ABSTRACT

CHAPEK, C. L. The effects of a ten-week step aerobic training program on aerobic capacity of college-aged females. MS in Adult Fitness/Cardiac Rehabilitation, 1992, 62pp. (J. Porcari)

The purpose of this study was to examine the effects of a 10-week step aerobic training program on the maximal oxygen consumption (VO_{2max}) of college-aged women (mean age = 19.4 yrs). Fifty apparently healthy females between the ages of 18 and 25 years participated in the training study. Subjects in the experimental group exercised 3 times per week for 10 weeks. The average heart rate maintained during the training was 150 bpm which represented 76% of HRmax. Twenty-one experimental group Ss and 29 control group Ss performed a maximal treadmill test to volitional exhaustion prior to and upon completion of the study. The variables analyzed included resting HR (bpm), body weight (lbs), rating of perceived exertion (RPE), treadmill run time, absolute VO_{2max} (L/min), relative VO_{2max} (ml/kg/min), V_{E}max (BTPS) (L/min), RERmax, and HRmax (bpm). The results showed significant (p < .05) between-group differences in mean treadmill run time, absolute VO_{2max}, relative VO_{2max}, HRmax, and V_{E}max. The experimental group had increases in treadmill run time (33.1%), absolute VO_{2max} (11.5%), relative VO_{2max} (11.7%), HRmax (1.0%), and V_{E}max (6.7%) which were significantly greater than the control group. No significant (p > .05) between-group differences were observed in body weight, RERmax, RPE, and resting HR.
THE EFFECTS OF A TEN-WEEK STEP AEROBIC TRAINING PROGRAM ON AEROBIC CAPACITY OF COLLEGE-AGED FEMALES

A THESIS PRESENTED TO THE GRADUATE FACULTY UNIVERSITY OF WISCONSIN-LA CROSSE

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

BY

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DECEMBER 1992
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Master of Science, Adult Fitness/Cardiac Rehabilitation

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ACKNOWLEDGEMENTS

Sincere appreciation is extended to my chairperson, Dr. John Porcari for the tremendous amount of time, support, guidance, and enduring patience he gave me throughout the past year.

I would like to express sincere thanks and appreciation to my committee members, Dr. Glenn Brice and Dr. Sandy Price, for all their time and editorial assistance.

A warm appreciation is extended to Elizabeth Huntley for her true friendship and support throughout this endeavor.

Special thanks and love goes to my family and Thomas Roberts for their continual love, support, and never ending faith in me.
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CHAPTER I
INTRODUCTION

During the last 10 years one of the most popular forms of exercise has been aerobic dance. Traditional aerobic dance consists of a series of specially choreographed routines which combine locomotor and non-locomotor movements performed to the accompaniment of music. Its roots go back to the early 1960's when Dancercize was introduced by Debbie Drake. This idea was ahead of its time and never became a popular mode of exercise (Cooper & Cooper, 1988). However, in 1969 Jacki Sorenson introduced another version of exercise set to music which she called aerobic dance. Sorenson developed aerobic dance in an effort to combine recreational pursuit with cardiovascular conditioning (Eickhoff, Thorland, & Ansorage, 1983).

The widespread popularity of aerobic dance has prompted several researchers to study its physiological effects on the body. The data support the contention that aerobic dance does provide a useful means of enhancing cardiorespiratory fitness (Johnson, Berg, & Latin, 1984; Milburn & Butts, 1983; Perry, Mosher, La Perriere, Roalstad, & Ostrovsky, 1988; Vaccaro & Clinton, 1981). Since the creation of aerobic dance in 1969 many other variations of aerobic dance have evolved. One of the most exciting new forms of aerobic dance is step aerobics (De Mond, 1990). The Institute for Aerobics Research (1990) defines step aerobics as "a dynamic and new exercise program that
involves stepping up and down from a platform to the accompaniment of music" (p. 1).

Step aerobics training combines the high intensity of stair climbing with the low impact and safety of walking. The general opinion is that step training programs can improve aerobic conditioning, muscular strength and endurance, flexibility, and body composition (Francis & Francis, 1990). Research reveals that the energy expenditure of step training is almost identical to that of running 7 miles per hour with an impact similar to walking (Francis & Francis, 1990). However, there has been no published research found regarding the actual training effects of step aerobics.

**Purpose of the Study**

The purpose of this study was to examine the effects of a 10-week step aerobics training program on the maximal oxygen consumption \( \text{(VO}_2\text{max)} \) of college-aged females.

**Need for the Study**

The cardiovascular benefits of aerobic exercise using one of the traditional modes of aerobic training such as jogging, swimming, and cycling are well documented. More recently aerobic dance programs have increased in popularity. Several researchers have examined the energy cost per minute of aerobic dance routines and concluded that aerobic dancing can be a useful modality for cardiorespiratory training (Cearly, Moffatt, & Knutzen, 1984; Johnson et al., 1984; Milburn & Butts, 1983; Vaccaro & Clinton, 1981).

The "hottest" workout around is step aerobics (De Mond, 1990). With the increasing popularity of step aerobics, it is important to
determine and provide the aerobic enthusiast with information on whether or not step aerobics will induce a positive cardiovascular training effect.

Hypotheses

The following null hypotheses were tested in this study:

1. There will be no significant difference in the changes in $VO_{2\text{max}}$ expressed in absolute terms (L/min) exhibited by the experimental and control groups following the 10-week study period.

2. There will be no significant difference in the changes in $VO_{2\text{max}}$ expressed in relative terms (ml/kg/min) exhibited by the experimental and control groups following the 10-week study period.

3. There will be no significant difference in the changes in maximal heart rate ($HR_{\text{max}}$) exhibited by the experimental and control groups following the 10-week study period.

4. There will be no significant difference in the changes in maximal respiratory exchange ratio (RER$_{\text{max}}$) exhibited by the experimental and control groups following the 10-week study period.

5. There will be no significant difference in the changes in maximal ventilation ($V_{E\text{max}}$) exhibited by the experimental and control groups following the 10-week study period.

Assumptions

In the conduct of the present study it was assumed that:

1. Subjects did not participate in any additional aerobic activities outside of the step aerobics training program.

2. Subjects did not modify their dietary habits during the training study.
3. Subjects abstained from food, caffeinated beverages, drugs, alcohol, and tobacco for at least 4 hours prior to the testing session.

4. The changes in aerobic capacity as measured on the treadmill test reflected the actual changes in $\text{VO}_2\text{max}$ resulting from the step training program.

**Delimitations**

This study had the following delimitations:

1. The subjects were active, college-aged females between the ages of 18 and 25 years who were attending the University of Wisconsin-La Crosse during the Fall Semester, 1991.

2. The experimental group were students enrolled in the Fall Semester, 1991 step aerobics class which was offered through the Intramural Program on Monday, Wednesday, and Friday at 6:45 a.m.

3. The training period was 10 weeks in duration.

4. The subjects involved in the study were apparently healthy, non-smoking individuals.

**Limitations**

This study had the following limitations:

1. The subjects who participated in the study were not selected on a random basis.

2. The motivational levels of the subjects could not be completely controlled during the 10-week training study.

3. The learning effect in novice step aerobics participants may have had an affect on initial performances.
Definition of Terms

The following terms were used in this study:

**Aerobic Dance** - a fitness activity designed to improve cardiorespiratory endurance which consists of vigorous, rhythmic steps and routines to the accompaniment of music (Cooper & Cooper, 1988).

**Aerobic Exercise** - aerobic exercises are endurance activities such as running, swimming, and cycling. These forms of aerobic exercise increase the amount of oxygen that the body can process within a given time (Cooper & Cooper, 1988).

**Maximal Heart Rate** - maximal heart rate is the maximum number of times the heart beats in 1 minute. Maximal heart rate is determined by measuring the highest heart rate obtained during a treadmill test when the subject has reached volitional exhaustion (Brooks & Fahey, 1984).

**Maximal Oxygen Consumption (VO_{max})** - the maximal amount of oxygen which an individual can transport and utilize. Maximal oxygen consumption can be expressed in both absolute (L/min) and relative (ml/kg/min) terms (Brooks & Fahey, 1984).

**Rating of Perceived Exertion (RPE)** - a subjective value selected by the subject which best represents the overall intensity of exercise (Borg, 1973). The RPE is used to assess when maximal exercise is being approached.

**Respiratory Exchange Ratio (RER)** - the ratio of the volume of carbon dioxide expired to the volume of oxygen consumed during the same time interval, as measured by open-circuit spirometry (Fox, Bowers, & Foss, 1988).
**Step Aerobics** - step aerobics is an exercise program that involves stepping up and down from a platform to the accompaniment of music (Institute for Aerobics Research, 1990).

**Training Effect** - an increase in cardiorespiratory endurance consequent to an exercise program, typically measured as a change in VO$_2$max.
CHAPTER II
REVIEW OF RELATED LITERATURE

Introduction

The following review of related literature has been divided into three parts which include: maximal oxygen consumption, methods of determining VO\textsubscript{2max}, effects of physical training on VO\textsubscript{2max}, and physiological responses to step aerobics dance training.

