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ABSTRACT

SLAVIN, Sharon. Cardiovascular changes in women with computerized bicycle training. M.S. in Adult Fitness/Cardiac Rehabilitation, 1988. p. 66. (Dr. Patricia L. Hutchinson)

Thirty-four sedentary women with a mean age of 32 years were studied to determine the extent to which training effects would occur after a six-week computerized bicycle exercise program. In addition, training differences between 12- and 24-minute computerized protocols were examined. Subjects were divided into five groups: controls (C, n=10); program-12 (P-12, n=8); random-12 (R-12, n=4); program-24 (P-24, n=8); random-24 (R-24, n=4). All subjects received pre-training maximal bicycle testing, six-weeks of training (3 days wk⁻¹), and post-training maximal testing. A 7.9% increase was found in $\bar{VO}_{2\text{max}}$ (ml·kgBW⁻¹·min⁻¹) after training which was accompanied by a 15.0% increase in total ride time on the bicycle test. Although these changes approached significance and subjects reported that the workloads seemed easier after training (RPE = 16.71 ± 5.27), none of the comparisons were found to be significant. Small group sizes, large standard deviations and low intensity levels for training contributed to the lack of significance. Protocol comparisons revealed a nonsignificant tendency for the programmed protocols to increase $\bar{VO}_{2\text{max}}$ more (9.8% and 9.2%) than the random protocols (5.2% for both groups). It was concluded that computerized bicycle training is probably a suitable means of cardiovascular training for women when it is performed longer than six-weeks.
CARDIOVASCULAR CHANGES IN WOMEN WITH COMPUTERIZED BICYCLE TRAINING

A Thesis Presented
to
The Graduate Faculty
University of Wisconsin-La Crosse

In Partial Fulfillment of the Requirements for the Master of Science Degree

Sharon L. Slavin
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CHAPTER I
INTRODUCTION

Claims have been made that an exercise bicycle is one of the best available methods of conditioning (California Berkeley Newsletter, 1985). Previous estimates have indicated that over one million bicycle exercisers and ergometers were sold in the United States (Grossman, 1982). It is felt that stationary bicycles have several advantages for physical conditioning. Compared to jogging, the bicycles are less "daunting" for the beginner, since the body weight is supported. Therefore, less stress is applied to the lower extremities. This makes the stationary bicycle an attractive form of exercise for individuals with disorders such as obesity, arthritis and claudication, and numerous cardiovascular disorders.

Stationary bicycles are convenient, portable and small enough to fit almost anywhere (McKay & Banister, 1976). Cycle ergometers are also independent of electrical power. Health clubs, hotels, corporations and recreation centers are among the many businesses utilizing these bikes.

However, several disadvantages exist with this piece of equipment. "A lot of people who use an exercise bike a few times grow bored with it and give up, often because the bike is poorly designed, the seat is uncomfortable, or the pedaling motion is uneven" (Newsletter, 1985, p. 6). In addition, many stationary bicycles are not equipped to exercise the upper body. Therefore, changes seen in fitness levels are slower.
Recently, manufacturers of fitness equipment have made technological advancements not only in exercise equipment in general, but also in stationary bicycles. Companies have computerized the operation of the exercise bike in order to nullify some of the disadvantages stated above. Today, the trend for stationary bicycles is toward computerized programs offering feedback pertaining to individual fitness levels (Wilson et al., 1987).

The Bally Fitness Corporation developed the "Lifecycle" as one of the first computerized cycles which fitness clubs and individuals could afford. These newly developed Lifecycles have several built-in features to enhance training programs. First, the Lifecycles are based on a "self-motivational principle of interval training with progressive overload" (Bally Lifecycle Manual, 1986, p. 5). The program that is selected automatically changes the pedal resistance, simulating riding up and down imaginary hills. The hills are visualized on the display console throughout the workout. Second, a series of lights highlight the intensity of pedal revolutions per minute and the resistance in kilocalories. Bally considers these features to be exciting new motivational techniques for increasing the adherence rates of training programs. Third, the Bally Corporation also claims that "the ability to select a program to match individual needs is what distinguishes the Lifecycle as the world's most popular physical conditioning device" (Bally Lifecycle Manual, 1986, p. 5). Finally, due to the many programs built into the computer's memory, users will find flexibility in their exercise programs, and never outgrow the innumerable training challenges offered.
Aside from the advantages mentioned in the above paragraphs, the Bally Lifecycle offers advantages enhancing the comfort for the participant. The cycle has a large seat which can be adjusted to properly fit the heights of the participant. This feature should prevent undue stress to the knees. Also, the bike is designed to maintain an even pedaling motion throughout the entire workout.

An additional claim made by the Bally Corporation is that the percentage rate of compliance may be increased in those programs utilizing the Lifecycle (Bally Lifecycle Manual, 1986). Typically, in any exercise program, compliance was found to be 40%-50% within the first six months (Dishman, 1986). However, Lifecycles with their new motivational techniques and countless programs may have a positive influence on these percentages.

Currently there is very little literature available regarding energy costs and training effectiveness of computerized stationary bicycles. Because the Lifecycle may be an exercise alternative, it was studied to determine if there would be any cardiovascular training effects from the 12-and 24-minute protocols after a six-week exercise program.

**Purpose of the Study**

The primary research question to be answered was: to what extent cardiovascular training effects will occur in sedentary women after a six-week exercise program using computerized stationary bicycles? A subquestion to be answered was: to what extent will there be
cardiovascular training differences between the 12- and 24-minute computerized protocols?

**Null Hypotheses**

Based on the research questions, the following null hypotheses are offered:

1. There will be no significant cardiovascular training effects in sedentary women after a six-week exercise program on the Bally Lifecycle.
2. There will be no significant cardiovascular training differences between the 12- and 24-minute protocols.

**Assumptions**

The following are assumptions of the study:

1. That the subjects were nonexercisers and were not involved in any other form of exercise conditioning.
2. That the subjects were healthy with no physical limitations.
3. That all subjects exerted maximal effort during the training program and for each $\dot{V}O_2_{max}$ test.
4. That all equipment was calibrated accurately prior to all testing.
Delimitations

The study was delimited in scope in the following ways:

1. Subjects were females, 19 to 47 years of age, selected from the University of Wisconsin-La Crosse and from the community of La Crosse, Wisconsin.

2. Subjects were untrained as evidenced by a history of not exercising for a minimum of six-weeks prior to the study.

3. The training program was limited to six-weeks.

4. The training programs were limited to the 12-and 24-minute random and programmed protocols.

Limitations

The study was limited by the following factors:

1. Subjects were not randomly selected, but recruited from volunteers meeting specified criteria.

2. Sample size was limited by the time needed to collect the data and the availability of the subjects.

3. The stability and accuracy of the measuring instruments affected the interpretation of the data.

4. There was no control over subjects exercising on off days.

5. There was no control over subjects missing exercise sessions.
Definition of Terms

Terms used throughout this study are defined as follows:

1. **Beckman Metabolic Measurement Cart (BMMC)**--a self-contained device that collects and analyzes data for basic metabolic measurements. The program analyzes a mixture of expired oxygen (FE\textsubscript{O}\textsubscript{2}), carbon dioxide (FE\textsubscript{CO}\textsubscript{2}), volume (Ve), oxygen consumption in kilograms and liters (O\textsubscript{2} ml·kgBW\textsuperscript{-1}·min\textsuperscript{-1} and L·min\textsuperscript{-1}), carbon dioxide (VC\textsubscript{O}\textsubscript{2}), and respiratory exchange ratio (RER) (Metabolic Measurement Cart-Operating Instructions, 1975, pp. 1-51).

