The Effects of Nautilus Circuit Weight Training on Aerobic Capacity

Rhonda M. Ludwig

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THE EFFECTS OF NAUTILUS CIRCUIT WEIGHT TRAINING ON AEROBIC CAPACITY

by

Rhonda M. Ludwig

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requirements for the
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THE EFFECTS OF NAUTILUS CIRCUIT WEIGHT TRAINING ON AEROBIC CAPACITY

Rhonda M. Ludwig, M.A.
Western Michigan University, 1988

The purpose of this study was to identify whether Nautilus Circuit Training effected maximal oxygen uptake \( (V_0^{2\text{max}}) \) levels of novice weight trainers. Fourteen college age male and female subjects (18-23 years old) from physical education classes at Western Michigan University participated in a six week Nautilus Training Program (NTP). Each subject performed a pre and post maximal treadmill graded exercise test to determine \( V_0^{2\text{max}} \) levels. A randomized block ANOVA design was used to analyze the dependent variable, \( V_0^{2\text{max}} \). The mean of the pre-test \( V_0^{2\text{max}} \) level \( (42.83 \text{ ml x O}_2/\text{kg/min}) \) was found to be significantly higher than the mean of the post-test \( V_0^{2\text{max}} \) level \( (38.33 \text{ ml x O}_2/\text{kg/min}) \) at \( p<.05 \). It was concluded in this study that novice weight trainers who performed a NTP for six weeks, without a supplemental aerobic training program, experienced a decrease in aerobic capacity \( (V_0^{2\text{max}}) \).
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Rhonda M. Ludwig
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CHAPTER I

INTRODUCTION

The number of people participating in physical fitness programs has increased during the past decade. Men and women have come to understand the importance of a healthy lifestyle. The American College of Sports Medicine (ACSM) (1986) developed guidelines designed to increase and maintain cardiovascular endurance as well as change body composition or total body fat in healthy adults. The ACSM guidelines for increasing or maintaining cardiovascular endurance include (a) fifteen to sixty minutes of continuous aerobic activity, (b) aerobic activity three times a week, and (c) an activity intensity level of 60% to 90% of maximum heart rate. The aerobic activities, suggested by the ACSM, to increase cardiovascular endurance include (a) running, (b) walking, (c) swimming, (d) cycling, (e) cross-country skiing, and (f) rowing.

Aerobic exercise, however, is only one of the many components of a complete exercise program. Another component of a total exercise program is strength training. Strength training enhances the individual's ability to perform daily tasks and to pursue recreational activities. Strength training equipment and programs vary depending on
the training goals of the individual. An individual's training goals may include any one, or a combination of, the following categories: (a) increasing the strength of the muscle, (b) increasing of the size or bulk of the muscle, and (c) toning or sharpening the definition of the muscle.

A complete exercise program should incorporate both cardiovascular and strength activities. The time necessary to perform both types of activities, however, is often too much for the average person to work into his or her daily schedule. Consequently, many people look for a magic program that will incorporate both facets of exercise and take half the time to complete.

Circuit Weight Training (CWT) programs are designed to help the exerciser achieve both the cardiovascular and strength goals of his or her program in less time. The CWT program is usually designed so the exerciser will lift many repetitions at a low weight with a controlled rest interval between each exercise. A continuous exercise program such as the CWT program is said to increase cardiovascular capabilities while increasing muscular strength; however, these statements are not totally supported by professionals within the exercise profession.

The Nautilus Corporation has used CWT guidelines to develop a workout program using their machines (Wolf, 1984). When marketing the Nautilus line of weight
machines, the corporation claimed that their program could help the individual to make both cardiovascular and strength gains during a short workout session. For many health club owners, YMCA directors, coaches, and athletes, the Nautilus program was an alternative to the time-consuming workout regime. The question must be asked, however, whether the program suggested by the Nautilus Corporation is valid.

Statement of the Problem

This study investigated the effects of Nautilus Circuit Training on the maximal oxygen uptake levels of novice weight trainers. The subjects were placed on a Nautilus training program three times a week for six weeks; both the Nautilus exercise guidelines and equipment were used.

Purpose of the Study

The purpose of the study was to identify whether Nautilus Circuit Training had any significant effect on the maximal oxygen uptake levels of the novice weight trainer.

Need for the Study

Nautilus weight training equipment is used all across America in fitness clubs, YMCA's, colleges, universities and high schools. The Nautilus Corporation suggested that
their program elicited improvements in the cardiovascular fitness of the exerciser (Nautilus Sports/Medical Industries, 1980). This suggestion was thought to be valid by many health club instructors, coaches, athletes, and fitness enthusiasts.

The major concern of this study was to determine whether Nautilus training can improve the aerobic capacity of novice weight trainer. If the Nautilus program does not improve aerobic capacity, then the health club industry and all athletic programs should be properly informed.

Delimitations

The study was delimited to the following:

1. The subjects chosen for the investigation were college age (18-24 years old) students enrolled at Western Michigan University, Kalamazoo, during the winter semester, 1988. All the subjects were novice weight trainers.

2. The Nautilus weight training protocol employing Nautilus exercise guidelines and equipment was conducted three times a week for six weeks.

3. Each subject was pre- and post-tested using a treadmill graded exercise test suggested by Lamb (1984) to determine maximal oxygen uptake as a measure of aerobic capacity. See Appendix A for testing guidelines.
Limitations

The limitations of the study were as follows:
1. The subjects were selected for the treatment opportunistically rather than randomly.
2. Although the subjects were asked to limit their physical activity during their participation in the study, it was not feasible to monitor their compliance.

Assumptions

The assumption of this study was that all the subjects actively participated while following the testing and treatment protocols.

Hypothesis of the Study

The experimental hypothesis of this study was that the results of the pre- and post- maximal oxygen uptake testing would show no difference, as a result of the Nautilus Training Program (NTP).

Definition of Terms

The terms that were specific to this study were defined as follows:
1. Maximal Oxygen Uptake (VO₂max): defined by Lamb (1984) as the greatest volume of oxygen used by the cells.
of the body per unit of time. \( \text{VO}_2\text{max} \) is an indicator of an individual's aerobic capacity.

