost because there is a substantial reduction of energy intake (<1000 kcal/day) with these diets. Once the weight is lost little, if any, attention is given to a nutritionally balanced weight-maintenance plan, and the individual is likely to regain the weight that was lost using the novelty diet.

The rationale that major changes in eating and exercise behaviors are necessary to ensure long term weight control led to considerable research on behavior therapy. Behavior therapy is composed of six core characteristics: 1) an assumption that all behavior is acquired and maintained according to definable principles, 2) belief that people are best described by their behavior in specific situations, 3) an attempt to specify treatment measures as precisely as possible and to evaluate outcomes objectively, 4) individualized treatment, 5) the negotiation between patient and therapist on treatment goals, and 6) continuing assessment of treatment throughout its course (Stunkard, 1985). In the obese person behavioral assessment involves attention to: 1) the antecedents of eating that promote excessive intake (eg. separating eating from other activities, such as watching television), 2) eating slowly, and 3) selectively emphasizing the consequences of certain behaviors (Stunkard, 1981). Behavior therapy has been shown to be more successful in maintaining weight loss when compared to pharmacological therapy in obese subjects (Stunkard, 1985). Stalonas et al. (1984) showed a typical pattern of regaining all the weight lost during treatment of 36 individuals who participated in a behavioral program. Benefits of behavior modification may be enhanced when the treatment is combined with diet and exercise therapy.

The three essential components of a weight-control program are diet, exercise, and behavior modification. These elements are interdependent and mutually supportive. A program that utilizes all three components is more likely to lead to long-term weight control. A comprehensive, long-term weight-control program that encourages gradual changes in eating habits, exercise levels, and psychological factors is the only effective treatment for obesity. (Council on Scientific Affairs, 1988)

Exercise and Resting Metabolic Rate

Exercise is important in weight reduction primarily because it may increase 24-hour energy expenditure, increase weight loss and improve body composition, counteract ill effects of obesity (positive influence on insulin level, plasma lipid levels, blood pressure, and coronary efficiency), control appetite, counter decreases in resting metabolic rate (RMR) associated with reducing diets, and increase RMR post-exercise (Brownell, 1982).

Since RMR is associated with LBW, the maintenance of LBW may increase the chances of successfully losing plus maintaining weight loss (Ravussin et al., 1985). RMR represents the largest component of energy expenditure (Danforth, 1985). It would seem that small changes in LBW may make noticable changes in the total energy expenditure. It has been demonstrated that dietary restriction lowered RMR by an amount nearly double that expected on the basis of the resulting weight loss, but exercise caused the RMR to rise to a level appropriate to the dieters' prevailing body weight (Donahoe et al.,1984). Investigators have shown that aerobic exercise either increases (Lennon et al., 1985) or has no effect on RMR (Woo et al., 1982), but researchers have consistantly found a decrease in RMR in weight reduction without exercise (Tremblay et al., 1985).

According to Weltman et al. (1980) the primary effect of adding an exercise program to weight reduction is the possibility of maintenance of lean body weight (LBW) as compared with diet-only controls. Mole et al. (1989) found that daily aerobic exercise reversed the drop in RMR and LBW associated with severe caloric restriction. Since resistive exercise is shown to have a more pronounced affect on enhancing LBW than aerobic exercise, consideration should be given to this form of exercise in the treatment of obesity. However, few studies have been performed looking at the effect of resistive training and metabolic rate during caloric restriction, but Ballor et al. (1988) and Goldberg et al. (1975) found that resistive training actually increased regional muscle area after caloric restriction in humans and animals respectively. Ballor's study consisted of four groups (diet only (DO), diet plus weight training (DPE), control (C), and weight training only (EO)) of ten subjects each. The diet consisted of subtracting 1000 kcal/day from maintenance for each of the subjects, while the weight training was performed 3 days/week using a Universal eight station Gym. Body composition and upper arm radiogragh were examined with total body weight significantly decreaseing for the DO and DPE groups compared with C and EO groups. Lean body weight increased for EO compared with DO and C and increased for DPE compared with DO. Upper-arm muscle area increased for DPE and EO compared with C and DO. Donnelly (1989), found a decrease in LBW after resistive exercise and a very low calorie diet. Donnelly's four groups were control (C), endurance exercise (EE), weight training (WT), and endurance exercise plus weight training (EEWT). All subjects followed a 500 kcal/day liquid formula diet. Body composition and metabolic rate were determined. Results from baseline to 90 days showed EEWT lost significantly less LBM compared to C, EE, and WT. There were no significant changes in metabolic rate between any of the groups. Therefore, current evidence is inconclusive regarding the metabolic benefits of exercise during caloric restriction. Some studies indicate that exercise may return metabolic efficiency to normal while other investigations find that exercise may produce a more efficient organism, thus enhancing energy conservation.

Summary

The multiple health risks of obesity are both physiological and psychological in nature. For many persons, obesity is largely a result of a life-style imbalance between eating (energy intake) and physical activity (energy expenditure), and of firmly established cultural patterns and social and economic forces (Council on Scientific Affairs, 1988). Many forms of weight reduction have been tried through the years with limited success. The most successful weight loss programs are those that promote gradual changes in eating habits and exercise levels (Council on Scientific Affairs, 1988). Exercise (aerobic or resistive) may help maintain LBW. Since LBW is a component of RMR it appears important to minimize the loss of LBW, and thus RMR, which decreases rapidly using caloric restriction weight-loss alone. Stunkard and Penick (1979) speculate that dietary induced changes in RMR are an important consideration in unsuccessful weight loss regimens. RMR represents the largest component of energy expenditure, therefore strategies to maintain or increase RMR, as in the maintenance of LBW, may be the difference between being successful at losing weight and maintaining that weight loss or being unsuccessful.

CHAPTER III

JOURNAL MANUSCRIPT

THE EFFECT OF RESISTIVE EXERCISE ON RESTING METABOLIC RATE, LEAN BODY WEIGHT, AND PERCENT FAT DURING CALORIC RESTRICTION IN OBESE FEMALES

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(abbreviated title for running head)
Effect of Resistive Exercise and Diet on Body Composition

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ABSTRACT

Only a small number of the subjects who enter treatment for obesity maintain their target weight. Explanations for this include increased food efficiency and alterations in resting metabolic rate (RMR). The RMR has been shown to be reduced after weight reduction and it is believed that a benefit of exercise training is an adaptive increase in lean body weight (LBW) with a concurrent decrease in excess body fat. Since caloric restriction is essential for weight reduction, an increase or preservation of LBW is desirable. The purpose of this study was to assess the effect of caloric restriction (DO group; n = 6) and caloric restriction plus weight training (DWT group; n = 8) on total weight (TW), percent fat (% fat), lean body weight (LBW), and RMR during an 8 week study. Both groups met 3 days/week for 30-45 min/day to perform a specific exercise or flexibility routine. The DWT group performed three sets of ten lifts on seven resistive exercises under, supervision, while the DO group performed a set routine to increase flexibility, but result in no appreciable exercise. Subjects met weekly with a Registered Dietitian to provide information regarding nutritional and caloric content of food, as well as behavior modification techniques. Results revealed non-significant treatment effects between the

groups on the variables RMR, % fat, and LBW. A treatment effect was observed for TW, with the DO group significantly losing more weight. Total weight and % fat significantly decreased in both groups from pre to posttest. A significant difference was noted for the DWT group from 4 weeks - 8 weeks in RMR, although there was no effect from baseline - 8 weeks. Thus, resistive exercise when added to caloric restriction, increases strength, but results in slower weight loss when compared to diet only subjects while resulting in similiar losses in % fat.

Introduction

As many as 40 percent of the adult female population is considered to be obese (> 20% above desirable weight) (Bray, 1976). Clinical observations have shown connection between obesity and a variety of illnesses (National Institute of Health Consensus Development Conference Statement (NIHCDCS), 1985). Since only a small number of the subjects who enter treatment for obesity maintain their target weight (Wing & Jeffery, 1979) the most efficient method for weight loss needs to be investigated.

Weight loss induced by caloric restriction generally results in loss of both fat and lean body weight (LBW) with the percentage lost as LBW increasing relative to the severity of the caloric deficit (Durrant et al., 1980). Negative caloric balance induced by exercise or in combination with caloric restriction appears to minimize loses of LBW (Weltman et al., 1980). The above exercise was aerobic, which by itself is not known to result in gains, but only maintenance in LBW (Gettman & Pollock, 1981). Resistive weight training has shown increases of LBW during dietary-induced weight loss (Ballor et al., 1988). It was the purpose of this research to investigate the effect of caloric restriction either alone or in combination with a resistance weight training regimen on LBW, percent fat (% fat), resting metabolic rate (RMR), and total weight (TW).

Methods

Subjects

Prior to subject selection, permission was obtained from the Institutional Review Board for Research Involving Human Subjects to perform this study. Criteria used for subject selection included: 1) female, 2) nonsmoking, 3) obese (> 30% fat), and 4) age 18 - 23 years old. All subjects were given a written and oral explanation of the study including risks, benefits, and procedures prior to testing. Subjects completed a medical history form and signed a consent form prior to participating in any segment of the study.

Fourteen obese female subjects completed an eight-week weight loss study. After pretesting, the subjects were randomly assigned to either: 1) diet only (DO; caloric restriction, no exercise), or 2) diet plus weight training (DWT; caloric restriction plus weight training exercise). Subject characteristics are in Table 1.

Compliance

Exercising subjects (DWT) missed a total of 9 of a possible 192 exercise sessions resulting in a 95% compliance. The DO group missed a total of 14 of a total 192 flexibility sessions for a 93% compliance. The weekly dietary counseling meeting were missed 11 of a possible 112 times for a 90% compliance.

TABLE 1 Subject Characteristics (mean ± SEM).

GROUP	N	WEIGHT (kg)	% Fat	HEIGHT (cm)	AGE (yrs)
DWT	8	74.8±2.9	42.7±2.4	164.1±1.8	19.1±0.6
DO	6	80.3±4.1	41.0±2.5	166.1±3.4	19.8±0.6

Dietary intervention

Subjects (DO, DWT) followed a 1200-1400 kcal diet for the duration of the study. Baseline caloric requirements were estimated using three day (Thursday, Friday, Saturday) food records kept by the subjects. The average intake was then reduced by 1000 kcal/day. The minimum kcal that a subject was allowed to be lowered to was set at 1000 kcal/day. The diet was based on the diabetic exchange diet in which subjects choose foods from different catagories (American Diabetes Association, 1976). The nutritionally balanced diet consisted of 50% carbohydrate, 25% protein, and 25% fat. Subjects met weekly with a Registered Dietitian (RD) to provide information regarding nutritional and caloric content of food, as well as behavior modification techniques. Subjects were weighed at this time. Daily food records which were required to be kept by the subjects were turned in at this time.