2. **Karvonen Equation**--an equation to determine the intensity portion of the exercise prescription for individuals. Included in the equation are maximal heart rate (200 - age), heart rate at rest, a met (metabolic equivalent) level, and a percentage of intensity of conditioning. The intensity recommended by the American College of Sports Medicine (ACSM) is between 60% and 80% (Guidelines for Exercise Testing and Prescription, 1986, p. 67).
   \begin{equation}
   THR = (HR \text{ max} - HR \text{ rest}) (.6 \text{ to } .8 + \text{ met level}) + HR \text{ rest}
   \end{equation}

3. **Kilo-pound Meter (KPM)**--the work done when a mass of one kilogram is lifted one meter against the force of gravity (Lamb, 1978). The work unit is kilopond meter per minute (Michael & Harvath, 1965).

4. **Lifecycle Model 5000**--a computerized stationary bicycle that may be programmed to vary the duration and intensity of a workload. The bike houses a matrix of imaginary hills (Bally Lifecycle Manual).

5. **Maximal Oxygen Consumption (\dot{V}O\textsubscript{2max})**--the volume of oxygen consumed per unit of time. \dot{V}O\textsubscript{2max} represents the largest variation between the
rate of inspired oxygen entering the lungs and the rate of expired oxygen. This difference determines the amount of oxygen that was taken up, transported and utilized by the body (Lamb, 1978, p. 228).

6. **Met (Metabolic Equivalent)**—"a multiple of the resting rate of oxygen consumption" (ACSM, 1986, p. 159). One met equals 3.5 ml·kgBW⁻¹·min⁻¹ resembling the rate of oxygen consumption during rest.

7. **Respiratory Exchange Ratio (RER)**—the ratio of the metabolic gas exchange (volume of CO₂ expired and volume of O₂ consumed) determining the oxidation of nutrients needed to produce energy. Each food type (carbohydrate, fat or protein) influences the above ratio. Therefore, the numerical value of RER closely represents the amount of oxygen utilized (Lamb, 1978, p. 84).
CHAPTER II

REVIEW OF LITERATURE

Introduction

The purpose of this study was to determine whether cardiovascular training effects would be seen in a group of inactive women after a six-week training program, and whether there would be any differences between the 12- and 24-minute protocols that are installed in the Bally Lifecycles. The subjects of the study were 34 sedentary, but healthy women 19 to 47 years of age. The program consisted of a pre- and post-maximum oxygen consumption evaluation, followed by a six-week training program. The literature reviewed will relate to areas concerning the effectiveness of computerized bicycles as training devices for sedentary women. Specifically, the sections reviewed include: (1) development of computerized stationary bicycles, (2) cardiovascular changes with training, (3) exercise compliance, and (4) summary.

Development of Computerized Stationary Bicycles

The stationary bicycle has been improved to meet the needs of fitness enthusiasts in today's society. A variety of bikes have been designed and constructed in scientific laboratories around the world. In the late 1800's, Fick described one of the first mechanically braked ergometers. In the Fick ergometer, a braking strap was placed around the outside of a wheel which was turned by the patient (Mellerowicz &
Smodlaka, 1981). As the wheel rotated, a resistance was created, causing tension on a spring that was attached to a second strap.

Following the development of Fick's ergometer, a frictional bicycle was described by Holzer and Kalinka in 1935. This type of bicycle added to Fick's original piece of equipment. Fleisch improved the frictional ergometer by adding a "constant braking effect" and a speed regulator.

This device made it easier to maintain the revolutions per minute (rpm) at a particular power. This bike was referred to as an "ergostat" (Mellerowicz & Smodlaka, 1981). Following the improvements made by the above researchers, the Monark bicycle was built in Stockholm and is widely being used in many laboratories and fitness facilities around the world.

The Monark Bicycle has a brake band in contact with the greater part of the periphery of the flywheel. This is attached to a pendulum balance at the axle of its oscillation system which consists of an oscillating drum, an oscillating beam and an oscillating weight. The pendulum hangs straight down when the machine is at rest and is displaced by the pull of the brake band when the machine is in operation. The displacement and thus the pulling force can be read on a scale calibrated in kiloponds and newtons (Mellerowicz & Smodlaka, 1981, p. 34).

Since the early 1880s, the stationary bicycle has seen a lot of changes and improvements. Today the stationary bicycle has found its place in the world of computers. Precision engineering has made it possible to install effective and convenient programs in the bicycle. The computerized cycle provides the exerciser with feedback such as work rate, caloric expenditure, and oxygen uptake. The Lifecycle, a stationary bicycle, was developed by the Bally Corporation "to satisfy a range of personalized fitness needs of the beginner to the needs of most advanced fitness enthusiasts (Bally Lifecycle Manual, 1986, p. 5). This
computerized, state-of-the-art, electronic device was manufactured in the late 1980's. It was "based on the self motivational principle of interval training with progressive overload" (Bally Lifecyle Manual, 1986, p. 5). Three basic programs are installed in the bicycle: Manual, Hill Profile, and the Random Protocol. The manual program circumvents a fixed pedal resistant for each one of the 12 levels. The hill profile varies in accordance to its four phases: warm up, test, interval, training, and warm down. The test period is approximately 70% of the individual's maximum heart rate. The second portion of the program is its interval training program comprised of "four successive hills of increasing magnitude" (Bally Lifecyle Manual, 1986, p. 11). The third program, the random protocol, varies the terrain with every level. The last program of the bicycle offers either a 12- or a 24-minute exercise period for each protocol, providing aerobic training in a short amount of time.

This computerized bicycle is now very marketable. According to Grossman (1982), "the stationary bicycle exerciser and its more sophisticated counter part, the bicycle ergometer, are the best selling aerobic exercise pieces." (p. 32).

Cardiovascular Changes with Training

The American Heart Association states that the leading causes of death today are heart disease, cancer, stroke, and accidents. All of these risks are related to one's lifestyle (1987).

In a survey from the Canadian Journal of Public Health (1986) it was stated that an estimated 25% of the American population are
exercisers while the sedentary population contributes 58% of the total. Also, "men are slightly more active than women; this is consistent across all age groups and every province" (p. 285). It appears that among the sexes there are substantial differences in the reasons for being active. In particular, women rated "feeling better" higher than men; however, men rated the "challenge of the exercise" as a more important aspect of the program. The reason which seems to distinguish exercising women from men is "to control weight or look better" (p. 288).

**Cardiovascular Adaptations**

The role of exercise in prevention or treatment of coronary artery disease has been researched for many years and remains controversial. However, for most of the population, improvement in cardiovascular function, seen with exercise, may minimize the chance of heart disease. Several adaptations have been shown to occur in individuals as a result of physical activity. These adaptations include a lower heart rate during exercise and at rest, and an increase in cardiac output resulting in an increase in maximal oxygen consumption during bouts ($\dot{V}O_{2\text{max}}$) of exercise.

$\dot{V}O_{2\text{max}}$ is the ability of the circulatory system to deliver, transfer, utilize and extract oxygen from the blood stream. This value, $\dot{V}O_{2\text{max}}$, has been shown to be highly reproducible (R-95), relatively stable and the best indicator of individual fitness levels (Taylor et al., 1955). In order to achieve aerobic fitness the heart, lungs, and blood vessels must be functioning adequately. The two major factors
influencing $\dot{V}O_{2\text{max}}$ are cardiac output (central capacity) and $a-vO_{2}$ difference (peripheral mechanisms).