Maximal Oxygen Consumption

Maximal oxygen consumption (VO\textsubscript{2max}) is the maximal amount of oxygen the body can transport and utilize when exercising to exhaustion (Fox et al., 1988). The measurement of VO\textsubscript{2max} is determined by an individual's respiratory, cardiovascular, and skeletal capabilities for the uptake, transport, and utilization of oxygen (McConnell, 1988). Because of its functional significance, VO\textsubscript{2max} provides a good estimate of the potential of the cardiovascular system and is generally considered the best index of cardiorespiratory fitness (Girandola & Katch, 1973; Taylor, Buskirk, & Henschel, 1955).

McConnell (1988) stated that "VO\textsubscript{2max} may be the most physiologically significant and therefore, the most commonly measured parameter in the physiological assessment of athletes" (p. 57). According to the American College of Sports Medicine (ACSM) (1991), VO\textsubscript{2max} can be predicted from the peak exercise time or power output achieved during a standard maximal exercise test protocol, or from submaximal exercise tests. Maximal oxygen consumption can be altered by
several variables which include body composition, environmental conditions, and various cardiorespiratory diseases. Oxygen uptake values can be expressed in absolute terms (L/min) and relative to body weight (ml/kg/min).

According to the ACSM (1991) the accepted measure of determining a person's cardiorespiratory fitness level is to measure VO₂max directly. The direct measurement of VO₂max involves the analysis of expired air samples which are collected as the subject performs a graded maximal exercise test. Many modalities have been used to measure VO₂max in the laboratory setting. These include treadmill running, cycle ergometry, and bench testing (Fox et al., 1988).

**Methods of Determining VO₂max**

The two major modes of exercise testing used today are treadmill walking or running and stationary cycling. Values of VO₂max measured on inclined treadmills are usually 5 to 15% higher than those obtained on either the bicycle or step bench (Fox et al., 1988; Hermansen & Saltin, 1969; McArdle & Magel, 1970). The reason higher values are obtained during treadmill testing may be due to differences in size of the active muscle mass, this being the largest during a treadmill run (Fox et al., 1988). Another reason for the difference may be because running or walking is more natural to most individuals. The use of the cycle ergometer to determine VO₂max has a significant disadvantage which is due to the overloading of the quadriceps muscle at high intensities. In individuals unaccustomed to cycling, this may cause fatigue before maximal values can be obtained (Shephard, 1987). Such fatigue, according to Fox et al. (1988) would occur prior to maximally stressing
the circulatory and respiratory systems which would lead to smaller VO2max values.

Criteria have been established for indicating when an individual has attained their VO2max. These include: volitional exhaustion, respiratory exchange ratio (RER) of at least 1.0 to 1.10, blood lactate level above 100 mg%, heart rate within 10 beats of predicted maximum, and rating of perceived exertion (RPE) of 19 or 20 (McConnell, 1988).

The exact method or protocol used in determining VO2max values will vary depending on the purpose of the investigation, subject comfort, and the preference of the investigator. There are several reliable test procedures that are used to measure a person's VO2max on the treadmill.

Taylor et al. (1955) presented a discontinuous testing protocol which consisted of intermittent stages that were performed on four successive days. A constant running speed was used and each stage was increased by 2.5% grade increments. The subjects returned each day, until the increase in grade failed to result in a VO2 increase of at least 150 ml of O2/min. This leveling off of the VO2 indicated that a person had reached the limit of their cardiovascular system and this was considered to be that person's "true" physiological VO2max.

Mitchell, Sproule, and Chapman (1957) used a discontinuous protocol that allowed rest periods between each exercise increment. These authors used a modification that could be completed in one laboratory visit. The subject began the test by walking for 10 minutes at 3 miles per hour on a 10% grade. This preliminary warm-up period allowed the individual to become adjusted to the treadmill. After a 10 minute rest period, the subject began running at 6 miles per hour at 0% grade for
2.5 minutes. Expired gas was collected for analysis from minute 1:30 to 2:30. Following the first bout of exercise a 10 minute rest period was allowed. For the next run the speed remained constant but the grade was increased 2.5%. This procedure was repeated until maximal values were obtained.

A protocol presented by Saltin and Astrand (1967) went one step further than the Mitchell, Sproule, and Chapman method. This protocol did not provide a rest period between stages. The Saltin-Astrand method was considered a continuous testing protocol. Prior to beginning the test, the subject warmed up for 10 minutes at a workload of approximately 50% of their predetermined starting load. During the run to volitional exhaustion, the treadmill was elevated 2.7% every 3 minutes. Consecutive 1 minute gas collections were made (Saltin & Astrand, 1967).

According to the ACSM (1991), there are other graded treadmill exercise test protocols that have been used successfully to determine VO$_2$max. One of these protocols is the Bruce, which involves change in speed and grade every 3 minutes. The advantage of this protocol is the relative brevity, since tests end very quickly. Several recent studies have shown that one of the disadvantages of this protocol is that there may be a 10 to 20% lower VO$_2$max, which is attributed to the very rapid increase in the grade and speed (ACSM, 1991). Another popular testing protocol is the Naughton-Balke, which utilizes a constant walking speed with 2 to 3% increases in grade every 2 to 3 minutes (ACSM, 1991).

Research findings generally support a constant running speed with periodic gradient increases to elicit the highest VO$_2$max values. Taylor
et al. (1955) suggested that grade alone should be incremented because most subjects are unable to maintain their running stride at higher speeds. In 1968, the International Biological Programme recommended a standard protocol using a constant speed and 2.5% grade increments every 2 minutes (McConnell, 1988).

**Effects of Physical Training on VO₂max**

Training can induce favorable physiological changes in the cardiorespiratory system. The changes resulting from training are greatly influenced by the frequency, duration, and intensity of the program. Jogging, walking, swimming, cycling, and various forms of aerobic dance are quite popular in the United States, and there has been a considerable amount of research conducted which has focused on the physiological benefits of these activities. The next portion of the review of related literature focuses on five modes of exercise and the effects these training programs have on VO₂max.

**Responses to Run/Walk Training**

Walking and jogging are common forms of exercise for millions of people across the country. Numerous researchers have examined the physiological effects of jogging and walking in men and women (Brown, Harrower, & Deeter, 1972; Burke, 1977; Burkett, Fernhall, & Walters, 1985; Eisenman & Golding, 1975; Gettmann et al., 1976; Jette, Sidney, & Campbell, 1988; Massicotte, Avon, & Corriveau, 1979; Mileisis et al., 1976; Pollock, Cureton, & Greninger, 1969; Wilmore, Royce, Girandola, Katch, & Katch, 1970).

A frequently asked question is how often must one participate in an aerobic exercise to attain positive physiological effects. Pollock et
al. (1969) addressed the issue of the effects of the frequency of training on work capacity, cardiovascular function, and body composition. Nineteen men volunteered to participate in the study. The men were randomly assigned to one of the two experimental groups. Group I exercised 2 days per week and Group II, 4 days per week, for 20 consecutive weeks. Each exercise session consisted of the men walking, jogging, or running for 30 minutes continuously. Results showed that both experimental groups improved significantly in all work capacity and cardiovascular variables. The group that exercised 4 days per week elicited more of a significant improvement in VO$_{2\text{max}}$, V$_{E\text{max}}$, maximal oxygen pulse, and body composition than the group which exercised 2 days per week. The investigators concluded that performance was directly related to the frequency of training and that the range for improvement in cardiovascular fitness is significantly greater for a 4-day per week program than a 2-day per week program.

An investigation by Gettmann et al. (1976) examined the training responses of 55 county jail inmates to 1, 3, and 5-day per week exercise programs. Subjects ranged in age from 20 to 35 years and were randomly assigned to 1 of 4 groups. The training sessions were 30 minutes long and subjects exercised at 85-90% of HR$_{\text{max}}$ for 20 weeks. The mode of exercise consisted of endurance oriented walking or running on a treadmill with the run to walking ratio increasing significantly with advancing weeks of conditioning. The investigators found that the cardiovascular responses to 1, 3, and 5-day per week training programs improved in direct proportion to the frequency. Improvements in VO$_{2\text{max}}$ expressed in ml/kg/min increased 8% in the 1-day per week group, 13% in
the 3-day per week group, and 17% in the 5-day per week group. These results were similar to those reported by Pollock et al. (1969).

The American College of Sports Medicine (1991) stated that the conditioning period of 20 to 30 minutes in length is typically required to improve or maintain functional capacity. Wilmore et al. (1970) researched the physiological alterations resulting from a 10-week jogging program. Fifty-five volunteers were randomly divided into 2 groups. One group trained 12 minutes per day, 3 times per week while the other group trained 24 minutes per day, 3 times per week. Both groups demonstrated significant increases in vital capacity, VO2max, and oxygen pulse. Also, significant decreases in resting systolic and diastolic blood pressure, resting heart rate, and HRmax were found.