Exercise treatments

Subjects in the DWT group performed resistance weight training, under supervision, 3 days/week using free weights. The training routine included the following exercises: bench press, military press, biceps curl, triceps extension, calf raise, leg extension, and sit-ups (Spraque & Reynolds, 1983) (Table 2). Ten repetitions (60-70% of 1 repetition maximum) were completed in the first two sets of each

TABLE 2 Weight Training Regimen

LOWER BODY	
	Calf Raises
	Leg Extension
	Sit-Ups
UPPER BODY	
	Bench Press
	Military Press
	Biceps Curl
	Triceps Extension

exercise and as many repetitions as the subject could perform were completed in the third set. Resistance was increased when 12 or more repetitions could be completed in the third set. Individual exercise records were maintained by the exercise supervisor, and included the subjects daily training weight and repetitions completed per set. Other forms of exercise were actively discouraged. The DO group met three times a week for 30-45 minutes and performed a fixed stretching routine designed to increase their flexibility but result in no appreciable exercise.

Body composition

Body density was determine on the first two days of the test week using hydrostatic weighing with residual-lung-volume correction (Katch et al., 1967). Ten repeat trials were performed with the heaviest five trials averaged and used as the underwater weight. Residual-lung-volume measurements were made out of the water with the oxygen rebreathing technique with the subjects in the same supine position as used in the hydrostatic weighing (Wilmore, 1969). The average of two repeat trials were used as the criterion score. Percent fat was calculated from body density using the Siri equation (Siri, 1956). Fat weight was determined by multiplying percent fat times body weight and LBW was determined by subtracting fat weight from body weight.

Resting metabolic rate

For determination of resting metabolic rate (RMR), subjects reported to the Human Performance laboratory between 6:00-8:00 AM on a fixed schedule, having fasted for 12 hours. Each subject met the same day (Mon. - Fri.) for baseline, 4 week, and 8 week measurements. After being weighed, the women rested quietly for 30 minutes in a supine position with a speak-easy face mask in place for acclimation. After this rest period, RMR was determined by collecting a 5-minute sample of expired air into a 60L Douglas bag. The expired air was immediately analyzed for CO_2 and O_2 using a Beckman LB-2 CO_2 analyzer and a Beckman OM-11 oxygen analyzer. The analyzers were calibrated before and after the analyses using a certified gas mixture (18.2% O_2, 3.02% CO_2). The remaining volume of expired air was evacuated into a 120L Tissot spirometer. The volume used from the analyzers plus the corrected Tissot reading determined the total volume. This process was completed immediately following each trial to prevent temperature changes in the gases. Using the Haldane transformation of the VO_2 equation VO_2 was calculated (Fox et al., 1981).

Data Analysis

Statistical analyses compared change scores within and between groups representing pre-treatment to post-treatment changes in % fat, TW, LBW, and RMR in the two groups (DO and

DWT). This procedure utilized a two way (time and treatment) repeated measures analysis of variance (ANOVA). Significance was set apriori at an alpha level of 0.05. A post-hoc ANOVA was performed to probe potential differences between the means from baseline - 4 weeks and from 4 weeks - 8 weeks. All data was analyzed using the Statistical Analysis System (SAS).

Results

The two way ANOVA revealed that the groups did not significantly differ over time for RMR, % fat, and LBW, but the DO group did significantly lose weight more rapidly than their DWT counterparts as indicated by a significant interaction between group and time for this factor.

Post-hoc analysis revealed that the decrease in TW was significant from baseline - 4 weeks and 4 weeks - 8 weeks for the DO group, but only significant after the 8 week treatment for the DWT group. The decrease in fat weight occured from baseline - 4 weeks for both groups but only from 4 weeks - 8 weeks in the DO group. This indicates that fat weight was lost initially (baseline - 4 weeks) for the DWT group and throughout the study for the DO group. Percent fat decreased from baseline - 4 weeks for both groups but not from 4 weeks - 8 weeks. Lean body weight within groups remained unchanged from baseline - 8 weeks in both groups.

Bench press maximum (1 RM) increased from baseline - 8 weeks in the DWT group, but remained unchanged in the DO group. Resting metabolic rate significantly decreased from 4 weeks - 8 weeks in the DWT group, although there was no difference from baseline - 8 weeks (Table 3).

Discussion

Both the DO and DWT groups significantly decreased % fat and TW over the 8 weeks ($p < 0.05$), although changes were modest and less than anticipated. However, the DO group significantly lost weight more rapidly when compared to the DWT group, while the other variables (RMR, % fat, and LBW) were not significantly different between the groups over time. This would suggest that the method of weight reduction (diet or diet plus weight training) may affect the amount of weight lost over eight weeks, but does not effect % fat that is lost. These findings in fat loss are in agreement with the findings of Nieman et al. (1985). In addition, Ballor et al. (1988) also found that resistance training did not accelerate the fat loss relative to a diet only group, which is consistent with the findings in this study. The weight loss findings are not consistent with those of Ballor et al. (1988) and Nieman et al. (1985) who found no difference in weight loss between exercise and dietary treatments. The direct caloric cost of the resistive exercise in this study was relatively low (approxemately 140 kcal/session, based on the work of Ballor et al. 1988) and likely did not affect weight loss substantially. It is possible that there was a difference in dietary compliance for the DWT group. However, this was not tested. Again, the small sample in the study may be influencing these findings, and thus must be interpreted with caution, given the conflicting existing literature.

When weight training was added to caloric restriction (DWT group), no significant differences in LBW were detected over the 8 weeks, when compared to the DO group. The small sample size may have affected the findings since 7 of the 8 subjects increased LBW from baseline - 8 weeks, albeit non-significant.

The gradual and modest weight loss seen in the DO group may account for the sparing of lean tissue, as the LBW measures did not significantly change. Conflicting results have been attained when resistive exercise is added to caloric restriction. Ballor et al. (1988) found an increase in arm muscle area, using radiograph, over eight weeks in obese females and Goldberg et al. (1975) found similiar results using animals. Donnelly et al. (1989) found a decrease in LBW with weight training and caloric restriction (500 kcal/day) after 90 days. The reason for conflicting results may be due to the power of the caloric

TABLE 3
Eight week body composition, RMR and bench press changes (mean ± SEM).

Variable	Group*	PH#	Baseline	4 weeks	8 weeks
Weight (kg)	DWT	C	74.8±2.9	73.4±3.1	72.8±3.3
	DO	A,B,C	80.3±4.1	77.4±3.8	75.9±3.9
Lean body weight (kg)	DWT		42.4±1.0	43.6±1.1	43.9±1.1
	DO		47.0±1.7	46.8±1.8	47.1±1.8
Fat weight (kg)	DWT	B,C	32.3±2.9	29.8±2.9	28.9±3.0
	DO	A,B,C	33.3±3.5	30.6±3.4	28.8±3.3
Percent fat	DWT	A,C	42.7±2.4	40.1±2.0	39.1±2.5
	DO	A,C	41.0±2.5	39.2±2.3	37.4±2.7
Resting metabolic rate (ml/kg/min)	DWT		2.8±0.3	3.1±0.1	2.6±0.1
	DO		2.3±0.2	2.7±0.2	2.6±0.2
Calories (kcal/kg/min)	DWT		1.0±0.1	1.1±0.1	0.9±0.1
	DO		0.9±0.1	1.0±0.1	1.0±0.1
Bench press max. (kg)	DWT	C	28.4±1.4	-	35.6±2.2
	DO		35.0±2.1	-	35.4±2.8

* DO = Diet only group, DWT = Diet plus weight training
\# PH = For variables revealing significant within group differences over the 8 weeks, a post-hoc ANOVA was performed; A (significant baseline - 4 weeks), B (significant 4 weeks - 8 weeks), and C (significant baseline - 8 weeks) $p < 0.05$.

restriction. There may be a threshold where the dietary stimulus is stronger than the exercise training stimulus. In Ballor's study, the average caloric intake was 1200-1500 kcal/day while Donnelly's subjects were restricted to 500 kcal/day. These marked differences may influence the preservation or loss of lean body mass.

The RMR significantly decreased from 4 weeks - 8 weeks in the DWT group, although there was no effect from baseline - 8 weeks or between groups. The mechanism for this change is unclear. Increased efficiency of the muscles is an attractive explanation. However, the measurement of RMR is a reflection of aerobic metabolism while the exercise stimulus was anaerobic. A larger sample is needed to further explain these findings to avoid committing a Type II error. This is similiar to the LBW results which did not significantly change during the study. The modest overall change in measures of body composition may not have been powerful enough to change RMR. Varying results have been found in previous studies with Donnelly et al. (1989) finding that RMR did not change with a decrease in LBW. This is in contrast to findings of Mole et al. (1989) which found an increase in RMR with increases in LBW and decreases in RMR in the diet only group which decreased LBW.

Muscular strength (1RM) increased in the DWT group and was unchanged in the DO group. The increase in strength without a statistically significant increase in LBW may have occured as a result of an exercise induced capacity to simultaneously recruit greater number of muscle fibers (Brouha, 1988). Improved psychological parameters secondary to improvements in physical fitness may be another contributing factor (Ikai et al., 1961). The increased strength may also be due to selective atrophy and hypertrophy which could go undetected by hydrostatic weighing.

In the present investigation, the differences in LBW did not reach statistical significance between the DWT and DO groups. Thus, resistive training when added to caloric restriction, increases strength, but results in less total weight loss when compared to diet only subjects while resulting in similiar losses in % fat. It is recognized that the groups in this study were small in number and results must be interpreted with caution. Studies involving larger numbers over a greater treatment period would provide clearer results.

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CHAPTER IV

Summary and Research Recommendations

Summary

The most successful weight loss programs promote gradual changes in eating habits and exercise levels (Council on Scientific Affairs, 1988). Aerobic exercise has been traditionally promoted due to the higher caloric cost and favorable long-term health benefits. As such, previous studies have primarily investigated the effects of aerobic exercise and weight loss, with few studies examining the potential effects of resistive exercise. More recently, the rationale that resting metabolism is influenced by lean body mass, which in turn is enhanced by resistive exercise, has increased the attention of researchers. As weight training is becoming more popular, it would be beneficial to determine if this form of resistive exercise with caloric restriction could be used as a legitimate weight loss method while maintaining lean body weight.