Depending on the initial fitness level of an individual, one may expect no change, minor improvement or a marked increase of 50% to 100% in maximal oxygen uptake (Pollock, 1973). However, Pollock and associates found that 15%-20% improvement was a typical average for the middle age population (1973). Saltin (1968) also found that the initial fitness level of subjects needed to be assessed prior to determining the effectiveness of training programs. In Saltin's Dallas study (1968), it was concluded that the investigation found improvements of 4% to 100% depending on how the initial fitness level was defined.

The oxygen transferred from the air to the body's tissues follows several steps in the oxygen transport chain (Blomqvist & Saltin, 1983). The chain consists of the pulmonary transport, the heart's ability to eject the blood and lastly, the distribution of the blood to the sites where oxygen is needed (Blomqvist & Saltin, 1983).

In a study by the above authors, the data collected demonstrated that there were minimal effects in training that were caused by changes in pulmonary function. Rather, the primary changes seen in initial fitness levels were caused by an efficient distribution of cardiac output (1983).

With training, cardiac output will increase approximately four times the resting value. The two primary factors effecting cardiac output are stroke volume and heart rate.

Stroke volume was found to be approximately 50% of the increase seen with physical training in sedentary individuals (Rowell, 1974). It has also been shown to account for "all of the increases in $\dot{V}O_{2\text{max}}$ in
subjects who are already trained and all of the decreases in $\dot{V}O_{2}\text{max}$ during total bed rest" (Saltin, 1968, p. 15). The cardiac adaptations that contribute to the increase in stroke volume are an "increase in heart volume due to hypertrophy or an increase in contractility of the myocardium (Barnard, p. 118). Astrand and Rodahl summarize the cardiac adaptations as follows:

When the position is changed from supine to standing or sitting, there is a diminution in end-diastolic size of the heart and a decrease in stroke volume. If muscular exercise is then performed, the stroke volume increases to approximately the same size or to a higher level as obtained in the recumbent position (p. 87).

In accordance to an increase in stroke volume following training, investigators have found there is a corresponding decrease in heart rate at rest (Guyton, 1981). As the need for cardiac output continues during maximum exercise, stroke volume will reach its maximum; however, the rate of contractility will increase. This increase in heart rate contributes to the resting value, resulting in an increase in blood supply to the working muscles (Guyton, 1981). However, there are several factors influencing this increase in heart rate, including the sympathetic drive on the heart. For example, beta blocking agents will reduce heart rates by 20-30 beats per minute (Ekblom, 1986). It has also been demonstrated that hypothermia, a lower body temperature, attributes to a reduction in physical performance. "Thus, when the circulation is influenced by some drugs or by hypothermia the maximal aerobic power is also limited by heart rate" (Ekblom, 1986, p. 17).

The second major factor effecting cardiovascular adaptations concerns $a-vO_2$ difference. $A-vO_2$ difference reflects the amount of oxygen
carried by the arterial blood and the amount of oxygen extracted by the skeletal muscles. The increase seen in \( a-vO_2 \) difference during exercise is a combination of a slight increase in arterial oxygen due to hemoconcentration and a drastic decrease in oxygen extraction. Due to this shift in oxygen utilization, more oxygen is unloaded at the tissue levels, increasing energy production. This response is very controversial among the researchers. Several feel that with endurance training, a change in \( a-vO_2 \) difference will occur whereas others disagree with this thought. According to Kilbom, women training at low level intensity will not have any changes in \( a-vO_2 \) difference. To support this finding, Cunningham and Hill (1975) studied 17 women and again found that with low level training there was an increase stroke volume with no changes in \( a-vO_2 \) difference. However, the article did cite that long term, high intensity training may demonstrate an increase in both stroke volume and \( a-vO_2 \) difference. These results contradict the studies done by Saltin et al., (1968) and Rowell (1974). These authors have documented that while training males, changes in \( \dot{V}O_{2\text{max}} \) occurred due to increases in both stroke volume and \( a-vO_2 \) difference. The reasons why this may occur could be that the initial fitness levels and the length of training were different.

**Sex Differences in Training**

Since the early 1950's, several ideas concerning women and training have been discussed. Morehouse and associates stated, "...at puberty development of ability for strenuous exercise stops or even declines in girls while it continues to advance in boys" (1958 p. 27). It was also thought that,
the entire country has become a laboratory for testing
the popular hypothesis that the differences in male
and female responses to exercise observed prior to the
1970's could be ascribed in part to sport, particularly
sports that require endurance, strength and power
(Drinkwater, 1984, p. 21).

In the 1970's, Hanson and Nedde commented that the male sex has a higher
morbidity rate due to cardiovascular disease which may be the reason
that more training and exercise studies have been done with males
compared to those done for women. During the later 1960's and early
1970's, women became more involved in physical activity, including all
ages of women and all endurance sports. The enactment of Title IX
enables the female athlete to be part of the jogging boom and the
changing definition of sport for women (Drinkwater, 1984). Thus,
"whether or not there is a female response to exercise which is solely
mediated by the factor of sex has not yet been determined " (Drinkwater,
1973, p. 126). However, it has been documented that males have a 20%-25% greater \( \dot{V}O_{2max} \) than females (Drinkwater, 1973). The sex difference
in \( \dot{V}O_{2max} \) has been shown to be related to sex differences in fat-free
tissues, level of hemoglobin and heart size (Zwiren, Cureton, &
Hutchinson, 1983; Hutchinson, 1983; Cureton et al., 1985).

In research comparing women to women, similar training adaptations
found in male studies can be seen. In a study done by Flint and
associates 1974, it was demonstrated that after a six-week training
program three times per week, an 8% decrease in heart rate occurred.
This closely correlates with Kilbom's 9% decrease found in her study.
According to the data documented by Hanson and Neede (1974), significant
training effects also occurred in women after endurance training. After an eight month study these researchers found decreases in $\dot{V}E$, $\dot{V}O_2$, $\dot{V}CO_2$, respiratory quotient, and heart rate (1974). Another study done by Cunningham and Hill (1975), demonstrated that long term training of sedentary females resulted in an increase in stroke volume and $a-VO_2$ difference similar to results found in male training studies.

In general, it has been clearly shown that "the dimension and functional capabilities of the female oxygen transport system have repeatedly been smaller than those of males" (Hanson & Neede, 1974, p. 114). However, when training studies have been performed using only female subjects and the results have been compared with other studies, training effectiveness is evident. In fact, the level of physical activity may override the sex difference. It has been documented that active females have an increase in $\dot{V}O_2_{max}$ compared to their male counterparts who are inactive (Drinkwater, 1985).

**Exercise Compliance**

The trend toward healthier lifestyles can be seen in the increase in the number of participants reported by various exercise facilities which offer fitness programs. All age groups are involved in physical activity. The participants range from children to senior citizens. Reasons given for entering various fitness programs may be different for individuals; however, self-reported data indicates that the anticipation of health-related benefits is the key (Heinzelman & Bagley, 1970). Regardless of the increase in participation, initial motivation or the type of program, many people never attain their goals and discontinue
their activities (Wankel, 1984). Therefore, a question and a problem arises concerning the compliance rate of exercise programs.

Today, the statistics demonstrate a "40% to 50% dropout rate within the first six months to a year after the start up" (Dishman, 1986, p. 127). Dishman (1986) in his study, estimated that two out of every four persons will start a regular exercise program, and one of these two will stop within six months to a year. There were various reasons given for noncompliance; however, the most common excuses cited are lack of time, no spouse support and inconvenience (Dishman, 1986).