Milesis et al. (1976) conducted a similar study to determine the effects of 15, 30, and 45 minutes of walking and running on maximum performance and cardiorespiratory fitness variables. In general, all 3 groups showed favorable improvements in VO2max, treadmill performance times, maximum oxygen pulse, diastolic blood pressure, and total skinfold fat. Both of these studies (Milesis et al., 1976; Wilmore et al., 1970) found that the physiological improvements were directly proportional to the duration of daily exercise. The subjects training in the longer duration sessions showed greater improvements.

Walking and jogging studies involving female subjects are not as well documented as those involving male participants. Burkett et al. (1985) studied the physiologic effects of distance run training on untrained teenage females between the ages of 13 and 19 years. A group of nine females served as the control group. The 10 subjects in the
An experimental group underwent a 20-week training program, designed to increase the subjects' average mileage from 0 to 32.2 km per week over the course of the study. After the training it was found that the experimental group had a 9.3% increase in VO₂max, whereas the control group showed no gain.

In another study Brown et al. (1972) investigated the effects of cross-country running on preadolescent girls. Twelve girls ranging from 8 to 13 years of age were studied. The training sessions were held 4 to 5 times per week for 1-2 hours per session. These training schedules called for continuous running over gradually increasing distances. Depending on their age, these girls were able to cover 4 to 7 miles in the middle and later portion of the season. The subjects were assessed before and after 6 and 12 weeks of training. The runners demonstrated an 18% increase in VO₂max after 6 weeks and a 26% increase after 12 weeks.

Eisenman and Golding (1975) conducted a study comparing the effects of training on VO₂max in girls and young women. Four groups of volunteers were used. The two experimental groups consisted of eight girls (12-13 years) and eight young women (18-21 years) who trained for 14 weeks. Two control groups were used consisting of eight girls and eight young women who were similar in age to the experimental group. The training sessions were conducted for 30 minutes, 3 times per week, with the training consisting of running and bench stepping. By the final weeks of the training, the subjects were jogging approximately 1.8 miles per session and completing 150 steps on an 18 inch bench. A
maximal treadmill test was performed prior to training and after the 2nd, 6th, and 14th weeks.

After the training it was found that both the girls and the women in the experimental groups had significantly higher VO$_2$max values regardless if it was expressed in absolute or relative terms. The young women and girls increased their VO$_2$max when expressed relative to body weight (ml/kg/min) by 17.6 and 16.1%, respectively. There was no significant change found in either of the control groups. In addition to changes in VO$_2$max, adaptation to the training also reflected favorable changes in V$_E$max. Maximal ventilation was significantly greater after training for both of the experimental groups.

There have been few jogging studies published which compare the effects of aerobic training between sexes. The purpose of two different investigations was to determine whether there was a difference between gender responses to similar training. Massicotte et al. (1979) conducted a study involving 23 sedentary males and 11 sedentary females. Subjects participated in a 20-week physical conditioning program consisting of 10 minutes of warm-ups, 20 minutes of running or walking, 25 minutes of exercises, and 5 minutes of relaxation. The subjects conditioned 3 days per week and worked at an intensity of 70-89% of HRmax. Results of the study showed that the effects of training significantly increased the VO$_2$max, oxygen pulse, and the work done at 90% of the HRmax. Results also revealed significant decreases in oxygen uptake, heart rate, V$_E$, respiratory quotient, and respiratory equivalent at given submaximal work levels. However, there were no significant
differences in the magnitude of cardiorespiratory changes between the males and the females.

Burke (1977) also compared the physiological effects of jogging programs in untrained college-aged men and women. The two experimental groups consisted of 9 males and 8 females, who participated in the training 3 days per week for 8 consecutive weeks. The training sessions included 0.5 mile interval runs separated by 0.25 mile walks. The total training distance progressed from 1 to 2.5 miles over the course of the study. The total distances that were run were equal for both sexes. However, the training times between the men and women differed. The data revealed a significant increase in VO$_2$ whether expressed in relative or absolute values, with results being similar for males and females. Males showed a 17% increase in VO$_2$max and females a 24% increase (ml/kg/min). In conclusion, Burke (1977) stated that "the average female can expect relative improvement in aerobic power similar to that of a male following a period of systematic training" (p. 515). Both studies concluded that physiological effects of training were similar in males and females, if the frequency, duration, and intensity of training were similar. The slight difference found in these two studies can probably be accounted for by the initial physical performance of the subjects. According to Pollock, Miller, Janeway, and Linnerud (1971) subjects with low fitness status have considerably more potential for improvement as a result in training.

Walking has been identified as an activity which provides cardiorespiratory improvement and enjoyment for many people. In a study done by Jette et al. (1988) it was found that middle-aged males and
females who trained for 30 minutes, 3 times per week, for 12 consecutive weeks indicated significant improvement in cardiorespiratory fitness. Each volunteer walked at a pace that elicited 60% of VO₂max. Results indicated that males increased their maximal values 9.7% and females 17%. The author concluded that an exercise prescription based on an appropriate pace is an effective procedure to enhance cardiorespiratory fitness of sedentary, middle-aged men and women.

Responses to Swim Training

Swimming is also a very popular form of aerobic exercise. In the last decade the number of registered masters swimmers (25 years and older) has jumped from 6,000 to 20,000. According to National Family Opinion, Inc., 95.9 million Americans identified themselves as swimmers (Cooper & Cooper, 1988). Swimming is one of the best aerobic exercises since it requires a person to use the major muscles of the body but places a limited amount of strain on the joints. It has been documented by several researchers that swimming does elicit significant benefits in males and females (Butts, Pein, & Stevenson, 1984; Lieber, Lieber, & Adams, 1989).

Lieber et al. (1989) conducted a study which examined the effect of run training and swim training. Thirty-seven sedentary males, 28-35 years old, were either run trained, swim trained, or served as controls. Both the runners and swimmers exercised 60 minutes, 3 days per week, for 11.5 weeks. Each subject exercised at a heart rate intensity equivalent to 75% of their HRmax obtained during the treadmill VO₂max test. The study revealed that runners, swimmers, and controls significantly increased in treadmill VO₂max over the 11.5-week training period. The
runners and the swimmers increased their VO$_2$max by 28 and 25%, which was significantly greater than the 5% increase of the control group.

Another study conducted by Butts et al. (1984) investigated the effects of swim training on cardiovascular fitness in men and women. Subjects were all members of an intercollegiate swim team. In this study, 14 males and 14 females underwent an 8-week training program swimming 90 minutes per day, 5 days per week, at an initial exercise intensity of 60% of their HRmax. During the final 6 weeks of the swim training the subjects exercised at an intensity of 80-85%. The results of the study showed that VO$_2$max, expressed in both absolute and relative terms, increased significantly for both sexes. Men and women improved their absolute VO$_2$max (L/min) by 2.9 and 8.7%, and their relative VO$_2$max (ml/kg/min) by 10.2 and 9.7%, respectively. No significant improvements were found for either sexes in maximal V$_E$, heart rate, and RER. Peak power values were also measured and it was found that men increased in peak power by 4.6% and women by 13.5%. This variation in improvement can be accounted for by the fact that initially the women had lower levels of fitness (46% below the male values) so there was considerable room for improvement as a result of training. From this study, it was concluded that both sexes respond similarly to an identical training stimulus, and that swim training does elicit a positive physiological alteration in an individual's cardiorespiratory system.

Responses to Cycle Training

Perhaps the biggest boost to American cycling came in 1986 when Greg LeMond became the first American to win the world's oldest and most popular bicycle road race, the Tour de France. Several researchers have
investigated the effects of cycling on cardiovascular endurance (Fringer & Stull, 1974; Shire, Avallone, Boileau, Lohman, & Wirth, 1977; Yeager & Brynteson, 1970).

Yeager and Brynteson (1970) studied the effects of varying training periods on the development of cardiovascular efficiency of college-aged women. Eighteen sedentary women were randomly divided into 3 experimental groups. Each of the subjects was randomly assigned to 1 of the 3 treatments, which differed only in the length of time that they exercised on the cycle ergometer. Group I exercised for 10 minutes, Group II for 20 minutes, and Group III for 30 minutes per session. Each subject exercised at an average heart rate of 144 bpm, 3 days per week, for 6 consecutive weeks, pedaling at a frequency of 50 rpm. The results indicated that all 3 groups significantly improved in cardiovascular fitness. The predicted VO₂ max values for the 10, 20, and 30 minute groups increased 5, 5, and 8 ml/kg/min, respectively. The data suggests that the 30 minute group showed significantly greater gains than the other two groups. The authors concluded that a 30 minute training session may lead to greater cardiovascular gains when compared to shorter training intervals.

The effects of high resistance-slow rate (HR-SR) and low resistance-fast rate (LR-FR) cycle training on cardiorespiratory function and body composition were studied by Shire et al. (1977). The 34 women who volunteered to be in the study were randomly assigned to HR-SR, LR-FR, or control groups. The experimental subjects trained on a cycle 3 days per week with the time per training session progressively increasing from 20 to 25 minutes over a 10-week period. The workload
was set at 70% of each subject's pretraining VO2max. The training groups increased VO2max, maximal oxygen pulse, and total ride time when compared to the control group. There were no significant differences between the two training groups. According to the author these results suggest that cardiorespiratory adaptations are independent of these modes of training.

