COMPARISON OF ISOENERGETIC AEROBIC VERSUS AEROBIC PLUS RESISTANCE EXERCISE PROGRAM DURING A WEIGHT LOSS PROGRAM

by

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Thesis submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

Education

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May 1993

Blacksburg, Virginia

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(Abstract)

Nineteen obese women were studied to determine the effects of two different exercise prescriptions which differed in the type of activity but were matched for total energy expenditure. All women met once per week for twelve weeks as a group to receive the same recommendations concerning dietary modification. A low fat, self selected diet of approximately 1200-1500 kcal was recommended. Ten women participated in a walking program four days/week (GP1) which progresses to 160 minutes per week at 70% HR max. The second group (GP2) of nine women did two days/week (up to 90 minutes/week) walking and two days/week resistance training (up to 90 minutes/week). The resistance training consisted of eight exercises, 8-15 repetitions, at 50-85% of 1 RM, and three sets. All exercises were supervised and attendance for all women was greater than 92% of all the sessions. Losses of body weight (BW) (-5.7$\pm$ 1.1 kg and - 4.5$\pm$ 1.0 kg for GP1 and GP2, respectively), body fat (-3.9$\pm$ 1.1 kg and -4.9 $\pm$ 1.0 kg for GP1 and GP2 , respectively) and fat free mass (-2.1 $\pm$ .7 kg and -1.6 $\pm$ .9 kg for GP1 and GP2, respectively), and percent body fat (-2.1 $\pm$ .7 and -1.5 $\pm$ .9 for GP1 and GP2, respectively) were significant over time for both groups with no significant differences between groups. However, GP1 tended to lose more percent body fat and FFM than GP2. Absolute RMR showed a nonsignificant decrease overtime for both groups (-139.7 $\pm$ 107.5

kcal/day and -48.1 $\pm$ 75.0 kcal/day for GP1 and GP2, respectively). RMR expressed per bodyweight (kg) or fat free mass was maintained for both groups over the experiment (+.4 RMR/kg and -1.1 RMR/FFM respectively for GP1 and +.6 RMR/kg and -.04 RMR/FFM respectively for GP2). In conclusion, the total energy cost of exercise rather than the type of activity seems most important in body composition and metabolic rate changes during weight loss.

ACKNOWLEDGEMENTS

I am very happy and appreciate the opportunity to go this far in my education. I am fully aware that many people are not as lucky. Because of these facts, I dedicate the completion of this work to the guidance, patience and love of God. Everytime I wanted to give up, which was often and seemed the easiest thing to do, God was constantly present to remind me of His blessings. My favorite verse is Jeremiah 29:11, "For I know the plans I have for you, says the Lord, To give you a future and a hope".

I would like to thank my mom for encouraging me to pursue this degree. This thesis is a small testimony of her love and dedication to me and my goals. My brother and sisters also deserve some recognition for their constant encouragement. They told me I could do anything if I put my mind to it.

Special gratitude is extended to the following individuals:

Dr. Janet Walberg Rankin for her cooperation and faith in my ability to finish this project. I'm sure when I left VPI, it appeared that I would never, ever finish. I value the experience of working with her on this project and the opportunity to travel to California.

Sheri Davis for her positive attitude and countless hours spent on new fun ideas which helped me and our participants survive some of the hot summer days when no one wanted to exercise. Where are you now Sheri?

Dr. Don Sebolt for his years of support and friendship and for serving on this Thesis committee. His advice served to improve the outcome of this thesis. More importantly, he gave so much positive feedback. Whether for schoolwork or personal life, he always helped me to be strong and put my best foot forward.

Dr. Ron Bos for encouraging me to be outgoing. He constantly found things to praise me on and give constructive criticism when needed, especially in the area of getting my paperwork in on time. Look at this Dr. Bos!

My roommates, Amy and Pat, who put up with my "all talk and no action" form of procrastination. They even helped me come up with some ways to procrastinate.

Barry Joyner for helping answer so many of my questions about the wonderful world of statistics. I seriously thought I would not finish this paper because I never understood the stats area, but I think God had other plans and sent this patient man to me. Thanks for the open door.

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CHAPTER ONE

INTRODUCTION

Obesity is a prevalent health problem in the United States and is associated with an increased risk of diabetes, hypertension, and hypercholesteremia (Burton et al., 1985). It affects 25% of the total population and among 40% of the female population (Van Itallie et al., 1985). Dietary intervention has been shown to be a successful approach with widely varying degrees of long term success. With so many diets in existence, offering quick weight loss; guidelines for proper weight loss are needed to ensure safe and effective results (ACSM guidelines, 1983).

While the primary goal is to maximize weight loss, special consideration is needed to ensure preservation of fat free mass (FFM) and physical performance while maximizing fat loss. Associated with the decrease in body weight when dieting, there sometimes is a decrease in resting metabolic rate (RMR) (Donohoe et al., 1984; Warwick et al.,1981). Declines in RMR may ultimately result in difficulty with subsequent weight and hinder maintenance of weight loss. It is here, when a plateau is hit, the dieter usually goes back to old eating habits and gains substantial amounts of weight back.

Recent studies are nonspecific as to what mode of exercise is proper to combine with energy restriction to prevent a substantial loss in FFM while maximizing fat loss. The proper prescription of exercise to elicit optimal physiologic and metabolic changes in overweight people needs in depth research. The selection of exercise protocols for overweight people is limited by the physical mobility of the individual subjects and their capacity to sustain an exercise mode over a period of time.

Aerobic exercise is a suggested exercise which will elicit cardiovascular improvement and decreases in body weight to increased caloric expenditure. An adaptation to the training involves an increased utilization of fat during exercise (Mole et al., 1983). Yet, when coupled with energy restriction, equivocal results have been reported by researchers. Several researchers have shown that this mode of exercise will accelerate fat loss while reversing or preventing a further decline in RMR (Bielinski et al., 1985; Lennon et al., 1985; Mole et al., 1988); whereas others have shown that exercise has no effect on RMR (Hill et Al ., 1987). The intensity-duration threshold of aerobic exercise needs to be investigated more thoroughly to fill the void in the literature.

Resistance training is another form of exercise used by researchers in conjunction with energy restriction to enhance weight loss and prevent a further decline in FFM. While this mode does not utilize as many kilocalories per session as aerobic exercise; researchers have investigated its' preservative effect of RMR and FFM. Ballor et al. (1988) reported increases in lean body weight in response to weight training in obese women with a caloric deficit of 4200 kJ below baseline caloric requirements.

Difficulty getting into and onto equipment may be a major detriment to a weight training program for obese individuals. Hence, it is not surprising more research is done in the area because the initial motivation and adherence by the participants may be low.

A combination of both aerobic and weight training exercises added to an energy restrictive diet is another possibility to moderate declines of FFM and RMR compared with diet alone. Research supporting this combination has not been well documented. Two recent studies showed no advantage of this exercise regimen over diet alone or other exercise protocols for weight loss or declines in RMR (Donnelly et al., 1991; Lemon et al., 1989).

In summary, since overweight individuals experience difficulties in weight reduction and exercise programs, more work is needed in this area of exercise prescription to ensure healthy and productive results. Manipulation of the type of exercise used may affect the degree of weight loss and amount of decrease in FFM and RMR.

STATEMENT OF THE PROBLEM

In designing an exercise program for individuals who are extremely overweight, the type of exercise needs to be clearly defined to maximize weight and fat loss while moderating the decrease of both FFM and RMR. Should participants engage only in aerobic activity to enhance fat utilization? Or, should subjects engage in both aerobic exercise and resistance training to minimize loss of FFM but at the risk of increased dropout or injury? Attempting to preserve crucial fat free mass and RMR during the weight loss phase are important goals for a weight loss programs.

RESEARCH HYPOTHESIS

After nineteen obese women, divided into two groups: diet plus aerobic exercise (group 1) and diet plus aerobic exercise and resistance training (group

2); participated for 12 weeks in a reducing diet and exercise program:

H1: There was no difference in total body weight, body fat, or fat free mass between group one and group two over the experimental period.

H2: There was no difference in resting metabolic rate between group one and group two over the experimental period.

SIGNIFICANCE OF THE STUDY

Weight loss is a major goal of many obese individuals. However, many have difficulty achieving this goal by simply changing their caloric intake; i.e. reducing fat intake, or starting or increasing exercise participation to lose one to two pounds per week. Many wish to see quick, dramatic changes to feel better. A sensible 1200 kilocalorie diet has been shown to be an effective way to reduce weight without medical supervision. Choosing foods from all the food groups and reaching all nutritional needs is essential.

The addition of exercise to the 1200-1500 kilocalorie diet may help weight loss management. Involvement in physical training has been shown to demonstrate weight loss and increase the percentage of fat loss. Since exercise plays a major role in weight loss and its' maintenance, investigation into the most effective mode exercise, when coupled with dietary intervention, for optimal weight loss needs to be examined.

DELIMITATIONS

The following delimitations are inherent in the design of this study:

1. Only women from 25-45 years old participated in the study.

2. Only subjects who had a body mass index (BMI) BMI > 25.5 were included. Moreover, participation in the study was also restricted to clients who were free from any medical complications, such as orthopedic problems, diabetes, or heart disease.
3. Subjects who were currently losing weight or on a restricted diet were excluded.
4. The exercise used was limited to supervised walk/jog sessions or weight lifting sessions. Subjects were allowed to miss only eight exercise sessions to receive their fifty dollar incentive back.
5. The women were followed for a total of 12 weeks.

LIMITATIONS

Thus, the following limitations restrict the generalizability of the findings:

1. Applicability of results is limited to this particular sample of subjects, trained under methods specific to this particular training program and caloric restriction.
2. Compliance of the diet was voluntary, thus the assumption that all the subjects remained on the same caloric level cannot be made. Compliance to the diet was difficult to enforce because of individual food preferences.
3. Adherence to the exercise program was voluntary, thus the assumption that all subjects complied to their exercise prescription cannot be made (e.g. reaching target heart rate zone in each

session or giving full effort in resistance training).

4. Lack of control of certain variables which may affect a participant's performance, such as sleep, physical involvement and emotional stress, which could influence results.

DEFINITIONS OF TERMS

Aerobic Group- Participants were randomly assigned to this group. They engaged in walking activity four days a week in target heart rate range (60-70% of max. heart rate). Heart rates were taken at the middle and the end of the activity and recorded. As the weeks progressed, time duration increased from twenty minutes to forty minutes on Monday/Friday sessions, as described below, whereas, Tuesday/Thursday sessions, as described below, only increased from twenty to thirty minutes.

Body Fat- Included both essential and nonessential lipid stores.

Body Mass Index (BMI)-(kg/m2) body weight in kilograms divided by the subject's height in meters squared. It is the reflection of degree of overweight. Research finds that those with a BMI over 27 are at higher risk for various diseases including heart disease, diabetes, and cancer.

Combination Group-Participants, randomly assigned to this group, engaged in walking activity on Monday/Fridays and participated in resistance training on Tuesday/Thursdays, as described below.

Fat Free Mass (FFM)-All of the body's nonfat tissue including the skeleton, water, muscle, connective tissue, organ tissue, and teeth.

Kcal-Kilocalorie which is a measure used to express heat of energy value of food and physical activity. It is defined as the amount of heat necessary to raise the temperature of one kilogram (one liter) of water one degree Celsius.

Obesity-Excessive quantities of total body fat (greater than 30% for women) relative to height.

Resistance Training-The sessions began with five exercises (two sets each, 15 repetitions, 50-85% of 1 RM). Additional exercises, up to a total of seven, were added every second week.

Resting Metabolic Rate (RMR)-Energy expenditure required to maintain normal physiological processes. Minimum rate of energy expenditure early in the morning after waking from sleep, having subject abstain from food and heavy physical for at least 12 to 18 hours, and resting in a relaxed supine position for at 30 minutes in a quiet thermonuetral environment.

RMR/kg-Resting calorie use per kilogram of subject's bodyweight.

RMR/FFM-Resting calorie use per kilogram of subject's fat free mass.

BASIC ASSUMPTIONS

The basic assumptions were made:

1. It was assumed that the investigators accurately recorded all pre and post testing data.
2. It was assumed that all the subjects followed all instructions prior to data collection.
3. It was assumed that subjects correctly counted their heart rate during the exercise training sessions.

SUMMARY

While the many medical complications that arise from obesity are severe, the psychological, emotional, and social coping can be just as damaging. The need for a sensible diet and workable exercise program combined with behavior modification is essential so many of these problems are reversed. It was the purpose of this study to identify the effectiveness of varying exercise protocols in conjunction with a 1200 kilocalorie diet on weight loss and change in FFM and RMR. Literature revealed equivocal results with the different exercise protocols. With more people needing and searching for a solution to their weight problem, more research is needed to identify the effectiveness and safety of aerobic exercise, resistance training, or a combination of the two.

Chapter II

LITERATURE REVIEW

Introduction

Despite a growing awareness of the detrimental effects of excessive body fat on health and longevity, the incidence of obesity in the United States has risen. Today there are approximately 34 million overweight Americans (Lew et al., 1979). The disease exists among 25% of the total population and among 40% of the female population (Van Itallie et al., 1985). Not only are there physical and psychological handicaps associated with obesity, but the National Institute of Health has concluded that obesity is associated with increases in risk of diabetes, hypertension, hypercholesteremia, and several forms of cancer (Burton et al., 1985; National Institute of Health Consensus Development Panel, 1985).

Hence, weight reduction is a goal for many people. Ideally these people would like to maximize fat loss while minimizing loss of lean tissue and decline in physical performance. Yet, many individuals attempt to lose weight by quick starvation techniques; unaware that they are losing not only body fat, but also a large percentage of lean body mass.

In an attempt to minimize the reduction in lean body mass and RMR, researchers sought to find an effective treatment for weight loss that would be long term and harmless to the individuals. Many found that inactivity was a major contributor to the weight problem rather than excessive caloric ingestion (Thompson et al., 1975; Pavlou et al., 1989), reduced energy expenditure or both. Since this revelation, researchers have investigated the connection between weight reduction and exercise. Evidence suggests that physical activity may be particularly important in helping sustain initial losses through increased total energy output and preservation of lean body mass.

It is generally accepted that dieting, i.e. reducing the amount of calories consumed; will cause weight loss. The addition of exercise to a weight loss program helps to tip the scales towards loss due to the negative caloric balance. The problem arises when examining the type and percentage of tissue lost: fat or lean body mass. This relationship was investigated during a moderately controlled, 1200-1500 kcal/ diet and exercise program. Thus the following literature review will summarize the present knowledge on energy restriction versus energy restriction with exercise on body weight, FFM and RMR. Hence, the review is subdivided into the following areas:

1. Body weight and composition changes with energy restriction.
2. Body weight and composition changes when energy restriction is combined with exercise.
3. Resting metabolic rate changes with energy restriction and weight loss.
4. Resting metabolic rate changes with energy restriction and aerobic exercise.
5. Changes in resting metabolic rate with energy restriction and resistance training.