According to Dishman (1986), in order to understand noncompliance one must first understand the reasons for compliance. "Figures significance of noncompliance with supervised programs must be evaluated in relation to contemporary leisure activity levels" (Dishman, 1986, p. 135). In a report by Powell and Paffenbarger (1985), the data collected demonstrated a marked increase in sport participation for ages 35 to 69 years. Furthermore, surveys conducted in the United States and Canada confirm that the American population has demonstrated an increase in the activity level; however, this increase was largely limited to high income, white collar and well-educated groups. These surveys concluded that only 20% of the population were exercising at a high enough intensity to increase or maintain their cardiovascular fitness.

Despite the lack of substantial means of decreasing the sedentary population, the future looks promising. A better understanding of what compliance is and how it can be measured is being researched. In an article by Martin and associates (1970), it was discussed that in regards to low levels of compliance, several behavioral management
strategies installed could enhance any exercise program. Shaping, for example, installs a simple, easily performed activity which provides a large quantity of positive reinforcement. "It is the process by which behavior is dissected into a series of successive approximations that are gradually progressed to the desired end products" (Martin & Dubbert, 1984, p. 200). A second behavior strategy is reinforcement control. Praising individuals after each exercise session successfully increases compliance. Third on Martin and associates' list is stimulus control. This tool makes use of prompts and cues that stimulate exercise. These and other types of exercise prompts are strategies that need to be employed in all programs in order to increase compliance rates.

Summary

The development of the computerized bicycle has been improved to meet many diverse needs. Fick's early stationary bicycle has seen many changes: the first friction bicycle is now a modern computerized mode of training. Today, the Bally Lifecycle has found its place in the fitness community. This computerized stationary bicycle is self motivational and challenging. This newly developed Lifecycle has offered another means of cardiovascular training for both males and females.

The previous pages have reviewed several topic areas concerning women and cardiovascular changes. As discussed by Pollock (1973), many of the adaptations with training seen in males are also applicable to females. However, Zwiren, Cureton, and Hutchinson (1983), have demonstrated that fat-free tissue, heart size and the level of hemoglobin in women does indeed have an effect on training studies.
Several investigators researching this area have found that women cannot achieve the same level of aerobic fitness as men. However, training effectiveness is evident when only comparing female studies. Thus, much more education and motivation is needed to increase the involvement of women in the area of cardiovascular fitness.

Exercise and the benefits received by exercise are well documented. The number of participants are increasing, with the future looking even more promising. Continued interest and research in cardiovascular endurance training, particularly involving women, could have a tremendous effect on exercise patterns in today's society.
CHAPTER III

METHODS AND PROCEDURES

Introduction

The primary research question to be answered in this project was: to what extent cardiovascular training effects will occur in sedentary women after a six-week exercise program using computerized stationary bicycles? The subquestion to be answered was: to what extent will there be cardiovascular training differences between the 12-and 24-minute computerized protocols?

In this chapter, the methods used in the collection and analysis of the data are described. The chapter is divided into the following six sections: subjects, organization and data collection, procedures, maximum oxygen consumption tests, training sessions and statistical treatment of the data.

Subjects

A total of 34 untrained female subjects volunteered to participate in the training program; 24 served as the exercisers with the remaining 10 used as controls. The subjects selected were citizens of La Crosse, Wisconsin and students and faculty of the University of Wisconsin-La Crosse. The participants ranged from ages 19 to 47 and were assumed to be untrained but healthy individuals. Untrained
subjects for this study included those women who were not involved in a specific aerobic activity for at least six or more weeks prior to the testing. Three percent of the subjects reported having been involved in high school athletics, while no one reported being involved on the college level.

Physical characteristics of the subjects are presented in Table 1. The average weight of the subjects was 145 pounds with an average height of 65.5 inches.

Table 1

<table>
<thead>
<tr>
<th>Physical Characteristics of The Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Age (yrs.)</td>
</tr>
<tr>
<td>Height (in.)</td>
</tr>
<tr>
<td>Weight (kg.)</td>
</tr>
<tr>
<td>Weight (lb.)</td>
</tr>
</tbody>
</table>

The experimental group was randomly assigned to either the 12-or 24-minute random or programmed cycling protocols (Table 2).
Table 2

Protocols

<table>
<thead>
<tr>
<th>Variable</th>
<th>Random-12</th>
<th>Programmed-12</th>
<th>Random-24</th>
<th>Programmed-24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity(%\text{VO}_2)</td>
<td>60% + mets</td>
<td>60% + mets</td>
<td>60% + mets</td>
<td>60% + mets</td>
</tr>
<tr>
<td>Duration(min.)</td>
<td>24</td>
<td>24</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Frequency(days/wk.)</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>No. of subjects</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

Prior to the six-week training program, all subjects were evaluated on the following items: (1) fitness history and (2) maximal oxygen consumption (\text{\dot{VO}}_{2\text{max}}). Following the six-week training program, all subjects were re-evaluated to determine post \text{\dot{VO}}_{2\text{max}}.

Organization and Data Collection Procedures

Interview. Upon arrival at the Human Performance Laboratory at the University of Wisconsin, La Crosse, all subjects received an informed consent form (Appendix A). The form was read by and explained to the participant prior to any evaluations or activity. In addition, all subjects completed a physical activity history (Appendix B). The subjects who agreed to participate in the study were assigned a specific time to perform a bicycle test to determine \text{\dot{VO}}_{2\text{max}} in the laboratory.
Before their testing date, all subjects were given instructions concerning the abstinence from food, tobacco, alcohol and caffeine for at least three hours before testing (ACSM, 1986). It was also suggested to the female participant that she avoid wearing restrictive clothing.

**Height Measurements.** For each height measurement, the subjects stood without their shoes on and with their back to the measuring device. Directions were given to place their feet together and have their arms relaxed at their sides. With their eyes directed straight ahead, the measuring arm was adjusted to lightly rest on the top of their head. The measurement was taken and recorded to the nearest one-fourth of an inch or five-tenths of a centimeter.

**Weight Measurements.** Weight for each subject was measured to the nearest one fourth of a pound. The scale was calibrated prior to each weighing and subjects were weighed without shoes.

**Seat Adjustments.** The proper seat height was adjusted on both the Monark stationary bicycle and the Bally Lifecycle 5000 for every subject. The seat height was determined according to the guidelines established by the American College of Sports Medicine (1986).

**Maximum Oxygen Consumption Tests**

**Heart Rates.** The subjects were than prepared for heart rate monitoring by using alcohol to cleanse the sites of oils and dead cells of the
skin. Skin resistance was determined by using the Ohm meter. A lead two system was used to measure the electrical activity of the heart. Included in this lead system were three electrodes placed on various body areas. The reference electrode was placed on the right arm, the exploring electrode was placed at a V₅ position and a ground lead was placed on the right lower border of the rib cage. The wires were then attached to the Quinton ECG single lead channel recorder.

**Blood Pressures.** A Trimline sphygmomanometer was positioned above the elbow, and the brachial artery was palpated in order to feel the pulse. The arm was supported and the cuff was increased to a point well above the resting systolic pressure. The pressure was released slowly and the sound was listened to until a change occurred. Blood pressures were recorded at the second minute of each stage. Approximately a thirty-second notice was given to the investigator in order to attain a reading.

**Perceived Exertion.** Prior to the \( \dot{V}O_{2\text{max}} \) test, all subjects received an explanation of the Borg scale of perceived exertion (RPE) and the importance of this measurement (Appendix C). In summary, it was expressed as the amount of difficulty the subject felt during exercise. This information was obtained from the subject at the completion of each testing stage.

