THE EFFECTS OF A SIX-WEEK COMBINED RESISTANCE TRAINING AND DIET PROGRAM ON VO2 MAX IN TRAINED AND UNTRAINED INDIVIDUALS

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Chapter I

Introduction

Functional capacity (VO2 max) is the greatest rate of oxygen utilization attainable during heavy work (Howe & Franks, 1986) and has received wide acceptance as the primary determinant of cardiorespiratory endurance capacity (Davis, Frank, & Wasserman, 1979). Regular physical activity has been shown to improve cardiovascular fitness (VO2 max) (Stone et al., 1991) and it has been reported that individuals with higher VO2 max values show lower levels of coronary heart disease than those individuals that are sedentary(Blair et al., 1983). Participation in physical fitness activities is increasing and both men and women have become more conscious of the importance of better health by improving their cardiorespiratory capacities and losing body fat (Gettman & Pollock, 1981).

Exercise recommended by the American College of Sports Medicine, includes both aerobic activity and resistance training (The American College of Sports Medicine, 1990). The use of large muscle mass exercises and the volume and relative intensity of training are related to the improvement of cardiovascular fitness (Stone et al., 1991). Many studies (Gettman et al., 1979; Poehlman et al., 1992; Smutok et al., 1993; & Nakao, Inoue, & Murakami, 1995) have suggested that aerobic training can significantly increase functional capacity. While research remins unclear, weight training is generally believed to have a limited effect on VO2 max (Stone et al., 1991). However, research is currently being conducted on a new and unique resistance training and dietary program called Biometrics "One-on-One".

Biometrics "One-on-One" program is a weight management program that is currently being studied and analyzed for its effects on functional capacity, body fat percentage, lean body mass, blood lipid profile, and associated parameters. This program includes a strictly prescribed diet in regards to both caloric intake and water consumption. The program participants are provided with a personal trainer three times a week throughout the six-week program to assist with resistance training and stretching exercises. The resistance training exercises are performed with a high resistance and low repetitions and are usually completed in 20 minutes. The main goal of Biometrics "One-on-One" program is to preserve or increase lean body mass during weight loss (Biometrics, 1994).

Justification of Study

An improvement in VO2 max in individuals, has been shown to increase physical work capacity, reduce fatigue, and reduce the incidence of cardiovascular disease (Stone et al., 1991). Aerobic exercise has been studied and documented to result in increased VO2 max (Davis, Frank, & Wasserman, 1979). With the exception of circuit weight training, resistive training has not generally been regarded as effective in eliciting increases in VO2 max. In fact, the mechanism by which weight training can increase VO2 max remains unclear (Stone et al., 1991). Research data including diet and VO2 max is very limited, however one study found that a high protein diet preserves VO2 max during weight loss(Davis & Phinney, 1990). Since the data is still unclear on whether resistance training has any effect on VO2 max, it is important that research determine if Biometrics "One-on-One" program (resistive training combined with a low-fat, high-fiber, modified-caloric diet) can improve VO2 max.

Statement of the Problem

The purpose of this study was to determine if a six-week combined resistance training and diet program will significantly increase VO2 max in trained and untrained individuals.

Hypotheses

As a result of the six-week combined resistance training and dietary modification program:

1. There will be no significant difference in absolute VO2 max values for males based on training status.
2. There will be no significant difference in absolute VO2 max values for males based on time (pre vs. post).
3. There will be no significant difference in absolute VO2 max values for males based on the interaction of training status and time.
4. There will be no significant difference in relative VO2 max values for males based on training status.
5. There will be no significant difference in relative VO2 max values for males based on time (pre vs. post)
6. There will be no significant difference in relative VO2 max values for males based on the interaction of training status and time.
7. There will be no significant difference in absolute VO2 max values for females based on training status.
8. There will be no significant difference in absolute VO2 max values for females based on time (pre vs. post).
9. There will be no significant difference in absolute VO2 max values for females based on the interaction of training status and time.
10. There will be no significant difference in relative VO2 max values for females based on training status.

11. There will be no significant difference in relative VO2 max values for females based on time (pre vs. post).
12. There will be no significant difference in relative VO2 max for females based on the interaction of training status and time.

Extent of Study

Limitations

1. The sample only included apparently healthy adult males and females.
2. The sample size was limited to 15 people.
3. No attempt was made to randomly select the sample subjects.
4. A control group was not used.

Delimitations

1. No attempt was made to separate the effects of diet vs. the effects of resistance training on VO2 max.
2. Subjects did not keep records of dietary compliance.
3. Study only lasted six weeks.
4. No attempt was made to determine changes in body composition.

Assumptions

1. Subjects completed the Biometrics "One-on-One" Health Questionnaire honestly and accurately.
2. Specific data (treadmill test with metabolic cart) relative to the present study was accurately collected.
3. Subjects followed recommendations concerning dietary changes and liquid intake.

Definitions

The following terms were used as a part of the study:

Aerobic - with oxygen (Katch & McArdle, 1993).

Absolute VO2 Max - value of functional capacity expressed in L/min (ACSM Resource Manual, 1991).

Anaerobic - without oxygen (Katch & McArdle, 1993).

Circuit Training - a sequence of resistance exercises done one after the other in the same workout with short periods of rest in between exercises (Howe & Franks, 1986).

Concentric contraction - a shortening of the muscle as a result of the contraction of that muscle (ACSM Resource Manual, 1991).