Body weight and composition changes with energy restriction

In 1978, James and coworkers showed that in obesity not only is body fat increased but the lean body mass is also higher. Their results showed that lean body mass was increased by 36 percent in men and 32 percent in women when compared to lean men and women. These results were confirmed by Forbes (1983). He found a range of 22-30 percent higher lean body mass (LBM) in obese individuals. This LBM increase has important implications when an obese subject undergoes weight reduction. Since water loss is initially a major contributor to the rapid weight loss seen when consuming hypocaloric diets, significant loss of lean body mass is an accompanying result. The excess LBM will be lost from the surplus protein tissue as well as body water and therefore nitrogen excretion exceeds intake on most reducing diets. In a ten day study by Yang and Van Itallie (1976) of obese women consuming an 800 kcal/day diet, they calculated body fat loss as 59% and fat free mass (FFM) as 40.5% of the weight loss. Similar results were found in Hill et al. (1987) five week study where sedentary obese subjects consumed an 800 kcal/day diet. It was found that 51% of the weight loss was fat and 43 % was lean body mass.

Webster et al. (1989) conducted a short three week weight loss study involving 108 obese women consuming an 800 kcal/day diet. Patients were confined to a metabolic ward where no patient was allowed to go off the ward at anytime and visitors were asked not to bring in any food. The average weight loss was 5.02 kg. Researchers found that during the first week, the average weight loss was 0.33 kg/day but decreased day by day to approximately 0.21

kg/day in weeks two and three. They support the fact that a high proportion of initial weight loss is attributed to water. The researchers associated the water to that water formerly associated with glycogen.

Finally in 1987, Barrows et al.'s four to six month study of 15 women consuming a very low calorie diet (420 kcal/day) showed a mean weight loss of 1.1 kg/week. Fat accounted for 83% and lean body mass for 17% of total body weight loss. Researchers suggest that over time there is an increase in fat loss accompanied by an increased tendency to conserve body nitrogen and preserve lean body mass.

While weight reduction through severe caloric restriction has been to shown to have good success at reducing body weight, the percentage attributed to lean body mass is disturbing. The shorter studies show a higher percentage of loss attributed to lean body mass than the longer studies. After the primary loss of water, researchers explain further losses are attributed to a loss in intrinsic metabolically active tissue (Mole et al., 1990). It would appear that a longer experimental period is beneficial to maximize fat losses while minimizing lean tissue loss.

Body weight and composition changes when energy restriction is combined with exercise

Several studies have suggested that the addition of aerobic exercise may reduce the loss of lean tissue during dieting. Thus, exercise may improve fat free mass to fat ratio, either by accelerating fat losses, reducing lean tissue loss or by actually increasing muscle mass (Pavlou et al., 1985). When exercise and dieting are combined, the goal is to increase energy expenditure in order to accelerate weight loss and preserve lean body mass.

In a study by Hill et al. (1989), forty moderately obese women were placed on one of two restricted diets and were randomly assigned to a sedentary or aerobic condition. The exercising subjects participated in a moderate aerobic training program consisting of brisk walking five times per week at a target heart rate of 60-70% of maximum heart rate. The supervised sessions consisted of a ten minute warmup followed by a period of brisk walking that progressively increased from twenty minutes the first week to 50 minutes per session by the eighth week. After the twelve week study, the exercised subjects showed greater reductions in both body weight and body fat percentage than did the nonexercise subjects. The exercisers lost 86% of their weight from fat and 14% from fat free mass, while the nonexercisers lost 73% of their weight from fat and 27% from fat free mass. The effects of exercise on body weight and body fat in this study could by due to greater adherence to the diet by exercising subject's or to exercise's effect on substrate oxidation which leads to greater total energy expenditure and a greater oxidation of fat.

Similar results were found in a 16 week study by Hammer et al. (1989) who compared a 1200 kcal/day diet versus a restrictive 800 kcal/day diet with and without exercise. The supervised exercise session consisted of brisk walking and/or jogging five times per week. Subjects began the first week by walking/jogging 1.6 km per session and increased their distance to 4.8 km by week six and remained there. Initial work intensity was set at 60% of VO2 max.

for week one and increased to 70-85% . While all subjects lost significant amounts of weight and body fat, more was lost by those subjects assigned to the exercise groups as compared to those not exercising. These findings support the idea that aerobic exercise can help to preserve free fat weight and maximize fat loss during energy restriction.

Unfortunately, all investigators have not reported such positive effects of exercise on body weight and fat loss. Phinney et al.'s (1988) four week study showed no significant differences in weight loss between the sedentary (-6.9 kg) subjects and the exercising (-6.5 kg) subjects. The exercising subjects were allowed nine days of a VLCD (720 kcal/day) for adaptation, then began a four week program of cycling. All supervised training was performed at 50% of VO2 max. five days per week. The durations of exercise were: first week, one-half hour once daily; second week: one hour daily; third and fourth week: one hour twice daily.

Several studies have shown that the addition of exercise to a weight loss regime had no effect or showed a decline in fat free mass. A study by Bogardus et al. (1984) showed a decline in lean body mass for women consuming a hypocaloric diet and exercising three times per week as compared to those not exercising. Similar results were found by Hagan et al. (1986). While both groups consumed a similar 1200 kcal/day diet, the exercising subjects tended to lose more lean body mass than the diet alone group. The supervised aerobic conditioning group consisted of twelve weeks of walking and/or jogging, five days per week for thirty minutes per session. Intensity was not measured. Body weight and fat weight loss in the diet plus exercise group (-10.4, -24%) were significantly greater than for the diet only group (-7.8, -20%), while both groups significantly greater than the exercise only and control groups.

A recent 12 week study by Donnelly et al. (1991) supports the idea that exercise has no effect on body composition. Investigators placed sixty-nine obese women on a liquid diet (522 kcal/day) and randomly assigned them to either a control group or one of three exercise groups. The groups were diet only (C), diet plus endurance exercise (EE), diet plus weight training (EEWT). The endurance exercise group worked out four days per week and progressed from 20 minutes at baseline to 60 minutes at the end of the study. Various exercises were included, such as: walking, biking or rowing. Subjects worked at 70% of heart rate reserve. The strength training was conducted four days per week on Universal equipment. They progressed from two sets of six to eight repetitions at 70% 1RM to three sets of six to eight repetitions at 80% 1RM. The study reported no statistically significant differences in percent body fat, fat weight, FFM or percentage of fat weight loss to total body weight loss among the four groups. These findings are supported by other investigations (Hammer et al., 1989; Neiman et al., 1988).

The disparity of results between the studies may be attributed to the amount of caloric restriction, intensity-duration relationship of exercise load, or length of the studies. While all five studies reviewed required five days of supervised participation by the subjects, the other factors of intensity-duration and diet varied extensively. The extended 1200 kcal/day diet of both Hill et al. (1989) and Hammer et al. (1989) showed that the exercised subjects had significantly greater reductions in both body weight and body fat percentages than nonexercised subject. Although the intensity varied slightly between the two studies (60-70% and 70-85%, respectively), both required approximately 30-40 minutes of exercise in their target heart rate zone. These results are in contrast to Phinney et al.'s (1989) short five week study. Subjects were exercised at a lower intensity of 50% VO2 max. for a minimum of one-half hour and working up to two hours a day. The researcher's concluded that since the subject's were consuming a very low calorie diet (720 kcal/day), the extended sessions may have blunted the exercise benefits. Of all the three potential elements causing the discrepancies between the results, the length of the study period may be the most important aspect when evaluating the success of exercise in promoting weight loss (Epstein and Wing, 1980). VanDale and Saris (1989) compared the effects of a calorie restricted diet with and without an exercise program of aerobics, fitness and jogging. After five weeks, no difference in weight loss were apparent between the two groups. However, at 14 weeks, a significantly greater mean weight loss was apparent in the exercising group. The efficiency of including exercise in a program involving caloric restriction is indicated by numerous studies which show improved weight loss, often in amounts greater than the additive effects of either strategy alone.

Resting metabolic rate changes with energy restriction and weight loss

Changes in resting metabolic rate (RMR), the energy expenditure required to maintain normal physiological processes, have been linked to the loss of lean body mass. Caloric restriction is well known to lower the resting energy expenditure, perhaps as much as 30%, and this is suggested to be a key factor contributing to the failure of many obese individuals to reach and maintain their goal (Mole et al., 1989; Elliot et al., 1989). The lowering of RMR is the human body's attempt to conserve during food restriction. Studies show that ingestion of a hypocaloric diet leads to progressive reductions in RMR (Apelbaum et al., 1976; Hill et al., 1989; Foster et al., 1990).

A more recent study by Abraham and Wynn (1987), was conducted to see whether there was any long term adaptive reductions in resting metabolic rate to the loss of lean tissue. Thirteen patients were studied for 35 days of continuous dieting, nine patients were studied for more than 72 days, and seven patients were studied for 140-200 days. The duration of the diet was dependent on how much each person had to lose. The diet contained 50-53 grams of protein and 2.74-3.30 MJ of carbohydrate. All patients were studied in a metabolic ward. In those patients who had not dieted before admission to the program, the six men exhibited a significant reduction (17.8%) in resting energy expenditure during the first two weeks but no more from days 17-35. There was no significant fall in the metabolic rate in the women studied. Researchers attributed these results to their lower lean body mass. Subjects that were exposed to prolonged periods of dieting had nonsignificant linear decreases of RMR and LBM.

Another study reporting the effect of dieting on RMR was conducted by Foster et al. (1990). All 16 patients were prescribed a 1000-1200 kcal/day balanced diet for a four week adaptation period. Researchers then randomly assigned subjects to one of two groups: 1) Continue on balanced diet for remaining 20 weeks and 2) consume 500 kcal /day diet for eight weeks. Subjects in group two, during week 13-16, added 200 kcal/day each week so that by week 17, they were consuming 1000-1200 kcal/day. Patients in the two groups lost similar amounts of weight during the first four weeks, when both consumed a 1000-1200 kcal/day diet. Group two subjects lost more weight during weeks 5-10 than those in group one (9.1 kg vs. 4.0 kg, respectively). There was no significant changes between the groups in weight loss from weeks 11-15. Unexpectantly, group two patients gained almost 1 kg during the last ten weeks of treatment whereas the group one patients lost an additional 2.5 kg. Hence, there were no significant differences between the groups in changes in body fat or FFM from baseline to the end of the treatment. There was little change in the RMR from baseline of group one at the end of the study, while group two showed a 17% decrease from baseline RMR after only two weeks on the VLCD. The decline in RMR was nearly three times as great as the corresponding decline in weight, suggesting that the short term decrease in RMR was related to primarily to the reduction in intake rather than in weight. A rebound in RMR accompanying the increased caloric intake was apparent when RMR returned to within 8.4% of baseline (week 17). When the changes in RMR were normalized to FFM, group two patients showed an 8.1% reduction in the ratio from baseline to the end of treatment. Despite similar losses of FFM, group one showed a 4.1% increase in RMR:FFM. This difference, though not significantly different, was attributable to a larger decline in RMR in group two subjects. Researchers concluded that it may be more advantageous metabolically for individuals to lose weight when consuming a moderately restricted diet to limit radical fluctuations in RMR.

None of the studies established whether this condition of depressed RMR was temporary or long lasting. However, one study of seven obese women found a depressed RMR-FFM ratio up to eight weeks after a massive weight loss on a modified fast (Elliot et al.,1989). This prolonged drop in RMR can hinder continuing and future attempts for extended weight loss by obese individuals.

Resting metabolic rate changes with energy restriction and aerobic exercise

Total energy expenditure is determined by RMR, thermogenesis in response to environmental stimuli, most notably food, and the energy cost of exercise. Research shows that aerobic exercise may have a stimulatory effect on energy expenditure not only during but also after an exercise session. The magnitude of this effect is determined by the mode, intensity, and the duration of the exercise (Epstein and Wing, 1980).

Acute changes in metabolic rate following exercise were measured by Bahr et al. (1987) in six subjects for 12 hours and again 24 hours after four conditions: at rest, 20, 40, and 80 minutes of exercise at 70% VO2 max. The subjects consumed three 1200 kcal meals that were eaten 2, 7, and 12 hours after both the exercise and rest conditions. The results show that RMR, when compared to control data, was elevated during the 12 hours after all three exercise sessions but not 24 hours after cessation of exercise. The elevation was linearly related to the duration of exercise.

Shah et al. (1988) investigated the effect of moderate aerobic exercise on energy expenditure in 16 post obese and 16 lean control women during a 24 hour and shorter periods. The subjects weighed their food intake for seven days on dietary scales. After the diets were analyzed, the subjects selected foods from a standardized menu and the portions were adjusted so the energy value was close to their customary intake. Each subject spent three separate 24 hour sessions at different activity levels (sedentary, normal, aerobic) in the respirometer. The aerobic session had subjects on a bicycle ergometer for four ten minutes periods followed immediately by mild step exercise. Subjects worked at 60-80% of heart rate maximum. The aerobic sessions did not significantly stimulate the 24 hour RMR of either the post obese or lean control subjects. The stimulation when expressed in absolute energy units was only 50 kcal and 30 kcal respectively. These results are supported by Brehm and Gutin (1986).

The potential of exercise training to enhance the amount of energy expended under resting conditions is of considerable importance given the relative contribution of resting energy expenditure to the total energy output. Tremblay et al.'s (1986) eleven week study had eight moderately obese women engaging in an exercise training program which included five hours of aerobic exercise per week (at 50% VO2 max.). The training program induced a significant eight percent increase in RMR in these subjects despite a reduction in body weight.

A number of studies have examined the effects of aerobic exercise training programs and caloric restriction on RMR. The theory is that the combination will not only accelerate fat loss but preserve fat free mass and slow down or prevent the decline in RMR more effectively than diet alone. In a five week study conducted by Neiman et al. (1988), 21 mildly obese individuals were placed on a 1300 kcal/day diet and randomly selected to be in a control or exercise group. The exercise group participated in 45 minute walk/jog sessions at 60% VO2 max., five times per week. Approximately 320 kcal were expended per session. While both groups lost similar amounts of weight and body fat, the exercise group showed a six percent elevation in RMR from predietary control. Researchers concluded that RMR may be improved when combined with caloric restriction if the intensity of the exercise is sufficient.