**Oxygen Consumption Determination (\( \dot{V}O_{2\text{max}} \)).** The Beckman Metabolic Measurement Cart was employed to determine the exchange of respiratory gases and their values. A headpiece and mouthpiece were placed on the
subject at the beginning of each test. The hose from the headpiece was connected to the BMMC in order to collect the expired air. Specific measurements monitored were, total minute volumes ($\dot{V}e$), milliliters of oxygen per body weight ($ml\cdot kgBW^{-1}\cdot min^{-1}$) and respiratory exchange ratio (RER). The BMMC was calibrated using standard gas mixtures before and after each test to determine the accuracy of the data. A second piece of equipment needed for the study was the Burdick EK8. This device recorded the heart rate during each of the tests. Heart rates were taken fifteen seconds prior to the completion of each minute. Rates were determined by counting the number of small squares between cardiac cycles (R waves) for each minute of the test.

Protocol. The bicycle test consisted of a continuous ride to exhaustion of the subject. Prior to the start of the test, each subject was required to stretch, weigh in and was given a standardized set of instructions (Appendix D).

Once the headgear was placed on the subject, the test was started. A Monark bicycle was used and recalibrated for all of the testing. The pedal speed was held constant at fifty revolutions per minute (rpm) and monitored by the use of a metronome. Each subject was required to stretch prior to the $\dot{V}O_{2\text{max}}$ test. A three-minute warm up was given in order to prepare the muscles for performance. All subjects began the test at three hundred kilopond meters (kpm) and was increased 150 kpm every two minutes until the subject could no longer maintain the rhythm (Table 3). Prior to increasing the resistance, the subjects were informed that a change would occur. Heart rate, and expired air were
obtained fifteen seconds prior to the completion of each minute. Blood pressure and perceived exertion were obtain at the completion of each two-minute stage. Each participant was asked to communicate to the investigator when she was within thirty seconds of her maximal effort in order to record all needed data.

Table 3

**Bicycle Protocol**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Duration</th>
<th>RPM</th>
<th>KPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm-Up</td>
<td>3min.</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>2min.</td>
<td>50</td>
<td>300</td>
</tr>
<tr>
<td>2</td>
<td>2min.</td>
<td>50</td>
<td>450</td>
</tr>
<tr>
<td>3</td>
<td>2min.</td>
<td>50</td>
<td>600</td>
</tr>
<tr>
<td>4</td>
<td>2min.</td>
<td>50</td>
<td>750</td>
</tr>
<tr>
<td>5</td>
<td>2min.</td>
<td>50</td>
<td>900</td>
</tr>
<tr>
<td>6</td>
<td>2min.</td>
<td>50</td>
<td>1050</td>
</tr>
</tbody>
</table>

**Testing.** The subjects were encouraged to give their best effort throughout the entire test; however, it was stressed that the completion of the test was in their control. The criteria for determining that \( \dot{V}_{O_2\max} \) was reached included: (1) respiratory exchange ratio was 1.00
or greater, (2) heart rate response was at or greater than age-predicted maximum, (3) the ratings of perceived exertion corresponded to the number value representing exhaustion and (4) a plateau in oxygen L·min⁻¹ indicated a difference of less than 150 L·min⁻¹. (Taylor et al., 1955). Even following the above criteria, a true maximum effort may not be achieved because of higher concentrations of lactate at lower heart rates found with bicycle testing limiting true exhaustion (Daniels et al., 1980). It also has been found by several investigations, that a bicycle test results in a ten percent lower value than a treadmill test (Astrand & Rodahl, 1977).

Post Test. Following the completion of the six-week training program, comparison results were received for (1) \( \dot{V}O_{2\text{max}} \) and (2) scale weight. Similar procedures for post-tests evaluations were adhered to as previously mentioned in the above paragraph.

Training Sessions

Exercise Prescription. At the completion of the subject's initial maximal oxygen consumption test, an exercise prescription was determined. The standard procedure used to determine this prescription was as follows: \((\text{max heart rate} - \text{resting heart rate}) \times (60\% + \text{met level}) + \text{the resting heart rate achieved at the pre } \dot{V}O_{2\text{max}} \text{ test.}\) All subjects were given a resting heart rate of 72 beats per minute, since true resting heart rates were unable to be determined due to the anxiety of the subjects.
Training Sessions. Following the completion of the pre-$\dot{V}O_{2\text{max}}$ test, each subject was randomly assigned either to the 12-minute random or programmed protocols or the 24-minute random or programmed protocols. On the day of the $\dot{V}O_{2\text{max}}$ test, times, starting dates and exercise prescriptions were determined for each individual. Each participant was required to exercise for six-weeks, three times a week, and to abstain from other exercise activities. On arrival for their exercise sessions, subjects weighed in on the scale and performed a three-minute warm-up. Each training session was supervised in the Human Performance Laboratory by the investigator of the study. The investigator programmed the Lifecycle for all subjects, recording before and after blood pressures and heart rates (Appendix E). The heart rates were determined by self-monitoring either the radial or carotid arteries for ten seconds. In order to determine if self-monitored heart rates were accurate, all subjects were randomly prepped and monitored with the EK8 system at various times during the six-weeks of training. At the completion of the session, each participant was reminded of the next exercise test.

Statistical Treatment of the Data

The research data was analyzed in the following way: the means and standard deviations were statistically computed for each of the four exercise groups (programmed-12, programmed-24, random-12 and random-24). Also, the means and standard deviations were computed for the exercising group as a whole versus the control group. A one way Anova was used to determine differences between groups for the physiological variables.
CHAPTER IV

RESULTS AND DISCUSSION

The primary research question of this study was as follows: to what extent cardiovascular effects will occur in sedentary women after a six-week exercise program using computerized stationary bicycles? A subquestion to be answered was as follows: to what extent will there be cardiovascular training differences between the 12- and 24-minute computerized protocols? This chapter will include a discussion of means and standard deviations of the variables, pre-to post-training comparisons, post-training between group protocols, a discussion of results and the summary.

RESULTS

Means and Standard Deviations of the Variables

Tables 4a and b includes the means and standard deviations of the physical characteristics and the maximal metabolic variables for controls, exercisers, programmed-12 (P-12), programmed-24 (P-24), random-12 (R-12) and random-24 (R-24) protocols. Thirty-five subjects began the study and 34 subjects completed the entire study.

The subjects in the P-12, P-24 and R-12 groups were similar in age and height, yet considerably older than the controls and R-24 group. Also, the control and R-24 groups were significantly heavier (p<.05) than the P-24 group and somewhat heavier than the other two groups.
### PRE-TRAINING MAXIMAL METABOLIC VARIABLES

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>AGE (yrs)</th>
<th>WEIGHT (kg)</th>
<th>HEIGHT (in)</th>
<th>(\dot{V}<em>{O</em>{2}}_{\text{max}}) L min(^{-1})</th>
<th>(\dot{V}<em>{O</em>{2}}_{\text{max}}) ml kgBW min(^{-1})</th>
<th>HRmax (bpm)</th>
<th>RIDETIME (sec)</th>
<th>RER</th>
<th>RPE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
</tr>
<tr>
<td><strong>Controls</strong></td>
<td>10</td>
<td>27 ± 6.18</td>
<td>70.3 ± 18.79</td>
<td>59.2 ± 20.86</td>
<td>2.06 ± 0.34</td>
<td>31.11 ± 8.37</td>
<td>180.4 ± 16.48</td>
<td>591.6 ± 103.4</td>
<td>1.12 ± 0.06</td>
<td>17.00 ± 1.90</td>
</tr>
<tr>
<td><strong>Exercisers</strong></td>
<td>24</td>
<td>33.7 ± 9.89</td>
<td>64.2 ± 11.99</td>
<td>58.7 ± 18.24</td>
<td>1.84 ± 0.61</td>
<td>30.81 ± 6.13</td>
<td>175.8 ± 1.04</td>
<td>570.4 ± 135.9</td>
<td>1.09 ± 0.12</td>
<td>18.40 ± 0.21</td>
</tr>
</tbody>
</table>