Eccentric Contraction - a lengthening of the muscle during its contraction (ACSM Resource Manual, 1991).

Electrocardiogram (ECG) - a tracing of the electrical activity of the heart during a complete contraction/relaxation cycle (Howe & Franks, 1986).

Glucose - the ready form of carbohydrates (Katch & McArdle, 1993).

Glycogen - the storage form of carbohydrate. It is used in the muscles for the production of energy (Katch & McArdle, 1993).

Graded Exercise Test - a multi-stage test that determines a person's physiological response to different intensities of exercise and/or the person's VO2 max (Howe & Franks, 1986).

Maximal Oxygen Consumption (VO2 max) - the greatest rate of oxygen utilization attainable during heavy work. Measured in L/min or ml/kg/min (Howe & Franks, 1986).

Relative VO2 Max - value of functional capacity expressed in ml/kg/min (ACSM Resource Manual,1991).

Resistance (Strength) Training - Exercise using a wide variety of muscular strength and power-building methods and modes to increase muscular size, strength, and endurance. The performance of various exercises not only using free weights and machines, but the use of resistance provided through hydraulics, elastic bands, springs, and isometrics, involving concentric and eccentric contractions (ACSM Resource Manual, 1991 & Howe & Franks, 1986).

Twelve-lead ECG - a record of the electrical activity of the heart from different directions, with six limb leads and six chest leads (Howe & Franks, 1986).

Chapter II

Review of Literature

Traditionally, it has been believed that only aerobic exercise could increase VO2 max. In fact the American College of Sports Medicine (1995) states that in order to develop cardiorespiratory fitness an individual should: (1) exercise three to five days a week; (2) exercise at an intensity of 60% to 90% of maximum heart rate; or 50% to 85% of VO2 max; (3) perform 15 to 60 minutes of continuous activity at this intensity; and (4) activity should involve continuous use of large muscle groups.

Resistance training is one of the fastest growing activities in the United States and is widely used to improve various aspects of fitness (Stone & Wilson, 1985). The research on resistance training and its effects on VO2 max is limited. As a result, the effect of resistance training on the cardiovascular system remains unclear (Stone et al., 1991). However, the following review of articles provides valuable information about resistance training and VO2 max.

Resistance Training and VO2 Max

In 1973, Fahey and Brown conducted a study to test the effect of weight training on VO2 max. Fifteen male subjects lifted three days a week for nine weeks. Low (five) repetitions and maximum resistance were used during the study period. Fahey and Brown (1973) found a nine percent decrease in relative VO2 max.

Wilmore et al. (1978) studied the effect of circuit weight training on VO2 max. The study included twelve women and sixteen men. The subjects lifted weights three days a week for ten weeks. The training program allowed for fifteen-second rest periods between each 30-second set. During each 30-second session, the subjects performed as many repetitions as possible. The results of this study showed that the women increased ($P<0.05$) their relative VO2 max by eleven percent, while the men showed no increase ($P>0.05$) in relative VO2 max. Wilmore et al. (1978) concluded that participants who are more physically fit (ie: men being stronger than women) need a higher level of training to increase their cardiorespiratory fitness.

Hurley et al. (1987) conducted a study to determine the benefits of a resistance training program on coronary risk factors and VO2 max. The experimental subjects included eleven untrained males between the ages of 40 and 55 years. The control group was made up of ten untrained males ages 40 to 64 years. None of the subjects were smokers or had any manifestations suggestive of coronary heart disease. VO2 max was measured by a graded treadmill test (Bruce protocol) before and after the training program. The subjects trained on Nautilus exercise machines three to four days a week for sixteen weeks. Each exercise session consisted of one set of fourteen exercises. The subjects performed 8 to 12 repetitions maximum (RM) for all upper body exercises and 15 to 20 RM for all lower body exercises. The weight was adjusted according to strength gain throughout the study. The subjects followed a program requiring a two second concentric contraction and a four second eccentric contraction and less than 15 seconds of rest between exercises. The results of this study showed no significant ($P>0.05$) change in relative VO2 max.

In 1979, Gettman et al. conducted a study to determine the differing effects of circuit weight training versus aerobic exercise (jogging) on VO2 max. The first eight weeks of the study, the subjects circuit trained three days a week. The subjects lifted ten to fifteen repetitions per set. After eight weeks of circuit weight training, the subjects increased their relative VO2 max by three percent ($P<0.05$). The second eight weeks, the subjects jogged at 85 percent of their maximum heart rate three days a week. After eight weeks of jogging, the subjects improved their relative VO2 max an additional eight percent ($P<0.01$). The third eight weeks of the study, half of the subjects continued jogging, while the other half went back to weight training. At the end of the third eight weeks, both groups had maintained relative VO2 max equally. In conclusion, Gettman et al. (1979) suggested that once fitness is attained, it takes less effort to maintain it.