2. Aerobic endurance: the ability to persist at a physical activity that relies heavily upon oxygen for energy production (Lamb, 1984).

3. Cardiovascular: pertains to the heart and blood vessels (Henson, 1986).

4. Repetition: one movement through the range of motion at a specific weight.

5. Set: a series of repetitions performed without rest.


7. Maximal Graded Exercise Test: an assessment used to determine maximal oxygen uptake. Subjects are asked to perform increasingly more difficult increments of work. Subjects continue until exhaustion or oxygen intake fails to increase with increases in workload.
CHAPTER II

REVIEW OF LITERATURE

This chapter provides a brief overview of the literature pertinent to this study. The selected exercise mode and Nautilus Training Program (NTP) is discussed in respect to its effects on the aerobic capacity of an individual. The results from the studies are expressed in terms of maximal oxygen uptake. In addition, this chapter reviews procedures used to measure aerobic capacity and discusses the efficiency of these methods of measurement.

Exercise Mode

Exercise Principles

The American College of Sports Medicine (ACSM) (1986) presented guidelines for establishing an exercise program to enhance the health related components of physical fitness. The ACSM listed the health related components as (a) cardiovascular endurance, (b) body composition, (c) flexibility, and (d) muscular strength and endurance. The ACSM prescribed the following guidelines for enhancing and maintaining cardiovascular fitness: (a) The activity should use large muscle groups, for long periods of time, and be rhythmical and aerobic in nature (i.e., running-jogging, walking-hiking, swimming, skating, bicycling,
rowing, cross-country skiing); (b) the intensity of the activity should be 60-90% of the individual's maximal heart rate or 50-85% of the individual's maximal oxygen uptake (VO₂\text{max}); (c) the duration of the activity should be 15 to 60 minutes of continuous aerobic activity (an activity lasting 20 to 30 minutes is required to improve functional aerobic capacity); and (d) the frequency of exercise is three to five days per week.

The ACSM (1986) stated that muscular strength and endurance had little direct relationship to cardiovascular fitness. It was argued, however, that muscular endurance was important to an individual's total fitness level because it enhances one's ability to perform a task with less physiological stress. A study by Hickson, Roesn-koepter, and Brown (1980) supported the ACSM's position on strength training. In addition Hickson et al. (1980) concluded that strength training had no effect on VO₂\text{max} when measured during treadmill exercise.

Circuit Weight Training

Many studies have been conducted to measure physiological responses to circuit weight training (CWT). The results from these studies vary. Some of the studies supported the statements made by the ACSM (1986) while other studies refuted their claims.

One of the earliest studies was conducted by Nagle
and Irwin (1960), which examined the cardiorespiratory effects of weight training. Two groups of 17 males were used in an eight-week training program. One group was involved in low-repetition/high-resistance weight training, while the other group trained using a high-repetition/low-resistance program. There was no significant change in the cardiorespiratory responses of the individuals to the exercise.

A subsequent study by Allen, Byrd, and Smith (1976) investigated the effects of a high-sustained heart rate observed during CWT, while using high-resistance and low-repetition, on cardiovascular endurance. The program consisted of twelve weeks of intensive CWT, three days a week for 27 minutes. Each workout session consisted of 30 seconds of high-resistance/low-repetition work followed by 60 seconds of recovery time. It was concluded that CWT had no effect on the cardiovascular system.

Wilmore, Parr, Girandola, et al. (1978) investigated the ability of a CWT program to elicit alterations in strength, muscular endurance, and body composition in both males and females. The CWT consisted of (a) an intensity of 40-60% of the individual's maximal weight, (b) 30 second work periods, and (c) 15 second rest intervals. The training was conducted for a period of ten weeks, three times a week. The results showed an 11% increase in $V_{O2\text{max}}$ for the 12 women tested, but no change for the 16
men tested. Thus, it was concluded that the CWT program showed more promising results when used by unfit women but not unfit men.

Another study conducted by Wilmore, Parr, Ward, et al. (1978) compared the energy cost of circuit weight training in males and females. Each subject performed a three circuit workout (10 stations/circuit) with a 30 second work interval and a 15 second rest interval per station. The subjects worked with weights that were 40% of maximal effort. Maximal heart rate (HRmax) and VO$_2$max values were assessed. In this study Wilmore, Parr, Ward, et al. (1978) concluded that when body composition was considered, essentially there were no differences in the energy expenditures for males and females during CWT.

Gettman, Ayres, Pollock, and Jackson (1978) investigated the effects of CWT on strength, cardiorespiratory function, and body composition in adult males. Seventy males were assigned to three groups; (a) CWT group, (b) continuous running (RN) group, and (c) control group. The training groups exercised three days per week for 45 minutes. The CWT group performed 20 repetitions at each machine with the weight set at 50% of a one-repetition maximum. Each subject completed two full circuits of exercises. The RN group performed a 30 minute jog/walk program at 85% of their HRmax. The results of this study showed that the CWT does increase strength. The VO$_2$max
results, however, varied according to the method in which they were calculated. When the $V_{O_2}^{max}$ was calculated in terms of liter per minute, the CWT showed an increase. When the $V_{O_2}^{max}$ was calculated in terms of milliter of oxygen times kilogram of lean body weight a minute, no increases occurred. The RN group showed a significant difference in $V_{O_2}^{max}$ and treadmill times from the CWT group. When the $V_{O_2}^{max}$ was expressed in milliter of oxygen times kilogram of lean body weight a minute, the RN group was superior to both the CWT group and the control group. Gettman et al. (1978) concluded that the CWT specifically increased strength but only elicited a small aerobic effect.