Using a design similiar to Ballor et al. (1988) this study investigated the effect of resistive exercise on total weight, lean body weight, percent fat, and resting metabolic rate. Specifically, this study was conducted to assess the effects of caloric restriction and caloric restriction plus weight training on measures of body composition including percent fat (% fat), lean body weight (LBW), total weight (TW), and resting metabolic rate (RMR) in sedentary, nonsmoking college-age women.

Fourteen women completed the eight week study. The two groups of subjects included: 1) Diet only (DO) (N = 6) and 2) Diet plus weight training (DWT) (N = 8). Subjects were randomly assigned to either the DO or DWT group. All subjects followed a 1200-1400 kcal diet based on the diabetic exchange list diet, designed for weight loss of approximately 1kg/week. Subjects met with a Registered Dietitian on a weekly basis. The weight training program consisted of six exercises performed using free weights, while the DO group performed flexibility exercises 3 days/week for 30-45 minutes. At baseline and weeks 4 and 8 subjects were tested for TW, RMR, LBW, and % fat. Measures of muscular strength were assessed before and after the training program. Body density was determined using hydrostatic weighing; muscular strength was determined by 1RM utilizing the bench press exercise. A repeated measures ANOVA (training and time) was conducted to statistically analyze the data. The level of significance was set at $p < 0.05$.

Both the DO and DWT groups significantly decreased % fat and TW over the 8 weeks ($p < 0.05$), although changes were modest and less than anticipated. However, the Do group significantly lost weight more rapidly when compared to the DWT group, while other variables (RMR, % fat, And LBW) were not significantly different between the groups over time. A one way post-hoc ANOVA revealed that the DO group significantly lost weight from baseline - 4 weeks and from 4 weeks - 8 weeks, while the DWT group significantly lost weight from baseline - 8 weeks only. The decrease in fat weight occured from baseline - 4 weeks for both groups, but only from 4 weeks - 8 weeks in the DO group. This indicated that fat weight was lost initially (baseline - 4 weeks) for the DWT group and throughout the study for the DO group. The % fat losses for both groups were significant from baseline - 4 weeks, but not from 4 weeks - 8 weeks. This would suggest that the method of weight reduction (diet or diet plus weight training) may affect the amount of weight lost over eight weeks, but not the % fat lost. These findings in fat loss are in agreement with the findings of Nieman et al. (1985). In addition, Ballor et al. (1988) also found that resistance training did not accelerate the fat loss relative to a diet only group, which is consistent with the finding of this study. The weight loss findings are not consistent with those of Ballor et al. (1988) and Nieman et al. (1985) who found no difference in weight loss between exercise and dietary treatments. The direct caloric cost of the resistive exercise in this study was relatively low (approximately 140 kcal/session, based on the work of Ballor et al. 1988) and likely did not affect weight loss substantially. It is possible that there was a difference in dietary compliance for the DWT group. However, this remains to be tested. Again, the small sample in the study may be influencing these findings, and thus must be interpreted with caution, given the conflicting existing literature.

When weight training was added to caloric restriction (DWT group), no significant differences in LBW were detected over the 8 weeks, when compared to the DO group. The small sample size may have affected the findings since 7 of the 8 subjects increased LBW from baseline - 8 weeks, albeit non-significant.

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The RMR significantly decreased from 4 weeks - 8 weeks in the DWT group, although there was no effect from baseline - 8 weeks or between the groups. The mechanism for this change is unclear. Increased efficiency of the muscles is an attractive explanation. However, the measurement of RMR is a reflection of aerobic metabolism while the exercise stimulus was anaerobic. A larger sample is needed to further explain these findings to avoid committing a Type II error. This is similiar to the LBW results, which did not significantly change during the study. The modest overall change in measures of body composition may not have been powerful enough to change RMR. Varying results have been found in previous studies with Donnelly et al. (1989) finding that RMR did not change with a decrease in LBW. This is in contrast to findings of Mole et al. (1989) which found an increase in RMR with increases in LBW and decreases in RMR in the diet only group which decreased LBW.

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In the present investigation, the differences in LBW did not reach statistical significance between the DWT and DO groups. Thus, resistive training, when added to caloric restriction, increases strength, but results in less total weight loss when compared to diet only subjects while resulting in similiar losses in % fat. It is recognized that the groups in this study were small in number and results must be interpreted with caution.

Research Implications. The results of this study contribute information regarding changes in body composition that occur in response to 8 weeks of caloric restriction and weight training in originally sedentary, nonsmoking college-age women.

The decrease of % fat and maintanance in LBW allow this program to be of practical application to women possessing characteristics similiar to those of the subjects (e.i. those interested in losing weight while maintaining or increasing LBW). Weight training three days per week combined with reduced caloric intake (1200-1400 kcal) appears to result in a significant reduction in body fat and increase in lean body weight within 8 weeks.

Recommendations for Future Research. The results of this investigation reemphasize the need for a longitudinal study to determine if one of the groups was more successful than the other group in maintaining weight loss. Varying quantity of aerobic training, caloric restriction and contrasting findings with diet plus weight training groups would provide further discrimination of exercise modality. Having the weight training group perform a more strenuous resistive regimen on a Universal or Nautilus-type equipment may increase the chances of further enhanced LBW, since more muscle groups could be stimulated. Also, since spotting is unnecessary while using the Universal or Nautilus-type equipment, the subjects could perform more lifts in the same time as the free weights. Another dietary approach could explore the effects of greater caloric restriction to determine if a threshold exists where the diet stimulus is stronger than the exercise training stimulus, be it aerobic or resistive training. Such research might better define the optimal amount of caloric restriction when combined with exercise.

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APPENDIX A

METHODOLOGY

Subject Selection

Prior to subject selection, permission from the University Human Subjects Committee was obtained (Appendix C). Volunteer subjects who responded to a public advertisement were screened to participate in this study. Criteria for selection for subjects included:

1) Apparently healthy nonsmoking females, aged 18-23.
2) Sedentary, defined as not participating in a regular (three times per week) aerobic or resistive exercise program.
3) Without any orthopedic or physical contraindications that would prevent them from participating in resistive exercise.
4) Obese (>30% body fat), as measured by hydrostatic weighing.
5) Not engaged in dietary caloric restriction.
6) Weight-stable, defined as not having gained or lost 5 pounds in the past month.

General Method

Instructional Procedures. Prior to the initial testing, all subjects were given both written and oral explanation of the study, including its risks and benefits (Appendix D). All subjects signed a written consent form agreeing to the procedures of the study (Appendix E).

Each subject completed a detailed medical history questionnaire (Appendix F) to ensure that they were at low relative risk for orthopedic problems that may be associated with resistive exercise.

Subjects then participated in an orientation session to familiarize themselves with the indirect calorimetry system, including breathing apparatus (facemask) used to collect metabolic data, and hydrostatic weighing tank for assessment of body composition.

Procedures

On the first test day, half of the subjects underwent a body composition assessment including anthropometric measures and hydrostatic weighing to assess subject's body density, percent fat, and lean body weight. The remaining subjects were measured on test day two. On test day one thru six subjects came to the lab between 6:00 AM and 8:00 AM on a fixed schedule for assessment of resting metabolic rate (RMR). Subjects were then randomly assigned to one of the two groups: 1) Diet only (DO) and 2) Diet plus weight training (DWT). The DO and DWT subjects were tested to determine their one repetition maximum (1RM) on the bench press on test days three and four. On test days three, four, and five all subjects (DO & DWT) kept a three day food record which was analyzed by the Registered Dietitian (RD). On test day five DO subjects were tested for flexibility using a sit and reach flexibility test. The training and diet began two days following the DO flexibility testing. Training (DWT group) consisted of resistance weight training under supervision 3 days/week using free weights for eight weeks. Each session consisted of a 5-minute warm-up, followed by a routine including three sets of six exercises: bench press, military press, biceps curl, triceps extension, calf raises, leg extensions, and sit-ups as described in the Gold's Gym book of bodybuilding (Spraque & Reynolds, 1983). Ten repetitions (60-70% of 1RM) were completed in the first two sets of each exercise and as many repetitions as the subject can perform were completed in the third set. Resistance was increased when 12 or more repititions were completed in the third set. Individual exercise records (Appendix G) were maintained by the exercise supervisor and included the subject's daily training weight and repetitions completed per set. Other forms of exercise were actively discouraged. The DO group met three times a week for 30-45 minutes and performed a set program designed to increase their flexibility (Appendix H).

Concomitant with the training, subjects followed a reduced calorie diet designed to elicit a weight loss of 1-3 lbs/week. Subjects (DO, DWT) attended weekly nutritional sessions with the RD to assure compliance with the prescribed dietary regimen. Weekly dietary recall sheets were kept by both groups and turned in at this time.

Measures of resting metabolism and body composition were assessed at baseline, and weeks 4 and 8 of the treatment. Muscular strength and flexibility were assessed pre and post treatment.

Experimental Procedures

Estimate of Body Composition. Subjects reported to the Human Performance laboratory where data was collected to assess their respective body density. Body weight was measured, then each subject was allowed time in the hydrostatic weighing tank to get habituated. Ten trials were performed with the heaviest five trials averaged and used as the true underwater weight. The hydrostatic weighing tank was calibrated before and after each subject. Body density was determined using hydrostatic weighing with residual lung volume correction (Katch et al., 1967). Residual lung volume measurements were made out of the water with an oxygen rebreathing technique (Wilmore, 1969), with the subjects in the same supine position as used in the hydrostatic weighing. The average of two repeat determinations were used as the criterion score. Percent fat was calculated from body density using the Siri equation (Siri, 1956). Fat weight was determined by multiplying percent fat by total body weight. Lean body weight was determined by subtracting fat weight from total body weight.

Estimate of Resting Metabolic Rate (RMR). For determination of RMR, subjects reported to the laboratory between 6:00-8:00 AM on a fixed schedule, having fasted for 12 hours. After being weighed, subjects rested quietly for 30 minutes in a supine position with a speak-easy face mask in place for acclimation. After this rest period RMR was determined by collecting a 5-minute sample of expired air into a 60L Douglas bag with a Collins 3-way "Y" valve. This was connected to a flexible hose attached to a face mask with 2 one-way valves. The expired air was immediately analyzed for CO_2 and O_2. The analyzers were calibrated before and after the analyses using a certified gas mixture (18.2% O_2, 3.02% CO_2). The remaining volume of expired air was evacuated into a 120L Tissot spirometer. The volume from the analyzers plus the corrected Tissot reading determined the total volume. This process was completed immediately following each trial to prevent temperature changes in the gases. Using the Haldane transformation of the oxygen consumption (VO_2) equation, VO_2 was calculated (Fox et al., 1981).