Seventy eight overweight subjects (38 men and 40 women) consumed the same exchange diet and were randomly assigned to three treatment groups in Lennon et al.'s (1985) study. Researchers defined overweight as an individual is 15-35% above maximum weight on the Metropolitan Life Insurance Table. There was a diet group (C), a diet-exercise group which selected their own activities (D), and a diet prescribed exercise group (P) which adhered to a program of aerobic jogging exercise. Group P assigned to either a white, blue or red activity program and to Level I-IV depending on their maximum MET level achieved on pretreatment Bruce tests. Exercisers in group D were instructed to perform activities for thirty minutes daily, while group P trained every other day. Dietary restrictions were estimated from the formula: Ideal body weight (in lbs)

X 10, and the value obtained was rounded to the closest caloric level indicated by the diet exchange program, 1200, 1500, and 1800 kcal/day. RMR was reported in ml O2 consumed per kg body weight since there were no significant differences in weight loss or body composition between the groups. RMR increased significantly in group P over both groups C and D (10, 2, 4%, respectively). Researchers noted that while weekly caloric expenditure was similar between the exercising groups, the expenditure per session in group P was 100 percent greater than in group D. Investigators indicated a significant correlation between percent change in VO2 max. and the percent change in RMR. They suggest that the improvement in VO2 and the change in RMR are related to the training intensity. They propose that a "threshold" intensity level of exercise needs to be attained before any effect on RMR can be attained. This threshold intensity could be that necessary to elicit an increase in VO2 max. of 11-12 percent, the change in VO2 max. observed in group P. Group D increased VO2 max. by 9.11 percent, but did not demonstrate a significant increases in RMR over controls. When comparing and contrasting male and female subjects, the control females showed a slight decrease (-3%) in RMR whereas D and P females demonstrated increases (2%, 7% respectively) in RMR. The female P group was significantly higher than control group. In contrast, the control and D males demonstrated the same percent change in RMR, and males were somewhat higher. In conclusion, researchers associated an increase in VO2 max. with an increase in RMR, without any change in body composition. Also, the incorporation of any level of exercise may be of greater importance for female than males to prevent the decline in RMR during caloric restriction.

Another study that demonstrates that exercise can reverse a depressed metabolic rate caused by severe caloric restriction was conducted by Mole et al. (1988). Subjects consumed a 500 kcal/day diet for four weeks, with the subjects remaining sedentary during the first two weeks. The second half of the study had the subjects continue on the diet while exercising (jog, swim, or bike) thirty minutes daily at 60% VO2 max. Average total weight lost was 6.6 kg. After two weeks of dieting, RMR decreased to approximately 87% of the predietary control value. Researchers suggest that exercise stimulates energy expenditure and fat oxidation, leading to a reduction in body fat.

Although the connection between exercise, weight loss, and preservation of RMR is supported by the literature, other investigators have reported the inability to elicit elevations in RMR using moderate training programs. Hill et al.'s (1987) study investigated food restriction and a progressive walking program for obese. The five week study placed the eight women on an 800 kcal/day diet and randomly assigned them either a sedentary or exercise group. The exercisers began a daily, supervised progressive walking program where they would walk 1.6 km with increments of 0.4 km added every third day until 5.6 was reached, based on individual capabilities. Intensity of the exercise was not reported. Researchers found a similar decrease in RMR in both groups at the beginning of the study (53.7 kcal/h EX vs.50.9 kcal/h NEX). RMR remained constant after one week for sedentary subjects but continued to decline for exercising subjects. The total decline in RMR was 19.1% for exercising and 17.3% for nonexercising subjects. The additional decrease may be due to the increasing energy expenditure associated with the walking session.

Hammer et al.'s (1989) study found similar RMR decreases in the exercise and sedentary groups. This study used a 2X2 factorial design, crossing exercise (X) versus nonexercise (NX) with a 1200 kcal/day diet (AL) versus restricted 800 kcal/day diet (R). The subjects were randomly assigned to one of four treatment groups. While body weight and percent losses were significant in all groups, larger decreases were seen in the subjects assigned to the restricted diet/exercise group. There were no between group differences in RMR throughout the study, but there was a significant overall decline in absolute RMR of five percent for the exercising subjects only. This decrease was attributed to reductions in body surface area and changes in body composition.

Resting metabolic rate declined five percent in the group of subjects as a whole in Hill et al.'s (1989) study. Each subject was randomly assigned to either a constant calorie diet or an alternating calorie diet; both diets providing an average of 1200 kcal/day over a 12 week period. Within each diet condition, subjects were randomly placed into either an exercise or nonexercise group. The exercisers walked five times per week at a target heart rate of 60-70% of VO2 max. The variation in diet did not affect the amount of weight loss whereas exercise led to greater total weight loss. RMR was reduced by five percent in all subjects. Both diets in the study represent moderate caloric restriction and the drop in RMR was totally explained by the drop in FFM. Also, exercise, while it did not affect RMR, lead to greater weight loss and more reductions in percent body fat.

The theory that exercise may promote a decline in RMR is suggested by several recent studies. In Heymsfield et al.'s (1989) five week study, obese women consumed a 900 kcal/day diet and were assigned to either a sedentary or exercise group. The exercisers expended approximately 1000 kcal/week in a supervised walking program. The walking distance was increased gradually over several weeks to 5.6 km. No intensity was reported. The energy cost of walking at an equivalent rate on a treadmill was determined once for each patient towards the end of the underfeeding period. Both groups lost similar amounts of weight, yet the exercisers lost more fat and less FFM. A 20% decline in RMR was found in exercising subjects whereas nonexercisers experience only a 10% drop. Researchers were unclear as to the mechanism of the large drop in the exercisers' RMR.

A partial explanation of the inconsistent results may be attributed to the differences in the relative duration and intensity of the exercise component implemented by researchers. There may be an intensity-duration threshold for exercise to produce a prolonged effect on RMR. Both Lennon et al. and Neiman et al. had their subjects engage in 30-45 minutes of exercise at a moderate (60-70%) intensity; 4-5 times per week. Also, their caloric restriction was moderate; approximately 1200-1400 kcal/day. While the studies showing a decline in RMR also exercised their subjects five times a week, the calories were restricted to 900-1000 kcal/day and they exercised at higher intensities. As stated earlier, a longer study may be more important when evaluation the success of exercise in preserving RMR and promoting weight loss.

Changes in resting metabolic rate with energy restriction and weight training

A less commonly used exercise to help promote weight loss is resistance training. Although its' adoption has been slowly accepted because its' energy cost is significantly lower than aerobic exercise, resistance training offers some extraordinary benefits. Weight training may prevent the loss of lean tissue which may accompany caloric restriction and possibly increase muscle mass. It forces muscles to overcome greater than normal load which may lead to muscle hypertrophy and hopefully a preservation in lean body mass. Since muscle tissue is metabolically active tissue, this would tend to increase or preserve metabolic rate and energy requirements.

A five week study by Krotkiewski et al. (1979) showed that strength training results in an increase in muscle tissue thickness, fiber area and increased glycolytic capacity. Subjects engaged in daily maximal isokinetic contractions of the quadriceps using a Cybex II dynameter. The reduction observed in fat thickness in the leg was secondary to the change in leg geometry; the same fat surrounded an increased muscle volume. Since muscle tissue is metabolically very active, the increase in muscle tissue thickness would tend to maintain or increase metabolic rate and energy requirement even when in a hypocaloric state. Metabolic rate was not measured in this study.

Even though a majority of the studies on the use of resistance training have been done with animals or in nonenergy restricted individuals, researchers are beginning to investigate the use of resistance training while in negative energy balance. Researchers are interested to learn if muscle hypertrophy or lean body mass preservation could occur when resistance training is paired with caloric restriction. Ballor et al.'s (1988) eight week weight loss study assessed the individual and combined effects of weight loss and weight training on body weight and body composition in 40 obese women. They were assigned to one of four groups: control, diet without exercise, diet plus weight training, and weight training without diet. Subjects did resistance training, under supervision, three days per week at eight stations (ten repetitions the first two sets and as many repetitions as possible on the third set). The diet plus exercise (DPE) and diet only group's fat weight loss, although not different from each other, are statistically different from control and exercise only groups. The diet plus exercise and exercise only groups had significant increases in lean body weight compared with the diet only group. The exercise only group changes in LBM are also significantly larger than the control group changes. Data from this study indicates that weight training added to a caloric restriction program results in maintenance of LBM and regional increases in muscle area. The researchers concluded that resistance training and caloric restriction act independently of each other during weight loss, i.e. energy restriction affected body fat while resistance training increased fat free mass.

Similar results were cited by Gettman et al. (1979). They reported a four percent decrease in body fat for males participating in an eight week strength training and weight reduction program. While both of these studies did not measure RMR, the preservation of LBM may assist in preventing the decline in metabolic rate in a hypocaloric state.

While both aerobic and resistance training have been investigated separately for their effect on weight loss and preservation of lean body mass and RMR, very few studies have combined these two exercises in obesity rehabilitation. A study by Pavlou et al. (1989) placed 31 overweight women on a 1000 kcal/day diet for eight weeks. They were randomly assigned to either a sedentary or exercise group. The subjects exercised 60 minutes, three times per week. The program consisted of a 30-40 minute aerobic activity (60-85% heart rate max.) and progressive muscle strengthening program where all muscle groups were utilized. No weight lifting devices were used. Researchers reported that exercising subjects lost more weight (8.3 kg vs. 6.4 kg) and had a greater decrease in percent body fat (-6.7 vs. -4.5) than the sedentary group. While no change in lean body mass was reported in either group, there was a decrease in RMR in the sedentary group. The exercisers' RMR remained unchanged. The results of this study support the concept that aerobic exercise combined with muscle strengthening exercise prevents dietary induced decrease in RMR.

Lemon et al. (1989) investigated RMR and body composition changes due to aerobic and resistance exercise over an extensive sixteen week study. Four groups of ten overweight women participated in eight weeks of a very hypocaloric (405 kcal/day) diet followed by eight weeks of a 1500 kcal/day maintenance diet. Two groups were created to act as control groups. Subjects were matched on the basis of body mass index into one of five groups, i.e. two control groups plus three dieting groups which participated in either aerobic exercise, isotonic resistance, or a combination group (subjects cycled the first eight weeks and weight trained the following eight weeks). The aerobic group consisted of three 20 minute periods of exercise per week while the resistance training group worked six body parts (3 X10 at 60-70% of 1RM for the first eight weeks followed by ten weeks of 4 X10 at 60-95% of 1 RM). Similar patterns of weight loss were observed in dieting only and dieting with exercise groups. There was a uniform increase in percent of weight as FFM in dieting groups as expected from the weight loss, but no significant difference between diet only and any of the exercise groups. There was no significant difference in RMR between diet only and any exercise group. The pattern of RMR change indicated the main losses in weeks 0-3, with the maximum in the diet only group, with relative stability in week 3-8. The metabolic rate per kg FFM tissue, however, showed a significant difference ($P<0.05$) in the isotonic training groups, with improvement to 107% of starting values by week 16 in spite of weight losses of 11.3 kg in the diet plus resistance training and 13.1 kg diet plus combined exercise group.

These findings agree with those of Donnelly et al. (1991). Sixty-nine obese females received 90 days of a liquid diet providing 2184 kJ/day. They were randomly assigned into one of four groups: diet only, diet plus endurance exercise, diet plus weight training, or diet plus endurance exercise and weight training. Endurance exercise was conducted four days per week and progressed from twenty minutes at baseline to 60 minutes at the end of the study. Various modes of exercise, including walking, cycling, and rowing were utilized to increase adherence and hit all major muscle groups. Intensity of exercise was set at 13 rate perceived exertion from days one to 14 and was replaced with 70% heart rate reserve from days 15 to 90. Strength training was conducted four days per week. Universal gym equipment was used and progressed from two sets of six to eight repetitions at 70% 1 RM to three sets of six to eight repetitions at 80% 1 RM. Changes in body weight, percent fat, fat weight and fat free mass were not different between groups. Declines in RMR were 7% to 12% of baseline values with no differences among groups. Finally, all groups improved their physical work capacity by the end of the study. There were significant improvements in those subjects engaging in aerobic exercise. The researchers concluded that controlled aerobic and isotonic resistance training can be undertaken and sustained during periods of weight reduction. The study did not identify any advantage of using various exercise regimes in combination with a VLCD over a VLCD alone with respect to RMR, body weight loss, or body composition changes. The use of weight training did not appear to moderate declines in FFM or RMR compared with diet alone or diet plus endurance exercise. However, increases were realized for work capacity and strength by the groups that underwent exercise training compared with those on a VLCD only. The use of exercise in conjunction with resistance training is supported, but the exercises should be carefully selected to ensure that the overweight subject will stay with the program for an extended period of time and reach their goal.

While the increased body weight of an obese individual is associated with a higher amount of lean body weight, the type of caloric restriction and exercise program they decide to follow for weight loss is important to limit exorbitant losses of lean body mass. The reduction in body weight during energy reducing dietary intervention is associated with a reduction in lean body mass (Krotkiewski et al., 1977). Therefore, engaging in a strength training program may be beneficial to the subject to preserve LBM and metabolic rate. Documentation supporting the use of resistance training is limited. Even though this is disappointing, the present data open the door to engage in more extensive investigation.

Summary

The psychological and health consequences associated with obesity often lead individuals to participate in weight reducing activities. However, severe energy restriction can sometimes cause decreases in FFM and RMR. Researchers are looking for ways to prevent these changes. Aerobic training has been prescribed in conjunction with energy restriction because it has been shown to decrease or prevent the loss of lean body mass while enhancing fat loss. Resistance training has a more variable effect on weight loss, but numerous studies reported increases in lean body mass during unrestricted eating and a few suggest that muscle hypertrophy is possible during energy restrictive diets. Hypothetically, a combination of both exercises would benefit the overweight individual. Since a larger amount of lean tissue is lost in caloric restriction, the gains attributed to strength training could help preserve RMR. Optimal combinations of exercise and energy restriction may exist that can preserve RMR and promote fat loss. The optimal prescription remains elusive and more research is needed to find a combination of caloric restriction, aerobic exercise and/or resistance training to maximize weight loss and minimize losses in lean body mass and RMR. Obese individuals are often discouraged by the fact that even the most rigorous activities produce relatively small changes in body weight or body composition. Immediate effects are limited. However, the cumulative effect induced by physical activity along with energy restriction may have beneficial consequences over time.