Fringer and Stull (1974) completed a study which measured the levels of cardiorespiratory endurance of women following a specific training program. Forty-four moderately active college women between the ages of 17 and 28 years trained on a cycle ergometer. Each subject exercised 2 times per week for 10 consecutive weeks. Each session consisted of one "all-out" ride at a cadence of 60 rpm, beginning at a work load of 360 kgm/min. The load was increased by 180 kgm/min every 2 minutes until volitional exhaustion. Changes which occurred after the initial 10 week period included higher maximal values for VE, VO2, oxygen pulse, heart rate, and total work output. The VO2max after posttesting was 2.716 L/min or 46.52 ml/kg/min which was an increase of approximately 37%. These data support the hypothesis that those who begin with low VO2max values tend to make the greatest gains during training.

Responses to High Impact Aerobic Dance Training

During the last 10 years one of the most popular forms of exercise has been aerobic dance. By 1986 it had been estimated that there were approximately 23 million Americans enrolled in aerobic dance classes (Cooper & Cooper, 1988). The widespread popularity of aerobic dance has prompted several researchers to study the effectiveness of aerobic dance
as a training modality. Several studies (Cearley et al., 1984; Igbanugo & Gutin, 1975; Johnson et al., 1984; Milburn & Butts, 1983; Perry et al., 1988; Rockefeller & Burke, 1979; Vaccaro & Clinton, 1981) have investigated the effects of high impact aerobic dance training on oxygen uptake and have found their results to be similar.

Igbanugo and Gutin (1975) investigated the energy cost of 3 intensities of aerobic dance. In this study the researchers had 2 male and 2 female graduate students dance 7, 2-3 minute routines alternating with 6, 15-90 second recovery intervals of continuous walking. Each of the subjects danced the routines by following a videotape taken of an experienced aerobic dance teacher. This method allowed for the uniformity of dance movements and insured equivalent intensity levels. The relative (ml/kg/min) oxygen consumption values for females, for the low, medium, and high intensity routines were 12.97, 20.9, and 27.25, respectively. Males had slightly higher values for each level. The authors concluded that the energy expenditure for the low intensity routine was metabolically similar to walking, the medium intensity routine was similar to playing tennis, and the high intensity was similar to playing hockey. They also concluded that aerobic dance can be a very useful modality for cardiorespiratory training, rehabilitation, and weight reduction.

Rockefeller and Burke (1979) conducted a study to investigate the effects of a 10-week aerobic dance program on VO₂max of college-aged women. Twenty-one women participated in aerobic dance classes three times per week with each class lasting approximately 40 minutes. Subjects were tested prior to beginning the training program and
following the 10 weeks of training. Testing involved a discontinuous progressive work test on a Monarch bicycle ergometer. Posttest results revealed a favorable increase in $VO_2\text{max}$ of 13%.

Vaccaro and Clinton (1981) studied the effects of a 10-week aerobic conditioning program. Ten college-aged women ranging in age from 19 to 27 years were examined for $VO_2\text{max}$ and body composition before and after the program. Each subject participated in a 45 minute aerobic dance session 3 days per week. Before and after the 10-week training, the subjects were assessed for body composition using hydrostatic weighing and $VO_2\text{max}$ using a progressive treadmill test. The study revealed a significant increase in $VO_2\text{max}$ following the training period. The mean pretest value for the 10 subjects was 31.1 ml/kg/min. The posttest $VO_2\text{max}$ value of 38.2 ml/kg/min showed a significant increase of 7.1 ml/kg/min. No significant changes occurred in percent body fat following the 10-week training regimen. The authors concluded that there was a 22.9% improvement in $VO_2\text{max}$ which indicates that the training period was of sufficient intensity, frequency, and duration to elicit favorable changes in $VO_2\text{max}$.

Cearly et al. (1984) investigated the effects of a 2 and 3-day per week aerobic dance program on $VO_2\text{max}$. In this study 18 untrained females enrolled in an aerobic dance class and were randomly assigned to the 2 experimental groups. The subjects trained 2 or 3 days per week for 10 consecutive weeks, with each session consisting of 10 to 15 minutes of warm-ups and 15 minutes of continuous aerobic dance which progressively increased to 30 minutes by the sixth week of training. Each subject exercised at an intensity of 75% of their $HR\text{max}$. Each
session concluded with a 5 to 10 minute cool-down. The data revealed that VO₂max improved significantly (10.7%) from pretest to posttesting in the subjects who participated in the 3-day per week regimen. The group that participated in the 2-day per week regimen had a significant increase in VO₂max of 4.9%. These results are comparable to the results of Vaccaro and Clinton (1981). The authors concluded that aerobic dance does provide a useful means of enhancing cardiorespiratory fitness in college-aged women.

The cardiovascular benefits of aerobic dance training were also investigated by Johnson et al. (1984). In this study, 23 sedentary females volunteered to participate in an aerobic dance program. The purpose of the investigation was to compare the effect of 2 different training frequencies of aerobic dance on oxygen uptake, body composition, and personality. Each subject trained for 30 minutes during week number 1 and by week 13 they had progressed to 90 minutes per session. Group I trained twice a week and Group II trained 3 times per week for 13 consecutive weeks, with subjects exercising at 70% of their HRmax. The results of the study revealed that there were significant changes in VO₂max for both groups. There was a 11.1% increase in VO₂max for the group that exercised twice a week, and a 5.4% increase in the group that exercised 3 times per week. According to the authors the greater percent increases in the group that exercised twice a week may have been due to the initially lower VO₂max scores and the higher levels of percent body fat. It has been noted by several authors that greater VO₂max changes can be expected from subjects with lower levels of fitness and higher percents of body fat (Pollock et al.,
1971). The authors concluded that when an individual participates in aerobic dance 2 to 3 times per week at appropriate levels of intensity, duration, and frequency changes in the cardiorespiratory system will occur.

The purpose of a study conducted by Perry et al. (1988) was to compare the training responses to interval versus continuous aerobic dance. Sixty-six students volunteered to participate in the study. A total of 24 subjects completed the interval dance training, 21 completed the continuous dance training, and 21 served as the control group. Both the interval and continuous dance groups met 3 hours per week for a 12-week period, training at 80-85% of their HRmax. The continuous aerobic dance class consisted of a 10 to 15 minute warm-up period, 30 to 35 minutes of continuous dance, and concluded with a 10 minute cool-down. The interval dance class began with a mild warm-up followed by a series of 7 to 10 routines that were 3 to 5 minutes in length. Each routine was alternated with a brisk walk or jog for 3 minutes. The session ended with a cool-down period. The subjects all performed a graded exercise test on the cycle ergometer prior to and at the end of the training period. Both experimental groups showed significant improvements in VO$_2$max and O$_2$ pulse. Also, the data from both groups revealed significant differences in adiposity. The results between groups showed that the interval group had a significantly greater increase in absolute and relative VO$_2$max than the continuous training group (18 vs. 11%). Because of the magnitude of the changes, it was concluded that interval training may be a more effective training protocol than traditional aerobic dance.
A study by Milburn and Butts (1983) compared the training responses of aerobic dance and jogging in college aged-females. Forty-six untrained females ranging in age from 18 to 29 years participated in the study. The two experimental groups consisted of 15 subjects enrolled in an aerobic dance class and 19 in a jogging class. The control group was made up of 12 subjects from a bowling class. The aerobic dance and jogging groups exercised 30 minutes per day, 4 times per week, for 7 consecutive weeks. Each subject worked at a training intensity of 75% of their actual HRmax. The data showed that both the jogging and aerobic dance groups significantly increased their VO_{2max}, VE_{max}, and maximal treadmill run times. The data also showed significant decreases in both of the groups HRmax. The investigation revealed that the joggers increased relative VO_{2max} by 8.2% while the dancers' values increased by 10.2%. The results of this study indicated that when aerobic dance and jogging are performed at similar intensities and duration, equal improvements of cardiorespiratory fitness can be achieved.

Responses to Low Impact Aerobic Dance Training

High impact aerobic dance is one of the most popular forms of exercise today. Numerous studies (Cearly et al., 1984; Johnson et al., 1984; Milburn & Butts, 1983; Perry et al., 1988; Vaccaro & Clinton, 1981) have investigated the effects that high impact aerobic dance has on aerobic capacity. A report in 1989 indicated that there was a definite need to assess ways to prevent aerobic dance injuries (Williford, Blessing, Olson, & Smith, 1989). One preventative method that is known today may be low impact aerobic dance. According to
Williford et al. (1989) the definition of low impact aerobic dance is that which "requires the dancer to keep one foot on the floor at all times, thus reducing the amount of impact shock claimed to be associated with injuries in traditional aerobic dance". There have been very few studies reported which examine the effects of low impact aerobic dance on cardiovascular fitness.