Nutritional Program. Subjects (DO, DWT) followed a reduced calorie diet for the duration of the study. Baseline caloric requirements were estimated using a three day food record kept by the subjects. The average intake was then reduced by 1000 kcal/day. The minimum calories per day that a subject was allowed to be lowered to was set at 1000 kcal/day. The average kcal/day was 1200 to 1400 for the fourteen subjects. The reduction in caloric intake was based on a computer analysis of the three day food records (Thorn, 1982). The dietary protocol was taken from the American Diabetes Association exchange program (American Diabetes Association, 1976). The nutritionally balanced diet consisted of 50% carbohydrate, 25% protein, and 25% fat. Weekly sessions were conducted with the RD to provide subjects with information regarding nutritional and caloric content of food, as well as behavior modification techniques. Subjects were weighed at this time.

Research Design

A randomized control group pretest - posttest design was used in this study. The subjects were randomly assigned to the experimental (DWT) or control (DO) group.

Statistical Analyses

External Validity. The characteristics of the subjects; sedentary overfat nonsmoking females aged 18-23, allow the experimental findings from this study to be generalized only to a population possessing similiar characteristics.

<u>Internal Validity</u>. Variance was minimized by: 1) familiarizing subjects with testing equipment and protocol prior to initial tests, 2) having pre and post tests follow identical protocols, and 3) calibrating the equipment prior to all testing.

<u>Data Analysis</u>. Statistical analyses compared change scores within and between groups representing pre-tratment to post-treatment changes in % fat, TW, LBW and RMR in the two groups (DWT and DO). This procedure utilized a two way repeated measures analysis of variance (ANOVA). Significance was set apriori at an alpha level of 0.05. All data were analyzed using the Statistical Analysis System (SAS). The summary results for these measures are located in Appendix B.

A repeated measures ANOVA revealed the following variables to be significantly different ($p < 0.05$) within groups from pretest to posttest (baseline - 8 weeks):

1. TW decreased 4.4 ± 0.7 kg in the DO group.
2. TW decreased 1.9 ± 0.7 kg in the DWT group.
3. % fat decreased 3.6 ± 0.4% in the DO group.
4. % fat decreased 3.7 ± 0.6% in the DWT group.
5. Bench press maximum increased 7.2 ± 1.2 kg in the DWT group.

6. Fat weight (FTKG) decreased 4.5 $\pm$ 0.7 kg for the DO group.
7. Fat weight (FTKG) decreased 3.4 $\pm$ 0.5 kg for the DWT group.

No significant differences were observed within groups in the following ($p > 0.05$).

1. LBW in the DO group.
2. LBW in the DWT group.
3. RMR in the DO and DWT groups.
4. Bench press maximum in the DO group.

Between group (DO vs DWT) analyses revealed no significant differences in the following dependent variables over the eight weeks, RMR, % fat, and LBW. A treatment effect was observed for TW, with the DO group significantly losing more weight. When correlating LBW and VO2 there was no significant correlation at either pre, mid, or post-treatment measurement.

<u>Conclusions</u>. Based on the results of this study, the researcher retained the following null hypotheses:

1. There was no difference in RMR between or within groups pre to post-treatment in obese females after 8 weeks in the following two groups: 1) DO and 2) DWT.

2. There was no difference in % fat loss between groups in obese females after 8 weeks in the following two groups: 1) DO and 2) DWT.
3. There was no difference in LBW change between or within groups in pre to post-treatment obese females after 8 weeks in the following two groups: 1) DO and 2) DWT.

The researcher failed to retain the following null hypothesis:

1. There was no difference in TW loss between groups in obese females after 8 weeks in the following two groups: 1) DO and 2) DWT.

APPENDIX B

RAW DATA/STATISTICS

RAW DATA

SUBJ	TRT	WGTPRE	WGTMID	WGTPST	FATPRE	FATMID	FATPST
1	1	86.2	85.4	86.2	50.2	45.9	47.5
2	1	80.3	79.5	79.2	43.2	39.9	40.3
3	1	80.4	76.6	76.5	44.6	40.3	40.8
4	1	61.0	58.7	57.4	34.8	36.8	33.3
5	1	78.0	80.3	79.5	53.1	48.6	48.4
6	1	69.1	68.1	67.9	35.7	33.3	31.5
7	1	74.9	73.0	71.9	43.4	43.1	40.8
8	1	68.1	65.2	63.9	36.7	32.4	29.8
9	2	78.8	75.3	74.1	35.3	34.8	30.5
10	2	75.6	73.4	72.4	34.8	33.4	31.7
11	2	98.3	93.5	91.8	47.1	44.0	43.1
12	2	83.8	83.0	82.1	48.7	48.1	47.0
13	2	75.6	72.1	69.4	42.9	38.3	39.0
14	2	69.7	67.2	65.4	37.3	36.4	33.2

TRT 1 = DWT

2 = DO

Weight (WGT) expressed in Kgs

Percent fat (% fat) expressed in percent

RAW DATA

SUBJ	TRT	VO2PRE	VO2MID	VO2PST	LBWPRE	LBWMID	LBWPST
1	1	1.34	2.60	2.26	42.9	46.2	45.3
2	1	3.20	3.13	2.95	45.6	47.8	47.3
3	1	2.23	2.78	2.44	44.5	45.7	45.3
4	1	3.43	3.73	2.74	39.8	37.1	38.3
5	1	2.13	2.94	2.46	36.6	41.3	41.0
6	1	4.32	3.19	2.56	44.4	45.2	46.5
7	1	2.70	3.01	2.71	42.4	41.5	42.6
8	1	2.73	3.71	2.90	43.1	44.1	44.9
9	2	2.34	2.88	2.65	50.9	49.1	51.5
10	2	2.99	2.99	2.93	49.3	48.9	49.5
11	2	1.83	2.19	2.39	52.0	52.4	52.3
12	2	2.27	2.22	1.90	42.9	43.1	43.5
13	2	2.71	3.11	2.98	43.2	44.5	42.3
14	2	1.80	2.89	2.60	43.7	42.7	43.7

TRT 1 = DWT

2 = DO

Lean body weight (LBW) is in Kgs

Oxygen uptake (VO2) is in ml/kg/min

RAW DATA

SUBJ	TRT	FTKGPRE	FTKGMID	FTKGPST	RMPRE	RMPST
1	1	43.3	39.2	40.9	34.1	47.7
2	1	34.7	31.7	31.9	25.0	32.3
3	1	35.9	30.9	31.2	27.3	31.8
4	1	21.2	21.6	19.1	31.8	38.7
5	1	41.4	39.0	38.5	22.7	27.3
6	1	24.7	22.9	21.4	27.3	38.7
7	1	32.5	31.5	29.3	27.3	31.8
8	1	25.0	21.2	19.0	31.8	36.8
9	2	27.8	26.2	22.6	43.2	47.7
10	2	26.3	24.5	23.0	29.5	27.3
11	2	46.3	41.1	39.6	36.8	36.8
12	2	40.8	39.9	38.6	36.8	31.8
13	2	32.4	27.6	27.1	29.5	32.3
14	2	26.0	24.5	21.7	34.1	36.4

TRT 1 = DWT

2 = DO

Fat weight (FTKG) expressed in Kgs

Repetition maximum (RM) expressed in Kgs

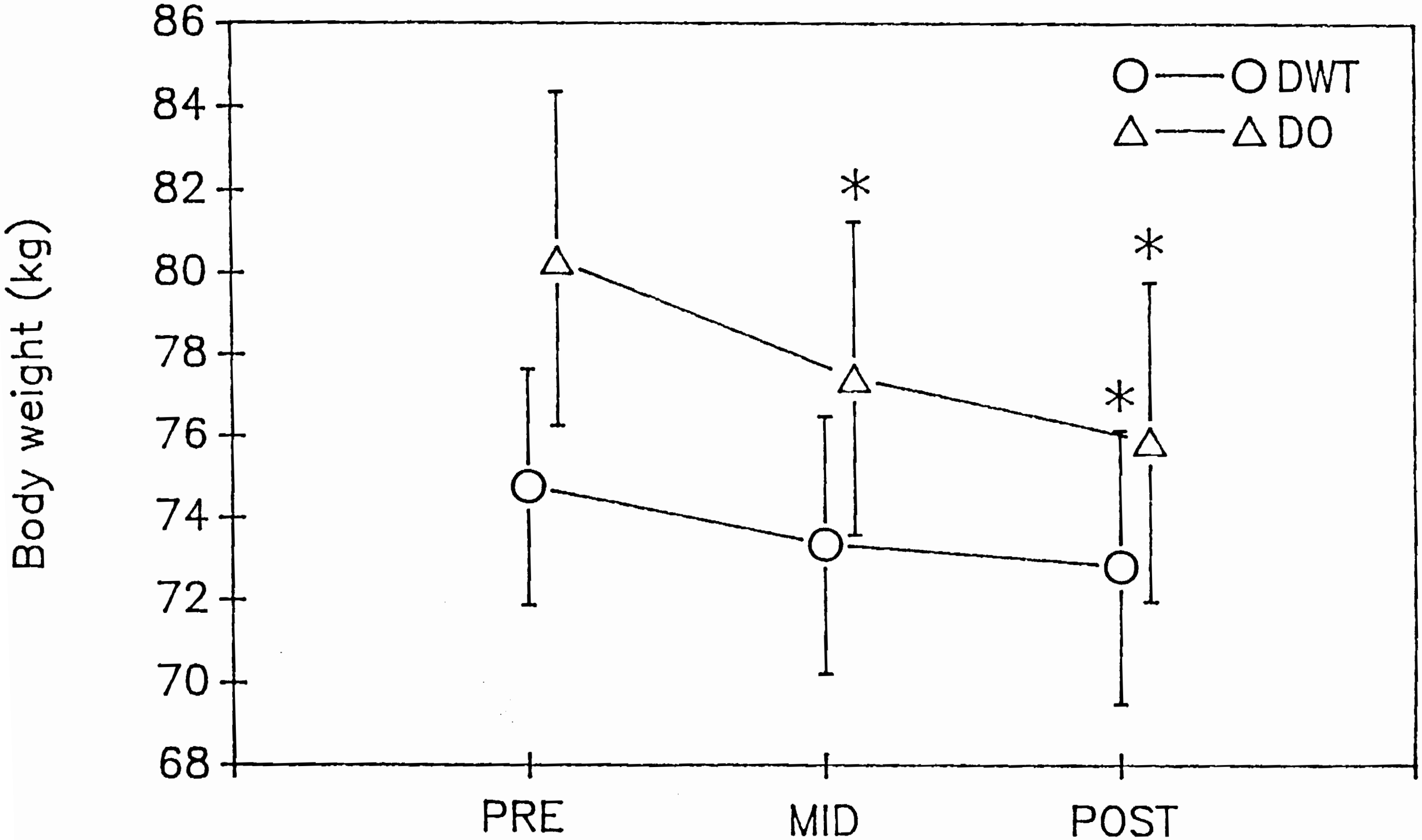

Figure 1. Pre, mid, and posttest body weight measures.
* indicates significant difference from baseline ($p < 0.05$)