Poehlman et al. (1992) conducted a study to determine the difference between aerobic and resistance training on VO2 max. The study involved 96 young males who were in good health. All of the subjects met the American College of Sports Medicine's (1995) apparently healthy classification. The subjects were divided into one of three groups depending on their mode and level of participation in exercise training. The untrained group, which consisted of 42 individuals, did not participate in any regular physical training (endurance or strength). The aerobically trained group consisted of 36 subjects. These individuals were runners who had participated in endurance activities for an average of 4.8 ± 1.2 years and run an average of 77 ± 19 kilometers (km) per week. The resistance-trained group consisted of 18 body-builders who had been training for an average of 4 ± 1 years five to six times per week. Their training program involved a moderate resistance (70 to 80 percent of one-repetition maximum) and high repetitions (10 to 20) in three to five sets with short rest intervals between exercise bouts. The subjects used both free-weights and exercise machines. Their programs were designed so that they worked out the upper and lower body muscles on alternating days. None of the body-builders reported endurance activities or past or present use of anabolic steroids. All of the subjects were tested 36 to 48 hours after their last exercise session. VO2 max was assessed by a continuous and progressive maximal treadmill test. The running speed was selected by the subjects, and the initial incline was set at zero percent and then increased by 2.5% every two minutes until volitional fatigue. All the subjects reached their age predicted maximal heart rate and maximal respiratory quotient greater than 1.0 during the treadmill test. Relative VO2 max was higher in the aerobically trained males ($P<.01$) than in resistance-trained males. However, the resistance-trained males had a higher relative VO2 max ($P<.05$) than the males who were sedentary.

Smutok et al. (1993), studied the differing effects of aerobic and strength training on VO2 max among men at increased risk for CHD. The study involved 44 untrained males who had a mean age of 50 years. However, seven of the men did not complete the study. The subjects were volunteers who had agreed to participate in this 20 week study. The subjects were divided into three groups including a strength training, an aerobic training, and a control group. All of the subjects met the following criteria: nonsmokers, not taking insulin, and no evidence of CHD. However, all of the subjects were at increased risk for CHD based on having at least two of the following risk factors: abnormal lipid profile, abnormal blood glucose level, or hypertension. VO2 max was measured during a continuous treadmill test. The strength training group worked out three times a week on nonconsecutive days for twenty weeks. The strength trainers performed two sets using the maximum amount of weight they could lift 12 to 15 times per set. The strength trainers performed 11 different exercises and modified sit-ups. The weights were adjusted through out the program as strength levels increased. Only a 90-second resting interval was allowed between each set. Before the training session began, the subjects performed static stretches and calisthenics. The aerobic training group also began each exercise bout with warm-up and flexibility exercises. The aerobic trainers then walked and/or jogged on a treadmill for 30 minutes a day three days a week for 20 weeks. The first week the speed of the treadmill was adjusted so that an exercise intensity of 50 to 60 percent of each subject's maximum heart rate reserve was maintained. The relative intensity was increased to 60 to 70 percent during the second week and to 75 to 80 percent thereafter. The control group did not participate in any regular exercise, but underwent the same testing procedure as the other two groups. At the end of the twenty weeks, relative VO2 max had increased by 19 percent ($P<0.0001$) in the aerobic training group, but did not change ($P>0.05$) in strength training or control groups.

In 1995, Nakao et al. investigated the effect of adding a jogging program to a weight lifting program on VO2 max. The weight lifting program consisted of high intensity, low repetitions, and long rest periods between sets. The study included 26 untrained male students and involved weight training for three years. VO2 max was tested at the beginning, one year, two years, and three years after training. Nineteen of the subjects lifted weights five days a week for three years, four of the subjects performed the same weight lifting program for three years with an additional jogging program that consisted of jogging two miles once a week during the third year of the study, and the remaining three subjects followed the weight lifting program the first year and the combined weight lifting-jogging program the second and third years. The results of this study showed that relative VO2 max decreased significantly during the first year, decreased insignificantly during the second year, and leveled off during the third year for the weight training-only group ($P<0.05$). The remaining two groups showed a decrease in VO2 max until the jogging program was started, then VO2 max returned to its initial level and then leveled off.

Diet and VO2 Max

Few studies have been conducted concerning diet and VO2 max. However, in 1990, a study (Davis & Phinney) was conducted to determine the effects of two very low calorie diets on physical performance. The study included ten moderately obese women. Diet 1 (n=5) subjects consumed 450-550 kcal per day from common foods which were adjusted to provide protein at 1.5 grams per kilogram initial body weight and less than 10 grams carbohydrates. Diet 2 (n=5) subjects consumed a formula that consisted of 420 kcal per day and provided 70 grams of protein and 30 grams of carbohydrates. Subjects on Diet 1 lost a total of 17.5 kilograms, while subjects on Diet 2 lost 18.1 kilograms body weight. VO2 max was tested on a cycle ergometer before and after the women lost 17 kilograms body weight. Absolute VO2 max did not change ($P<0.05$) as a result of Diet 1, but it decreased ($P>0/05$) with the consumption of Diet 2. The authors concluded that the higher protein intake of Diet 1 allowed better preservation of VO2 max.

Summary of Articles

The above articles display many different effects and types of resistance training. High resistance, low repetition weight training has generally demonstrated significant decreases in relative VO2 max (Fahey & Brown, 1973, & Nakao, 1995). Circuit weight training, however, seems to increase or maintain relative VO2 max in males and females (Wilmore et al., 1978, Gettman et al., 1979, & Hurley et al., 1987). Circuit weight training has shown to increase relative VO2 max more in women than in men (Wilmore et al.,1978). Trained individuals must work harder than untrained individuals to increase relative VO2 max (Wilmore et al., 1978). The weight training programs that were not classified as either high resistance, low repetition or circuit weight training (Gettman & Ayres, 1978, Gettman et al., 1979, Poehlman et al., 1992, & Smutok et al., 1993) have demonstrated either an increase or maintenance of relative VO2 max in trained and untrained males.