**Table 4b**

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>AGE (yrs)</th>
<th>WEIGHT (kg)</th>
<th>HEIGHT (in)</th>
<th>(\dot{V}<em>{O</em>{2}}_{\text{max}}) L min(^{-1})</th>
<th>(\dot{V}<em>{O</em>{2}}_{\text{max}}) ml kgBW min(^{-1})</th>
<th>HRmax (bpm)</th>
<th>RIDETIME (sec)</th>
<th>RER</th>
<th>RPE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
<td><strong>X ± SD</strong></td>
</tr>
<tr>
<td><strong>Controls</strong></td>
<td>10</td>
<td>27 ± 6.18</td>
<td>70.3 ± 18.79</td>
<td>59.2 ± 20.86</td>
<td>2.06 ± 0.34</td>
<td>31.11 ± 8.37</td>
<td>180.4 ± 16.48</td>
<td>591.6 ± 103.4</td>
<td>1.12 ± 0.06</td>
<td>17.00 ± 1.90</td>
</tr>
<tr>
<td>P-12</td>
<td>8</td>
<td>38 ± 9.42</td>
<td>63.7 ± 42*</td>
<td>63.9 ± 23.06</td>
<td>1.71 ± 0.35</td>
<td>27.17 ± 4.73</td>
<td>168.3 ± 5.23</td>
<td>480.2 ± 96.21</td>
<td>1.09 ± 0.08</td>
<td>18.50 ± 0.93</td>
</tr>
<tr>
<td>P-24</td>
<td>8</td>
<td>34 ± 9.75</td>
<td>61.7 ± 8.77*</td>
<td>63.4 ± 1.30</td>
<td>1.66 ± 0.36</td>
<td>30.52 ± 6.17</td>
<td>173.6 ± 17.03</td>
<td>549.3 ± 85.08</td>
<td>1.08 ± 0.15</td>
<td>19.00 ± 0.93</td>
</tr>
<tr>
<td>R-12</td>
<td>4</td>
<td>31 ± 10.80</td>
<td>64.2 ± 22.14*</td>
<td>49.0 ± 2.73</td>
<td>2.19 ± 0.59</td>
<td>35.05 ± 6.76</td>
<td>184.3 ± 12.82</td>
<td>690.2 ± 204.9</td>
<td>1.08 ± 0.14</td>
<td>18.30 ± 1.70</td>
</tr>
<tr>
<td>R-24</td>
<td>4</td>
<td>26 ± 8.50</td>
<td>70.2 ± 15.49</td>
<td>62.7 ± 4.50</td>
<td>1.79 ± 1.24</td>
<td>34.40 ± 4.98</td>
<td>187.3 ± 14.36</td>
<td>689.0 ± 59.26</td>
<td>1.11 ± 0.14</td>
<td>19.00 ± 0.82</td>
</tr>
</tbody>
</table>

*\(p < .05\)
Tables 4a and b also indicates the mean pre-training values for the following maximal metabolic variables: oxygen uptake ($\dot{V}O_2$, L·min$^{-1}$ and ml·kgBW$^{-1}$·min$^{-1}$); heart rate (HR, bpm); rate of perceived exertion (RPE); ride time (secs) and respiratory exchange ratio (RER).

The variables used to determine maximal effort on the bicycle test were HR$_{max}$ (bpm), RPE and RER. Specific criteria defining these variables are described in Chapter 3. It was expected that subjects in the study would attain a predicted maximal heart rate of approximately 188 bpm based on a mean age of 32 years. Three of the four groups were within a few beats of this predicated value. However, the P-12 group had an average maximal pre-training heart rate which was significantly lower (p<.05) than any of the other groups. This was somewhat surprising in view of the fact that the mean age of the P-12 group was 26 years of age. All four groups achieved a mean RER of 1.00 and an RPE of greater than 17. Therefore, it was assumed that a maximal effort was given by all subjects on the bicycle test.

The R-12 group’s mean pre-training $\dot{V}O_{2\max}$ expressed in L·min$^{-1}$ was significantly (p<.05) greater than that of the other three groups of exercisers. However, when expressed in ml·kgBW$^{-1}$·min$^{-1}$, there was no difference between any of the groups, indicating that all groups were in similar physical condition at the beginning of training. The average $\dot{V}O_{2\max}$ (ml·kgBW$^{-1}$·min$^{-1}$) for all exercisers was 30.81 and 31.11 for the controls.

All exercising subjects were required to train for six-weeks, three times per week and to abstain from other exercise activities. The average training intensity level maintained by the subjects in this
study was 68.8%. During the training period, all but 7 subjects increased at least one workload above their beginning intensity level. The increases in intensity were made based on training heart rates taken during each session. If the subject's average heart rate for several training sessions was lower than that prescribed, they were moved up in intensity. The largest increase was seen in one subject within the R-24 group (level 2 to level 4). Of the 7 subjects who did not increase, one refused while the other six did not meet advancement criteria (Appendix F).

Pre to Post-Training Comparisons

Tables 5a and b includes the pre-training and post-training values for the controls, all exercisers and the individual exercise groups for the following variables: $\dot{V}O_{2\text{max}}$ (L·min⁻¹ and ml·kgBW⁻¹·min⁻¹), ride time (secs), RER and RPE.

All exercise groups increased $\dot{V}O_{2\text{max}}$ (ml·kgBW⁻¹·min⁻¹) an average of 2.45 ml·kgBW⁻¹·min⁻¹ as a result of the training program. This change represents a 7.9% increase in fitness level. Although the increase represents a definite trend, none of the pre to post-training differences for $\dot{V}O_{2\text{max}}$ (ml·kgBW⁻¹·min⁻¹) were statistically significant. The standard deviations of the mean pre to post-training $\dot{V}O_{2\text{max}}$ (ml·kgBW⁻¹·min⁻¹) values were also quite large. The combination of small group sizes, large standard deviations and small average change in values accounted for the lack of significance. In addition, no significant differences were found for ride time and RER for any of the group pre to post-training comparisons. However, ride time increased nonsignificantly by 15.0% with training. Statistical significance
**PRE-TRAINING AND POST TRAINING MAXIMAL VO$_2$ VALUES**

Table 5a Controls and Exercisers

<table>
<thead>
<tr>
<th>GROUPS</th>
<th>N</th>
<th>VO$_2$ max L/imin</th>
<th>VO$_2$ max ml/kgSW min.</th>
<th>RIDETIME (sec)</th>
<th>RER</th>
<th>RPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls</td>
<td>pre 10</td>
<td>2.06 ± 0.33</td>
<td>31.11 ± 8.37</td>
<td>591.65 ± 103.36</td>
<td>1.12 ± 0.06</td>
<td>17.00 ± 6.02</td>
</tr>
<tr>
<td></td>
<td>post 20</td>
<td>2.02 ± 0.26</td>
<td>30.23 ± 7.04</td>
<td>785.90 ± 68.34</td>
<td>1.15 ± 0.05</td>
<td>13.50 ± 9.11</td>
</tr>
<tr>
<td>Total</td>
<td>pre 24</td>
<td>1.84 ± 0.06</td>
<td>30.81 ± 6.13</td>
<td>570.45 ± 135.19</td>
<td>1.09 ± 0.11</td>
<td>18.71 ± 1.04</td>
</tr>
<tr>
<td>Exercisers</td>
<td>post 26</td>
<td>2.12 ± 0.42</td>
<td>35.26 ± 6.46</td>
<td>656.26 ± 133.66</td>
<td>1.14 ± 0.09</td>
<td>16.71 ± 5.27</td>
</tr>
</tbody>
</table>