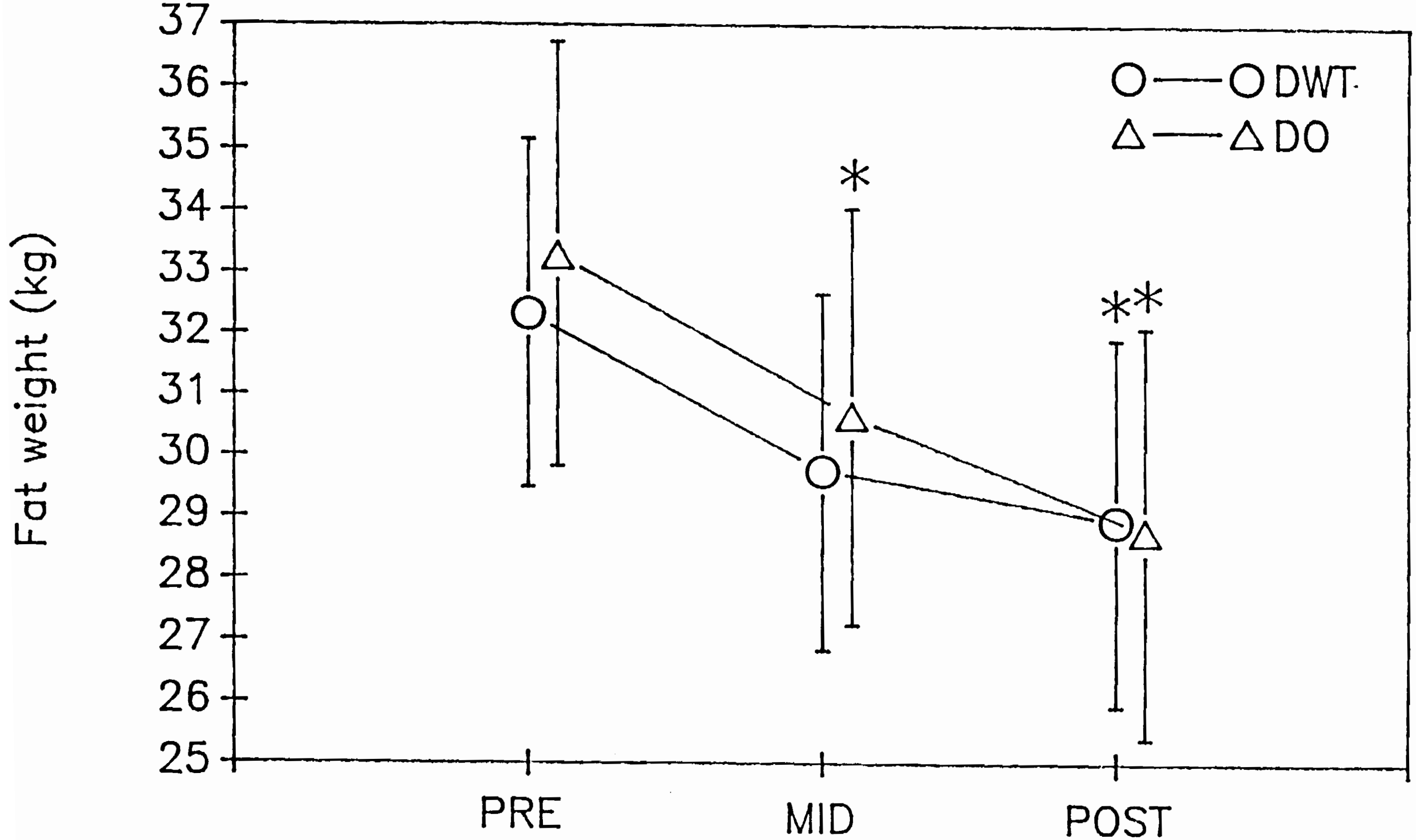

Figure 2. Pre, mid, and posttest fat weight measures.
* indicates significant difference from baseline ($p < 0.05$)

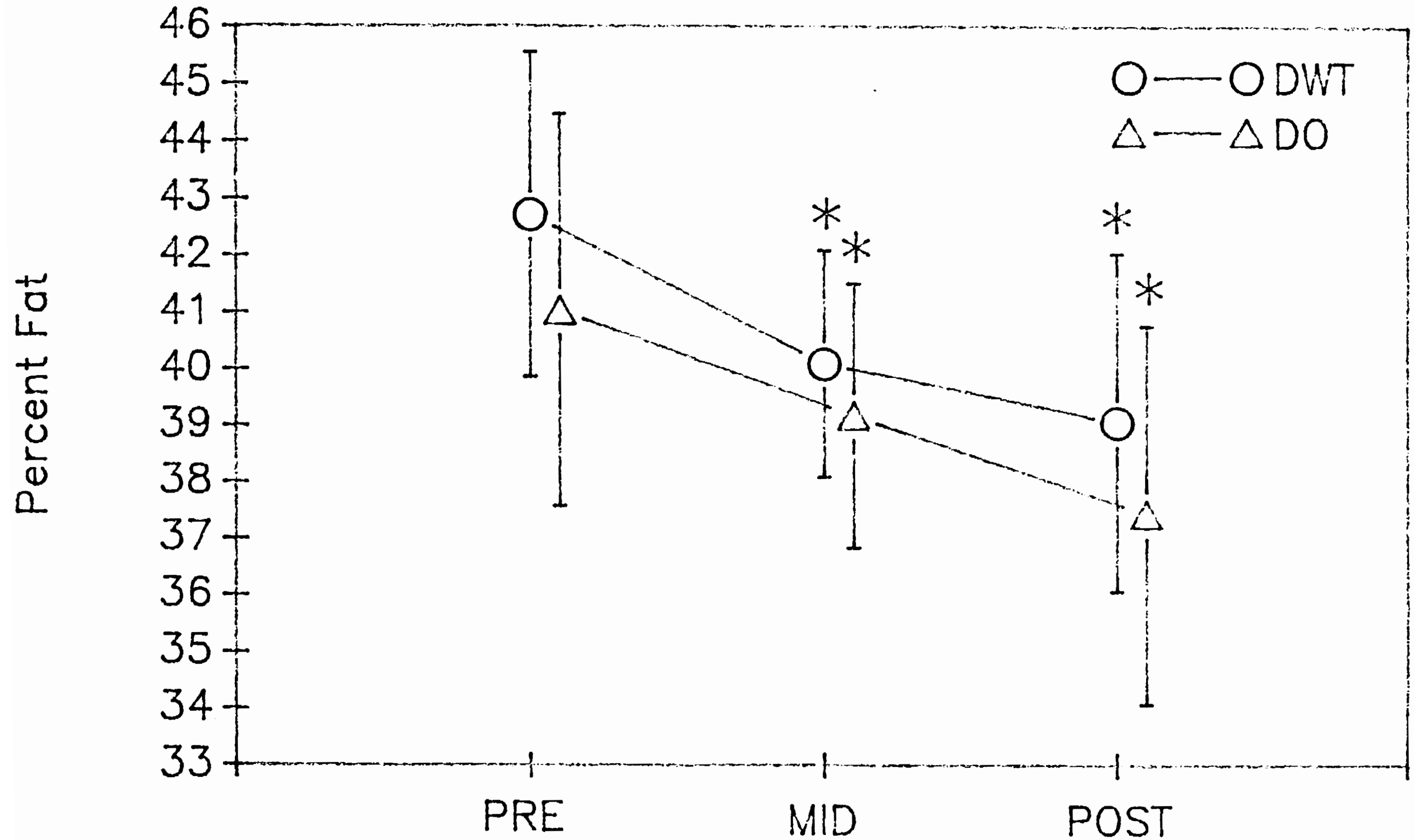

Figure 3. Pre, mid, and posttest percent fat measures.
* indicates significant difference from baseline ($p < 0.05$)

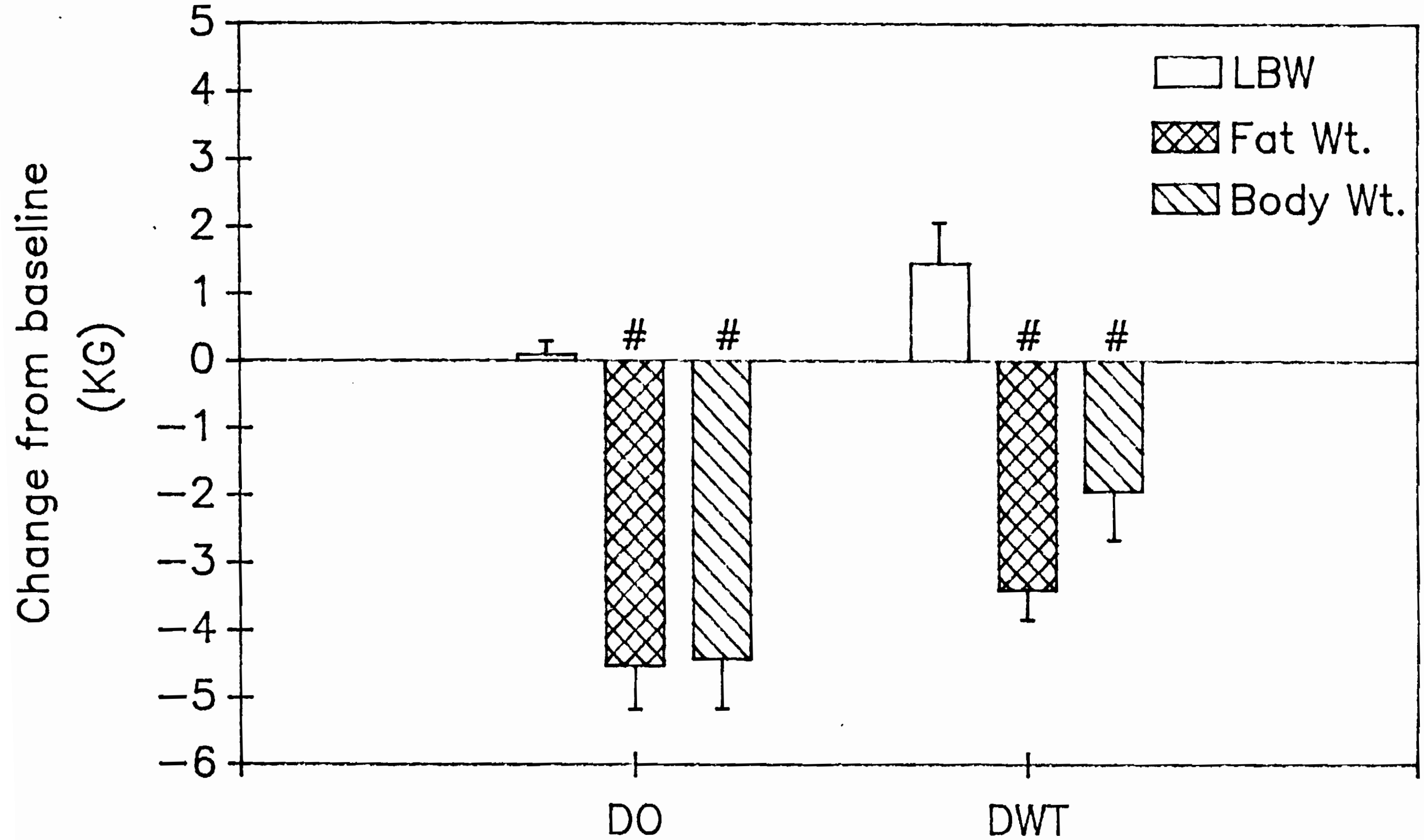

Figure 4. Body composition changes. LBW = lean body weight, DO = diet only, and DWT = diet + weight training. # Significant difference pre − post; $p < 0.05$