The studies that compared weight training and aerobic training (Gettman et al., 1979, Poehlman et al., 1992, & Smutok et al., 1993) found that aerobic training increases relative VO2 max significantly more than weight training (including circuit weight training).

The available literature reporting the effect of diet and VO2 max is very limited. Most of the available literature, including the studies mentioned previously, researched obese individuals. David and Phinney (1990) found that a diet high in protein can help preserve absolute VO2 max even when weight loss occurs.

Overall, there is an indication that resistance training (with the exception of high resistance, low repetition weight training) has a positive effect on VO2 max. However, the results are very inconsistent. In a review of literature, no studies were found that examined the combined effect of a resistance training and dietary modification program on VO2 max. The present study investigated the effects of a six-week combined resistance training and diet program on VO2 max in trained and untrained individuals.

Chapter III

Methods and Procedures

The research was an investigation of the effect of a six-week resistance training program combined with a low-fat, high-fiber, modified-caloric diet on VO2 max. The research was approved by a Midwestern University Internal Review Board human subjects committee.

Subject Selection

The study originally consisted of seventeen subjects, eight males and nine females who were between the ages of 25 and 60 years. Through the course of the study one male and one female dropped out, leaving data for only fifteen subjects. The subjects were volunteers from a Midwestern University campus.

The subjects for the study were characterized as either trained or untrained. Trained individuals performed at least thirty minutes of continuous aerobic activity three or more times per week on a regular basis for at least six months up until the time of the study. The untrained individuals had not engaged in any regular physical activity prior to the study. There were eight trained and seven untrained subjects in the study. Subject data is given below in Table I.

Each of the subjects completed a Biometrics "One-on-One" Health Questionnaire (Appendix A) and signed an informed consent statement by Biometrics (Appendix B). In addition, the subjects signed an informed consent statement that was approved and provided by a Midwestern University Wellness Center permitting blood samples to be taken (Appendix C).

Table I

Subject Data

SBT	M/F	T/UT	BW1(lb)	BW2(lb)	AV1	AV2	RV1	RV2
01	F	T	140.00	132.50	2.78	2.67	43.7	44.3
02	M	T	289.00	269.00	6.37	5.95	48.6	48.4
03	F	UT	171.00	164.00	1.79	1.79	23.0	24.0
04	M	T	183.50	171.50	4.06	3.88	48.7	50.1
05	F	T	133.00	127.50	2.12	2.09	35.1	36.1
06	M	T	180.50	175.50	4.08	3.95	49.7	49.5
07	F	T	145.50	140.75	2.66	2.63	40.2	41.1
08	F	UT	205.50	196.00	2.54	2.38	27.2	26.7
09	F	UT	181.75	170.50	3.39	3.03	41.0	39.1
10	M	UT	204.50	182.50	5.29	5.31	56.9	64.0
11	M	UT	251.00	238.50	5.13	5.23	45.0	48.2
12	F	T	152.50	142.50	2.85	2.54	41.1	39.2
14	M	UT	315.00	293.00	5.81	5.73	40.6	43.0
16	M	UT	295.00	225.00	2.86	3.23	26.8	31.5
17	F	UT	169.00	163.00	2.38	2.18	31.0	29.4

SBT = subject
T = trained
UT = untrained
BW1 = pre body weight
BW2 = post body weight

AV1 = pre AVO2 max
AV2 = post AVO2 max
RV1 = pre RVO2 max
RV2 = post RVO2 max

Collection of Data

All pre and post measurements were taken on a morning after a twelve-hour fast. All pre measurements for trained and untrained subjects were taken 48 hours after the trained subjects' last exercise bout. All post measurements were taken 48 hours after the last exercise bout. Measurements included body weight, blood pressure, 11-site circumference test, seven-site skin fold test, and a Bruce Protocol Exercise Test.

The exercise test, administered relative to this study, was the standard Bruce treadmill protocol. The exercise test was administered at the same time in the morning prior to the first training session and after the last training session. Subjects blood pressure, heart rate, and expired gases were measured at rest, every three minutes during the test, and for five minutes after the test, using a 12-lead Quinton ECG monitor (Model Q5000), Quinton blood pressure monitor (Model 412), and Quinton metabolic cart (Model Q-plex 1).

Dietary Program

Each subject was given a customized six-week meal plan. The meal plans followed the current dietary guidelines and the Food Pyramid, which promotes a low-fat ($20 \pm 2\%$) and high-fiber (25 gm/day). The subjects chose individual menus meeting these guidelines as well as suiting their personal preferences and nutritional concerns. Each of the subjects were provided a nutrient distribution plan that allowed for

58 percent carbohydrates, 20 percent fat ±2 percent, and 20 percent protein. The diet plan also required the subjects to drink two thirds ounces of water per pound of body weight daily, but not to exceed 160 ounces.

Daily caloric intake was restricted for all subjects. Females were allowed 1400 kcal during weeks one and two, and 1300 kcal and 1200 kcal during weeks three and four and weeks five and six, respectively. The males in the study were allowed 1800 kcal during weeks one and two, 1700 kcal weeks three and four, and 1600 kcal weeks five and six.

Personal trainers encouraged compliance of food and water intake. Compliance was also verbally self-reported by the participants during every exercise session.