Comparison of Isoenergetic Aerobic versus Aerobic Plus Resistance Exercise program during a Weight Loss Program

Cheryl Parker

ABSTRACT

Nineteen obese women were studied to determine the effects of two different exercise prescriptions which differed in the type of activity but were matched for total energy expenditure. All women met once per week for twelve weeks as a group to receive the same recommendations concerning dietary modification. A low fat, self selected diet of approximately 1200-1500 kcal was recommended. Ten women participated in a walking program four days/week (GP1) which progressed to 160 minutes per week at 70% HR max. The second group (GP2) of nine women did two days/week (up to 90 minutes/week) walking and two days/week resistance training (up to 90 minutes/week). The resistance training consisted of eight exercises, 8-15 repetitions, at 50-85% of 1 RM, and three sets. All exercises were supervised and attendance for all women was greater than 92% of all the sessions. Losses of body weight (BW) (-5.7 $\pm$ 1.1 kg and -4.5 $\pm$ 1.0 kg for GP1 and GP2, respectively), body fat (-3.9 $\pm$ 1.1 kg and -4.9 $\pm$ 1.0 kg for GP1 and GP2, respectively), fat free mass (-2.1$\pm$.7 kg and -1.6 $\pm$ .9 kg for GP1 and GP2, respectively) and percent fat (-2.1 $\pm$ .7 and -1.5 $\pm$ .9 for GP1 and GP2, respectively) were significant over time for both groups with no significant differences between groups. However, GP1 tended to have more of a reduction in percent body fat and FFM than GP2. Absolute RMR showed a

nonsignificant decrease overtime for both groups (-139.7 $\pm$ 107.5 kcal/day and -48.1 $\pm$ 75.0 kcal/day for GP1 and GP2, respectively). RMR expressed per bodyweight or fat free mass was maintained for both groups over the experiment (+.4 kcal/kg and -1.1 kcal/kg FFM respectively for GP1 and +.6 kcal/kg and -.04 kcal/kg FFM respectively for GP2). In conclusion, the total energy cost of exercise rather than the type of activity seems most important in body composition and metabolic rate changes during weight loss.

Introduction

It is generally accepted that obesity, defined as having a body composition with over thirty percent body fat, represents a significant health risk. Prescriptions of energy restriction alone have been shown to be a successful approach with widely varying degrees of long term success. While the primary goal is to maximize weight loss, special consideration is needed to ensure the preservation of fat free mass (FFM) and resting metabolic rate (RMR). Declines in RMR may ultimately result in difficulty with subsequent with loss and hinder maintenance of weight loss.

Physical activity is promoted as an important adjunct in the treatment of obesity (Bjorntorp, 1979). Exercise can influence the development of obesity as well as achieving long term weight management. The exercise component may positively influence RMR by increasing post exercise metabolic rate from acute exercise sessions by causing an increase in RMR associated with exercise training and possibly increasing energy expenditure during nonexercise times (Tremblay et al., 1986; and Pavlou et al., 1986). When combined with caloric restriction, evidence suggests that exercise assists in maintaining lean body mass, maximizing fat loss and increasing energy output. Recent studies are nonspecific as to what mode of exercise is proper to combine with energy restriction to prevent losses in FFM.

Numerous studies have examined the effect of diet and aerobic exercise on body composition and RMR. The evidence is equivocal on the combination in regards to RMR. Several researchers have shown that this mode of exercise will accelerate fat loss while reversing or preventing a further decline in RMR

(Bielinski et al., 1985; Lennon et al., 1985 and Mole et al., 1988); while others have shown that exercise has no effect on RMR.

Resistance training is another form of exercise used by researchers in conjunction with energy restriction to enhance weight loss and prevent a further decline in FFM. While this mode does not utilize as many kilocalories per session as aerobic exercise; researchers have investigated its' preservative effect FFM and RMR (Ballor et al., 1988).

A combination of both aerobic and weight training exercises added to energy restrictive diet is another possibility to moderate declines of FFM and RMR compared with diet alone. Research supporting this combination has not been well documented. Two recent studies showed no advantage of this exercise regime over diet alone or in conjunction with other exercise protocols for weight loss or declines in RMR (Donnelly et al., 1991; Lemon et al., 1989).

The purpose of this study was to investigate the quantity and mode of exercise needed to achieve optimal fat and weight loss and preserve RMR in obese individuals during a weight loss diet. Manipulation of the type of exercise used may affect the degree of weight loss and amount of decrease in FFM and RMR.

Methods

Nineteen obese women were selected from a group of 32 obese volunteers. Subjects were selected by the following criteria: female, aged 25-45 years, body mass index (BMI) > 25.5, not currently on a weight reducing diet, and have no health problems which would exclude their participation in exercise or caloric restriction. Before being accepted in this study, the subjects were asked to get clearance from their personal physician to exclude any subjects with abnormalities (high blood pressure, diabetes, eating disorders) that could affect their ability to sustain a 1200-1500 kcal/day diet.

All initial measurements were taken three days before the beginning of the experiment. These included: hydrostatic weighing to determine body composition, body weight and height, and indirect calorimetry for resting metabolic rate determination. These measurements established the baseline data.

All the participants were asked to follow several conditions which were necessary to ensure reliable results. The following were included: no exercise or food for 12 hours prior to scheduled test, refrain from drinking drinks with caffeine, no smoking, and to try to drink eight glasses of water 24 hours before testing.

Resting metabolic measurements were implemented first and required the subject to lay supine in a dark quiet room for thirty minutes. Twenty five minutes into this period, the head mask and Douglas bag were attached so the subject could get used to breathing into the apparatus. Expired air was collected in the Douglas bag for three five minute periods. The air was analyzed in calibrated O_2 and CO_2 analyzers (Applied Electrochemistry analyzers S-3A and CD-3A, respectively) for one minute, then the remaining volume of air was measured by a Tissot tank. One liter was added to the volume measured in the Tissot tank to account for the air which was drawn through the gas analyzers. An average of the three tests was taken and used in

RMR calculation. Subjects were weighed to the nearest 0.1 kg in light street clothes and with either bare feet or stockings.

Body composition was measured by hydrostatic weighing before and after the experimental regime. Hydrostatic weighing was conducted in a metal tank with a seat. Occasionally, additional weight was held by patients who were excessively buoyant to obtain more accurate underwater weights. The chair was attached to a load cell which transmitted the results of the trial to a recording computer. Patients were instructed to expel as much air from lungs as possible during immersion. This underwater procedure was repeated eight times, where the highest three values were averaged and used in calculation of body composition. Residual volume was determined by oxygen dilution by following the procedure of Wilmore et al. (1980) after the hydrostatic weighing procedure.

Bench press, lateral pull-down, knee flexion and knee extension were measured by use of the one repetition maximum method (1 RM) with Universal Gym Equipment (Universal Gym Equipment Inc., Cedar Rapids, IA) by following the procedures of Wilmore and Costill (1988). One RM was determined by administering a series of trials to determine the greatest amount of weight that may be lifted a single time. The above strength activities were chosen because they represent major muscle groups and because the exercise session could be completed in twenty to twenty five minutes. Also, all the women completed a timed one mile walk to estimate their aerobic performance.

The nineteen women were ranked from highest to lowest according to body mass index and sequentially divided into two groups. Group one (GP1) was involved in a progressive walking program four days per week during the noon hour. On Mondays and Fridays, the participants started walking for thirty minutes and increase to 45 minutes, while Tuesdays and Thursdays sessions went from 20 to 30 minutes at 60-70 % estimated maximum heart rate, as determined by the Karvonen heart method, at the end of the study (refer to Table one). The combination group or Group two (GP2) combined the Monday/Friday walking sessions of GP1 with Tuesday/Thursday resistance training sessions (refer to Table two). Because of busy work schedules and family obligations, many of the participants had difficulty exercising at the predetermined time. The investigators scheduled several early morning and after work sessions for individuals to make up sessions they missed.

All women met together once per week with the principle investigator for a nutrition education session. At the first meeting, the 1200-1500 kcal/day diet, "The Joy of Eating", and group assignments were revealed and explained. Each week the nutrition education sessions covered a specific topic such as: fad diets, finding hidden fat, eating out, reading labels, overeating, new "low fat" foods in the stores, the importance of fiber, social support, cooking light, blowing it, and success stories.

The sessions allowed the subjects to have a question and answer session so they could talk about any problem they were having or share any successful tips they discovered. Also, new low fat recipes were tested and given out. The principle investigator also announced who lost the most amount of weight that week as well as the individuals with the greatest overall weight loss. These individuals were given rewards which included exercise mats, cookbooks, and free blood cholesterol checks.

The diet was prescribed using the diabetic exchange system with foods grouped into three categories: red, yellow or green. Foods within each category were grouped into a red, yellow, or green classification based on the grams of fat per serving. Subjects were asked to choose foods primarily from the green foods, occasionally from the yellow and rarely from the red foods. The goal of each participant was to consume no more than 40 grams of fat per day and work down to 30 grams per day. The sample diet supplied 1370 kcals with 60% carbohydrates, 26% protein, and 12% fat.

Statistical Methods

All intragroup and intergroup comparisons were performed by the appropriate multivariate analysis methods using the Statistical Program for the Social Sciences (SPSS) statistical package. T-tests were performed on all pretest values between group one and group two to see if there were any differences between groups prior to the experimental period. Tests performed only at the start and end of study (eg, RMR) were assessed by repeated measures ANOVA. A statement of significance implies a probability (P) value < .05 unless otherwise stated. Data are presented in the text and tables as mean ± SEM. Correlational analysis was also done to look at the relationship between certain variables.

Results

Twenty subjects were enrolled in the study, of whom nineteen completed the 12 week protocol. One subject dropped out due to extensive international travel obligations. Only one of the subjects had physical limitations which prevented her from participating in the exercise program. She used the stationary bike for four sessions to complete her exercise training. Tolerance to the diet and exercise program was very good. All exercise sessions for all women was greater than 92% of all the sessions. There were no significant diferences between the pretest values of group 1 and group 2.

Weight loss

Total body weight loss (kg) showed a significant decrease from baseline to week 12 for all subjects (5.5 ± 2.2 kg) (Figure 1). Table 3 gives the group means for weight loss during the experimental period. There was a significant loss of body weight in both groups compared with prestudy values. There was no significant difference between the two groups, but group one tended to lose more body weight (5.7 ± 2.2 kg) than group two (4.5 ± 2.1 kg).

Insert table three and figure one here

Body Composition

There was a significant change (3.76%) in percent body fat, as determined by hydrostatic weighing, from initial pretest values for the total group (-1.8 ± .6) (Figure 2). There was no significant difference between the two exercise groups, but group one lost (-2.1 ± .7) body fat while group two lost (-1.5 ±.9) body fat. (Table 4). Total fat lost (kg) showed a significant decrease from baseline to week 12 for all subjects (-3.4 ± .9 kg). While the two groups were not significantly different from each other, group one tended to lose more fat mass (-3.9 ± .5 kg) than group two (-2.56 ± .4 kg).

There were also significant decreases in fat free mass over the total groups of subjects (1.8 ± .5 kg) (Figure 3). While there were no significant differences between the two groups, group one lost 2.1 ± .7 kg of fat free mass while group two lost only 1.6 ± .9 kg of fat free mass (Table 4). There is no significant interaction between the groups and level of observation.

Insert table four and figures 2 &3 here

Resting Metabolic Rate

Absolute RMR showed a nonsignificant decrease (5.23%) overtime for both groups combined (-96.3 ± 65.9 kcal/day). The mean decrease in daily resting metabolic rate at the end of the experimental period for group one was 7.5% (-139.7 ± 107.5 kcal/day) and 2.6% for group two (-48.1 ± 75.0 kcal/day) (Table 5). While there was no significant difference from baseline to week 12 when RMR was expressed per body weight (kg) or fat free mass, RMR/kg tended to increases slightly for the combined groups (.44 ± 81 kcal/kg) while RMR/FFM tended to decrease slightly (-.61 ± 1.4 kcal/ kg FFM).

Insert table five here

Performance

There was a significant difference in the one mile timed walk for all participants from baseline measurements to the end of the study. There was a decrease (-2 minute and eighteen seconds) in the one mile walk for all subjects. There was no significant difference between the two groups. Group one decreased their one mile walk time by two minutes and eighteen seconds while group two decreased their times by two minutes and sixteen seconds.

There were significant differences in leg extension (+14.9 $\pm$ .7 kg) and leg curl (+4.8 $\pm$ 3.0 kg) strength in all subjects from baseline to week 12. Group two had significantly larger increases leg extension strength (+25.3 $\pm$ .5 kg) than group one (5.5 $\pm$ 1.0 kg). While there was no significant differences between the two groups with the leg curl, group 2 tended to increase hamstring strength (12.5 $\pm$ 4.5 kg) more than group one (1.0 $\pm$ .6 kg). The large variation within a group may be a large factor in not seeing significant differences here.

When looking at upper body strength, there were significant differences in lat pull down strength from the baseline data to week 12, but no significant changes in bench press strength. While there was only (.3 $\pm$ .09 kg) small increase in bench press strength across all subjects, there was a significant difference between groups. Group two increased strength (+5.55 $\pm$ .1 kg) while group one had a decrease in strength (-6.55 $\pm$ .2 kg). There was also a significant difference between groups and lat pull strength. Group one had a decrease in strength (-11.25 $\pm$ 1.5 kg) while group two had a slight increase from baseline values (+4.4 $\pm$ .74 kg).

Discussion

Long term prospective studies indicate that obesity is associated with increased morbidity and mortality, which is attributed to a variety of causes, including coronary heart disease, hypertension, and diabetes (Rabkin et al., 1984). Successful treatment of obesity and improvement in physical fitness could reduce the risk of these deadly diseases. Both dietary and exercise intervention can be used for long term weight management. A comparison of results of this research to other studies of similar length shows similar weight loss changes in subjects engaging in a multicomponent program of both dietary and exercise intervention (Pavlou et al., 1989; Hill et al., 1989; Hammer et al., 1989).

The American College of Sports Medicine (ACSM) suggests that exercise conducted a minimum of three days per week for 20 minutes in duration and of sufficient intensity to expend at least 300-500 kcal per exercise session is the threshold stimulus for body and fat weight reduction (1976). In addition, ACSM believes that during weight loss, exercise conditioning spares the loss of fat free weight (ACSM, 1978). The recommended weight loss is approximately 1-2 lbs/week. Our results contradict these concepts and support the view of Itallie and Yang that loss of body weight occurs when energy expenditure is greater than energy consumption, with the extent of weight loss related to the magnitude of the energy deficit. In our study, while significant energy deficits for both groups were created by exercises and recommended caloric restriction, a discrepancy between actual and expected weight reduction was observed. All the exercising subjects, working out four days per week and matched for caloric expenditure, lost an average of only .43 kg per week.