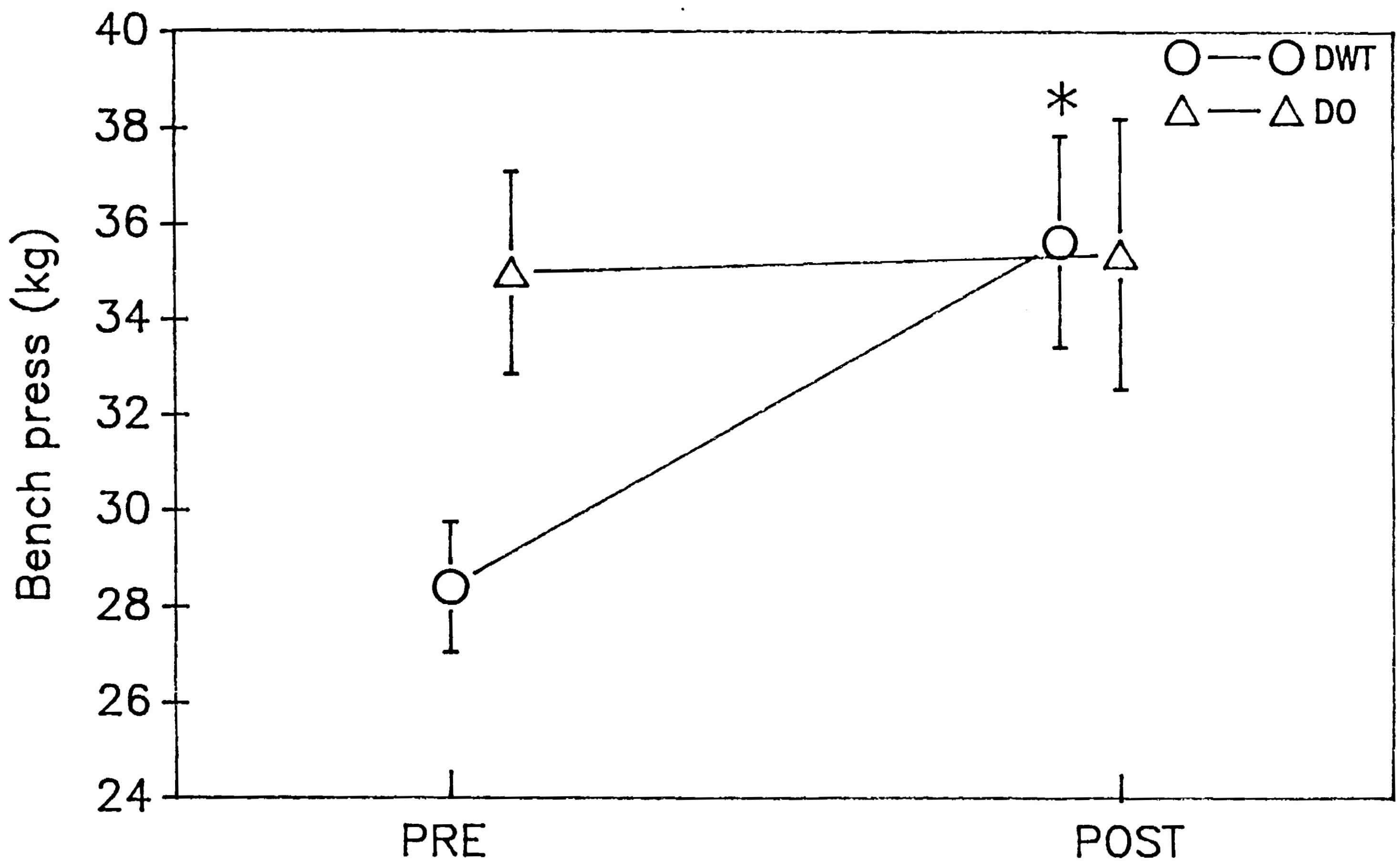

Figure 5. Pre and posttest bench press measures.
* indicates significant difference from baseline ($p < 0.05$)

STATISTICAL ANALYSES

Summary ANOVA Table for body weight measure

Source	DF	SS	MS	F	P
TRT	1	183.49	183.49	0.73	0.4091
ERROR	12	3009.53	250.79	-	-
TIME	2	72.33	36.17	30.59	0.0001
TIME*TRT	2	10.81	5.40	4.57	0.0389
ERROR	24	28.37	1.18	-	-

Summary ANOVA Table for DWT group from baseline - 8 weeks for body weight

Source	DF	SS	MS	F	P
WGT	2	16.01	8.00	5.90	0.0320
ERROR	14	19.01	1.35	-	-

Summary ANOVA Table for DWT group from baseline - 4 weeks for body weight

Source	DF	SS	MS	F	P
WGT	1	15.68	15.68	4.64	0.0681
ERROR	7	23.64	3.38	-	-

Summary ANOVA Table for DWT group from 4 weeks - 8 weeks for body weight

Source	DF	SS	MS	F	P
WGT	1	2.31	2.31	4.37	0.0748
ERROR	7	3.69	0.53	-	-

Summary ANOVA Table for DO group from baseline - 8 weeks for body weight

Source	DF	SS	MS	F	P
WGT	2	60.74	30.37	32.40	0.0009
ERROR	10	9.37	0.94	-	-

Summary ANOVA Table for DO group from baseline - 4 weeks for body weight

Source	DF	SS	MS	F	P
WGT	1	49.88	49.88	26.57	0.0036
ERROR	5	9.39	1.88	-	-

Summary ANOVA Table for DO group from 4 weeks - 8 weeks for body weight

Source	DF	SS	MS	F	P
WGT	1	14.42	14.42	31.96	0.0024
ERROR	5	2.26	0.45	-	-

Summary ANOVA Table for % fat measure

Source	DF	SS	MS	F	P
TRT	1	0.0021	0.0021	0.17	0.6834
ERROR	12	0.1419	0.0118	-	-
TIME	2	0.0092	0.0046	28.21	0.0001
TIME*TRT	2	0.0001	0.0001	0.39	0.6816
ERROR	24	0.0039	0.0002	-	-

Summary ANOVA Table for DWT group from baseline - 8 weeks for % fat

Source	DF	SS	MS	F	P
FAT	2	0.0057	0.0029	14.55	0.0004
ERROR	14	0.0027	0.0002	-	-

Summary ANOVA Table for DWT group from baseline - 4 weeks for % fat

Source	DF	SS	MS	F	P
FAT	1	0.006	0.006	9.75	0.0168
ERROR	7	0.004	0.0005	-	-

Summary ANOVA Table for DWT group from 4 weeks - 8 weeks for % fat

Source	DF	SS	MS	F	P
FAT	1	0.0009	0.0009	2.56	0.1536
ERROR	7	0.0023	0.0003	-	-

Summary ANOVA Table for DO group from baseline - 8 weeks for % fat

Source	DF	SS	MS	F	P
FAT	2	0.0039	0.0019	16.59	0.0007
ERROR	10	0.0012	0.0001	-	-

Summary ANOVA Table for DO group from baseline - 4 weeks for % fat

Source	DF	SS	MS	F	P
FAT	1	0.002	0.002	7.54	0.0405
ERROR	5	0.001	0.0003	-	-

Summary ANOVA Table for DO group from 4 weeks - 8 weeks for % fat

Source	DF	SS	MS	F	P
FAT	1	0.002	0.002	5.83	0.0605
ERROR	5	0.002	0.0003	-	-

Summary ANOVA Table for LBW measure

Source	DF	SS	MS	F	P
TRT	1	138.43	138.43	3.75	0.0769
ERROR	12	443.47	36.96	-	-
TIME	2	4.22	2.11	1.85	0.1836
TIME*TRT	2	4.49	2.24	1.96	0.1621
ERROR	24	27.40	1.14	-	-

Summary ANOVA Table for DWT group from baseline - 8 weeks for LBW

Source	DF	SS	MS	F	P
LBW	2	9.6560	4.8280	3.19	0.1043
ERROR	14	21.2219	1.5158	-	-

Summary ANOVA Table for DWT group from baseline - 4 weeks for LBW

Source	DF	SS	MS	F	P
LBW	1	11.23	11.23	2.13	0.1880
ERROR	7	36.95	5.28	-	-

Summary ANOVA Table for DWT group from 4 weeks - 8 weeks for LBW

Source	DF	SS	MS	F	P
LBW	1	0.617	0.617	0.76	0.4137
ERROR	7	5.72	0.817	-	-

Summary ANOVA Table for DO group from baseline - 8 weeks for LBW

Source	DF	SS	MS	F	P
LBW	2	0.0382	0.1909	0.31	0.6294
ERROR	10	6.1775	0.6177	-	-

Summary ANOVA Table for DO group from baseline - 4 weeks for LBW

Source	DF	SS	MS	F	P
LBW	1	0.371	0.371	0.30	0.6066
ERROR	5	6.159	1.231	-	-

Summary ANOVA Table for DO group from 4 weeks - 8 weeks for LBW

Source	DF	SS	MS	F	P
LBW	1	0.718	0.718	0.32	0.5944
ERROR	5	11.11	2.222	-	-

Summary ANOVA Table for RMR measure

Source	DF	SS	MS	F	P
TRT	1	0.9507	0.9507	1.78	0.2075
ERROR	12	6.4262	0.5355	-	-
TIME	2	1.1658	0.5828	3.87	0.0547
TIME*TRT	2	0.3256	0.1628	1.08	0.3550
ERROR	24	3.6133	0.1506	-	-