Resistance Exercise Program

Each subject had a one-on-one personal trainer during each exercise session. The exercise sessions were approximately thirty minutes in length and were scheduled three times per week. Before every exercise session the subjects weighed in and warmed up on a treadmill or stationary bicycle for five minutes.

During weeks one and two, the subjects performed six different exercises including: knee extension, knee flexion, chest press, lateral pull-down, lateral shoulder raise, and abdominal crunches. In addition to these exercises, bicep curls and tricep press downs were performed during the remaining weeks three through six. The knee extension, chest press, and lateral pull-down were all performed on Universal machines. Free weights were used for lateral shoulder raises and abdominal crunches. The subjects started the training program using a light-weight resistance (60-70% of subjects 10 repetition maximum).

The resistance training consisted of one set of six repetitions per exercise. There was a ten second count on the concentric, or positive, contraction and a two second count on the eccentric, or negative, contraction. The first training session included instruction on proper form and lifting techniques using light-weight resistance. The resistance was increased by five pounds for the upper body exercises and by ten pounds for the lower body exercises when the subject could perform six unassisted repetitions with proper form.

Statistical Analysis

The VO2 max data relative to this study was collected before and after the six-week Biometric One-on-One program for statistical analysis. A series of two-way Analysis of Variance with repeated measures was used to determine possible differences in absolute VO2 max and relative VO2 max with respect to: training status (trained vs.

untrained); time (pre vs. post); and training status by time interaction for both males and females. Differences were further delineated using a Neumann Keuhls Post-Hoc Test. The 0.05 level of significance was utilized throughout.

Chapter IV

Results and Discussion

The purpose of this study was to determine if a six-week resistive training and diet program would significantly improve VO2 max and seek possible difference based on training status. Biometrics "One-on-One" is a six-week resistive training program combined with a low-fat, high-fiber, calorically restricted diet as previously described in Chapter III. The current study investigated the effects of the program on VO2 max in trained and untrained individuals. Subjects ranging from 25 to 60 years of age from a Midwestern University and a Midwestern city volunteered to participate in this approved study. Seven males and eight females completed all aspects of the study. The graded exercise test was administered after a twelve-hour fast and at the same time in the morning prior to the first and 48 hours after the last training session. A two-way Analysis of Variances with repeated measures and Neumann Keuhls Post-Hoc Tests were used to statistically analyze the data.

All subjects followed a customized meal plan suited for individual preferences and nutritional concerns. Throughout the entire study, daily caloric intake was strictly prescribed. In addition, the subjects consumed two thirds ounces of water per pound of body weight, but not exceeding 160 ounces per day.

The training sessions were conducted, one on one, with personal trainers to ensure proper form and technique. Training sessions lasted approximately thirty minutes and were held three times a week. All training sessions included a five minute warm-up, six (weeks one and two) to eight (weeks three through six) resistive training exercises, and stretching for flexibility.

The resistive training consisted of one set of six repetitions per exercise. Each repetition consisted of a ten-second concentric contraction and a two-second eccentric contraction. The amount of weight lifted was increased throughout the six weeks to accommodate strength gain.

Results

The results have been divided into four categories: absolute VO2 max in males, absolute VO2 max in females, relative VO2 max in males, and relative VO2 max in females.

Results for Absolute VO2 Max in Males

There was no significant difference in training status or time in absolute VO2 max among males. However, there was a trend toward significance ($P=0.052$) in time by training status difference in absolute VO2 max among males. The trained males had a mean reduction (4.84L/min$\pm$1.33 vs 4.59L/min$\pm$1.17) in absolute VO2 max, while the untrained males had a mean increase (4.77L/min$\pm$1.31 vs 4.89L/min$\pm$1.12) in absolute VO2 max. Results are given in Table II.

Table II
Analysis of Variance Results for Absolute VO2 Max
Males

Source	ss	df	ms	F
TSTATUS	.04	1	.04	.01
Error	15.09	5	3.02	
TIME	.02	1	.02	1.06
TIME X TSTATUS	.10	1	.10	6.42 (.052)
Error	.08	5	.02	
TOTAL	15.33	13		

Neumann Keuhls Post-Hoc Test

	Pre	Post
Trained	4.84	4.59
Untrained	4.47	4.88

Results for Absolute VO2 Max in Females

The results of this study did not show a significant ($p>0.05$) difference in training status. However, there was a significant ($p<0.05$) time difference in absolute VO2 max among females with pre values being higher than post (2.65L/min$\pm$0.49 vs 2.41L/min$\pm$0.39). Time by training status results for absolute VO2 max in females did not show a significant ($p>0.05$) difference. The results for these groups are given in Table III.

Table III
Analysis of Variance Results for Absolute VO2 Max
Females

Source	ss	df	ms	F
TSTATUS	.05	1	.05	.11
Error	2.60	6	.43	
TIME	.09	1	.09	9.15*
TIME X STATUS	.00	1	.00	.37
Error	.06	6	.01	
TOTAL	2.80	15		

*significant at the .05 level.

Neumann Keuhls Post-Hoc Test

Pre:	2.65
Post:	2.41

Results for Relative VO2 Max in Males

The results of this study did not show a significant ($p>0.05$) difference in training status for relative VO2 max in males. There was a significant ($p<0.05$) time difference in relative VO2 max among males with post values higher than pre values (47.8 ± 9.5 vs 45.2 ± 9.7). Additionally, untrained males relative VO2 max values increased significantly ($p<0.05$) more than trained males values (4.4 vs 0.3). The results for these groups are given in Table IV.