Having the subjects engage in any physical fitness activities, regardless of mode, would seem to create the necessary energy deficits and increased weight loss.

While there was a significant difference from baseline values in all exercising subjects, there was no difference in weight loss between the different exercise regimes. Group one lost 64% of its weight as fat and 36% as FFM while group two lost 67% of its' weight as fat and 33% as FFM. The low number of subjects in each group may be one reason for this value. A larger sample size would allow researchers to see more significant differences if they existed.

An underestimation of food intake and an overestimation of physical activity are suggested as other likely causes of the imbalance since exercise adherence was greater than 92% of all sessions. Because this study did not strictly police dietary intake, i.e. dietary guidelines were presented and encouraged, subjects may have felt guilty about overeating and underreported portion sizes or ingested foods not recommended for successful weight loss (Fricker et al.,1989). Researchers found that obese people were found to eat more than the lean people, but eat less when using a one or three day record method. Only a few subjects in both groups were able to lose large amounts of weight (12 kg) while others barely lost two kg.

Group one's results are supported by similar treatments of moderate caloric restriction with aerobic exercise tested by Hagan et al. (1986) and Zuti and Golding (1976). Both studies show that a walk/jog program enhanced body fat loss, but Hagan et al. found no fat free mass sparing by exercise with 1200 kcal/day intake. Several studies have shown that treatments with both energy restriction and exercise decrease fat free mass, but that aerobic exercise attenuates the loss of fat free mass versus sole diet restriction (Bosello et al., 1981; Hill et al.,1987). Neither we nor Garrow et al. (1986) found that exercise preserved FFM. According to Garrow et al. (1986), FFM loss can comprise up to 25% of the total weight loss without negative consequences. As weight loss occurs there is a reduction in the muscle needed to support the body's weight. The decrease in FFM and consequently a decrease in RMR may slow weight loss for all subjects (r=.64).

The use of resistance training coupled with aerobic exercise theoretically could be the solution for loss of fat free mass and RMR during energy restriction. But results are equivocal. Donnelly and Jacobson (1988) reported that weightlifting four times per week in conjunction with endurance exercise and a low calorie diet caused less fat free mass loss and more fat loss in obese women than a group that did aerobic exercise only. The fat lost in the aerobic endurance only group accounted for only 76% of the body weight lost while fat made up 86% of the weight lost in the combined exercise group. This could be attributed to the large negative energy deficit experienced by Donnelly and Jacobson's subjects. Also, Ballor et al. (1988) reported increases in lean body mass (diet plus exercise group = .43 kg) in response to weight training in obese women with a caloric restriction. Unfortunately, the results of group two in this recent study did not show such impressive results. Our subjects were permitted to weight train only two days/week and walk two days/week for the twelve period. Donnelly et al. (1991) showed similar results with resistance training. Donnelly et al.'s weight lifting subjects participated in approximately 320-480 reps/week during the study at 70-80% 1 RM. Our subjects participated in approximately 120 reps/week (60%) at the beginning of the 12 week study and ended up completing 420 reps/week at the end. Ballor et al.'s (1988) completed approximately 720 reps/week (8 exercises, 3 sets, 3 days a week). No intensity was set. The overload on the muscle to stimulate muscle growth and increase strength was double that of the present study. Consequently, it appears that our novice lifters needed an additional number of sets in each workout and throughout the study to see the preservative effects of resistance training to FFM. This may explain why there is such a disparity of results between reports. Ballor concluded that resistance training and caloric restriction act independently of each other during weight loss, i.e. energy restriction affected body fat while resistance training increased fat free mass.

Restrictive dieting often results in a decline in RMR and is given as an explanation for a reduced rate weight loss over time (Apfelbaum et al., 1976). Some studies indicate a reduction in daily energy expenditure was explained by a combination of the following components: (1) decrease in RMR related to loss in lean tissue; (2) decrease in energy cost of movement related to body movement. Negative energy expenditure was created by placing our subjects on a moderately restrictive diet and four day a week exercise program. In the present study, resting metabolic rate showed a nonsignificant decrease (5.23%) across all the subjects, with no difference between the exercising groups. Researchers attribute the decrease in RMR to decreases in FFM and the negative energy balance. These results are supported by other researchers (Hammer et al., 1987; Hill et al., 1989). Hill et al. (1989) showed a 5% decrease across all subjects without a difference between exercise regimes. Exercise was able to reverse to a decline in RMR from dieting other recent studies (Mole et al., 1989). Mole's subjects consumed a very low calorie diet for two weeks. RMR decreased to 85% of predietary level. After implementing an exercise program, RMR returned returned to baseline. In the present study, while there was no significant difference between the two exercising groups, group one decreased RMR (-139.7 $\pm$ 107.5 kcal/day, x $\pm$ SEM) and group two (-48.13 $\pm$ 75.0 Kcal/day). This slight decrease in RMR could be attributed a combination of the large negative energy deficit created by caloric restriction and physical fitness activities and the reduction in FFM despite the addition of aerobic and resistance training. The intensity and volume of exercise was not sufficient enough increase FFM to counteract the drop in RMR. Correlational analysis shows that the decrease in fat free mass (r=.64) and kcal/kg (r=.94) affected RMR.

Timed walk performances at the end of the experimental period showed significant improvements for all subjects. All subjects increased their walking times by 12.97%. This can be attributed to the decrease in weight and fat weight and an increase in fitness level. Donnelly et al. (1991) found similar results, where the combined endurance exercise and weight training group had similar or better results in oxygen consumption and fitness than the endurance exercise group. They reported that the weight training in addition to endurance may simply reflect additional benefits of increased volume of exercise. It is well established that aerobic conditioning even in the absence of weight loss will significantly increase maximal aerobic fitness level. In addition, it is known that the magnitude of this increase is related to the frequency, duration, and intensity of exercise training and to the initial fitness level (ACSM,1978). Hagan et al. (1985) attributes the increase in fitness level by an increase in maximal cardiac output and maximum arterial-venous oxygen difference. There were no significant differences between the two exercising groups. While the differences in initial fitness levels could possibly explain this difference, the significant increases in total body strength could be an important factor. Strength was preserved or increased in the combination group that performed weight training. Group two significantly increased strength when compared to group one in lat pull down, bench press and leg extension. Because endurance exercise is not known to increase strength, the decline reported is not surprising.

The results of this study do not identify any advantage of using any one exercise regime over the other when in combination with a restrictive diet with respect to RMR, body weight, or body composition changes. However, the combination group did tend to preserve FFM and RMR slightly better than the aerobic group (GP1). Once again, the small sample size and differences in initial fitness levels may have hindered seeing significant differences. Participation in exercise in conjunction with dietary intervention is necessary to help make weight maintenance a more tangible, realistic goal for obese individuals.

There may be several reasons why there were not differences between the two exercising groups: (1) The participants only lifted weights two times per week. (2) The intensity level and number of repetitions completed each week in this study was half the number completed in by Ballor et al.'s (1988) subjects where positive effects of resistance training are evident, (3) The caloric restriction was not monitored closely enough to ensure that the participants were creating a significant negative energy deficit , (4) There was a wide range of initial fitness levels in both groups.

In summary, our findings do not identify any advantage of using a combination of weight training with aerobic training as compared to aerobic training only in combination with a moderate diet with respect to RMR, body fat, fat mass, and percent body fat. The use of weight training did not appear to moderate declines in FFM or RMR in group two. However, increases were realized for one mile timed walk and strength by groups that underwent resistance training. More lengthy, intensive research is needed to investigate the benefits of resistance training in conjunction with aerobic exercise.

Table one. Aerobic exercise schedule for Group 1

(Group two follows Mon.-Wed. only)

Week	Mon./Wed. (minutes)	Tues./Thurs. (minutes)	intensity (% of Maximum HR)
1,2	30	20	50
3,4	35	25	60
5,6	40	25	60
7	45	25	60-70
8,9	45	30	60-70
10-12	45	30	70-75

Final exercise intensity was set at 75% of maximum heart rate as calculated by resting heart rate and age in Karvonen method.

Table two. Weight training schedule followed by combined group (GP2)

Week	times/week	# exercise	sets	repetition	intensity (% of 1 RM)
1	1	5	1	15	50
2	2	5	1	15	50
3-4	2	6	1	15	60
5	2	7	1	15	60
6	2	7	2	15	60
7	2	7	3	15	60-70
8	2	7	3	15-12-10	60-70-80
9-10	2	7	3	12-10-8	60-70-80
11-12	2	7	3	12-10-8	60-70-85

Table three. Baseline and post test values for weight by groups.

	Pre test	Post test
group one (kg)	78.1 ± 4.1	72.4 ± 4.1*
group two (kg)	82.4 ± 5.0	77.9 ± 4.8*

Values are mean ±SEM

Group one = dietary intervention and aerobic training only (n=10)

Group two = dietary intervention and aerobic training with resistance training (n=9).

*Significantly different ($p < .05$) from baseline value.

Table four. Baseline and post test values for percent body fat, fat mass and fat free mass by group

	GROUP ONE		GROUP TWO	
	pre test	post test	pre test	post test
Fat Mass (kg)	31.0 ±3.3	27.1±3.1*	32.9+3.7	28.0 ±3.2*
% Body Fat	38.9±2.2	36.8±2.1*	39.5±2.7	38.0±2.3*
Fat Free Mass (kg)	47.2±1.5	45.1±1.6*	49.5±2.9	47.9±2.6*

Values are means (x± SEM)

*Significantly different ($p < .05$) from baseline value.

Group one = dietary intervention and aerobic training only.

Group two = dietary intervention and aerobic and resistance training.

Table five. Baseline and post test values for Resting Metabolic Rate (RMR), RMR/kg, and RMR/FFM by group

	GROUP ONE		GROUP TWO	
	pre test	post test	pre test	post test
RMR (kcal/day)	1886.2±91.9	1773.7±72.1	1866.9±84.7	1818.8±110.6
RMR/kg (kcal/kg)	23.7±.9	24.1±1.6	22.8±1.1	23.4±1.3
RMR/FFM (kcal/kg FFM)	40.7±1.9	39.5±1.9	37.7±1.9	37.7±1.2

Values are means ± SEM

Group one = dietary intervention and aerobic training only (n = 10)

Group two = dietary intervention and aerobic and resistance training (n = 9

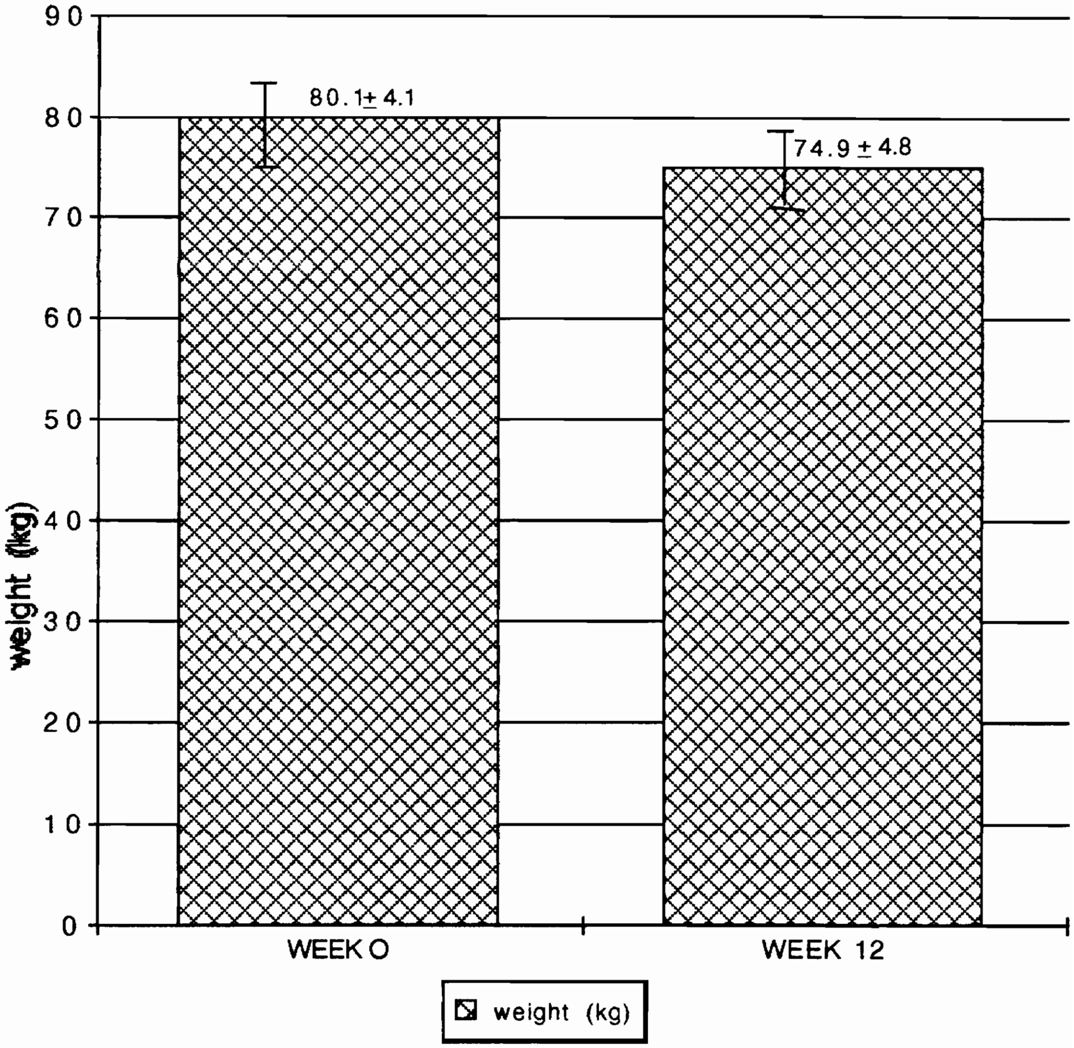

Figure one: Significant changes in mean body weight from baseline to week 12 for both groups combined.