McCord, Nichols, and Patterson (1989) conducted a study which investigated the effects of a low impact aerobic dance program on VO\textsubscript{2}max, submaximal heart rates, and body composition in females ranging in age from 17 to 29 years. Sixteen women volunteered to participate in the study. Each subject exercised 45 minutes, 3 times per week, at 75-85% of their maximal heart rate reserve. Each training session consisted of a 5 to 10 minute warm-up, 30 to 35 minutes of low impact aerobic dance, and a 5 minute cool down period. The results of the study revealed that there was a small but significant increase in VO\textsubscript{2}max, a significant decrease in submaximal heart rates, and significant changes in body composition without changes in body weight at the end of the training period. It was found that relative VO\textsubscript{2}max (ml/kg/min) increased from 38.38 to 41.30, an increase of 7.6%, while VO\textsubscript{2}max in L/min increased from 2.31 to 2.43, a 5.2% increase. The author concluded that low impact aerobic dance is effective in producing positive cardiovascular benefits and body composition changes.

**Physiological Responses to Step Aerobics Dance Training**

Step aerobics training is a unique and simple form of exercise which consists of stepping up and down from a platform using a variety of arm and step patterns. Step training is a high intensity workout
that is similar to stair training with the impact and safety similar to walking. The "step", introduced by Step Reebok is an adjustable, nonskid step developed specifically for step training. The "step" is adjustable to heights of 4, 6, 8, 10, or 12 inches. Step aerobics appeals to a wide range of exercisers because it allows a person to work at a high intensity with a low impact force and it is adaptable to all fitness levels by varying the intensity and step height.

Gin Miller is considered the pioneer of "Step Training". Miller began step training while rehabilitating a serious knee injury. Her physical therapist had advised her to begin doing step exercises 3 times per day to rehabilitate her knee. Miller found that this not only helped her knee, but it dramatically increased her cardiovascular endurance. She then began to incorporate step-ups into her low impact aerobic dance class where she received an overwhelming and excited response. Since Miller began "stepping up" in 1989, the idea of step training has quickly spread across the country. The Reebok Shoe Company (Reebok International, 1989) in conjunction with Gin Miller, have made step training one of the newest trends in aerobic exercise today.

A minimal amount of research has been conducted on the effects of step aerobics training. Francis and Francis (1990) were commissioned by Reebok to conduct extensive physiological testing in the laboratories at San Diego State University. Eight volunteers walked 3 miles per hour on a treadmill and performed a Step Reebok routine on a 12 inch platform at a rate of 120 steps per minute. The results of the study revealed that the energy expenditure of the step training (12.2 METS) was almost exactly the same as that of running 7 miles per hour (11.5 METS). Both
running and step training were found to be about four times as demanding as walking. The maximum force on the feet during walking and step training were equal to approximately 1.25 times the weight of one's body. The forces on the feet during running were measured to be as high as 3 to 4 times body weight. It was concluded that the impact forces were lower than running, therefore fewer injuries would result.

Summary

The preceding review of related literature has shown that a variety of aerobic exercise training programs such as running, swimming, cycling, and various forms of aerobic dance can elicit positive physiological changes in cardiorespiratory fitness. Step training is one of the newest trends in aerobic exercise today. Its popularity is leading many individuals across the country to exercise on a regular basis. Preliminary research has been conducted which indicates the energy expenditure of step aerobics is virtually identical to running at a pace of 7 miles per hour. Due to the increasing popularity of step aerobics it is important to establish reliable information on whether or not step aerobics will elicit a cardiovascular training effect. The lack of literature found regarding the training effects of step aerobics on VO2max indicates a need for further research in this area. Therefore, this study will determine the physiological responses to a 10-week step aerobics training program in college-aged women.
CHAPTER III

METHODS AND PROCEDURES

Introduction

This study was part of a larger project which also investigated changes in body composition consequent to participation in a 10-week step aerobics training program. The purpose of this study was to examine the effects of the same program on VO\textsubscript{2max}. The research methods are presented in the following order: subject selection, instrumentation, determination of VO\textsubscript{2max}, testing procedures, step aerobics training program, and statistical analyses.

Subject Selection

Experimental Group

The subjects in the experimental group included 30 female volunteers ranging in age from 18 to 25 years. The subjects were students attending the University of Wisconsin-La Crosse during the Fall Semester, 1991. The subjects in the experimental group were enrolled in the 6:45 a.m. step aerobics class offered by the Intramural program. The volunteers were recruited by the investigator during the registration for the Intramural step aerobics class.

Prior to participation in any phase of the step aerobics training study, each volunteer completed a Health History/Current Lifestyle Form (see Appendix A) designed to screen for coronary and metabolic disease. Eligible subjects then completed an Informed Consent document (see Appendix B).
Control Group

Thirty-six subjects served in the control group. The subjects were college-aged females attending the University of Wisconsin-La Crosse during the Fall Semester, 1991. Signs were posted on campus to attract the attention of potential subjects who had the desire to become involved in a scientific research study. The subjects in the control group were similar to the experimental group in anthropometric characteristics, age, and activity level. Prior to participation in the study all subjects completed a Health History/Current Lifestyle Form (see Appendix A) and an Informed Consent document (see Appendix B).

Instrumentation

Cardiorespiratory endurance is defined as "the ability to perform large-muscle, dynamic, moderate-to-high intensity exercise for prolonged periods," according to the ACSM (1991, p. 39). The accepted measure of cardiorespiratory endurance is directly measured \( \text{VO}_{2\text{max}} \). A Quinton Instruments Motorized Treadmill (Quinton Instruments Company, 1989) was used to conduct the maximal treadmill exercise test. The gas analysis measurements for the \( \text{VO}_{2\text{max}} \) test were measured using a Quinton Q-Plex metabolic cart (Quinton Instruments Company, 1989). Calibration of the analyzers was performed immediately before and after each \( \text{VO}_{2\text{max}} \) test with known gas concentrations of oxygen and carbon dioxide, previously determined through the Scholander Gas Analysis technique. The ventilatory gas volumes were calibrated with a 3 liter syringe. Each subject had their heart rate measured during the maximal exercise tests using the UNIQ CIC Heart Watch and Monitor, Model 8799 (Computer Instruments Corporation, 1986).
Determination of $\text{VO}_{2\text{max}}$.

The Quinton Instruments motorized treadmill was used for both the pretesting and posttesting maximal treadmill exercise tests. The following variables were analyzed in this study: $\text{VO}_{2\text{max}}$ (L/min), $\text{VO}_{2\text{max}}$ (ml/kg/min), $V_{\text{E}}\text{max}$, HRmax (bpm), maximal RPE, and RERmax.

Testing Procedures

Pilot Testing

A pilot study was conducted prior to the start of the step aerobics training study. The pilot study was conducted to establish tester reliability for maximal treadmill exercise testing. Pilot testing was conducted on 10 volunteers.

Practice Session

Subjects were required to report to the Human Performance Laboratory at the University of Wisconsin-La Crosse prior to the actual testing day for pretest instructions and preparation. Upon arrival for the practice session, the nature of the study and the risks involved were thoroughly explained by the investigator. In order to participate in the training study and laboratory procedures, each subject completed the Informed Consent document which contained a written agreement stating that the subject would not modify their current level of activity or change their diet over the course of the study. After the paper work was completed a period of familiarization with testing procedures was conducted. This allowed the subject to become accustomed to the equipment which included headgear, nose clip, and a mouth piece. The practice session consisted of how to get on and off the treadmill, and walking and running at testing speeds. The subjects began by
walking on the treadmill at a 0% grade as the speed was gradually increased. The subjects selected a speed that they felt comfortable running at for the maximal treadmill test. This speed was recorded and used for the pretesting and posttesting.

Testing Session

Each subject reported to the Human Performance Laboratory well rested and after abstaining from food, caffeinated beverages, drugs, alcohol, and tobacco for at least 4 hours before the testing session (see Appendix D) (McConnell, 1988). Prior to the hydrostatic weighing, the subjects' height was measured to the nearest 0.5 inch, weight was measured to the nearest 0.5 pound, and age was recorded. A warm-up consisting of various static stretching exercises was performed prior to the maximal treadmill test. The Q-Plex was calibrated with known Scholandered gas samples and programmed for gas analysis every 30 seconds of exercise. Then, with the headgear in place and the mouth piece attached to the Q-Plex metabolic cart, the test began.

The treadmill test began with a slow walking pace at 0% grade. The treadmill speed was increased gradually until the previously self-selected treadmill running speed was achieved. Data collection and treadmill run time used in the statistical analyses began at this point (see Appendix E). The initial grade was set for 0% for the first 2 minutes and was increased 2.5% every 2 minutes thereafter until volitional exhaustion. The test was terminated when the subject was unable to continue and grasped the handrails for support. At this point the treadmill speed and grade were decreased for a cool-down. Heart rate and RPE were recorded at the end of each 2 minute stage and at
maximal exertion (see Appendix C). Ratings of Perceived Exertion were recorded using the Borg 6-20 scale (Borg, 1973). Metabolic measurements were recorded every 30 seconds and at maximal exercise.

**Step Aerobics Training Program**

The 10-week step aerobics training program consisted of a 60 minute class which met 3 times per week. The classes met in the Mitchell Hall Dance Studio every Monday, Wednesday, and Friday at 6:45 a.m. All step aerobic sessions consisted of 15 minutes of warm-up, 30 minutes of aerobic exercise, and a 15 minute cool-down period.