A subsequent study conducted by Gettman, Ayres, Pollock, Durstine, and Grantham (1979) was designed to determine the physiological effects of eight weeks of circuit strength training (CST), eight weeks of jogging, followed by eight weeks of CST or jogging. The CST consisted of exercises of 10-15 repetition per set using isokinetic devices. The jogging program consisted of a three mile per day jog. During the final eight weeks, the subjects were randomly assigned to either the jogging group or the CST group. The CST group showed a three percent improvement in their $V_{O_2}^{max}$ during the first eight weeks. After the eight weeks of jogging, the subjects $V_{O_2}^{max}$ improved another eight percent. After the final eight weeks, the CST
group showed no significant decreases in their $V_{O_2}^\text{max}$ levels. Thus, it was concluded that the CST could maintain $V_{O_2}^\text{max}$ potential for at least eight weeks. This may be due to the fact that once fitness levels were attained, less effort is required to maintain those levels.

Research was conducted by Gettman, Culter, and Stran-thman (1980) to compare the cardiovascular effects of an isotonic circuit weight training (IT-WT) program with a slow speed isokinetic circuit strength training (IK-ST) program. Twenty-nine males trained for 20 weeks, three days a week, for 20-30 minutes. Pre and post oxygen up-take ($V_{O_2}$), body composition, and strength values were compared. The study concluded that the training protocol used by both groups were equally effective in increasing aerobic capacity and strength.

A follow-up study conducted by Gettman and Pollock (1981) stated that CWT should not be considered an adequate aerobic program within itself. CWT may be considered, however, a supplementary aerobic activity for the development of optimal cardiorespiratory fitness. In addition, a CWT program may be of value when used in a beginning exercise program, as long as work intensity is controlled. Gettman and Pollock (1981) suggested that CWT programs should consist of two to three circuits with ten exercises in each circuit. The duration of each exercise session should be 20-30 minutes and consist of 10-15

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repetitions per exercise at 50% of maximum strength.

Gettman, Ward, and Hagan (1982) investigated the physiological effects of a program of combined running and weight training (RUN/CWT) with a CWT program. The study had three testing groups: (a) CWT/Run group, (b) CWT group, and (c) control group. The CWT program consisted of 12-15 repetitions completed in 30 seconds at 40% of maximal strength. The research suggested that the workouts consisting of more than 15 repetitions at an intensity greater than 50% of maximal weight could not be tolerated by subjects attempting to complete a CWT in 20-30 minutes. The CWT/Run group ran for 30 seconds at 60% of the max followed by 30 seconds of CWT. The study concluded that the CWT program was as effective in increasing VO₂max as the CWT/Run program.

**Nautilus Circuit Weight Training**

The purpose of the above mentioned studies was to determine if CWT programs improve VO₂max levels. The results of the studies conducted to determine the effects of NCWT on VO₂max levels are varied.

Nautilus Sports/Medical Industries agreed to participate with the United States Military Academy (USMA), West Point in a joint venture to study the effects of NCWT. The study was designed to determine: (a) the relative effectiveness of different methods of strength training;
(b) how to use the Nautilus equipment; and (c) how to identify the consequences of a short duration, high intensity strength training program (Peterson, 1975). Strength and cardiovascular gains, degree of flexibility, and overall body compositions were assessed during this study. Members of the Corps of Cadets served as subjects. The subjects were monitored by physicians from the U. S. military hospital that were contracted by the Nautilus Corporation. \( V_{O_2}^{\text{max}} \) values were estimated from the submaximal bicycle ergometer test results. Peterson (1975) summarized the results of the study:

Contrary to most commonly held beliefs on the subject of strength training, Nautilus training significantly improved the cardiovascular condition of the subjects. By maintaining the intensity of the workouts at a high level and by limiting the amount of rest between exercises, the training resulted in improvements in each of the 60 separate measures of cardiovascular fitness. Contrary to widespread opinion, not only will a properly conducted program of strength training produce increases in muscular strength, but it will also significantly improve an individual's level of cardiovascular conditioning. (p. 16)

Messier and Dill (1985) conducted a comparative study between a NCWT program, free weight (FW) program, and a running (R) program. The study investigated the effects of the three programs on muscular strength and \( V_{O_2}^{\text{max}} \). The NCWT program utilized equipment manufactured by Nautilus Sports/Medical Industries. The equipment was advertised as having the capability to elicit maximal changes in both cardiorespiratory fitness and strength in healthy
adults. The guidelines set by Peterson (1975) were (a) 10 to 12 exercises or stations (four to six lower body and six to eight upper body exercises), (b) subjects must complete one circuit (one circuit consisted of all stations), and (c) subjects performed each exercise until they reached temporary muscle fatigue. This exercise prescription was conducted for ten weeks, three times a week. It was concluded that the NCWT program, described in this study may prove to be useful as a short-term alternative to the more traditional methods for maintaining or improving $V_O^{2\text{max}}$ levels in untrained individuals. In addition, the NCWT program may be beneficial for rehabilitating injured athletes and as a precursor for more strenuous aerobic training programs.

Measure of Aerobic Capacity

Maximal Oxygen Uptake

Maximal oxygen uptake was defined by Lamb (1984) as the greatest amount of oxygen used by the cells in the body per unit of time. The more efficient the body's cardiorespiratory system the higher the $V_O^{2\text{max}}$ values.

According to Henson (1986), $V_O^{2\text{max}}$ is measured by determining the difference between the amount of oxygen inhaled and the amount of oxygen exhaled. Henson (1986) stated that the average $V_O^{2\text{max}}$ values were: (a) 40 and 45
ml x O₂/kg/min for a twenty-year old female and male, respectively; (b) 55+ and 60+ ml x O₂/kg/min for high school female and male distance runner's, respectively; (c) 60+ and 70+ ml x O₂/kg/min for college female and male distance runner's, respectively; (d) 70+ and 75+ ml x O₂/kg/min for world class female and male athletes, respectively. An additional definition of the VO₂max fitness categories for males under 30 years of age, according to Henson (1986), were (a) VO₂max of less than 25.0 ml x O₂/kg/min was very poor; (b) VO₂max levels which range between 25.0 and 33.7 ml x O₂/kg/min were poor; (c) VO₂max levels of 33.8 to 42.5 ml x O₂/kg/min were considered fair; (d) VO₂max levels that fell between 42.6 and 51.6 ml x O₂/kg/min were considered good; and (e) a VO₂max level of above 51.6 ml x O₂/kg/min was considered excellent. The ACSM (1986) defined cardiovascular levels for 40 year-old males as (a) 3.5 - 13.9 ml x O₂/kg/min as poor, (b) 14.0 - 24.9 ml x O₂/kg/min as low, (c) 25.0 - 38.9 ml x O₂/kg/min as average, (d) 39.0 - 48.9 ml x O₂/kg/min as good, and (e) 49.0 - 56.0 ml x O₂/kg/min as high.