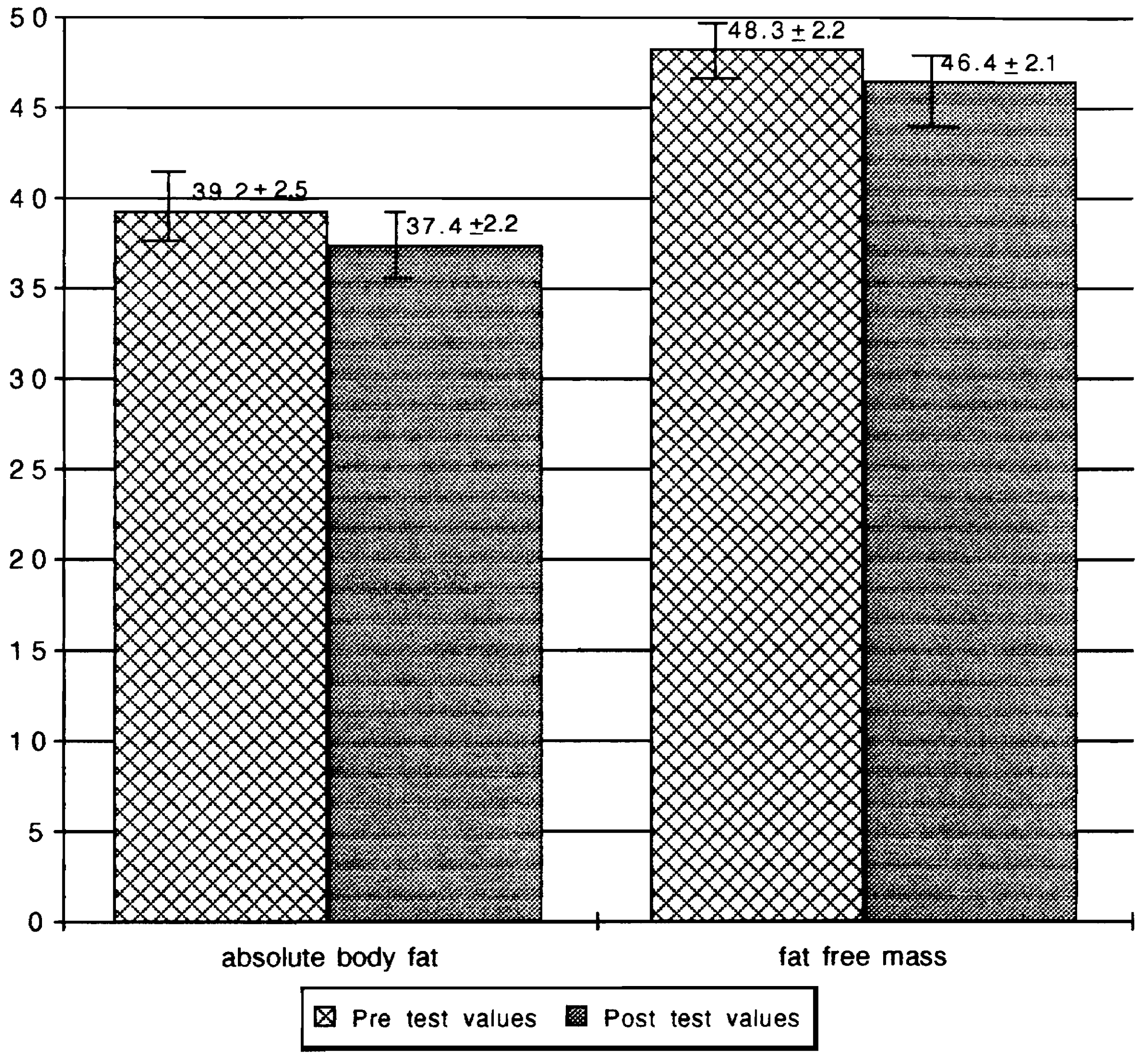

figure two : Significant changes in absolute body fat and fat free mass from baseline to week 12 for both groups combined.

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Chapter IV

SUMMARY AND RECOMMENDATIONS FOR FURTHER RESEARCH

Summary-

While a majority of recent research supports the finding that dynamic exercise coupled with caloric restriction (Hagan et al., 1986) enhances a weight loss program, researchers continue to try to determine the optimal exercise prescription to recommend to overweight individuals. Low to moderate (60% VO2) intensity exercises appear to be well tolerated and result in less orthopedic injuries in obese individuals. However, the best mode of exercise has yet to be determined to preserve resting metabolic rate and lean body mass while enhancing fat loss.

This study was implemented to determine the best mode of exercise, aerobic or aerobic plus resistance training, for an overweight population. Nineteen overweight women volunteered participate in the study. After answering all questions regarding their prior diet and exercise history, the participants signed informed consents and received a medical/physician consent forms. Hydrostatic weighing was completed by each subject to determine body composition. Anthropometric measurements were also taken. Resting metabolic rate was calculated by indirect calorimetry. After completion of these tests, subjects went through a series of performance tests both in the weight rooms to determine one repetition maximum (1 RM) and a timed one mile walk. Subjects were ranked from highest to lowest on the basis of body mass index and sequentially divided into one of two groups: diet plus aerobic exercise or diet plus aerobic and resistance exercise. Each group was matched for weekly caloric expenditure and exercised four days per week. Both groups walked for 25-40 minutes on Mondays and Fridays at approximately 60% VO2 as determined by Karvonen heart rate method. Heart rates were taken halfway and at the end of each exercise session to monitor subjects' exertion. On Tuesdays and Thursdays, group one (aerobic one) walked 20-30 minutes in target heart rate zone while group two (aerobic and resistance training group) exercised in the weight room. Group two started with five basic exercises (one set each, 15 repetitions), at 50-60% 1RM. At the end of the study, group two worked out at eight stations (three sets, 8-10-12 repetitions) at 70-85% of 1RM. All women met once a week for twelve weeks to receive the same dietary recommendations. All variables were measured after the twelve week experimental phase. All exercise sessions were supervised and attendance for all women was greater than 85% of all sessions.

The results of this investigation showed that both groups had significant losses in body weight, body fat , percent body fat, and fat free mass. However, group one tended to lose more body fat and fat free mass than group two. Also, absolute resting metabolic rate (RMR) showed a nonsignificant decrease over time for both groups. When looking at the groups separately, group one showed a greater decrease in RMR than group two. This could be attributed to the preservative effects of resistance training. RMR expressed per BW or FFM was maintained for both groups over the experiment.

This lack of significance and differences between groups may be attributed to:

(1) Low number of subjects in the study. The more subjects in a study allow for greater power in statistical analysis. While investigators would still see individual variability, a higher number of subjects would allow us to better see significant differences.

(2) Deviations from the diet. If several subjects did not adhere to the recommendation of the diet, i.e. 1200-1500 kcal/day or choosing low fat foods, their weight loss would be hindered. Few research studies have shown that diet alone is a successful weight loss strategy.

(3) Individual difference initial fitness. While no subject was engaged in a formal exercise program, there was definitely a spectrum of fitness levels and abilities in the group.

(4) Lack of control on the activity level outside the program criteria. While the researchers explained the importance of following the exercise regime they developed, some of the subjects were excited about their weight loss and their changing fitness levels and they would exercise on the weekends.

(5) Having the combined group (GP2) only resistance weight train only two days per week.

In conclusion, while there was no significance between the two groups, there was a tendency for the aerobic group to reduce body fat and fat free mass more than group two. And group two tended to preserve RMR more than group one. Thus, the total energy expenditure of the exercise rather than the mode of activity appears more important in anthropometric and metabolic rate changes during weight loss.

Research Implications

As the number of overweight and obese Americans increase, successful weight management therapies are needed to permanently reduce weight and educate. This large population is at increased risk not only for cardiovascular disease, diabetes, and hypertension but also the social alienation, prejudice, and pressure (Bray et al., 1986).

A comprehensive, long term weight control program is the only effective treatment for obesity. Reversal of obesity requires a sustained energy imbalance in favor of an energy deficit, the duration and extent of which determine the amount of weight loss. Research shows that a multicomponent program involving slightly restrictive dietary intervention and increased exercise provides the most successful approach for a majority of obese individuals (Hagan et al., 1986). That combination is supported by this study. Results show that following a moderately restrictive diet and engaging in moderate intensity exercises have significant effects on body weight, body fat percent, and fat free mass. The inclusion of exercise, whether aerobic training only or a combination of aerobic and resistance training, as an integral component of a program improves weight loss. Marson et al. (1984) were able to identify criteria for predicting successful weight maintenance in formerly overweight men and women on the basis of responses to mailed questionnaires. Of eight items found to successfully predict 95% of the relapses and 79% of the maintenance, frequency of exercise was one of the most powerful discriminators of successful weight maintenance.

Recommendations for Future Study

Research has reportedly shown the benefits of the combination of dietary intervention and exercise for weight loss rather than either mode independently. This research, while not looking at each mode separately, supports the fact that when combined, successful weight loss is possible. Unfortunately this study was not able to differentiate which mode of exercise or combination of exercises would be more successful to overweight individuals.

The following recommendation for further study are suggested to compliment the results of this investigation:

1. Inclusion of a larger sample size so investigators would be able to see more significant differences if they exist.

2. Increase control of diet by requiring weekly food diaries or supply prepackaged food. The latter choice is very expensive yet leads to more control over nutrient intake.

3. Add a diet only group and/or a diet plus resistance training group for further support of existing studies and to allow for more comparison and analysis of exercise modes to help the optimal exercise for obese individuals.

4. Increase the number of days the subjects participate in resistance training to three to four days per week.

5. Increase the intensity and number of sets completed in resistance training.

6. Increase the intensity of the aerobic portion of the program from 60% to 75% VO2 max.

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APPENDIX A

DETAILED METHODOLOGY

Detailed Methodology

Introduction-

The data in this study was collected in a pre test/post test manner to measure any changes in the dependent variables before and after the experiment. During the post test period, the subjects were scheduled on the same day and at the same time. They were also given a copy of the pre test instructions and asked to follow the same restrictions followed at the pre test measurements (appendix C).

Subject Screening and Selection-

In response to a campus advertisement, twenty adult females were selected for this study. Specific subject criteria were:

1. Between 25-45 years of age.
2. Subjects with a body mass index > 25.5 or above.
3. Subjects who were not currently dieting.
4. No contraindications to exercise or a restrictive diet as indicated by physician referral.
5. Willingness to adhere to all aspects of experimental protocol.
6. $50.00 deposit for adherence to experimental protocol during entire time: money was to be returned upon completion of the study.

All subjects were required to have a physical examination by a personal physician to verify good health prior to participation in the study (appendix C).

Preliminary Testing Procedures-

Each individual was fully informed about the nature of the study and gave her full consent. The study was reviewed and approved by the ethical committee of Virginia Tech.

Prior to the beginning of the study, each subject met with the principle investigator to discuss any potential problems. They were scheduled for pre test measurements. They were given two forms: (1) for physical and medical clearance, (2) a form which described the three tests they would be involved in and the procedures they should follow (refer to appendix C). All measurements were taken two days before the beginning of the experimental period and included hydrostatic weighing to determine body composition, body weight and height, circumference measurements, and indirect calorimetry for metabolic rate determination. These measurements established baseline data.

One hour prior to taking any measurements, all equipment was calibrated and tested several times. The oxygen and carbon dioxide measurements were calibrated with both room air and one hundred percent O2 sample. The underwater weighing tank also had the load cells calibrated at different weights to check for accuracy of results. Subjects were asked to come to the lab ten minutes before actual testing time to answer any last minute questions. Once there, all tests were explained and the waiver was signed (Appendix C).

Indirect Calorimetry-Subjects laid supine for thirty minutes in a quiet, dark room. Twenty five minutes into the rest period, the mask and Douglas bag were attached so the subjects would get comfortable breathing through the apparatus. After the full thirty minute rest period elapsed, the valve was switched so all expired air was collected in the Douglas bag for five minutes. The gas in the bag was then analyzed for CO_2 and O_2 content for one minute. The remaining volume of air was measured by the Tissot tank. One liter of air from the gas analysis was added to the Tissot measurement. Air collection was repeated three times (Appendix C). An average of the three trials was used in RMR calculation.

Height and weight-Height and weight measurements were determined prior to hydrostatic measurements and used to calculate body mass index (BMI) value. Subjects were weighed to the nearest 0.1 kg in light street clothes and with either bare feet or stockings.

Hydrostatic weighing- Eight measurements were taken on each subject. Subjects slowly descended into the tank and sat in a suspended chair. They were asked to submerge and try to remove any potential air bubbles in hair and swimsuit. The procedures were reported again. Additional weights were added to the subject if they tended to float to the surface. Subjects submerged and exhaled all possible air in their lungs. Once the investigator signaled that no more air bubbles were appearing, the assistant recorded the value. An average of the three highest underwater weights were used in the calculation of percent body weight and fat free mass value. Residual lung volumes were determined by oxygen dilution by following the procedure of Wilmore et al. (1980) after the hydrostatic weighing procedure.

Dietary Intervention- After three days of pre testing, the subjects met for the first nutritional session. They were given a detailed description of the "Joy of Eating" diet plan (Appendix D). All subjects were to follow this 1200 kcal/day diet. The diet was prescribed using the diabetic exchange system (similar to Weight Watchers diet plan). It was approximately 20% protein, 55% carbohydrate, and 25% fat. Subjects self selected their diets at home and were asked to record dietary intake. The diet listed foods as red, yellow, and green; with red and yellow items having higher fat and calories whereas green foods were recommended because they were lower in fat and calories. The goal of each participant was to consume no more than 40 grams of fat per day (30 % of calories from fat) and work down to 30 grams of fat per day (20% of calories from fat).

To further assist participants, they were told to choose from the following selection:

3 vegetable servings (1/2 cup)	2 protein servings
5 bread servings	2 fat servings
2 milk servings	1 snack serving
4 fruit servings	

Again, when choosing from each group, subjects were told to try and stay in the green group of foods.

Exercise Protocol- Following the two days of pre testing in the laboratory setting and two days after RMR testing, all subjects were directed to the weight room for one repetition max. (1RM) determination in the following lifts: Bench press, lat pulldown, leg extension, and leg curl (Appendix D). Subjects warmed up the muscles with five to ten repetitions with a light weight (40-60% of perceived exertion). They rested and stretched for one minute. They then increased the weight and practiced two to three 1 RM attempts spaced by thirty to sixty seconds rest. Finally, a 1 RM attempt was made. Weight was added until subject failed to complete the next lift. These values were for exercise prescription of group two and initial strength measurements for both groups. This 1 RM determination procedure was repeated at week six on all group two subjects to account for strength changes

The nineteen women were ranked from highest to lowest on the basis of body mass index and sequentially divided into two groups. Group one consisted of ten women and they participated in supervised walk/jog sessions four days per week (Monday, Tuesday, Thursday, Friday between 12-1pm). Mondays and Fridays were the extended sessions where subjects worked up to 45 minutes per session at the end of the study (at 75% max. heart rate). Tuesday and Thursday sessions still had subjects exercising at 75% of max. heart rate but for only twenty minutes per session.