Table IV
Analysis of Variance Results for Relative VO2 Max
Males

Source	ss	df	ms	F
TSTATUS	74.67	1	74.67	.37
Error	1004.82	5	200.96	
TIME	18.80	1	18.80	12.95*
TIME X TSTATUS	13.83	1	13.83	9.53*
Error	7.26	5	1.45	
TOTAL	1119.38	13		

*significant at the .05 level.

Neumann Keuhls Post-Hoc Test

Pre: 45.2
Post: 47.8

	Pre	Post
Trained	49.0	49.3
Untrained	42.3	46.7

Results for Relative VO2 Max in Females

Relative VO2 max values for trained females were significantly (P<0.05) higher than untrained female values (40.0 vs 30.2) both before and after the study. There was not a significant (P>0.05) difference in time nor time by training status in relative VO2 max for the females. The results for these groups are given in Table V.

Table V

Analysis of Variance Results for Relative VO2 Max
Females

Source	ss	df	ms	F
TSTATUS	384.16	1	384.16	5.97*
Error	385.85	6	64.31	
TIME	.72	1	.72	.87
TIME X TSTATUS	.42	1	.42	.51
Error	4.95	6	.83	
TOTAL	776.10	15		

*significant at the .05 level.

Neumann Keuhls Post-Hoc Test

Trained:	40.0
Untrained:	30.2

Discussion of Results

The effects of resistance training on VO2 max remain unclear (Stone et al., 1991). This study was conducted to help determine the effects of resistance training and diet on VO2 max in trained and untrained males and females. It should be noted that the present study was only conducted for six weeks, which is much less than the time span of the other studies reported. In addition, all of the studies vary in the amount of repetitions and sets required and the types of resistance exercises performed.

The absolute VO2 max for males demonstrated a trend toward significance (P=0.052) difference based on the interaction of time by training status. The trained males actually decreased insignificantly from 4.84±1.33 to 4.59±1.17 in absolute VO2 max, while the untrained males approached significant ($p=0.052$) increases in absolute VO2 max (4.77±1.31 to 4.88±1.12). These results are probably due to the fact that more physically fit individuals require a higher level of activity to increase fitness level as seen in Wilmore et al. (1978).

The absolute VO2 max for the females showed a significant ($P<0.05$) decrease (2.65L/min±0.49 vs 2.41L/min± 0.39) based on time. These results were unexpected and could be due to the females not pushing themselves as hard on the second treadmill test as the first.

There was a significant ($P<0.05$) increase in relative VO2 max in the males based on time and the interaction of time by training status. The relative VO2 max among males changed significantly ($p<0.05$) over time with post values higher than pre values (47.8±9.5 vs 45.2±9.7). In addition, untrained males relative VO2 max values increased significantly (p<0,05) greater than trained males values (0.3 vs 4.4). Again, these results are most likely because more physically fit individuals require a higher level of training.

The relative VO2 max for the females demonstrated a significant ($P<0.05$) difference based on training status.

The relative VO2 max for the females did not improve over time, yet the relative VO2 max for the trained females was consistently higher than the untrained females (40.0 vs 30.2). It is speculated that the amount of body weight lost by the females was not enough to increase relative VO2 max. However, it is peculiar that the untrained males increased relative VO2 max, while the untrained females did not. Taking a closer look at weight loss, one of the untrained male subjects lost 70 pounds which was significantly more than the weight lost by any of the other untrained males, making this particular subject an outlier when considering amount of weight lost. The amount of weight lost by the remaining untrained males was not significant. The untrained male that lost 70 pounds did not differ significantly in regards to increase in relative VO2 max compared to the other untrained males. The data suggest that weight loss did not have an effect on the significant increase of relative VO2 max in the untrained males. One explanation could be that the untrained males pushed themselves harder at the exercises than the untrained females.

The results concerning the trained males and females in this study compare with the results found by Gettman et al. in 1979. In this study, Gettman et al. found that circuit weight training could maintain relative VO2 max once it was attained. These findings are of great importance to endurance athletes who may become injured. According to these studies resistance training can maintain relative VO2 max even when aerobic activity is not performed for six weeks.

The results of the present study disagree with the results found by Fahey and Brown (1973) and Nakao (1995). These studies found that high resistance, low repetition resistance decreased relative VO2 max, while the present study demonstrates a maintenance of relative VO2 max. However, the present study only lasted six weeks, while the other studies lasted much longer (nine weeks or greater). If the present study lasted longer, the relative VO2 max values may have started to decline. The present study, as well as Gettman et al. (1979), demonstrate the belief that once fitness is attained it takes less effort to maintain it.

The results of the untrained males correlate with the Gettman and Ayres study (1978) that showed an increase in relative VO2 max in both slow and fast speed weight lifting. These results however, do not compare with the findings of Fahey and Brown (1973) or Smutok et al. (1993). Fahey and Brown (1973) found that a nine week resistance training program significantly decreased relative VO2 max in 15 male subjects. In 1993, Smutok et al. discovered that a 20 week resistance training program had no on male subjects effect.

Chapter V

Summary, Conclusion, and Recommendations

Summary

There is almost universal agreement that regular exercise is essential for the optimal function of the human body (Goldberg, 1989). Strength training and circuit weight training programs have not been shown to increase VO2 max as well as aerobic training programs (Fang, Sherman, Crouse, & Tolson, 1988). The benefits of resistance training programs on VO2 max are still unclear (Stone et al., 1991). Further, the effects of a resistance training program with a diet on VO2 max has not been determined. This study was held to determine the effects of diet and resistance training on VO2 max in trained and untrained individuals. The data collected in the study was analyzed using two-way Analysis of Variances with repeated measures and Neumann Keuhls Post-Hoc tests.