VO₂max was the best predictor available for determining aerobic endurance capabilities (Henson, 1986). According to Lamb (1984) there were three ways to measure VO₂max levels: (1) treadmill gradient exercise test, (2) bicycle ergometer exercise test, and (3) bench stepping test.
Treadmill Testing

Lamb (1984) stated that maximal treadmill testing was the most accurate way to measure VO\textsubscript{2}\text{max}. Treadmill testing, according to Lamb, was more accurate than the other methods because there was little difference in skill efficiency between subjects. When testing for VO\textsubscript{2}\text{max} the criterion for determining VO\textsubscript{2}\text{max} were (a) an increased workload did not produce an increased VO\textsubscript{2}, (b) high levels of blood lactate during exercise, and (c) achievement of a near maximal heart rate. Additional factors that Lamb felt should be considered when determining VO\textsubscript{2}\text{max} were: (a) exercise posture (horizontal and vertical), (b) muscle mass used in exercise, large muscle groups must be used if VO\textsubscript{2}\text{max} was to be obtained, (c) exercise intensity and duration must be great enough to elicit near maximal responses, and (d) a reliable test should not depend on the skill or motivation of the subjects.

Froelicher et al. (1974) compared the Bruce, Balke, and Taylor maximal treadmill exercise protocols. This study evaluated the reproducibility of the three test protocols in relation to maximal oxygen consumption and other physiological parameters. The results showed no significant difference in the mean heart rates obtained in the three test protocols. The Taylor protocol, however, yielded a higher mean maximal oxygen consumption than the Bruce or Balke.
Lamb (1984) developed a maximal oxygen treadmill graded exercise test for normal subjects. The test protocol included (a) walking pace of 3.4 or 3.75 mph at a grade of 5.0 to 7.5% for a period of two minutes with an $O_2$ cost of 24.8 ml x $O_2$/kg/min, (b) the grade was slowly increased for another six minutes until it reached 15.0%, and (c) the grade slowly decreased and the speed increased at one minute intervals until the speed reached 7.0 mph and a grade of 12.5%

In addition Lamb (1984) stated that submaximal testing may also be useful in testing for $V O_2$ max. The ACSM (1986) suggested that a submaximal exercise test exercises the subjects to a predetermined endpoint. The results of the submaximal test are then used to predict maximal performance. Submaximal testing may be useful in determining levels of fitness in apparently healthy individuals, however, the testing results were often unreliable. The ACSM (1986) felt that maximal exercise testing had an advantage over submaximal testing in most circumstances. Maximal testing gave more reliable results when compared to submaximal exercise testing. There were some risks, however, that were noted with the maximal exercise testing.

According to the ACSM (1986) the indicators that warrant the termination of an exercise test session were (a) The subjects requested to stop, (b) failure of a monitoring device, (c) progressive angina, (d) down stepping
ST-depression or elevation, (e) sustained supraventricular tachycardia, (f) ventricular tachycardia, (g) any significant drop in systolic blood pressure, (h) failure of systolic blood pressure to increase during exercise, (i) systolic pressure above 250mmHg and diastolic pressure greater than 120mmHg, (j) R wave or T wave premature ventricular complexes, (k) unexplained bradycardia, (l) onset of a second or third degree heart block, (m) multifocal PVC's, and (n) increasing ventricular ectophy.

Summary

A review of the studies examined supported the contention that CWT programs elicited moderate gains in VO2 max levels when compared to traditional aerobic programs. Gettman and Pollock (1981) suggested that CWT programs may be helpful, when used with new exercise programs and/or to maintain aerobic fitness over short periods of time.

Gettman et al. (1981) compared isotonic and isokinetic equipment and suggested that it was not a matter of the type of equipment used in CWT programs but rather the workload. Variables, such as intensity, duration, and frequency, must be considered and controlled no matter what type of equipment was used. Peterson (1975) reported that Nautilus equipment and the Nautilus training program could significantly improve cardiovascular fitness.

The ACSM (1986) noted that the most reliable method
of testing VO$_2$ max levels was by using a maximal exercise test. A maximal exercise test, according to Lamb (1984), defines an individual's VO$_2$ max. The VO$_2$ max is the greatest volume of oxygen used by the cells of the body per unit of time (Lamb, 1984).

When comparing these studies several questions came to mind. First, was Peterson's (1975) study reliable? Peterson used a submaximal exercise test to determine the VO$_2$ max levels of his subjects. The ACSM (1986) stated that maximal exercise testing produced more reliable results than submaximal exercise tests. Peterson's (1975) study may have produced different results if a maximal treadmill test was used. Secondly, Peterson (1975) used trained athletes as subjects; therefore, would a trained individual's VO$_2$ max increases be higher, producing a significant difference in aerobic improvements? According to Henson (1986) and the ACSM (1986), the VO$_2$ max levels for trained individuals were higher than those of untrained individuals. Whether the pre and post VO$_2$ max increases would have been more substantial in the trained subject, as opposed to the untrained subject, was not clearly stated. According to Messier and Dill (1985), the average person would not experience the same increases in VO$_2$ max as the trained individual, when using the basic exercise guidelines set by Nautilus.

The conflicting information and results presented in
This literature review supported the need for this study. The literature reviewed did not totally support or refute the claims made by the Nautilus Corporation. Further research is needed to conclusively prove or disprove the contention that Nautilus circuit weight training can improve cardiovascular endurance. The research conducted by Peterson (1975), however, does raise some questions. This study may not have produced the type of results that can be related to an average Nautilus user. The number of novice weight trainers far exceeds the number of highly skilled and trained athletes. More information is needed to determine the effects of Nautilus on the average individual in relation to cardiovascular fitness.
CHAPTER III
DESIGN AND METHODOLOGY

The purpose of this study was to identify whether a six week Nautilus Circuit Weight Training program had any significant effect on the VO\textsubscript{2}max levels in novice weight trainers.