Table 5b Protocol Groups

| P-12 | pre 8 | 1.71 ± 0.35 | 27.17 ± 4.73 | 570.45 ± 135.19 | 1.08 ± 0.08 | 18.50 ± 0.93 |
|      | post 8 | 1.90 ± 0.39 | 29.68 ± 5.33 | 656.26 ± 133.68 | 1.15 ± 0.11 | 16.25 ± 6.62* |
| P-24 | pre 8 | 1.86 ± 0.32 | 30.52 ± 6.17 | 549.27 ± 85.08 | 1.08 ± 0.12 | 19.00 ± 0.92 |
|      | post 8 | 2.04 ± 0.32 | 33.53 ± 5.85 | 657.84 ± 48.10 | 1.15 ± 0.12 | 18.50 ± 0.57 |
| R-12 | pre 4 | 2.19 ± 0.58 | 35.05 ± 6.76 | 690.20 ± 204.93 | 1.08 ± 0.14 | 18.25 ± 1.70* |
|      | post 4 | 2.33 ± 0.59 | 36.90 ± 8.12 | 714.96 ± 218.70 | 1.15 ± 0.06 | 13.50 ± 9.11 |
| R-24 | pre 4 | 1.79 ± 1.24 | 34.40 ± 4.96 | 689.02 ± 59.26 | 1.11 ± 0.14 | 19.00 ± 0.81 |
|      | post 4 | 2.49 ± 0.11 | 36.20 ± 6.63 | 785.90 ± 68.34 | 1.15 ± 0.12 | 18.50 ± 0.58 |

*p < .05
was obtained for RPE in pre to post-training comparisons for P-12 and R-12. This indicates that those groups perceived the maximal work to be easier after completing the training program, even though their fitness had not increased significantly.

**Computerized Protocol Differences**

A significant difference (p<.05) was obtained for $\dot{V}O_{2\text{max}}$ expressed as L·min$^{-1}$ between the R-24 (2.46 ± 0.11) and R-12 (2.33 ± 0.59) computerized protocols. However, there were no significant differences found for any of the computerized protocol groups when expressed as ml·kgBw$^{-1}$·min$^{-1}$. This result is surprising and not in agreement with other training studies using sedentary women. Figure 1 illustrates the differences (ml·kgBw$^{-1}$·min$^{-1}$) between the four protocol groups before and after the training program. The subjects training with the P-24 protocol increased their mean $\dot{V}O_{2\text{max}}$ (ml·kgBw$^{-1}$·min$^{-1}$) by 9.8 percent. This was the largest increase of any of the protocol groups (P-12/9.5%; R-24 and R-12/5.2%). As stated previously, this increase was not significant; however, the trend was for the programmed protocols to show a greater increase in fitness capacity. The mean oxygen uptake (ml·kgBw$^{-1}$·min$^{-1}$) after training of the two random protocol groups (R-12 and R-24) was higher than the means of the program protocol groups (P-12 and P-24). This difference is not meaningful since, the random protocol group's (R-12 and R-24) pre-training $\dot{V}O_{2\text{max}}$ values were higher. In addition to the significant differences found for $\dot{V}O_{2\text{max}}$ expressed in L·min$^{-1}$, there were also differences obtained in ride time. Programmed-24's maximal ride time (657.84 ± 48.10) was significantly (p<.05) greater than the P-12 ride time (656.26 ± 133.60). There was also a
Pre-training and Post-training Maximal VO2 Values

Maximal VO2 Values

- Controls
- Exercisers
- P-12
- P-24
- R-12
- R-24

- Pre-training
- Post-training
significant difference \( (p<.05) \) obtained between R-12 \( (714.96 \pm 218.70) \) and P-24 \( (657.84 \pm 48.10) \) protocols. Two possible statements can be made from the results of the data. First, a longer time period is needed when training in the program protocol, since the highest intensity level is not maintained for the entire duration. Secondly, even though the subjects in the P-24 protocol rode longer, the training intensity was not maintained as long as in the random protocol.

**Discussion of the Results**

The primary question to be answered by this study was: to what extent cardiovascular training effects will occur in sedentary women after a six-week exercise program using computerized stationary bicycles. An increase in \( \dot{V}O_{2\text{max}} \) \( (\text{ml} \cdot \text{kgBW}^{-1} \cdot \text{min}^{-1}) \) and bicycle ride time, as well as, a decrease in exercising heart rate are changes expected to occur with cardiovascular training on a stationary bicycle (Drinkwater, 1973). Changes in the values stated above generally reflect adaptations to training and increases in physical capacity which are expected to occur simultaneously (Astrand, 1984). No significant differences were obtained between pre-and post-training \( \dot{V}O_{2\text{max}} \) values expressed as \( \text{L} \cdot \text{min}^{-1} \) or \( \text{ml} \cdot \text{kgBW}^{-1} \cdot \text{min}^{-1} \) for any of the between-and within-group comparisons in this study. In many aspects however, these results followed the typical pattern seen in other studies using similar subjects and design. Kilbom (1971) found a significant 6% increase in \( \dot{V}O_{2\text{max}} \) \( (\text{ml} \cdot \text{kgBW}^{-1} \cdot \text{min}^{-1}) \) following a similar six-week training program on a bicycle ergometer. Yeager and Brynteson (1970), found a 5% increase in \( \dot{V}O_{2\text{max}} \)
following a cycle training program which was also statistically significant. Using the same computerized bicycles and subject sample as the current study, Ward et al. (1987), found an 8% increase in $\dot{V}O_{2\text{max}}$ (ml·kgBW$^{-1}$·min$^{-1}$) after training, which was also statistically significant.

In this study, a 7.9% increase in $\dot{V}O_{2\text{max}}$ (2.45 ml·kgBW$^{-1}$·min$^{-1}$) was found. This increase in percentage and absolute values is very consistent with the other studies previously mentioned but lacked significance. The lack of statistical significance can be explained primarily by the combination of small group sizes, large standard deviations and the small absolute changes in values.

In addition, two design problems probably contributed to the lack of significance in many variables. The first area of concern is the training intensity level. Fox and Mathews (1981), indicate that intensity levels vary individually and are affected by initial fitness levels. The authors further indicate that individuals who are not very fit will more than likely benefit significantly from lower intensity levels. Sedentary individuals with low fitness levels have been found to improve physical capacity at exercise intensities of 50% to 60% of $\dot{V}O_{2\text{max}}$ (ACSM guidelines, 1986; Medicine and Science in Sport and Exercise, 1978). Several authors have noted that 50% of $\dot{V}O_{2\text{max}}$ seems to be a training threshold for the first several weeks of training until an increase of 60% to 70% is appropriate (ACSM, 1986; Pollock, Wilmore and Fox, 1984 and Skinner, 1987). In this study, the initial aerobic capacity was 30.81 ml·kgBW$^{-1}$·min$^{-1}$ for all exercisers. The average intensity level of 68.8% used for training was established according to
American College of Sports Medicine Guidelines and reflected the functional capacities of the subjects. Training was designed to permit subjects to complete the entire exercise time period (either 12- or 24-minutes) of their selected protocol. In many cases, subjects were initially unable to complete the training sessions even at the lightest workload. With training, subjects completed workload times and were, in some cases, advanced to a higher workload. The literature documents that higher training intensity (even with a decreased duration) results in greater absolute changes in $\dot{V}O_{2\text{max}}$ than lower intensities. Perhaps the workloads should have been more intense even though the subjects would not have been able to complete the entire workload time period.