At the beginning of the 10-week training program each subject was instructed by the investigator on how to take a radial and carotid pulse. Then the subjects were instructed how to monitor their resting and exercise heart rates using a 10 second count. Each subject was prescribed a training heart rate (THR) of 70-85% of their $HR_{max}$ as determined from the treadmill test (ACSM, 1991). Each subject was instructed to maintain their THR during the aerobic portion of each training session. The maintenance of the THR was accompanied by altering the step height and performing various arm movements. Each subject periodically took their exercise heart rate during the aerobic portion of the training session to assure they were exercising at the prescribed intensity.

The importance of regular attendance was emphasized. Subjects were informed that elimination from the training study would take place if their attendance dropped below 27 of the 30 scheduled sessions.
Statistical Analyses

Subject characteristics were summarized using standard descriptive statistics. A two-way analysis of variance (ANOVA) with repeated measures was used to determine if significant changes occurred between the experimental and control groups as a result of the training period. Paired t-tests were used to test for within-group differences from pretest to posttest. Variables to be analyzed included VO$_2$max (L/min), VO$_2$max (ml/kg/min), $V_E$max, RERmax, RPE, and HRmax. The alpha level was set at .05 for all analyses.
CHAPTER IV
RESULTS AND DISCUSSION

Introduction

This study was a joint project that looked at the effects of a 10-week step aerobics training program on cardiorespiratory fitness and body composition of college-aged women. This portion of the study examined the effects of the program on VO$_2$\text{max}. This chapter consists of the presentation of results and a discussion of the findings for each variable. The findings are presented in the following order: subject characteristics, results of the training study, test of hypotheses, and a discussion of results as related to previous literature.

Subject Characteristics

Initially 29 experimental subjects and 36 control subjects were tested prior to the 10-week training program. However, only 21 experimental and 29 control subjects were included in the final statistical analyses. Eight experimental subjects were eliminated from the training study because their attendance dropped below the required 27 of the 30 scheduled sessions and seven control subjects were eliminated from the study because they did not complete the posttesting. Attendance for the 21 experimental group subjects who completed the study averaged 27 of 30 possible sessions (90%). The average heart rate maintained during the training was 150 bpm which represented 76% of subjects' HR\text{max}. Descriptive characteristics for the 50 subjects who completed the study are presented in Table 1. There were no significant
(p > .05) between-group differences in mean age, height, weight, VO₂max (ml/kg/min), or percent body fat prior to the 10-week investigation.

Table 1. Descriptive characteristics of subjects

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control (n = 29)</th>
<th>Experimental (n = 21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>19.5 ± 2.03</td>
<td>19.4 ± 1.63</td>
</tr>
<tr>
<td>Height (in)</td>
<td>66.2 ± 2.13</td>
<td>65.0 ± 2.79</td>
</tr>
<tr>
<td>Weight (lbs)</td>
<td>132.1 ± 14.51</td>
<td>135.0 ± 16.10</td>
</tr>
<tr>
<td>VO₂max (ml/kg/min)</td>
<td>51.5 ± 6.38</td>
<td>48.6 ± 5.64</td>
</tr>
<tr>
<td>Body Fat (%)</td>
<td>22.45 ± 4.788</td>
<td>25.63 ± 5.145</td>
</tr>
</tbody>
</table>

Note. All values represent mean ± standard deviation.

Results of the Training Study

Changes between groups were compared using a two-way analysis of variance (ANOVA) with repeated measures. Within-group comparisons were made using paired t-tests. The results of the analyses are presented in Table 2.

No significant (p > .05) between-group differences were found for body weight (lbs). However, the control group had a significant (p < .05) increase in weight of 1.8 lbs. The experimental group showed no significant (p > .05) change in body weight from pre- to posttesting.

Test results indicated that both the control and experimental groups significantly (p < .05) increased their mean run time on the treadmill from pre- to posttesting. Improvements of 9.5 and 33.1% were
Table 2. Results of the training study for the control group (n = 29) and the experimental group (n = 21)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pretesting</th>
<th>Posttesting</th>
<th>Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(x ± SD)</td>
<td>(x ± SD)</td>
<td></td>
</tr>
<tr>
<td>Weight (lbs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>132.1 ± 14.51</td>
<td>133.9 ± 14.82*</td>
<td>1.8 (1.4)</td>
</tr>
<tr>
<td>Experimental</td>
<td>135.0 ± 16.10</td>
<td>135.7 ± 15.70</td>
<td>0.7 (0.5)</td>
</tr>
<tr>
<td>Time (minutes)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>8.82 ± 2.228</td>
<td>9.66 ± 2.339*</td>
<td>0.84 (9.5)</td>
</tr>
<tr>
<td>Experimental</td>
<td>8.06 ± 1.470</td>
<td>10.73 ± 1.406*</td>
<td>2.67 (33.1)#</td>
</tr>
<tr>
<td>VO₂ (L/min)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>3.08 ± 0.423</td>
<td>3.24 ± 0.429*</td>
<td>0.16 (5.2)</td>
</tr>
<tr>
<td>Experimental</td>
<td>2.96 ± 0.431</td>
<td>3.30 ± 0.455*</td>
<td>0.34 (11.5)#</td>
</tr>
<tr>
<td>VO₂ (ml/kg/min)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>51.5 ± 6.38</td>
<td>53.5 ± 6.06*</td>
<td>2.0 (3.9)</td>
</tr>
<tr>
<td>Experimental</td>
<td>48.6 ± 5.64</td>
<td>54.3 ± 5.03*</td>
<td>5.7 (11.7)#</td>
</tr>
<tr>
<td>HRmax (bpm)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Control</td>
<td>198 ± 9.6</td>
<td>196 ± 9.0</td>
<td>-2 (1.0)</td>
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<tr>
<td>Experimental</td>
<td>198 ± 5.0</td>
<td>200 ± 5.2</td>
<td>2 (1.0)#</td>
</tr>
<tr>
<td>VEmax (L/min)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>104.5 ± 11.18</td>
<td>100.2 ± 10.72*</td>
<td>-4.3 (4.1)</td>
</tr>
<tr>
<td>Experimental</td>
<td>103.8 ± 12.63</td>
<td>110.8 ± 12.41*</td>
<td>7.0 (6.7)#</td>
</tr>
<tr>
<td>RER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>1.07 ± 0.043</td>
<td>1.08 ± 0.050*</td>
<td>0.01 (0.9)</td>
</tr>
<tr>
<td>Experimental</td>
<td>1.07 ± 0.048</td>
<td>1.10 ± 0.040*</td>
<td>0.03 (2.8)</td>
</tr>
<tr>
<td>RPE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>19.1 ± 0.56</td>
<td>19.9 ± 0.19*</td>
<td>0.8 (4.2)</td>
</tr>
<tr>
<td>Experimental</td>
<td>19.1 ± 0.92</td>
<td>19.9 ± 0.22*</td>
<td>0.8 (4.2)</td>
</tr>
<tr>
<td>RestHR (bpm)</td>
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<td></td>
<td></td>
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<tr>
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<td>71 ± 12.9</td>
<td>73 ± 8.9</td>
<td>2 (2.8)</td>
</tr>
<tr>
<td>Experimental</td>
<td>73 ± 12.4</td>
<td>74 ± 9.5</td>
<td>1 (1.4)</td>
</tr>
</tbody>
</table>

* = Significant change from pre- to posttesting (p < .05)
# = Significant change compared to the control group (p < .05)
recorded for the control and experimental groups, respectively. However, the experimental group showed a significantly (p < .05) greater increase compared to the control group.

Significant changes in the physiological responses to the training were also reflected in mean VO$_2$max values. Both groups demonstrated a significant (p < .05) increase in VO$_2$max from pre- to posttesting when expressed in absolute terms (L/min) and when expressed relative to body weight (ml/kg/min). The control group increased their VO$_2$max by 0.16 L/min (5.2%) and 2.0 ml/kg/min (3.9%), which was significantly less than the experimental groups increase of 0.34 L/min (11.5%) and 5.7 ml/kg/min (11.7%).

Maximal heart rates were similar for both groups during the Initial treadmill tests. Additionally, HRmax did not change significantly (p > .05) over the training period for either the experimental or the control groups. However, there was a significant difference found between groups (p < .05) from pre- to posttesting. The 2.0 bpm increase shown by the experimental group coupled with the 2.0 bpm decrease of the control group resulted in a significant (p < .05) interaction.

Initially, there were no significant (p > .05) differences in VEmax between the groups. However, the ANOVA results indicated a significant (p < .05) interaction did occur following the study. The experimental group increased their VEmax significantly (p < .05) after the 10 weeks of training (6.7%), while the control group showed a significant (p < .05) decrease of 4.1%.

Results for RERmax and RPE were similar. Both groups had significant (p < .05) increases from pre- to posttesting. However, the
changes between groups were not significantly (p > .05) different. There were no within or between-group changes in resting HR.