Findings

Based on the hypotheses stated and the limits of this study, the data yielded the following findings:

1. There was no significant ($P>0.05$) difference in absolute VO2 max values for males based on training status.

2. There was no significant ($P>0.05$) difference in absolute VO2 max values for males based on time (pre vs. post).
3. There was no significant ($P>0.05$) difference in absolute VO2 max values for males based on the interaction of training status and time.
4. There was no significant ($P>0.05$) difference in relative VO2 max values for males based on training status.
5. There was a significant ($P<0.05$) difference in relative VO2 max values for males based on time (pre vs. post).
6. There was a significant ($P<0.05$) difference in relative VO2 max values for males based on the interaction of training status and time.
7. There was no significant ($P>0.05$) difference in absolute VO2 max values for females based on training status.
8. There was a significant ($P<0.05$) difference in absolute VO2 max values for females based on time (pre vs. post).
9. There was no significant ($P>0.05$) difference in absolute VO2 max for females based on the interaction of training status and time.
10. There was a significant ($P<0.05$) difference in relative VO2 max values for females based on training status.
11. There was no significant ($P>0.05$) difference in relative VO2 max values for females based on time (pre vs. post).

12. There was no significant (P>0.05) difference in relative VO2 max values for females based on the interaction of training status and time.

Accordingly, hypotheses number 1,2, 3, 4, 7, 9, 11, and 12 were accepted, while hypotheses number 5, 6, 8, and 10 were not accepted.

Conclusion

The results of this study show that a combined resistance training and diet program can increase relative VO2 max in untrained males and maintain relative VO2 max in untrained females and trained males and females. Further, the results demonstrate a maintenance in absolute VO2 max in trained males and females and untrained males and females. In conclusion, a resistance training program can maintain VO2 max in trained males and females for up to six weeks. The benefits of resistance training on VO2 max for untrained males and females remains unclear.

Recommendations

The Biometrics "One-on-One" program is a promising program, but needs to be standardized with more common protocols. There are a number of things that could be done to improve this study. First, if the program was revised using an increased number of sets and repetitions with lighter resistance, the results on VO2 max could change significantly. Second, if the present study had lasted more than six weeks, the results could have been quite different. Six weeks may not be long enough to show significant changes in relative VO2 max or absolute VO2 max. Third, if subjects would have kept records of dietary compliance, this could have been factored into the results of the study.

The benefits of aerobic and resistance training definitely differ. Although VO2 max can be improved to a moderate extent with certain types of resistance training, greater improvements can be made with regular aerobic exercise (Stone et al., 1991). If maintenance of cardiovascular fitness or health is the main goal, then resistance training and diet are sufficient. However, improved cardiorespiratory fitness and endurance can best be accomplished with aerobic training.

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APPENDIX A

BIOMETRICS®
ONE • ON • ONE

HEALTH QUESTIONNAIRE

The following questions are used to determine whether or not you need to be seen by a physician prior to participation in Biometrics.

	YES	NO	
1.	❐	❐	Are you pregnant, nursing or less than six weeks post-partum? *If you checked "Yes" to the above question, you are not eligible to participate in Biometrics at this time. Because of the caloric restriction, Biometrics is not designed for women who are pregnant, nursing, and/or less than six weeks post-partum.*
2.	❐	❐	Are you six weeks to six months post-partum?
3.	❐	❐	Have you ever had a heart attack or has your doctor ever told you that you have cardiovascular/coronary heart disease?
4.	❐	❐	Have you ever been told by a doctor that you have high blood pressure?
5.	❐	❐	Do you have frequent chest pains upon exertion?
6.	❐	❐	Do you often feel faint or have spells of dizziness upon exertion?
7.	❐	❐	Do you have diabetes? *If you checked "Yes" to any of questions 2 - 7, you must receive clearance from your physician prior to participation in Biometrics.*
8.	❐	❐	Do you have a bone or joint problem that might be aggravated with exercise?
9.	❐	❐	Are you a male over the age of 40 or a female over the age of 50?
10.	❐	❐	Do you presently smoke?
11.	❐	❐	Have you ever been told that you have a high cholesterol level (>240 mg/dl)?
12.	❐	❐	Have either of your parents or any of your siblings been diagnosed with or died from cardiovascular disease before the age of 55?
13.	❐	❐	Are you currently under a physician's care for any metabolic-related therapy? *If you checked "Yes" to any of questions 8 - 13, the American College of Sports Medicine recommends that you receive clearance from your physician before beginning an exercise program; however, it is not mandatory for your participation in Biometrics.*

I have read this entire document and have answered all of the questions to the best of my knowledge.

____
Last Name, First (print)

______________________________ ____/____/____
Signature *Date*

APPENDIX B

BIOMETRICS
ONE•ON•ONE

INFORMED CONSENT

Last Name, First (print) ______________________ Date ___/___/___

Address ______________________ Home Phone (___) ______

______________________ Work Phone (___) ______

City ______ State ______ Zip ______

INTRODUCTION

In the text that follows you will find explanations of the procedures, benefits, risks, and precautions associated with Biometrics. Please take the time to read and understand all of the text on both front and back of this document.
If there are parts of this document that are unclear, please ask your Biometrics Program Director for clarification.