Summary ANOVA Table for DWT group from baseline - 8 weeks for RMR

Source	DF	SS	MS	F	P
RMR	2	1.1145	0.5573	2.63	0.1361
ERROR	14	2.9709	0.2122	-	-

Summary ANOVA Table for DWT group from baseline - 4 weeks for RMR

Source	DF	SS	MS	F	P
RMR	1	1.133	1.133	2.06	0.1940
ERROR	7	3.842	0.549	-	-

Summary ANOVA Table for DWT group from 4 weeks - 8 weeks for RMR

Source	DF	SS	MS	F	P
RMR	1	2.071	2.071	26.52	0.0013
ERROR	7	0.546	0.078	-	-

Summary ANOVA Table for DO group from baseline - 8 weeks for RMR

Source	DF	SS	MS	F	P
RMR	2	0.4691	0.2345	3.65	0.0799
ERROR	10	0.6424	0.0642	-	-

Summary ANOVA Table for DO group from baseline - 4 weeks for RMR

Source	DF	SS	MS	F	P
RMR	1	0.913	0.913	5.31	0.0694
ERROR	5	0.859	0.172	-	-

Summary ANOVA Table for DO group from 4 weeks - 8 weeks for RMR

Source	DF	SS	MS	F	P
RMR	1	0.115	0.115	3.10	0.1385
ERROR	5	0.185	0.037	-	-

Summary ANOVA Table for 1RM measure

Source	DF	SS	MS	F	P
TRT	1	68.401	68.401	1.20	0.2944
ERROR	12	682.897	56.908	-	-

Summary ANOVA Table for DWT group from baseline - 8 weeks for 1RM

Source	DF	SS	MS	F	P
1RM	1	208.803	208.803	34.44	0.0006
ERROR	7	42.438	6.063	-	-

Summary ANOVA Table for DO group from baseline - 8 weeks for 1RM

Source	DF	SS	MS	F	P
1RM	1	0.4800	0.4800	0.08	0.7924
ERROR	5	31.1300	6.2260	-	-

Summary ANOVA Table for FTKG measure

Source	DF	SS	MS	F	P
TRT	1	3.168	3.168	0.02	0.8997
ERROR	12	2296.023	191.335	-	-
TIME	2	111.416	55.708	47.28	0.0001
TIME*TRT	2	2.798	1.399	1.19	0.3224
ERROR	24	28.278	1.178	-	-

Summary ANOVA Table for DWT group from baseline - 8 weeks for FTKG

Source	DF	SS	MS	F	P
FTKG	2	50.422	25.211	21.65	0.0001
ERROR	14	16.306	1.165	-	-

Summary ANOVA Table for DWT group from baseline - 4 weeks for FTKG

Source	DF	SS	MS	F	P
FTKG	1	53.46	53.46	17.24	0.0043
ERROR	7	21.70	3.10	-	-

Summary ANOVA Table for DWT group from 4 weeks - 8 weeks for FTKG

Source	DF	SS	MS	F	P
FTKG	1	5.315	5.315	2.37	0.1673
ERROR	7	15.679	2.240	-	-

Summary ANOVA Table for DO group from baseline - 8 weeks for FTKG

Source	DF	SS	MS	F	P
FTKG	2	62.121	31.060	25.94	0.0001
ERROR	10	11.972	1.197	-	-

Summary ANOVA Table for DO group from baseline - 4 weeks for FTKG

Source	DF	SS	MS	F	P
FTKG	1	41.64	41.64	12.14	0.0176
ERROR	5	17.15	3.43	-	-

Summary ANOVA Table for DO group from 4 weeks - 8 weeks for FTKG

Source	DF	SS	MS	F	P
FTKG	1	21.56	21.56	18.01	0.0081
ERROR	5	5.98	1.19	-	-

APPENDIX C

REQUEST TO HUMAN SUBJECTS FORM

CERTIFICATION OF EXEMPTION OF PROJECTS INVOLVING HUMAN SUBJECTS

Principal Investigator(s) Dr. Reed Humphrey, Darren Robinson

Department(s) HPER

Project Title The effect of exercise on resting metabolism, lean body weight, total weight, and percent fat during caloric restriction in obese females

Source of Support: Departmental Research ** Sponsored Research __ Proposal No. ______

1. The criteria for "exemption" from review by the IRB for a project involving the use of human subjects and with no risk to the subject is listed below. Please initial all applicable conditions and provide the substantiating statement of protocol.

☐ a. The research will be conducted in established or commonly established educational settings, involving normal education practices. For example:

a) Research on regular and special education instructional strategies;
b) Research on effectiveness of instructional techniques, curricula or classroom management techniques.

☐ b. The research involves use of education tests (☐ cognitive, ☐ diagnostic, ☐ aptitude, ☐ achievement), and the subject cannot be identified directly or through identifiers with the information.

☐ c. The research involves survey or interview procedures, in which:

☐ a) Subjects cannot be identified directly or through identifiers with the information;
☐ b) Subject's responses, if known, will not place the subject at risk of criminal or civil liability or be damaging to the subject's financial standing or employability;
☐ c) The research does not deal with sensitive aspects of subject's own behavior (illegal conduct, drug use, sexual behavior or alcohol use);
☐ d) The research involves survey or interview procedures with elected or appointed public officials, or candidates for public office.

☐ d. The research involves the observation of public behavior, in which:

☐ a) The subjects cannot be identified directly or through identifiers;
☐ b) The observations recorded about an individual could not put the subject at risk of criminal or civil liability or be damaging to the subject's financial standing or employability;
☐ c) The research does not deal with sensitive aspects of the subject's behavior (illegal conduct, drug use, sexual behavior or use of alcohol).

☐ e. The research involves collection or study of existing data, documents, records, pathological specimens or diagnostic specimens, or which:

☐ a) The sources are publicly available; or
☐ b) The information is recorded such that the subject cannot be identified directly or indirectly through identifiers.

2. I further certify that the project will not be changed to increase the risk or exceed the exempt condition(s) without filing an additional certification or application for approval by the Human Subjects Review Board.

Note: If children are in any way at risk while this project is underway, the chairman of the IRB should be notified immediately in order to take corrective action.

Signature: Principal Investigator(s) Date Signature: Principal Investigator(s) Date

(Optional Approval) Signature: Board Chairman/Authorized Reviewer Date

CERTIFICATE
OF
APPROVAL FOR RESEARCH
INVOLVING HUMAN SUBJECTS
Division of HPER

The Human Subjects Committee of the Division of Health, Physical Education and Recreation has reviewed the research proposal of
Dr. Reed Humphrey and Darren Robinson
entitled The effect of resistive exercise on resting metabolic rate, lean body weight, total weight, and percent fat during caloric restriction in obese females

The members have judged the subjects participating in the related experiment (not to be at risk) as a result of their participation.

(If a risk proposal) Procedures have been adopted to control the risks at acceptably low levels. The potential scientific benefits justify the level of risk to be imposed.

Members of Divisional
Human Subjects Committee

Chairman	Date
	Date
	Date
	Date

REQUEST FOR APPROVAL OF RESEARCH PROPOSAL
IN THE DIVISION OF HPER

Submitted to

Dr. Charles Baffi
Chairman, Division Human Subjects Committee and/or
Chairman, Instructional Review Board

by

Dr. Reed Humphrey (principal investigator) & Darren Robinson
Principal Investigator

TITLE: The effect of resistive exercise on resting metabolic rate, lean body weight, and percent fat during caloric restriction in obese females.

BACKGROUND/SCIENTIFIC JUSTIFICATION: There has been a great deal of research focusing on the effect of caloric restriction on obesity, but very few studies have added resistive weight training and looked at the effect on resting metabolic rate (RMR), lean body weight (LBW), and percent fat (% fat). It is believed that a benefit of exercise training is an adaptive increase in LBW with a concurrent decrease in excess body fat. LBW has been shown to be the most predictive factor in determining RMR, but this is still a controversial issue.

PURPOSE(S): To determine the effect of weight training on total weight, percent fat, lean body weight, and resting metabolic rate during 8 weeks of caloric restriction.

EXPERIMENTAL METHODS & PROCEDURES: 30 obese (> 30% body fat) females aged 18-30 will be recruited to participate in this study. Before testing, subjects will be given a detailed consent form explaining all aspects of the study. After an orientational meeting the subjects will have their total weight, body fat, and RMR determined and will have their 1 repetition maximum strength and flexibility determined. Strength will be determined through the use of free weights. A 3-day food diary will be completed by the subjects and from this their daily caloric intake will be decreased by 1000 kcal/day as prescribed by a Registered Dietitian (RD). The study will last eight weeks with weekly meeting with the RD and testing (% fat, RMR) at baseline and weeks 4 and 8. After baseline measures are taken the subjects will be divided into two groups with half of the subjects in a flexibility group and the other half in a resistive weight training group. The two groups will meet three times per week for 30-45 minutes per session for the duration of the study. The weight training group will perform six different lifts at each session. (bench press, calf raises, military press, triceps extension, biceps curl, and leg extensions).

STATEMENT DESCRIBING LEVEL OF RISK TO SUBJECTS: The level of risk to the subjects is low in this experiment. The subject is given several trails during hydrostatic weighing to ensure subject comfort and maximum accuracy and reliability.

PROCEDURES TO MINIMIZE SUBJECT RISK (IF APPLICABLE): Described above.

RISK/BENEFIT RATIO (IF RISK PROJECT): Risk will be low and benefits will be high. The subject will get an accurate measurement of % fat and RMR. In addition, the subject will get dietary counceling once a week from a RD. The subject will be prescribed caloric restriction that should enable them to lose approximately 2 lbs/week for the duration of the study.

APPENDIX D

INFORMED CONSENT

HUMAN PERFORMANCE LABORATORY

Division of Health, Physical Education and Recreation
Virginia Polytechnic Institute and State University

INFORMED CONSENT

I,__________________________, do hereby voluntarily agree and consent to participate in a testing program conducted by the personnel of the Human Performance Laboratory of the Division of Health, Physical Education and Recreation of Virginia Polytechnic Institute and State University.

Title of Study: Effect of Exercise on Resting Metabolic Rate, Lean Body Weight, and Percent Fat during caloric restriction in obese females.