Test of Hypotheses

Based on the results of this study, the following null hypotheses were either rejected or accepted:

1. The null hypothesis, stating that there will be no significant difference in the changes in VO$_2$max expressed in absolute units (L/min) exhibited by the experimental and control groups over the course of the 10-week study, was rejected.

2. The null hypothesis, stating that there will be no significant difference in the changes in VO$_2$max expressed in relative units (ml/kg/min) exhibited by the experimental and control groups over the course of the 10-week study, was rejected.

3. The null hypothesis, stating that there will be no significant difference in the changes in HR$_{max}$ exhibited by the experimental and control groups over the course of the 10-week study, was accepted.

4. The null hypothesis, stating that there will be no significant difference in the changes in RER$_{max}$ exhibited by the experimental and control groups over the course of the 10-week study, was rejected.

5. The null hypothesis, stating that there will be no significant difference in the changes in V$_{E}$max exhibited by the experimental and control groups over the course of the 10-week study, was rejected.

Discussion of Results

This study was designed to examine the effects of a 10-week step aerobics training program on VO$_2$max of college-aged females. Upon
examining the statistical analyses, there were significant differences between group: after the 10 weeks of training for \( \text{VO}_{2\text{max}} \) (L/min), \( \text{VO}_{2\text{max}} \) (ml/kg/min), treadmill run time to exhaustion, \( \text{Ve}_{\text{max}} \), and HR\(_{\text{max}}\). No significant differences were observed between the control and experimental groups for body weight, RER\(_{\text{max}}\), resting HR, or RPE.

Improvements in cardiorespiratory fitness levels have been shown to be a function of intensity, frequency, and duration of physical training. Other factors which may interact to influence the magnitude of improvement are age, initial fitness level, performance level of the subjects, and the mode of training (ACSM, 1991). In the present study, the experimental group demonstrated a significant increase in \( \text{VO}_{2\text{max}} \), expressed in both absolute (L/min) and relative (ml/kg/min) terms of 11.5 and 11.7\%, respectively. These findings are in agreement with other training studies that have been conducted on college-aged women.

The literature is relatively consistent regarding the effect of aerobic training on \( \text{VO}_{2\text{max}} \) in females. The increased aerobic power of 11.7\% was comparable to the improvements reported in the studies of young women in which high and low impact aerobics, running, walking, cycling, and bench stepping were used as training modalities (Cearly et al., 1984; Eisenman & Golding, 1975; Jette et al., 1988; Johnson et al., 1984; McCord et al., 1989; Milburn & Butts, 1983; Shire et al., 1977; Vaccaro & Clinton, 1981). Gains in \( \text{VO}_{2\text{max}} \) ranging from 5.4 to 17.7\% were reported by the above investigators. These studies ranged from 7 to 14 weeks in duration, with exercise sessions averaging 3 times per week.
It has been frequently noted that greater VO$_2$max changes can be expected from subjects with lower initial fitness levels as a result of endurance training (ACSM, 1991). It should be noted at this time that the pretraining mean VO$_2$max in the present study was 48.6 ml/kg/min, which is considerably higher than values reported for untrained college females (Eisenman & Golding, 1975; Fringer & Stull, 1974; McCord et al., 1989; Milburn & Butts, 1983). According to the American Heart Association (1972) the average VO$_2$max relative to body weight (ml/kg/min) for college-aged females is 31 to 37 ml/kg/min. The 37.0% increase in VO$_2$max for example, found by Fringer and Stull (1974), who examined college-aged women before and after a 10-week interval bicycle training program was much higher than the change found in the present study. In that study, however, the pretraining mean VO$_2$max value was 33.8 ml/kg/min. The larger changes in the study may have, in part, been a reflection of the initially low VO$_2$max values of their subjects. Therefore, the lower magnitude of improvement in the present study may have been a result of the initially high VO$_2$max values.

Another possible factor for the small increase in VO$_2$max could relate to the relationship between training and testing modalities. McConnell (1988) comments that the specific exercise task employed for testing has a definite influence on the VO$_2$max response. When testing subjects, the cardiorespiratory training response is best demonstrated when the subject activates the specific muscle mass utilized in their training program (Fox et al., 1988). Therefore, VO$_2$max is dependent upon the mode of exercise and the specific training of the subject. The more closely a laboratory can simulate the specific muscular action
involved in training during the test, the more objective and valuable the \( VO_{2\text{max}} \) assessment (McConnell, 1988). For example, Corry and Powers (1982) demonstrated the importance of using specifically trained muscle groups by comparing trained runners and swimmers. The results of the study revealed significantly higher \( VO_{2\text{max}} \) values during (70.2 ml/kg/min) treadmill running when compared with swimming (60.0 ml/kg/min). But when an arm pulling motion similar to that of swimming was used, the swimmers obtained significantly greater values (47.1 ml/kg/min vs. 37.4 ml/kg/min). The specificity of the \( VO_{2\text{max}} \) response in athletes was also shown by Bouchard, Godbout, Mondor, and Leblanc (1979) and Stromme, Ingjer, and Meen (1977). Here the \( VO_{2\text{max}} \) of three different groups of rowers, skiers, and cyclists was determined while they ran on a treadmill and while they performed their specific sport. The results indicated that \( VO_{2\text{max}} \) was significantly higher when performing the specific sport activity than when running. Therefore, subjects in the present study may have elicited higher and more reliable \( VO_{2\text{max}} \) values if the laboratory testing activated the specific muscle mass utilized in the step aerobic training program.

A significant increase in time on the treadmill was observed within both groups. However, the increase by the experimental group was significantly greater than that for the control group. This corresponds with the results of Johnson et al. (1984) who found an increase in treadmill time of 18% resulting from a 3-day per week aerobic dance training regimen. Milesis et al. (1976) also reported an increased maximal treadmill run time from a 3-day per week training program. In view of the accompanying changes in \( VO_{2\text{max}} \), the increased run times
reflected in the present investigation seem to be directly related to a cardiovascular conditioning effect and provides sufficient evidence for an improved work capacity in the experimental group.

In the present study, adaptation to the training was also reflected in the changes in $V_{E\text{max}}$. There was a significant increase in $V_{E\text{max}}$ between the experimental and control groups after the 10-week study which is in accordance with the findings of several other investigators (Eisenman & Golding, 1975; Fringer & Stull, 1974; Milburn & Butts, 1983). The experimental group demonstrated a 6.7% increase over the course of the study. This increase in $V_{E\text{max}}$, which often accompanies training, can be partly attributed to the training effect in the respiratory muscles (Astrand & Rodahl, 1977).

There was a significant increase in $R_{ER\text{max}}$ found within each group but no significant interaction between groups. The increases were 0.9 and 2.8%, respectively. These findings conflict with earlier literature in which no significant differences in $R_{ER\text{max}}$ were detected before and after a swim training program (Butts et al., 1984). The slight increase in $R_{ER\text{max}}$ may be attributed to the fact that the subjects may have worked harder during the posttesting.

No significant changes in $HR\text{max}$ occurred within groups which is consistent with the findings of Eisenman and Golding (1975). Most often, investigators report that with training there may be no change in $HR\text{max}$ or a slight decrease (Milburn & Butts, 1983; Vaccaro & Clinton, 1981). The significant between-group differences in $HR\text{max}$ from pre- to posttesting resulted from the 2.0 bpm increase shown by the
experimental group coupled with the 2.0 bpm decrease of the control
group.

Body weight and body composition changes with aerobic training vary
greatly depending on several factors including diet, intensity,
duration, and frequency of training (Johnson et al., 1984; McCord et
al., 1989; Milburn & Butts, 1983; Rockefeller & Burke, 1979). No
significant changes in body weight occurred between the groups over the
course of the present study. The control group did have a significant
increase of 1.8 lbs. There had been no physical attempt to control the
subjects diet or exercise habits so this may account for the slight
weight gain which occurred within this group. In agreement with the
results of the current study, several investigators who conducted
studies of similar frequency, intensity, and duration have documented
little or no change in body weight among groups (Brown et al., 1972;
Fringer & Stull, 1974; Johnson et al., 1984; Milburn & Butts, 1983).

No significant change in resting HR occurred within or between
groups. These findings conflict with previous literature in which a
significant decrease in resting HR occurred (Johnson et al., 1984;
Milesis et al., 1976; Rockefeller & Burke, 1979). However, the results
of the present study may be attributed to the initially high \( \text{VO}_{2}\text{max} \) values of the experimental group subjects. According to Fox et al.
(1988) the magnitude of the decrease in the resting HR produced by
training is less when the initial level of fitness is greater.

Maximal heart rate varies greatly among individuals during exercise
testing. Therefore, it is helpful to be able to evaluate RPE to assess
whether or not the test is truly maximal and to assess when maximal
exercise is being approached. Ratings of perceived exertion using the category scales grows linearly as exercise intensity increases. When a subject has reached the subjective limit of fatigue, an RPE of 18 or 19 is often expressed (ACSM, 1991). The present study revealed a significant within-group increase but no significant interaction was detected. The within-group differences from pre- to posttesting resulted from the increase in RPE from 19.1 to 19.9 within both groups.
CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The primary purpose of this study was to examine the effects of a 10-week step aerobics training program on VO$_{2}$max of college-aged women. Sixty-five, apparently healthy females between the ages of 18 and 25 years participated in the training study. Each subject performed a maximal treadmill test to volitional exhaustion prior to and upon completion of the 10-week study. The variables analyzed included resting HR, body weight, RPE, treadmill run time, absolute VO$_{2}$max (L/min), relative VO$_{2}$max (ml/kg/min), $V_{E}$max (BTPS) (L/min), RERmax, and HRmax (bpm).