It is necessary that you understand the following as they pertain to Biometrics:

- The Health Questionnaire that you complete is meant to serve as a guide to assist you in determining whether to see your physician prior to participating in Biometrics. It is always prudent to check with your physician prior to participating in a new exercise and weight management program.
- Participation in the Initial Profile is required for participation in Biometrics.
- If, upon review of your Health Questionnaire or during your Initial Profile, you are found to be at risk for coronary heart disease, hypertension or any other condition that could be worsened through your participation in Biometrics, you may be required to obtain a Physician's Clearance prior to further participation in Biometrics.
- The Biometrics trainer is provided to encourage and motivate you to reach your goals. It is important that you communicate with your Biometrics trainer or Program Director if you are feeling any type of pain or discomfort during your workouts. You are the best judge of your exercise capacity.

Your Initial Profile Date ___/___/___

Your Initial Profile Time ________ am/pm

Your Program Director ______________________

Biometrics Phone Number (___) ______________

- Please wear loose fitting clothing to allow for accurate circumference and skinfold measures.
- If you are running late, or find that you are unable to make your appointment, please contact your Biometrics Program Director prior to your scheduled time.

CONFIDENTIALITY OF RECORDS

All personal information obtained as part of your participation in Biometrics will be kept strictly confidential. There will be no release of personal information without your written consent.

STATEMENT OF UNDERSTANDING

I understand the risks and benefits of participating in Biometrics and have chosen to do so without any formal preventive medical screening. I also understand that the Health Questionnaire and Initial Profile are not meant to be a medical screen and it is my responsibility to contact my physician concerning my medical/health preparedness to participate in Biometrics. I also understand that the Biometrics trainers and Program Directors are not authorized or trained in providing medical advice and/or determining my medical abilities and/or risks associated with participating in Biometrics.

I ______________________________, have read this entire document and fully understand its contents. I have indicated so with my signature below.

Biometrics Client Signature ______________________ Date ___/___/___

Witness Signature ______________________ Date ___/___/___

APPENDIX C

OKLAHOMA STATE UNIVERSITY
WELLNESS CENTER
INFORMED CONSENT FOR HEALTH RISK APPRAISAL AND HEALTH SCREENING

EXPLANATION OF PROCEDURE

The screening you are about to undergo is part of the Oklahoma State University Wellness Program. This screening includes completion of the health risk appraisal (HRA) questionnaire and measurement of the following variables: resting blood pressure, percent body fat (as determined by skinfold measurements), height, weight, and selected blood variables analyzed from the fingerstick method or from a venous sample.

It will be determined, prior to testing, that the tests are appropriate and safe for you. All testing will be conducted by trained personnel and procedures will be explained to your satisfaction at the outset.

POSSIBLE RISKS OF BLOOD TESTING

The potential risks associated with the venipuncture/fingerstick are:

(1) Venipuncture/fingerstick may cause some pain or discomfort. The exact amount, if any, will be dependent upon individual preconceptions and pain threshold levels.

(2) Possible hematoma (bruising) at the venipuncture/fingerstick site following the procedure. The occurrence or non-occurrence will be dependent upon bleeding/coagulation time and adherence to instructions pertaining to holding a cotton ball against the venipuncture/fingerstick site, with pressure, for five minutes following extraction of the needle or following the fingerstick.

(3) Slight risk of infection. Any break in the integrity of the skin is associated with a small degree of infection risk. However, if directions are followed, this risk is minimal.

CONFIDENTIALITY AND USE OF INFORMATION

I have been informed that the information which is obtained in the health screening will be treated as privileged and confidential and will consequently not be released or revealed to any person without my express written consent. I do agree to the use of any information for research or statistical purposes in an aggregate manner only. However, I understand that the professional/ medical staff may use my individual data to contact me for follow-up education.

I have read the foregoing, I understand it, and any questions which may have occurred to me have been answered to my satisfaction.

DATE ______________________________

SIGNATURE ______________________________

VITA

Mteesa Shouse

Candidate for the Degree of

Master of Science

Thesis: THE EFFECTS OF A SIX-WEEK COMBINED RESISTANCE TRAINING AND DIET PROGRAM ON VO2 MAX IN TRAINED AND UNTRAINED INDIVIDUALS

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Experience: Employed by Oklahoma State University Wellness Center as a Graduate Assistant, Personal Trainer, and Aerobics Instructor, 1994 to 1996; employed by Cardiology of Tulsa, 1997 to 1998; employed by Urologic Specialists of Oklahoma, 1998 to 1999. Currently employed by Roche Laboratories, Inc., Nutley, New Jersey.

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 04-16-96 **IRB#:** ED-96-109

Proposal Title: THE EFFECTS OF A COMBINED SIX WEEK RESISTANCE TRAINING PROGRAM AND DIET ON VENTIALTORY OXYGEN CONSUMPTION (VO2) AND FUNCTIONAL CAPACITY (VO2) AMONG COLLEGE STUDENTS

Principal Investigator(s): Frank A. Kulling, Mteesa K. Shouse

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING.
APPROVAL STATUS PERIOD VALID FOR ONE CALENDAR YEAR AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Reasons for Deferral or Disapproval are as follows:

Signature: John H. Wheeler

Chair of Institutional Review Board

Date: April 23, 1996