This chapter has been organized in the following manner; (a) subject selection, (b) testing procedures, (c) instrumentation, (d) treatment, and (e) statistical analysis.

Subject Selection

The fourteen subjects in this study were volunteers chosen from the physical education classes at Western Michigan University, Kalamazoo. The subjects were college age (18-23 year old) male and female novice weight trainers. The subjects were screened prior to selection to determine if they were in good health and free of known health risks (see Appendix A).

Testing Procedures

Subjects

Testing took place in the Exercise Physiology Lab in Sindecuse Health Center, at Western Michigan University,
Kalamazoo. Each subject was tested prior to and following the six week Nautilus training program. A consent form (see Appendix B), which explained the nature of the study and the possible risks involved, was signed by each subject before any testing took place. All test procedures were explained to the subjects prior to each test. Subjects were instructed to wear loose, comfortable clothing and exercise shoes during the testing period. Subjects were allowed to become familiar with the treadmill and the Beckman Metabolic Measurement Cart. Warm-up exercises were performed before the testing period by the subjects. During testing, subject's heart rate and blood pressure responses were monitored. If any irregularities in heart rate or blood pressure were recorded the testing was discontinued.

**Treadmill Test**

The maximal exercise test on the treadmill was performed using the Treadmill testing protocol for healthy subjects as defined by Lamb (1984)(see Appendix C). Subjects were allowed to use the handrails for balance and were instructed to stay close to the front of the treadmill. Spotters were used to help insure the safety of the subjects being tested.
**Oxygen Analysis**

The Beckman Metabolic Cart was used to analyze the expired air of each subject. Air analysis began at the fourth stage of the testing protocol and continued throughout the rest of the test at 30 second intervals. The test was discontinued when the subjects felt that they had reached volitional exhaustion. The pre and post $V_{O_2}\text{max}$ results from the Beckman Metabolic Cart were analyzed to determine if there were significant differences.

**Oxygen Analysis Equipment**

A Beckman Metabolic Measurement Cart (MMC) was used to analyze the amount of oxygen used by each subject at peak workload. The MMC is a self-contained device that measures metabolic ventilator or respirator measurements either manually or automatically. Oxygen measured in the MMC is measured by the Beckman OM-11 Oxygen Analyzer. Carbon dioxide is measured in the MMC by a LB-2 Medical Gas Analyzer. Programmed automatic operations were controlled by a Monroe Model 1810 Programmable Printing Calculator. The exercise program that was used by the Programmable Printing Calculator was the Exercise Program, Number 5539578. The program interrogated the MMC analyzer to measure (a) mixed expired oxygen ($FeO_2$), (b) mixed carbon dioxide ($FeCO_2$), (c) number of breaths ($V$), (d) expired gas temperature, (e) expired volume, (f) barometric...
pressure, and (g) time of measurement intervals. These input values were gathered in the proper sequence and calculated as follows; (a) minute volume, (b) oxygen consumption and (c) respiratory quotient. The MMC was calibrated, according to each VO₂ max test.

Treatment

The treatment was the Nautilus Training Program (NTP) (see Appendix D). The NTP was conducted for six weeks, three days per week. Subjects were oriented on the correct lifting techniques as suggested by Nautilus (Nautilus Sport/Medical Industries, 1980). An individualized NTP based on the subject's muscular strength was assigned to each subject. Subjects were instructed to lift between 8 to 12 repetitions at each station. If the subject could lift the weight 12 repetitions or more, they were instructed to increase the weight 5% at that station.

The rest period between work intervals was monitored by the investigator. Rest intervals at the onset of the NTP were 45 seconds. The high rest interval was designed to allow the subjects to become acquainted with the machines and the training program. Following the first week of training, the rest intervals were decreased by five seconds every other training session until the rest intervals reached 30 seconds. The 30 second rest intervals were maintained throughout the remaining training period.
The subjects lifted with a partner. One partner worked out while the other partner set the weights and seat settings for the partner who was working out. This allowed the subjects to move quickly and to meet the rest interval guidelines.

The investigator was present at all training sessions. The investigator visually monitored the subjects lifting techniques and the individualized training program.

Statistical Analysis

Raw data from the Pre and Post VO\textsubscript{2}max tests using the treadmill graded exercise test protocol were analyzed. Pre and Post test VO\textsubscript{2}max values were analyzed using a randomized block analysis of variance (ANOVA). The null hypothesis was tested at $p < .05$. 
CHAPTER IV

RESULTS AND DISCUSSION

The problem this study investigated was the effects of the Nautilus Training Program (NTP) on the maximal oxygen uptake ($VO_2_{max}$) levels of novice weight trainers. The experimental hypothesis of this study was that the results of the pre and post $VO_2_{max}$ test would show no difference, as a result of the NTP. Fourteen college age male and female subjects (18-23 years old) from physical education classes at Western Michigan University, Kalamazoo, participated in this study. The collection of the dependent variable, $VO_2_{max}$, was done with a Metabolic Measurement Cart during a maximal treadmill graded exercise test. A repeated measures randomized block ANOVA design was used to compare the dependent variable, $VO_2_{max}$. The results and analysis are presented as follows: Analysis of Subjects, Maximal Oxygen Uptake Results, and Discussion of the Results.

Analysis of Subjects

The 14 subjects, 9 male and 5 female, were screened prior to testing and were deemed to be in good health. Subjects were told not to participate in any aerobic activities during the 6 weeks of the NTP.
Supplemental aerobic activities were discontinued due to the possible effect of these activities on the dependent variable, $\text{VO}_2\text{max}$.