The statistical analyses included means and standard deviations for the physical characteristics of all subjects and the physiological responses to the actual VO$_{2}$max treadmill tests. Changes from pre- to posttesting within each group were made using dependent t-tests. Significant differences between groups were detected using a two-way analysis of variance (ANOVA) with repeated measures. The level of significance was set at .05 for all analyses.

Results showed significant between-group differences from pre- to posttesting in mean treadmill run time, relative VO$_{2}$max (ml/kg/min), absolute VO$_{2}$max (L/min), HRmax, and $V_{E}$max. Posttest results revealed significant (p < .05) increases for the experimental group in treadmill run time (33.1%), relative VO$_{2}$max (11.7%), absolute VO$_{2}$max (11.5%),
HRmax (1.0%), and V̇O₂max (6.7%) which were significantly greater than the control group. No significant between-group differences from pre- to posttesting were observed for body weight, RER, RPE, and resting HR.

**Conclusions**

Based on the statistical analyses of the data the following conclusion was reached:

1. A 10-week step aerobics training program is an effective method for improving cardiorespiratory fitness levels in college-aged females.

**Recommendations**

Based upon the results of this investigation, the following recommendations for future studies are made:

1. Investigate the effects of a step aerobics training program of longer duration.
2. Use sedentary females who have a lower aerobic capacity prior to the beginning of the study.
3. Compare a step aerobics program to other common modalities of exercise training.
4. Have subjects perform VO₂max tests on the Gauntlet 4000 or a bench step which are specific to the training modality.
REFERENCES


APPENDIX A

HEALTH HISTORY/CURRENT LIFESTYLE FORM
HEALTH HISTORY/CURRENT LIFESTYLE FORM
Step Aerobic Training Study

NAME ____________________________  S.S ___________  DATE _____
(Please Print)

ADDRESS ___________________________  CITY/STATE ______________________

PHONE ________________  AGE ______  BIRTH DATE ________________

HEIGHT ______  WEIGHT ______

IN CASE OF EMERGENCY, PLEASE CONTACT ________________________________

PHONE ________________________________

Check if you have or have had the following:

_____ Family history of coronary or other atherosclerotic disease in self, parents or siblings prior to age 55.

_____ Shortness of breath

_____ Chest Pain

_____ Blood Pressure ≥ 140/90 mm Hg

_____ Asthma

_____ Seizures

_____ Bone or joint injury

Explain ________________________________  Explain __________________________

DO YOU CURRENTLY SMOKE?  ___ Yes  ___ No

PHYSICAL ACTIVITY
I participate in the following activities:

_____ None  _____ Walking  _____ Running  _____ Biking  _____ Swimming

_____ Strength Training  _____ Aerobic Dance

How long do you exercise for?

_____ None  _____ 15 minutes or less  _____ 16-30 minutes  _____ 31-45 min

_____ 46-60 minutes  _____ More than 60 minutes

How many days per week?

_____ None  _____ One  _____ Two  _____ Three  _____ Four  _____ Five

_____ Six  _____ Seven

Do you experience any discomforts (shortness of breath, dizziness or pain) with exercise?  ___ Yes  ___ No

If yes, please explain: ____________________________________________________________

I hereby certify that all the above statements provided by me in this form are complete and true to the best of my knowledge.

Signature ____________________________  Date ______________

Witness ________________________________  Date ______________
APPENDIX B

INFORMED CONSENT
INFORMED CONSENT
University of Wisconsin-La Crosse

Project Title: The effects of a 10-week step aerobic training program on VO$_2$max and body composition of college-aged women.

Principle Investigators: John P. Porcari, Ph. D., Constance Chapek and Elizabeth Huntley

Subject name: ________________________________

You are invited to participate in this research study which will evaluate the physiological effects of a step aerobic training program. This study is open to females between the ages of 18 and 25 who meet the following criteria: 1) have no cardiovascular or orthopedic problems, 2) are on no medications which affect heart rate or blood pressure responses to exercise, 3) are non-smoking individuals, 4) are willing to complete testing procedures before and after the step aerobics training.

The training program will be 10 weeks in duration beginning September 4th, 1991 and ending November 14th, 1991. If you agree to participate in the step aerobic training group, you are required to attend each session; Mondays, Wednesdays, Fridays, 6:45-7:45 AM. Subjects missing more than three classes will be eliminated from the study. Your test results will remain confidential between yourself and the three investigators.

In conjuncture with the UW-L Intramural step aerobic class I, ________________________________ have volunteered to be a subject in this step aerobic training study conducted by Constance Chapek and Elizabeth Huntley. I understand that the benefits of participating in this research study include a free fitness evaluation and exercise prescription. I understand that participation in the experimental group involves regular attendance to the training program as well as undergoing the testing procedures prior to and upon completion of the training study. I also agree to work at the specified intensity indicated by my prescribed training heart rate. If I am a subject in the control group, I will be required to undergo testing procedures scheduled prior to and upon completion of the study.

I understand that I will have my body fat assessed by hydrostatic weighing and my maximal oxygen consumption (VO$_2$max) measured by a maximal treadmill test. I further understand the hydrostatic weighing procedure consists of being briefly submerged underwater with the option of my surfacing at any time. Potential risks include infection, accident, and possible drowning. I understand that the treadmill test consists of running to voluntary exhaustion on a motor driven treadmill. The initial speed of the treadmill will remain at a self-selected pace with an initial elevation of 0%; the grade will then increase 2.5% every 2 minutes until I reach exhaustion. Oxygen consumption will be monitored through the use of a Quinton Q-Plex metabolic cart. This will involve breathing through a mouthpiece so that expired air can be collected and measured.
As with any exercise, the possibility of adverse reactions exist, such as dizziness, shortness of breath, leg fatigue, chest pain, and even sudden death. I will feel tired at the end of the test. If any abnormal observations are noted, the test will be terminated immediately. I am free to stop any of the tests, or withdraw from the study at any time.

In addition, I agree not to modify my current diet or exercise habits for the duration of the study, other than for the training if I am so involved.

I, ____________________________, being of sound mind and body at the age of ________, do hereby consent to, authorize and request the persons named above (and co-workers, agents, and employees) to undertake and perform on me the proposed procedure, treatment, research or investigation (herein called "Procedure"). To the best of my knowledge I am not infected with a contagious disease or have any limiting physical condition or disability, especially with respect to my heart that would preclude my participation in the exercise testing or training. I have read the above document and I have been fully advised of the nature of the Procedure and the possible risks and complications involved, all of which risks and complications, I hereby assume voluntarily. I hereby acknowledge no representations, warranties, guarantees or assurances of any kind pertaining to the Procedure have been made to me by the University of Wisconsin-La Crosse, the officers, the administration, employees or by anyone acting on their behalf. I understand that I may withdraw from the study at anytime.

Signed at ____________________________,
this __________ day of ____________, 1991, in the presence of the witnesses whose signatures appear below opposite my signature.

Witnessed by:
APPENDIX C

BORG SCALE, RATING OF PERCEIVED EXERTION
Borg Scale, Rating of
Perceived Exertion (RPE)

6
7 Very, Very Light
8
9 Very Light
10
11 Fairly Light
12
13 Somewhat Hard
14
15 Hard
16
17 Very Hard
18
19 Very, Very Hard
20

(Borg, 1973, p. 92)
APPENDIX D

TESTING PREPARATION FORM
TESTING PREPARATION FORM

Hydrostatic Weighing and Treadmill Test Information

1. Please bring shorts, t-shirt, gym shoes, swimsuit, and towel.
2. Please abstain from food, caffeinated beverages, drugs, alcohol, and tobacco for at least 4 hours before testing.
3. Please do not engage in heavy exercise for 24 hours prior to testing.
4. Testing location: UW-L Human Performance Lab
   225 Mitchell Hall
   (2nd floor on southeast side of the building).

__________________________________________

NAME

Your Underwater Weighing and Treadmill Testing time has been scheduled for _______ at _______ AM / PM.

PLEASE keep this appointment. Testing must be completed this week. Your promptness is appreciated. If there is a conflict, please feel free to call Connie or Lisa at home, or leave a message at the lab.

   Connie - 785-7105
   Lisa  - 782-7031
   Lab   - 785-8685
APPENDIX E

VO₂_MAX TREADMILL TEST DATA SHEET
# VO₂max Treadmill Test

**Data Sheet**

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<tr>
<th>Name</th>
<th>Date</th>
<th>Pretest or Posttest</th>
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<th>Resting Heart Rate</th>
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## Experimental Group

## Control Group

### Table: Treadmill Testing Data

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