Group two or the combination group had its' nine subjects following the same exercise prescription as group one on Mondays and Fridays but they participated in resistance training for forty minutes on Tuesday and Thursdays. The weight training program began with five basic lifts of various body parts, 50-70% 1RM, 12-14 repetitions, two sets and developed into eight lifts, 70-90% 1RM, pyramiding repetitions and three sets per exercise.

EXERCISE PROTOCOL
GROUP ONE: AEROBIC ONLY

WEEK #	Dates	MONDAY/FRIDAY (IN MINUTES)	TUESDAY/THURSDAY (IN MINUTES)	INTENSITY
1	JULY 11-12	30	20	50%MHR
2	JULY 15-19	30	20	50% MHR
3	JULY 22-26	35	25	60%MHR
4	JULY 29-AUG 2	35	25	60%MHR
5	AUG 5-9	40	25	60%MHR
6	AUG 12-16	40	25	60%MHR
7	AUG 19-23	45	25	60-70%MHR
8	AUG 26-30	45	30	60-70%MHR
9	SEPT 1-5	45	30	60-70%MHR
10	SEPT 8-12	45	30	70-75%MHR
11	SEPT 15-19	45	30	70-75%MHR
12	SEPT 22-26	45	30	70-75%MHR

Final exercise intensity was set at 75% of maximum heart rate as calculated by resting heart rate and age in the Karvonen method.

EXERCISE PROTOCOL
TABLE TWO
GROUP TWO: AEROBIC AND RESISTANCE TRAINING

WEEK #	DATES	MONDAY/FRIDAY *aerobic training	TUESDAY/THURSDAY *resistance training
1	JULY 11-12	30 MIN,50%MHR	Workout one(described below)
2	JULY 15-19	30 MIN,50%MHR	SAME AS ABOVE
3	JULY 22-26	35 MIN,60%MHR	SAME AS ABOVE -add biceps curl
4	JULY 29-AUG 2	35 MIN,60%MHR	SAME AS WEEK3 -add abdominal work
5	AUG 5-9	40 MIN,60%MHR	SAME AS WEEK 4 -add military press
6	AUG 12-16	40 MIN,60%MHR	ALL 7 EXERCISES -2 sets, 15 repetitions
7	AUG 19-23	45 MIN,60-70%MHR	7 EXERCISES -3 sets 15 repetitions
8	AUG 26-30	45 MIN,60-70%MHR	7 EXERCISES -3 sets, 15-12-10 60-85% 1RM
9	SEPT 1-5	45 MIN,60-70%MHR	7 EXERCISES -3 sets, 12-10-8 60-85% 1RM
10	SEPT 8-12	45 MIN, 60-70% MHR	SAME AS ABOVE -add some inner/outer thigh floor work
11	SEPT 15-19	45 MIN,70-75%MHR	SAME AS ABOVE -show variation of exercises with free weights
12	SEPT 22-26	45 MIN, 70-75% MHR	SAME AS ABOVE

WORKOUT ONE

This initial program utilized only the major muscle groups which we tested in pretest 1 RM determination (bench press, lat pulldown, leg extension, and leg curl) plus a triceps pushdown exercise. The subjects did 15 repetitions and worked at 50-60% of 1 RM. This intensity level was chosen to reduce the amount of muscle soreness the subjects may experience. The subjects were shown how each exercise was to be performed and educated about the muscle they were using. Handouts were available for more information.

Every two weeks new resistance exercises were introduced and every other week a new floor exercise was shown so that eventually a total body workout would be implemented by the end of the experimental period. An intensity level of 60% and 15 repetitions were implemented for each new resistance exercise. At week three, a biceps exercise was added; week five, shoulder press. Week four, abdominal floor work and week ten, inner and outer thigh floor work was added. Subjects were shown proper technique and breathing principles. They were encouraged to do two sets of 15-20 repetitions.

APPENDIX B

RAW DATA

	Subject	Group	Observation	Bodyweight (kg)
1	1	1	Pre	81
2	2	1	Pre	73.6
3	3	1	Pre	96.3
4	4	1	Pre	106.4
5	5	1	Pre	74
6	6	1	Pre	67.1
7	7	1	Pre	71.8
8	8	1	Pre	71.2
9	9	1	Pre	69.7
10	10	1	Pre	69.9
11	1	1	Post	80.4
12	2	1	Post	71.4
13	3	1	Post	84.7
14	4	1	Post	101.6
15	5	1	Post	68.3
16	6	1	Post	60
17	7	1	Post	60.4
18	8	1	Post	66.7
19	9	1	Post	65.7
20	10	1	Post	64.4
21	11	2	Pre	71.8
22	12	2	Pre	107.9
23	13	2	Pre	72.2
24	14	2	Pre	64
25	15	2	Pre	87.2
26	16	2	Pre	71.8
27	17	2	Pre	98.8
28	18	2	Pre	93.9
29	19	2	Pre	74
30	11	2	Post	66.2
31	12	2	Post	97.6
32	13	2	Post	69.2
33	14	2	Post	62.3
34	15	2	Post	85.7
35	16	2	Post	67.8
36	17	2	Post	95.1
37	18	2	Post	91.7
38	19	2	Post	65.3

RMR (kcal/day)	RMR (kcal/kg)	RMR/FFM (kcal/FFM kg)	FFM (kg)	%Body Fat
1973.7	24.1	39.6	49.9	39.1
1703.7	23.1	34.3	49.7	32.5
2316.8	24.1	43.9	52.8	45.2
2320.2	21.8	44.1	52.6	50.5
1714.3	23.2	37.5	45.8	38.1
1783.9	26.6	37.8	47.2	29.7
1482.4	20.7	35.6	41.6	42.1
2134.1	29.9	55.5	38.5	46
1435.6	20.5	38.5	48.7	30.1
1609	23	35.9	44.8	35.8
2174.1	27	42.4	51.2	36.3
1545.6	21.6	31.4	49.2	31.1
1651.1	19.5	34.8	47.4	44
1749.1	17.2	33.8	51.8	48.9
2120.4	31	47.6	44.5	34.8
1901.7	31.7	43.6	43.6	27.3
1540.6	25.5	40.6	37.9	37.2
1808.6	27.1	48.7	37.1	43.5
1267.7	19.3	38.8	43.8	33.4
1590	24.7	35.8	44.4	31
1734	24.2	35.8	48.5	32.5
2150	19.9	38	56.7	47.5
1658	23	32.6	50.8	29.6
1492	23.3	39.2	38.1	40.5
2078	23.8	31.9	65	25.5
1856	26.5	51.2	41.3	42.5
2141	21.7	39.1	54.8	44.5
2060	21.9	41.4	49.7	47
1833	24.8	45.5	40.3	45.5
1654	24.9	35.9	45.9	30.6
1843	18.9	35.9	51.3	47.5
1610	23.3	33	48.7	29.7
1350	21.7	35.9	37.6	39.6
2556	29.8	42.1	60.7	29.2
1914	28.2	44.2	43.2	36.3
1966	20.7	35.4	55.6	41.6
1769	19.3	34.5	51.4	44
1673	25.6	45.4	36.9	43.5

Leg Extension (lbs)	Leg Curl (lbs)	Bench Press (lbs)	Lat pulldown (lbs)	Timed walk (seconds)
130	80	80	65	1024
120	67.5	67.5	50	960
170	80	95	72.5	1024
150	100	77.5	67.5	1044
125	60	75	65	1004
160	90	90	85	925
160	90	102.5	90	670
170	100	110	90	824
150	80	72.5	65	1071
100	90	55	52.5	916
120	80	62.5	65	829
135	70	60	45	819
150	70	80	65	829
160	95	62.5	62.5	744
160	85	75	57.5	1040
170	92.5	80	75	819
190	105	90	82	515
175	90	85	75	625
120	80	62.5	55	874
110	80	55	55	760
150	90	75	67.5	1072
120	100	112.5	82.5	1070
90	50	52.5	60	1054
120	70	70	50	919
170	90	75	65	930
240	90	100	75	919
130	70	75	90	1054
140	80	50	50	920
250	105	100	82.5	812
180	80	77.5	75	892
190	115	110.0	82.5	879
110	57.5	57.5	65	920
145	70	65	55	765
210	110	82.5	70	789
250	140	107.5	85	755
130	65	85	90	957
155	85	65	55	843
267.5	135	100	95	722

TWO WAY REPEATED MEASURES ANOVA.

Dependent variable: body weight

****

Source of Variation	DF	SS	MS	F	P
Group	1	228.2892	228.2892	0.605	0.447
Subject(Group)	1	6417.6398	377.5082	67.398	
Observation	1	249.4260	249.4260	44.531	<0.001*
Group X Observation	1	3.5123	3.5123	0.627	0.439
Residual	1	95.2198	5.6012		

****

DF = degrees of freedom

MS = mean square

*p < .05

TWO WAY REPEATED MEASURES ANOVA.

Dependent Variable: RMR

****

Source of Variation	DF	SS	MS	F	P
Group	1	3.516	3.516	0.268	0.611
Subject (Group)	1	2.228	1.3107	3.029	
Observation	1	8.2443	8.2443	1.906	0.185
Group X Observation	1	3483.375	3483.375	0.081	0.780
Residual	1	7.3550	4.3265		

****

df = degrees of freedom

ms = mean squares

TWO WAY REPEATED MEASURES ANOVA.

Dependent variable: Percent Body Fat

****

Source of Variation

	DF	SS	MS	F	P
Group	1	7.6358	7.6358	0.075	0.787
Subject (Group)	1	1720.4931	101.2055	32.193	
Observation	1	30.9606	30.9606	9.848	0.006*
Group X Observation	1	1.1753	1.1753	0.374	0.549
Residual	1	53.4431	3.1437		

****

df = degrees of freedom

ms = mean square

* $p < .05$

TWO WAY REPEATED MEASURES ANOVA.

Dependent Variable: FFM

****

Source of Variation	DF	SS	MS	F	P
Group	1	62.5457	62.5457	0.723	0.407
Subject (Group)	1	1471.5569	86.5622	29.531	
Observation	1	30.9415	30.9415	10.556	0.005*
Group X Observation	1	0.6542	0.6542	0.223	0.643
Residual	1	49.8316	2.9313		

****

df = degrees of freedom

ms = mean square

*p < .05

TWO WAY REPEATED MEASURES ANOVA.

DEPENDENT VARIABLE: RMR/LBM

****

Source of Variation	DF	SS	MS	F	P
Group	1	15.7109	15.7109	0.326	0.575
Subject (Group)	1	818.2691	48.1335	2.631	
Observation	1	8.5300	8.5300	0.466	0.504
Group X Observation	1	1.7426	1.7426	0.095	0.761
Residual	1	311.0858	18.2992		

****

df = degrees of freedom

ms= mean square

TWO WAY REPEATED MEASURES ANOVA

DEPENDENT VARIABLE: RMR/kg

****

Source of Variation	DF	SS	MS	F	P
Group	1	4.1685	4.1685	0.214	0.649
Subject (Group)	1	330.9020	19.4648	3.015	
Observation	1	3.0064	3.0064	0.466	0.504
Group X Observation	1	0.3664	0.3664	0.057	0.815
Residual	1	109.7420	6.4554		

****

df = degrees of freedom

ms = mean squares

TWO WAY REPEATED MEASURES ANOVA

Dependent variable: leg extension

****

Source of variation

	SS	DF	VAR. EST.	F	P
Group	5035.82	1	5035.82	1.57	.2278
Observation	2100.16	1	2100.16	10.09	.0055*
Interaction	926.43	1	926.43	4.45	.05*
Error	3539.03	17	208.18		

****

DF = degrees of freedom

*p< .05

TWO WAY REPEATED MEASURES ANOVA

Dependent variable: leg curl

****

Source of variation

	SS	DF	VAR. EST.	F	P
Group	216.26	1	216.26	0.35	.5615
Observation	394.9	1	394.90	3.35	.0500*
Interaction	313.22	1	313.22	2.66	.1212
Error	2001.25	17	117.72		

****

DF = degrees of freedom

*p< .05

TWO WAY REPEATED MEASURES ANOVA

Dependent variable: lat pull down

****

Source of variation

	S S	DF	VAR. EST.	F	P
Group	170.0	1	170.0	0.29	.5990
Observation	138.32	1	138.32	5.53	.0310*
Interaction	583.38	1	583.38	23.33	.0002*
Error	425.17	17	25.01		

****

DF = degrees of freedom

*p< .05

TWO WAY REPEATED MEASURES ANOVA

Dependent variable: bench press

****

Source of variation

	SS	DF	VAR. EST.	F	P
Group	233.96	1	233.96	0.65	.4320
Observation	6.32	1	6.32	0.59	.4524
Interaction	347.08	1	347.08	32.47	.0001*
Error	181.72	17	10.69		

****

DF = degrees of freedom

*p< .05

TWO WAY REPEATED MEASURES ANOVA

Dependent variable: one mile timed walk

****

Source of variation

	SS	DF	VAR. EST.	F	P
Group	6983.27	1	6938.26	0.28	.6020
Observation	179953.3	1	179953.3	41.32	.0001*
Interaction	12.05	1	12.05	0.00	.9587
Error	74030.2	17	4354.72		

****

DF = degrees of freedom

*$p < .05$

Subject Participation in Exercise Sessions

Actual session attended/ Number of sessions offered=attendance percentage

Group One	Group Two
Subject # 1 44/46=.958	Subject #11 45/46=.979
Subject # 2 43/46=.934	Subject #12 39/46=.848
Subject # 3 44/46=.958	Subject #13 42/46=.875
Subject # 4 41/46=.891	Subject #14 44/46=.958
Subject # 5 45/46=.978	Subject #15 45/46=.978
Subject # 6 44/46=.958	Subject #16 41/46=.891
Subject # 7 43/46=.934	Subject #17 39/46=.848
Subject # 8 46/46=1.00	Subject #18 42/46=.875
Subject # 9 41/46=.891	Subject #19 44/46=.958
Subject # 10 38/46=.826	Group Average=.912
Group Average=.932	