General demographic data for the subjects is reported in Table 1. The subjects' mean age was 21.4 years; the standard deviation was 1.34 years. Mean body weight for subjects' pre-test and post-test were 74 kg and 73.4 kg, respectively. The standard deviations were 12.83 kg and 12.3 kg for pre-test and post-test body weight, respectively.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Gender</th>
<th>Age</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>19</td>
<td>58.5</td>
<td>59.0</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>21</td>
<td>64.5</td>
<td>63.5</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>21</td>
<td>62.5</td>
<td>64.5</td>
</tr>
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<td>4</td>
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<td>F</td>
<td>20</td>
<td>63.5</td>
<td>61.5</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>24</td>
<td>100</td>
<td>97.0</td>
</tr>
<tr>
<td>7</td>
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<td>M</td>
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<td>M</td>
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<td>79</td>
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<td>10</td>
<td>M</td>
<td>20</td>
<td>60</td>
<td>59</td>
</tr>
</tbody>
</table>

Table 1: Demographic Data for Subjects

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Table 1—continued

<table>
<thead>
<tr>
<th>Subject</th>
<th>Gender</th>
<th>Age</th>
<th>Pre-test</th>
<th>Post-test</th>
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</thead>
<tbody>
<tr>
<td>11</td>
<td>M</td>
<td>21</td>
<td>70.5</td>
<td>69.5</td>
</tr>
<tr>
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<tr>
<td>13</td>
<td>M</td>
<td>20</td>
<td>72.5</td>
<td>72.5</td>
</tr>
<tr>
<td>14</td>
<td>M</td>
<td>22</td>
<td>89.9</td>
<td>90</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>21.4</td>
<td>74</td>
<td>73.4</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1.34</td>
<td>12.83</td>
<td>12.3</td>
<td></td>
</tr>
</tbody>
</table>

Maximal Oxygen Uptake Results

The VO_{2,max} results were obtained from each subject prior to and after six weeks of NTP. The raw scores produced by each subject on the pre and post VO_{2,max} test are shown in Appendix E. A randomized block ANOVA design was used to analyze the pre and post test scores to determine if there was a significant difference between the means. The summary table for the randomized block ANOVA is shown in Table 2.

The means of the pre-test and post-test VO_{2,max} were 42.83 ml x O_2/kg/min and 38.33 ml x O_2/kg/min, respectively. The analysis of variance indicated a significant difference between pre and post VO_{2,max} levels, F(1,13)=22.115
Thus the results indicated a decrease in VO$_2$ max from pre-to post-testing. As expected the VO$_2$ max values between subjects were significant, $F(13,13)=23.07$, $p<.05$. Subjects were expected to be at various levels of fitness which would effect VO$_2$ max levels.

![Table 2](image)

**Table 2**
Randomized Block Summary ANOVA for VO$_2$ max

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>142.02</td>
<td>1</td>
<td>142.02</td>
<td>22.115**</td>
</tr>
<tr>
<td>Subjects</td>
<td>1925.78</td>
<td>13</td>
<td>148.14</td>
<td>23.07**</td>
</tr>
<tr>
<td>Error</td>
<td>83.49</td>
<td>13</td>
<td>6.42</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2151.29</td>
<td>27</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**$p<.01$  *$p<.05$**

**Discussion**

Based on the results of this study, a Nautilus Training program of this nature will not produce increases in the aerobic capacity of novice weight trainers. Pre and post VO$_2$ max results were deemed to be significantly different at the $p<.05$. The VO$_2$ max values between subjects were also determined to be significant. Mean VO$_2$ max values decreased from the pre-test to the post-test. The results supported the hypothesis of this study that stated that a six week NTP would not produce any difference in
the $V_{O_2}^{max}$ values from the pre to the post-test.

**Exercise Protocol**

One possible explanation for the mean decrease in $V_{O_2}^{max}$ of 4.5 ml x $O_2$/kg/min was the exercise protocol or treatment. This study used the guidelines prescribed by Nautilus (Nautilus Sport/Medical Industries, 1980). Subjects were instructed to lift between 8-12 repetitions at each station. Rest intervals between work stations were between 30 and 45 seconds. Total workout time per exercise session ranged from 15-30 minutes. The ACSM (1986) prescribed the following standards for an exercise regime designed to maintain cardiovascular fitness: (a) use large muscle groups, (b) workout for a minimum of 20-30 minutes to improve functional aerobic capacity, and (c) use rhythmical and aerobic activities.

The workout duration of this study may not have been long enough to elicit aerobic gains. The workout sessions during the first week were 15-25 minutes in length, which is the lower end of the minimum recommended duration suggested by the ACSM (1986). Larger workout times may have been more advisable due to the nature of this study. Increased workout times would have required heavier workloads. Studies conducted by Gettman et al. (1978); Gettman et al. (1979); Gettman et al. (1982); and Messier and
Dill (1985) all used heavier workloads for a longer duration, which elicited modest gains in VO$_2$ max levels. These studies used between 12 to 15 repetitions per exercise. Increases in the number of repetitions above 12, in an effort to increase workout time or work-load, was not recommended by Nautilus (Nautilus Sport/Medical Industries, 1980). Nautilus recommended that novice weight trainers start out slowly to prevent injuries. Following the guidelines set by Nautilus was of paramount concern in this study, due to the fact that the average individual using the Nautilus machines will follow the guidelines set by the Nautilus Corporation.

**Detraining Effect**

Another possible reason for the decrease in mean VO$_2$ max was a detraining effect. This study required that the subjects discontinue all aerobic activities. The ACSM (1986) indicated that muscular strength and endurance had little direct relationship to cardiovascular fitness and was not considered an aerobic activity. Hickson et al. (1980) supported ACSM's position on strength training as well as stating that strength training had no effect on VO$_2$ max when measured during a treadmill test. In studies conducted by Nagel and Irwin (1960); and Allen et al. (1976) no significant increases in VO$_2$ max were found when
using a CWT program which also supports the ACSM's posi-
tion. Gettman and Pollock (1981) concluded that CWT
should not be considered an adequate aerobic program de-
dsigned to develop optimal cardiovascular fitness. If NTP
is not considered an aerobic activity by the above men-
tioned studies, then it could be concluded that the mean
\( V_O^{2}_{max} \) of the subjects in this study decreased because of
the lack of aerobic activity.