The purposes of this experiment include: Determining the effect of exercise on percent fat (%Fat), lean body weight(LBW), and resting metabolic rate(RMR) during 8 weeks of caloric restriction, LBW, %Fat, and RMR will be determined at baseline and at weeks 4 and 8.

I voluntarily agree to participate in this testing program. It is my understanding that my participation will include: 1) Caloric restriction of 1000 kcal/day based on dietary analysis. Counseling by a Registered Dietician and weekly educational programming included. 2) Body composition determinated by hydrostatic weighing, RMR determination (subject will report to the lab between 6:00-8:00 A.M. on a fixed schedule and rest in a supine position for 25 minutes, then the subject will breathe into a Douglas bag via a facemask for 5 minutes. The percent O_2 and CO_2 will be analyzed to determine RMR), and residual volume determination (subject will breathe into a bag that is filled with pure O_2 for 5-7 breaths exhaling maximally on the last breath.) at baseline and weeks 4 and 8. 3) Participation in a flexibility or resistive weight training regimen 3 times/week for the duration of the study.

I understand that participation in this experiment may produce certain discomforts and risks. These discomforts and risks include: Tendinitis, strains, sprains, bursitis, fractures, delayed muscle soreness, contusions, abrasions, and even the possibility of death. Also there are many other risks of injury including serious and disabling injuries which may arise due to participation in this study. It is not possible to specifically list each and every individual risk.

Certain personal benefits may be expected from participation in this experiment. These include: 1) a healthful, and gradual weight loss over the 8 week caloric restriction program, 2) free physical assessments including hydrostatic weighing to determine % fat, 3) a supervised exercise regimen including either a strength or flexibility program for 8 weeks, and 4) specific dietary instruction and educational program. Overall, I will learn valuable information concerning desired weight level, weight loss, and maintenance.

Appropriate alternative procedures that might be advantageous to me include: 1) Information regarding commercial weight-loss choices, and 2) information regarding fitness centers.

I understand that any data of a personal nature will be held confidential and will be used for research purposes only. I also understand that these data may only be used when not identifiable with me.

I understand that I may abstain from participation in any part of the experiment or withdraw from the experiment should I feel the activities might be injurious to my health. The experimenter may also terminate my participation should he feel the activities might be injurious to my health.

I understand that it is my personal responsibility to advise the researchers of any preexisting medical problem that may affect my participation or of any medical problems that might arise in the course of this experiment and that no medical treatment or compensation is available if injury is suffered as a result of this research. A telephone is available which would be used to call the local hospital for emergency service.

I have read the above statements and have had the opportunity to ask questions. I understand that the researchers will, at any time, answer my inquiries concerning the procedures used in this experiment.

Scientific inquiry is indispensable to the advancement of knowledge. Your participation in this experiment provides the investigator the opportunity to conduct meaningful scientific observations designed to make significant educational contribution.

If you would like to receive the results of this investigation, please indicate this choice by marking in the appropriate space provided below. A copy will then be distributed to you as soon as the results are made available by the investigator. Thank you for making this important contribution.

______I request a copy of the results of this study.

Date______________________ Time__________________ a.m./p.m.

Participant Signature__________________________________

Witness____________________________________
HPL Personnel

Project Director Dr. Reed Humphrey Telephone 231-5834

HPER Human Subjects Chairman Dr. Charles Baffi Telephone 231-8284

Dr. Charles Waring, Chairman, Institutional Review Board for Research Involving Human Subjects. Phone 961-5283.

APPENDIX E

WRITTEN CONSENT OF PROCEDURES

I, ____ agree to comply with the diet and exercise protocol of this study. This includes <u>not</u> participating in regular (three times per week) exercise class or routine except for the weight training or flexibility exercises that are prescribed for me. If I fail to comply in either the diet or exercise protocol I will infoem the Registered Dietitian or the exercise supervisor.

____

Participant

____

Witness

APPENDIX F

MEDICAL HISTORY FORM

PERSONAL INFORMATION

Name: ____________ Age: ______ Date of Birth: ____________ Sex: ____

Home Address: ____________ Home Telephone No.: ____________

Occupation: ______ Height/Weight ______ Social Security No.: ____________

HOSPITALIZATIONS

Please list the last three (3) times you have been hospitalized beginning with the most recent:
Type of Operation/Illness:

1. ____________ 2. ____________ 3. ____________

Month and year:

Duration:

Name & Location of Hospital:

FAMILY HISTORY

Have any members of your family had, or do they now have any of the following?
(Please indicate the age at which it occurred)

	Heart Disease	Diabetes	Stroke	High Blood Pressure	Obesity	Age of Occurrence
Mother						
Father						
Sister(s)						
Brother(s)						

MEDICAL HISTORY

1) Do you have any known allergies? YES ☐ NO ☐
If YES, please explain: ____________

2) Please check the following diseases or conditions which you had or currently have:

- ☐ High blood pressure
- ☐ High blood cholesterol
- ☐ High blood triglycerides
- ☐ Angina pectoris
- ☐ Heart attack
- ☐ Heart surgery
- ☐ Heart failure
- ☐ Heart murmur
- ☐ Rheumatic fever
- ☐ Scarlet fever
- ☐ Arteriosclerosis
- ☐ Aneurysm
- ☐ Anemia
- ☐ Infectious Mononucleosis
- ☐ Jaundice
- ☐ Hepatitis
- ☐ Phlebitis
- ☐ Diabetes
- ☐ Gout
- ☐ Asthma
- ☐ Pneumonia
- ☐ Bronchitis
- ☐ Abnormal Chest X-Ray
- ☐ Kidney Stones
- ☐ Urinary Tract infections
- ☐ Emphysema
- ☐ Thyroid problem
- ☐ Hernia
- ☐ Cancer
- ☐ Epilepsy or seizures
- ☐ Prostate problem
- ☐ Nervous/emotional problems
- ☐ Other

Please give dates and explanation, if applicable, to any of the above:

Problem	Date	Explanation

3) Please check the appropriate box:

Tobacco Smoking	☐ Non-user	☐ Former User	☐ Cigarettes, 10 or less per day	☐ Cigarettes 11-20 per day	☐ Cigarettes 21-31 per day	☐ Cigarettes, Over 32 per day
Cholesterol	☐ Don't know	☐ Below 200 mg%	☐ 201-230 mg%	☐ 231-255 mg%	☐ 256-280 mg%	☐ Above 281
Stress	☐ No Stress	☐ Occasional Mild Stress	☐ Frequent Mild Stress	☐ Frequent Moderate Stress	☐ Frequent High Stress	☐ Constant High Stress

4) Have you experienced, or do you currently experience any of the following on a recurring basis?

	At Rest		During Exertion	
	YES	NO	YES	NO
Shortness of breath	☐	☐	☐	☐
Dizziness or fainting	☐	☐	☐	☐
Daily coughing	☐	☐	☐	☐
Chest pressure	☐	☐	☐	☐
Chest pain	☐	☐	☐	☐
Joint soreness	☐	☐	☐	☐
Joint swelling	☐	☐	☐	☐
Ankle swelling	☐	☐	☐	☐
Slurring or loss of speech	☐	☐	☐	☐
Skipped heart beats	☐	☐	☐	☐
Fast heart rate	☐	☐	☐	☐
Unusually nervous or anxious	☐	☐	☐	☐
Sudden numbness or tingling	☐	☐	☐	☐
Loss of feeling in arms, hands, feet or legs	☐	☐	☐	☐
Blurring of vision	☐	☐	☐	☐

If YES to any of the preceding, please explain:

____

____

ORTHOPEDIC/MUSCULOSKELETAL INJURIES

Have you experienced or do you currently experience any of the following bone, joint, or muscle problems?

- ☐ Stiff or painful muscles
- ☐ Swollen joints
- ☐ Painful feet
- ☐ Severe Muscle Strain
- ☐ Limited range of motion at any joint
- ☐ Bursitis
- ☐ Arthritis
- ☐ Muscle Weakness
- ☐ Amputation
- ☐ Fractures or dislocations
- ☐ Tennis elbow
- ☐ Torn ligaments
- ☐ Pinched nerve
- ☐ Trick knee or other knee injury
- ☐ Head injury
- ☐ Shoulder injury
- ☐ Ankle injury
- ☐ Whiplash or other neck injury
- ☐ Slipped disc
- ☐ Curvature of the spine

Do any of the above limit your ability to exercise? YES ☐ NO ☐

If you answered YES to any of the above, please explain:

____

____

____

APPENDIX G

SUBJECT EXERCISE RECORDS

Human Performance Lab

Weight Loss/Strength Training Record

Name ________________________________

Date _________________ Supervisor ____________________

Exercise				Comments
Bench Press	/	/	/	
Leg Ext.	/	/	/	
Military Pr.	/	/	/	
Toe Raises	/	/	/	
Bicep Curl	/	/	/	
Tricep Ext.	/	/	/	
Sit-ups	/	/	/	

Date _________________ Supervisor ____________________

Exercise				Comments
Bench Press	/	/	/	
Leg Ext.	/	/	/	
Military Pr.	/	/	/	
Toe Raises	/	/	/	
Bicep Curl	/	/	/	
Tricep Ext.	/	/	/	
Sit-ups	/	/	/	

Date _________________ Supervisor ____________________

Exercise				Comments
Bench Press	/	/	/	
Leg Ext.	/	/	/	
Military Pr.	/	/	/	
Toe Raises	/	/	/	
Bicep Curl	/	/	/	
Tricep Ext.	/	/	/	
Sit-ups	/	/	/	

APPENDIX H

FLEXIBILITY PROGRAM

FLEXIBILITY PROGRAM

Each exercise was performed for 30 seconds and performed 3 times.

STANDING

1) Arm circles
2) Arms A. across chest
   B. "pat" yourself on the back
3) Neck A. forward
   B. left
   C. right
4) Side stretches
5) Knee lunge
6) Calf stretch against the wall
7) Soleus stretch against the wall

SITTING

1) Hurdle stretch
2) Straddle stretch
3) Butterflies
4) Legs in front and touch toes
5) Knees to chest
6) 1 leg to chest/ repeat with other leg
7) Ankle circles
8) Pretzel
9) Indian stretch forward

VITA

Darren Robinson was born on February 12, 1965 in Waukegan, Illinois. He was raised in Mosinee, Wisconsin. He went to high school at D.C. Everest where he played basketball and baseball. He received a Bachelor of Science degree in Physical Education from the University of Wisconsin-Madison.

In August of 1988 he came to Blacksburg Virginia to obtain his Masters of Science degree in Exercise Science. Upon completion of his degree he plans to work in either cardiac rehabilitation or corporate fitness. He hopes to someday coach basketball or own and design a golf course.