Overall average for both groups combined: .922

T-test on all pretest values

	Mean	SEM	P-value
Pre weight			
group 1	78.1	3.1	
group 2	82.4	5.0	0.517
Pre RMR			
group 1	1822.3	111.6	
group 2	1866.9	84.7	0.754
Pre kcal/kg			
group 1	23.7	.88	
group 2	22.8	1.1	0.528
Pre kcal/FFM kg			
group 1	40.7	1.9	
group 2	37.7	1.9	0.294
PreFat Free Mass			
group 1	47.1	1.45	
group 2	49.5	2.89	0.491
Pre Percent body fat			
group 1	38.9	2.2	
group 2	39.4	2.6	0.874
Pre leg extension			
group 1	143.5	7.5	
group 2	156.7	18.3	0.519
Pre leg curl			
group 1	83.8	4.1	
group 2	82.8	5.6	0.892
Pre lat pulldown			
group 1	82.5	5.3	
group 2	78.9	7.1	0.691
Pre bench press			
group 1	70.25	4.4	
group 2	69.2	4.8	0.871
Pre timed walk (seconds)			
group 1	946.2	38.5	
group 2	972.2	30.6	0.605

*p<.05

Correlation of Difference Scores (pre-post values)

Correlations:	weightdiff (kg)	RMRdiff (kcal/day)	RMR/FFMdiff (kcal/FFM(kg)	RMR/kg diff (kcal/kg)	FFMdiff (kg)	percfatdiff (%Body fat)
WTDIFF	1.0000	-.3463	-.1300	-.0994	-.6407*	-.1782
RMRDIFF	-.3463	1.0000	.9356**	.9206**	.0786	.1061
DIFFLBM	-.1300	.9356**	1.0000	.9244**	-.1612	.2186
DIFFKG	-.0994	.9206**	.9244**	1.0000	.0466	-.0890
DIFFFAT	-.6407*	.0786	-.1612	.0466	1.0000	-.6022*
DIFFPERC	-.1782	.1061	.2186	-.0890	-.6022*	1.0000
DIFFEXT	.1741	.3240	.3447	.3438	-.1628	.0136
DIFFCURL	.0719	.4156	.3205	.5412*	.0635	-.1761
DIFFLAT	-.2514	.3547	.2992	.3763	.2634	-.0245
DIFFCHST	-.2362	.1815	.0215	.1331	.2857	-.0724
DIFFTIME	-.0397	.6513*	.6485*	.6877**	.1396	-.1922

Correlations:	diff ext (kg)	diff curl (kg)	diff lat (kg)	diff chest (kg)	diff time (seconds)
WTDIFF	.1741	.0719	-.2514	-.2362	-.0397
RMRDIFF	.3240	.4156	.3547	.1815	.6513*
DIFFLBM	.3447	.3205	.2992	.0215	.6485*
DIFFKG	.3438	.5412*	.3763	.1331	.6877**
DIFFFAT	-.1628	.0635	.2634	.2857	.1396
DIFFPERC	.0136	-.1761	-.0245	-.0724	-.1922
DIFFEXT	1.0000	.3680	.3453	.3080	.2391
DIFFCURL	.3680	1.0000	.4046	.4259	.3860
DIFFLAT	.3453	.4046	1.0000	.7169**	.5212
DIFFCHST	.3080	.4259	.7169**	1.0000	.1394
DIFFTIME	.2391	.3860	.5212	.1394	1.0000

Fat Free Mass Change by Individual Subject

Subject #1	+1.3/51.2=+.025	Subject #11	-2.6/48.8=-.057
Subject #2	-0.5/49.2=-.01	Subject #12	-5.4/51.3=-.105
Subject #3	-5.4/47.4=-.114	Subject #13	-2.1/48.7=-.043
Subject #4	-0.8/51.8=-.015	Subject #14	-0.5/37.6=-.013
Subject #5	-1.3/44.5=-.029	Subject #15	-4.3/60.7=-.071
Subject #6	-3.6/43.6=-.083	Subject #16	+1.9/43.2=+.44
Subject #7	-3.8/37.9=-.100	Subject #17	+.8/55.6=+.014
Subject #8	-1.4/37.1=-.038	Subject #18	+1.7/51.4=+.033
Subject #9	-4.9/43.8=-.112	Subject #19	-3.4/36.9=-.092
Subject #10	-.4/44.4=-.009		

Percentage change for group one=-4.85%   Group two % change=1.19%

Percentage change in FFM for both groups combined=-1.83%

Percent Fat Change by Individual Subject

Subject #1	-2.5/36.3=-.068	Subject #11	-1.9/30.6=-.062
Subject #2	-1.4/31.1=-.045	Subject #12	-0/47.5=0
Subject #3	-1.2/44.0=-.027	Subject #13	+.1/29.7=+.003
Subject #4	-1.6/48.9=-.033	Subject #14	-0.9/39.6=-.023
Subject #5	-3.3/34.8=-.095	Subject #15	-+3.7/29.2=+.127
Subject #6	-2.4/27.3=-.088	Subject #16	-6.2/36.3=-.170
Subject #7	-4.9/37.2=-.132	Subject #17	-2.9/41.6=-.07
Subject #8	-2.5/43.5=-.057	Subject #18	-3.0/44.0=-.068
Subject #9	+3.3/33.4=+.099	Subject #19	-2.0/43.5=-.046
Subject #10	-4.8/31.0=-.155		

Percentage change for group one=-6.01%   Group two % change=-3.43%

Change in percent body fat for both groups combined=-3.23%

APPENDIX C

INFORMED CONSENT

INFORMATION DATA SHEETS

HUMAN PERFORMANCE LABORATORY

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

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 and Physical Education of Virginia Polytechnic Institute and State University.

Title of the Study:

Comparison of isoenergetic aerobic versus aerobic plus resistance exercise program during a weight loss program.

Purpose of the experiment include:

Determine if the changes in body composition or metabolic rate differ between obese women on a weight reduction diet who exercise aerobically and those women who do aerobic combined with resistance training.

I voluntarily agree to participate in this testing program. It is my understanding that my participation will include:

1. Following a modestly restricted calorie diet of approximately 1200 kcal/day diet for 12 weeks.

2. Attending a weekly nutrition education session of one hour for 12 weeks.

3. Participating in a supervised walk/jog and/or resistance weight training program four days per week for one hour per session for twelve weeks.

4. Having my body weight recorded weekly for 12 weeks.

5. Undergoing tests for body fat content using two methods: underwater weighing (required that you totally submerge underwater eight times for approximately 10-15 seconds per time) and bioelectric impedance (an imperceptible current is passed through the body). These tests will by done prior to and at the end of the weight loss program.

6. Testing of your resting metabolic rate (number of calories you burn) prior to and at the end of the weight loss program. This will require you to breathe into a mouthpiece for 30 minutes while lying down in the laboratory.

7. Testing of your muscle strength. This will included maximal

effort lifts using a Universal weight lifting machine.

I do understand that participation in this experiment may produce certain discomforts and risks. These include:

Risk of fatigue, irritability, hunger, and temporary cessation of menstrual periods due to the diet; risk of temporary muscle soreness from the exercise.

Slight risk of muscle injury (such as tendinitis, bursitis, strains, and sprains) or cardiovascular complications during exercise; slight risk of gall bladder problems due to weight loss.

Certain personal benefits may be expected from participation in this experiment. These include:

1. Knowledge of ones body composition, strength, and metabolic rate.

2. Weight loss (up to 24 pounds if a weight loss of two pounds per week is assumed with good compliance to the diet and exercise program).

3. Instruction on appropriate exercise technique.

4. Instruction nutrition and appropriate weight loss techniques.

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 that the activities might be injurious to my health.

I understand that is my personal responsibility to advise the researchers of any preexisting medical problems 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.

Date ____________________ Time ____________________

Participant signature ______________________________

Witness ____

Project Director __________________________________

HPE Human Subjects Chairman

HPE Division: Dr. Charles Baffi phone 231-8284

University: Dr. Ernie Stout phone 231-5281

3. Circle any symptoms listed below that you have experienced within the last year:

abdominal pain	swollen joints
chest pain	feeling faint
heart palpitations	leg pain with exercise
dizziness	low back pain

4. Circle any medications that you have taken over the past year:

blood thinner	heart rhythm medication
diabetic pill	high blood pressure medication
digitalis	insulin
diuretic	nitroglycerin
epilepsy	birth control pills

other (list)...............................

5. List any surgery you have had................................

6. Have you had any serious illnesses in the past year?__________
____

7. Have you given birth in the last year?______________________

8. Do you smoke? __________________
   If yes, how many cigarettes per day?________________

9. Do you currently exercise regularly? ____________________

   If yes, what type?____
   how often?____

   Did you used to exercise regularly?
   If yes, when?____
   What type and how much?____________________________________

10. Are you currently dieting to lose weight?____________________

How long have you considered yourself overweight?___________

How many times have you dieted and lost at least 15 pounds?_
____

What was you weight when you were 20 years old?______________

What was your weight six months ago?_________________________

Have you ever had unpleasant side effects or medical problems due to dieting?____

Do you have any food allergies or intolerance (e.g. milk allergy)?____

11. Are you currently experiencing any high stress situations at home or at work? This is asked to see whether this is an appropriate time for you to start a weight loss program? It is difficult to start something new during a time of high stress. Explain.

12, What is your typical weekly schedule? In other words, what times are you not available?

13. Do you plan to be out of town during the next three months? When?

RESTING METABOLIC AND BODY WEIGHT COMPOSITION PRETEST EXPLANATION AND INSTRUCTIONS

You are scheduled to come to the lab (Gym 230) at __________ am on ____________________ . You can expect to be in the lab between 1 1/2 to 2 hours.
If you have any additional questions or problems please call the lab at 231-5006 or Cheryl Parker at 951-9034.

RESTING METABOLIC RATE PRETEST

The purpose of this test is to measure the number of calories your body uses at rest.

When you come into the lab, you will be asked to lay in a comfortable position in a dark, quiet room for thirty minutes. While resting, you will be breathing room air through a face mask. After 30 minutes, we will collect your expired air in a large bag for five minutes. The air is analyzed to measure the oxygen and carbon dioxide content. The total amount of expired is also measured. This test is repeated two more times.

In order to ensure accurate measurements, we need you to do the following:

1. Refrain from exercise and food for 12 hours before scheduled test.
2. Refrain from drinking drinks with caffeine (coffee, diet soda) 12 hours before your scheduled test.
3. No smoking
4. Try to get a good, restful night's sleep.
5. Try to drink eight glasses of fluid, i.e. water 24 hours before testing.

BODY COMPOSITION PRETEST

This test is designed to estimate the percentage of fat and lean body mass in your body.

This test is made up of two parts. The first part measures the residual volume of air in the lungs or the amount of air left in the lungs after a maximum exhalation. You will exhale all the air in your lungs, then breathe a container of 100% oxygen as quickly and as deeply as you can. After 7 or 8 breathes, you will maximally blow all the air out of your lungs. The air left in the bag will be analyzed.

The second part of this test is the hydrostatic or underwater weighing. You will get into the tank slowly and sit in the suspended chair. You will be asked to submerge and remove all the air pockets that may be in your hair and suit. This test requires you to exhale out all the air in your lungs and submerge completely for approximately 10 seconds. This is repeated eight times.

Please follow all instructions above.

A swimsuit, towel, and a change of clothes is needed.

RESTING METABOLIC RATE
DATA SHEET

Name________________________________ Date____________________

Current weight____________________ Time____________________

Height______________________________ Baro. Pressure_________

Room Temp_______________

1. Rest thirty minutes

Trial One
Oxygen (O2) ______________ Carbon dioxide (CO2)__________
Tissot tank
final reading __________________________
start reading___________________________

difference _____________________________ (multiply by 10)

Total=_____/5 = __________* 132.9 (con fac)= ___________
= + 1000

= _______L/min

Trial Two
Oxygen (O2) ______________ Carbon Dioxide (CO2)____________
Tissot tank
final reading _________________________
start reading _________________________
difference _____________________________ (multiply by 10)

Total=_____/5 = _________* 132.9 = ______________________
= + 1000

= ____________L/min

Trial Three
Oxygen (O2) ________________ Carbon Dioxide_______________
Tissot tank
final reading _____________________________
start reading _____________________________
difference ______________________________(multiply by 10)

Total=_____/5 = _________*132.9 = _______________________
= + 1000

= ____________L/min

Body Composition Data Sheets

Name ________________________ Date ______________

Age ____________ Height __________ (cm) Dry weight __________ (kg)

Circumference

				average
Shoulder	_______	_______	_______	_______
Chest	_______	_______	_______	_______
Waist	_______	_______	_______	_______
abdomen	_______	_______	_______	_______
hip	_______	_______	_______	_______
thigh*	_______	_______	_______	_______
calf*	_______	_______	_______	_______
arm*	_______	_______	_______	_______

*taken on the right side

Underwater Weights

Water temperature ____________________ C

_______ _______ _______ _______ _______

_______ _______ _______ _______ _______

Average of highest three underwater weights ________________ lbs
Percent body fat ____________

Residual Lung Volume

PBar __________ mmHg Air temperature _________ C

FVC _______ _______ _______ _______ (AVG)

Calibration gas ______ % O2 _________ % CO2

Equilibrium gas ______ % O2 _________ % CO2 __________ % N

______ _________ __________

Volume of bag spiro __________ + 0.5 = ______________

Residual Lung Volume __________ ________ __________ AVG

VITA

Cheryl Parker was born in Orlando, Florida on April 1, 1967. This date seemed very appropriate for her. Her father was in the Air Force so she had a great opportunity to travel all over the country and Europe as a child with her brother and three sisters. This really opened her eyes to other cultures and customs. The experiences made her the person that she was because she was not shy and enjoyed meeting new people. She loved to move to new places, where she knew no one, and make as many new friends as possible.

Upon graduating from Poquoson High School in Poquoson, Virginia in 1985, she entered Virginia Tech. She managed to go through three majors and forty additional pounds. After graduating in Exercise Physiology in 1989, she returned that fall to enter the graduate program in Exercise Physiology, specializing in Adult Fitness and Cardiac Rehabilitation. During her three years, she was a graduate assistant in the department of Physical Education and Recreation where she taught a variety of aerobic and aquatic classes to students. She did her internship in the Cardiac Program. She really enjoyed walking, running and talking with all the participants (especially Lt. Jim Woods). Cheryl also worked at VTWC for three years. She really enjoyed her time at the facility, but especially loved the individuals that she encountered. She also taught aerobics for Campus Recreation and Intramurals to help pay her graduate bills and for fun.

Cheryl had a wonderful opportunity, because of her advisor, to work on a research project at UCD her second year of graduate school. She remembered this as one of the best times of her life.

Cheryl's first job was at Georgia Southern University as Campus Recreation and Intramural's Fitness Programmer. She really loved the opportunity stay at the college level and work with the students. She completed her thesis during her first year of work in Georgia. Upon completion in May 1993, she was commissioned into the Air Force in Aerospace Physiology. She wanted to return to school in a few years to continue her education.

Cheryl Parker