**Method of Testing**

The method used to test \( V_O^{2}_{max} \) is very important and
may be the reason why this study conflicted with the re-
sults of Peterson's (1975) study. The ACSM (1986) sugges-
ted that a maximal exercise test would give more reliable
results than a submaximal test. According to the ACSM,
submaximal exercise testing predicts maximal performance;
therefore, the testing results may be unreliable. Peter-
son (1975) suggested the NTP does increase cardiovascular
endurance; however, a submaximal exercise test was used.
This study used a maximal treadmill test to determine the
\( V_O^{2}_{max} \) of each subject.
The purpose of the study was to identify whether Nautilus Circuit Training had any effect on the maximal oxygen uptake levels of the novice weight trainer.

Summary

Fourteen male and female subjects from the physical education activities classes at Western Michigan University, Kalamazoo participated in a six week Nautilus Training Program. Each subject was tested prior to and following the treatment for aerobic capacity ($V_{O_2}^{\text{max}}$) using a maximal treadmill graded exercise test. Pre- and post-test $V_{O_2}^{\text{max}}$ results of each subject were compared. Significant differences were found between the pre- and post-test results and between subjects. A mean $V_{O_2}^{\text{max}}$ decrease of 4.5 ml x O2/kg/min between pre and post-test results was found. A randomized block analysis of variance (ANOVA) was used to analyze the data.

Conclusions

The conclusions of this study are as follows:

1. It is apparent from the results of this study that novice weight trainers using the Nautilus Training...
Program did not experience an increase in VO$_2$max levels as a result of the training. The post-test mean VO$_2$max results were 4.5 ml x 02/kg/min lower than the pre-test mean VO$_2$max results.

2. From the data collected in this study, it appeared that within the six week Nautilus training period the VO$_2$max levels of novice weight trainers may be negatively affected. Weight trainers experienced a significant decrease in aerobic capacity.

3. In addition the results of this study indicated that a Nautilus Training program may not be considered an aerobic activity, nor would Nautilus training be recommended as an activity designed to maintain cardiovascular fitness.

Recommendations

Further studies are recommended in which a larger and more varied subject population be tested. Such testing may define more appropriate uses of a Nautilus Training Program for novice weight trainers. Results of such research may establish further training uses of Nautilus equipment in the areas of physical fitness and rehabilitation.

Additional research is needed using the Nautilus training protocol, as recommended by the Nautilus Corporation. Strict adherence to the Nautilus guidelines is
essential in order to legitimately compare the results of such studies.

It is recommended that additional research studies use a maximal exercise test to determine \( VO_2 \text{max} \) levels for each subject. A maximal exercise test will produce more reliable and comparable data.

In addition, it is recommended that Nautilus re-evaluate the effects of their recommended regime for cardiovascular improvements. Nautilus should study the effects of their training program on novice weight trainer not on above average or elite athletes. From these additional studies Nautilus may be able to develop new, more reliable training procedures for the millions of novice weight trainers who use Nautilus each year.
Appendix A

Physical Activity Readiness Questionnaire
Physical Activity Readiness Questionnaire

Common sense is the best guide in answering these few questions. Read them carefully and answer them as they apply to you.

Yes No 1. Has your doctor ever said you have heart trouble?
Yes No 2. Do you frequently have pains in your heart and chest?
Yes No 3. Do you often feel faint or have spells of severe dizziness?
Yes No 4. Has a doctor ever said your blood pressure was too high?
Yes No 5. Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise?
Yes No 6. Is there a good reason not mentioned here why you should not follow an activity program even if you wanted to?
Yes No 7. Are you over the age of 65 and not accustomed to vigorous exercise?

If you have answered yes to one or more questions, and if you have not seen your personal physician recently, you should consult with him or her before completing the fitness evaluation.

Please answer the following questions completely and to the best of your ability.

Name: __________________________ Age: _____ Sex: ______
Address: ______________________________________________________
City: _______________ State: ___________ Zip: __________
Permanent Address: _____________________________________________
City: _______________ State: ___________ Zip: __________
Phone: (Home) ______________ (School) ________________________

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A. Check the following if you have a history of any of the following:

- Heart Attack
- Coronary Bypass
- Cardiac Surgery
- Chest Discomfort
- High Blood Pressure
- Extra, Skipped, or Rapid Heart palpi-
- Heart Murmurs, Clicks, or Unusual Cardiac Findings
- Rheumatic Fever
- Ankle Swelling
- Peripheral Vascular Disease
- Phlebitis, Emboli
- Unusual Shortness of Breath
- Lightheadedness or Fainting
- Pulmonary Disease
- including Asthma, Emphysema and Bron-
- Abnormal Blood
- Diabetes
- Stroke
- Emotional Disorders
- Medications of All Types
- Recent Illness, Hospitalization or Surgical Procedure
- Drug Allergies
- Orthopedic Problems, Arthritis
- Other:

B. Family History (parents, grandparents, aunts, uncles, and siblings)

- Coronary Disease (at what age?)
- Sudden Death (at what age?)
- Congenital Heart Disease

C. Other habits. Check if they pertain to you.

- Caffeine including cola drinks. Quantity per day:
- Alcohol. Quantity:
- Tobacco. Quantity:
- List any other habits or dieting:

- Exercise history with information on habitual level of activity: Type of exercise, frequency duration, and intensity.

I hereby state that the information given above is true to the best of my knowledge.

_________________________  ______________________
Signature                 Date
Appendix B

Informed Consent
Informed Consent

Purpose:

The purpose of this study is to determine whether Nautilus Circuit Training will improve functional aerobic capacity.

Explanation:

There are three phases in this study that involve your participation. The phases are: (a) a pre-training treadmill gradient exercise test, (b) a Nautilus circuit weight training program, and (c) a post training treadmill gradient exercise test. Prior to each of the treadmill gradient exercise tests your heart rate and blood pressure will be monitored by an EKG unit to establish resting levels and to determine if there are any irregularities. During the testing periods you will be monitored by the EKG unit. As you are exercising your expired air will be analyzed by a Beckman Metabolic Measurements Cart. The expired air will be collected by a breathing valve/mouthpiece connected to a plastic tube that you will wear during the later phase of the test.

The exercise on the treadmill will start slowly and at low levels of intensity. Exercise intensity will increase at regular intervals until you reach exhaustion or wish to discontinue for another reason. The test will also be stopped immediately if you feel any pain or other intolerable discomfort. The testing will occur in the Exercise Physiology lab in the Sindecuse Health Center on the campus of Western Michigan University, Kalamazoo, Michigan.

The training that you will participate in consists of Nautilus Circuit Weight Training, three times a week for a six week period of time. You will receive an orientation instructing you on proper lifting techniques. An individualized program will be designed for you. The training program will become more difficult as you progress. The level of difficulty and exercise intensity will depend on your capabilities. You may stop the training at any time due to injury or for any other reason. The Nautilus Training will occur at the Kalamazoo Young Men's Christian Association located on Maple Street off of Oakland Drive, Kalamazoo, Michigan.
Risks:

There is a possibility that during the testing or training phases of this study certain changes will occur. This includes: abnormal blood pressure responses; dizziness; irregular heart beats; and, in very rare cases, a heart attack. Changes that may occur during the training phases may include the following: muscle soreness, muscle fatigue, joint swelling, and muscle pulls. Every effort will be made to minimize the risks involved by: pretraining orientation and the designing of an individualized training program; pre-testing orientation and EKG monitoring; and testing observation and monitoring. In the case of an emergency, emergency equipment and personnel from the Urgent Care Unit are located down the hall from the testing lab in the Health Center.

Inquiries:

Any questions related to the testing or treatment procedures are welcome. You will be given information throughout the testing and training period. All procedures will be explained prior to testing and training.

Freedom of Consent:

Your participation in this study is voluntary. If you do not want to participate for any reason please inform the investigator immediately. The data from this study will be used to complete a thesis by Rhonda M. Ludwig to earn a degree at Western Michigan University.

I have read this form and understand completely the procedures that I will be involved in. I agree to participate in this study.

DATE: ______________  SIGNATURE: ____________________

WITNESS: ____________________
Appendix C

Treadmill Testing for Normal Healthy Subjects
Treadmill Testing for Normal, Healthy Subjects

<table>
<thead>
<tr>
<th>Stage No.</th>
<th>Speed</th>
<th>Grade</th>
<th>Time</th>
<th>$O_2$ Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.4</td>
<td>7.5</td>
<td>2</td>
<td>24.8</td>
</tr>
<tr>
<td>2</td>
<td>3.4</td>
<td>10.0</td>
<td>2</td>
<td>29.0</td>
</tr>
<tr>
<td>3</td>
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<td>4</td>
<td>3.4</td>
<td>15.0</td>
<td>2</td>
<td>37.1</td>
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<tr>
<td>5</td>
<td>3.75</td>
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<tr>
<td>10</td>
<td>7.0</td>
<td>12.5</td>
<td>1</td>
<td>62.0</td>
</tr>
</tbody>
</table>

Note: Data from Appendix C is from Physiology of Exercise, Responses and Adaptations (p. 181) by D. R. Lamb, 1984, New York: McMillan, Copyright by David R. Lamb.
Appendix D

Nautilus Training Program
Nautilus Training Program

1) Weight set according to number of repetitions subject is able to perform.

2) Repetition between 8 to 12 per machine.

3) Weights were lifted on a count of 2 and lowered on a count of 4.

<table>
<thead>
<tr>
<th>First Week</th>
<th>Rest Interval 45 seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machines:</td>
<td>Leg Extension</td>
</tr>
<tr>
<td></td>
<td>Abductor</td>
</tr>
<tr>
<td></td>
<td>Overhead Press</td>
</tr>
<tr>
<td></td>
<td>Double Chest Decline Press</td>
</tr>
<tr>
<td></td>
<td>Adductor</td>
</tr>
<tr>
<td></td>
<td>Abdominal</td>
</tr>
<tr>
<td></td>
<td>Low Back</td>
</tr>
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<table>
<thead>
<tr>
<th>Second Week</th>
<th>Rest Interval 45 seconds to 30 seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machines:</td>
<td>Same as First Week</td>
</tr>
<tr>
<td>Added:</td>
<td>Leg Curl</td>
</tr>
<tr>
<td></td>
<td>Duo Squat</td>
</tr>
<tr>
<td></td>
<td>Super Pullover</td>
</tr>
<tr>
<td></td>
<td>Double Chest Fly</td>
</tr>
<tr>
<td></td>
<td>Multi-Biceps</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Third Week</th>
<th>Rest Interval 30 seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machines:</td>
<td>Same as Second Week</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Fourth Week</th>
<th>Rest Interval 30 seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machines:</td>
<td>Same as Second Week</td>
</tr>
<tr>
<td>Added:</td>
<td>Multi-Triceps</td>
</tr>
<tr>
<td></td>
<td>Rotary Torso</td>
</tr>
<tr>
<td></td>
<td>Duo Squat</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Fifth Week</th>
<th>Rest Interval 30 seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>and</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sixth Week</th>
<th>Rest Interval 30 seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machines:</td>
<td>Same as Fourth Week</td>
</tr>
</tbody>
</table>
Appendix E

Raw Data: VO$_2$$_{\text{max}}$ Values
Raw Data: $\text{VO}_2\text{max}$ Values

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Pre-test (ml x O2/kg/min)</th>
<th>Post-test (ml x O2/kg/min)</th>
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</thead>
<tbody>
<tr>
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<td>35.93</td>
</tr>
<tr>
<td>2</td>
<td>34.57</td>
<td>32.76</td>
</tr>
<tr>
<td>3</td>
<td>35.04</td>
<td>35.81</td>
</tr>
<tr>
<td>4</td>
<td>32.00</td>
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</tr>
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<td>6</td>
<td>34.20</td>
<td>30.10</td>
</tr>
<tr>
<td>7</td>
<td>47.95</td>
<td>45.42</td>
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