The second area of concern in this study is total training time. The subjects in this study were trained for a total duration of six-weeks. As mentioned previously, subjects were unable, in general, to complete entire workloads during the training sessions. This resulted in the progression of training being somewhat slower than expected. The subjects; however, did improve their fitness levels as was indicated by increases in $\dot{V}O_{2\text{max}}$ and ride time. Yet these increases only approached significance ($p<.05$). It is felt that had the total training period been eight or twelve weeks, the increases would have been greater and probably statistically significant considering that the intensity level was somewhat low. Based on the obtained results the first null hypothesis is accepted.
The second question to be answered was as follows: to what extent will there be cardiovascular training differences between the 12-and 24-minute computerized protocols? Numerous studies have sought to evaluate duration of training by controlling the intensity and frequency of the exercise sessions. Investigations indicate that even at durations of 15 minutes or less, $\dot{V}O_{2\text{max}}$ can be improved. In a 10-week study by Wilmore and associates (1970), males training for 12-or 24-minutes improved significantly in most cardiovascular variables. The results of the latter group training 24-minutes produced higher increases in $\dot{V}O_{2\text{max}}$. While the 24-minute group showed a greater magnitude of change no statistical significance was found. Yeager and Brynteson (1970), trained females for six-weeks on a bicycle ergometer. These subjects randomly selected durations of 10, 20 or 30 minutes. In the study by the above authors, the results found that the group training for 30 minutes had the largest increase in $\dot{V}O_{2\text{max}}$; however, there were also training benefits found in the group riding for only 10 minutes. Other studies including the American College of Sports Medicine Guidelines (1980), suggest that training durations can begin as low as 15 minutes; however, as fitness levels increase so should the exercise time period.

Therefore, the lack of significant difference in the training responses of the 12-and 24-minute protocols in this study are typical findings. The protocol comparisons revealed a tendency for the program protocols to increase $\dot{V}O_{2\text{max}}$ more (9.8% and 9.5%) than the random protocols (5.2% for both groups). These results imply that the two
protocol durations are efficient for desired gains in training responses. Thus, the hypothesis stating that there will be no significant difference between the 12- and 24-minute protocol was accepted.
CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

SUMMARY

A vast amount of research has been done on cardiovascular changes found with training. However, male subjects have been studied almost exclusively in these investigations. Due to the physiological differences between the sexes, only generalizations about the effects of training on women can be made from the research. Therefore, the current study was concerned with cardiovascular responses of females after six-weeks of training. The study was also concerned with cardiovascular changes obtained after training on computerized bicycles. Research on this type of bicycle is very limited; therefore, it is difficult to make comparisons regarding training effects. Thus, the primary research question to be answered by this study was as follows: to what extent cardiovascular training effects will occur in sedentary women after a six-week exercise program using computerized bicycles? A subquestion to be answered was as follows: to what extent will there be cardiovascular training differences between the 12-and 24-minute computerized protocols? The above questions apply to the two hypotheses presented in this thesis.

Subjects selected for this study were 34 sedentary female volunteers, 19 to 47 years of age. All subjects were healthy and able to complete six-weeks of training on the computerized bicycle
for either 12- or 24-minutes, three times per week. The 24 training females were randomly selected for either the random or programmed protocols. The remaining 10 subjects were used as controls.

The following physiological parameters were determined for each test: oxygen uptake (L·min⁻¹ or ml·kgBW⁻¹·min⁻¹), heart rate (HR), rate of perceived exertion (RPE), respiratory exchange ratio (RER) and ride time (secs). The workloads and fitness levels were determined from the pre-training $\dot{V}O_{2max}$ test. During each of the training periods, heart rates and blood pressures were taken in the last two minutes of the sessions.

The statistical analysis of the data included: means and standard deviations for all variables received from the pre and post-training $\dot{V}O_2$ max tests. A one way Anova was computed to examine the differences in the physiological variables for the controls, the entire exercising group and the individual groups. The .05 level of significance was used for all statistical tests.

Conclusions

The following conclusions are based on the statistical information received after the six-week training program on the computerized bicycle:

1. There were no significant differences found in cardiovascular training effects in sedentary women after a six-week training program on computerized bicycles, and therefore, the null hypothesis was accepted.
2. There were no significant cardiovascular differences obtained between
the 12-and 24-minute protocols, and therefore, the second null hypothesis was accepted.

3. A nonsignificant increase 7.9% in fitness level was obtained for all subjects.

4. Protocol comparisons revealed a nonsignificant tendency for the programmed protocols to obtain greater increases in $\dot{V}O_{2max}$ (9.8% and 9.5%) than the random protocols (5.2% for both).

5. It appeared that the combination of small group sizes, large standard deviations and small average change in values contributed to the lack of significance in all statistical tests.

**Recommendations for Further Study**

Based on the results found from this study the following recommendations are offered for further research:

1. A similar study with a training period of 8 weeks or longer for further evaluation of computerized bicycles.

2. A similar study which would further employ higher intensity levels during training.

3. A study using a larger sample size, increasing the size of individual groups of exercisers for statistical significance.

4. A study comparing computerized bicycles to treadmill walking or jogging.

5. A study on active individuals in order to determine if their fitness levels are maintained or changed in any way.

6. A study that would involve a longer time period for training.
REFERENCES
REFERENCES


APPENDIX A

Inform Consent
Evaluation of Training Programs Developed by the Bally Fitness Products Corporation.

Principle Investigator: Sharon Slavin

Procedures: The primary purpose of the study is to evaluate if there are any cardiovascular benefits received from the training protocols that have been installed in the Bally Lifecycles. The protocols are either 12- or 24-minutes. A secondary purpose is to evaluate if there are any differences between these training protocols.

There will be two phases involved in the study: a) pre and post determination of maximum oxygen consumption; and b) a six-week training program. All women will be involved in both phases.

A pre-maximum oxygen uptake test will be performed. The physiological measurements include, ventilation rate, heart rate, oxygen uptake, and respiratory quotient. The test will be conducted on a stationary bicycle with increases in pedal resistance. You will be asked to ride the bicycle as long as possible—until fatigue. This test requires the investigator to monitor heart rates every minute, therefore, electrodes will be placed on the body. The participant will also be hooked up to a mouth piece that is connected to the Beckman Metabolic Cart which analyzes oxygen consumption. Along with the mouth piece, a nose clip will also be required. Following these initial procedures, subjects will be given a training protocol (12- or 24-min.). The training program is for six-weeks—three times a week. The times and meeting place will be decided after the preliminary evaluation. During each training session, individual weight will be recorded along with the monitoring of heart rates and blood pressures. Each session will begin with a three minute warm up and end with a cool down.

The research project may involve slight soreness during the initial portion of the training program. There is only a small potential for injury. Possible benefits to be expected include, an increase in present fitness level, weight reduction, and toning of muscles.
I_________________________age_________consent, authorize and request Sharon Slavin (co-workers) to undertake the procedures involved in this research project evaluating Bally Lifecycles. I have read the above procedures and have been informed of the nature of the study, possible risks and complications that may arise during the testing. In addition, I understand that if any abnormal observations occur, the test will be terminated. I also understand that I may withdraw from the program at any time.

I hereby acknowledge that no legal action will be taken against the University of Wisconsin-LaCrosse or anyone involved with this study. To my knowledge, no medical problems exist.

Subject Signature_____________________________________

Date__________________________

Witness________________________________________________

Principle Investigator____________________________________
APPENDIX B

Medical History Form
Self Administered Pre-Exercise Medical History

Name______________________________________ Sex________ Age____

Occupation__________________________________________

1. Do you have or have you ever had: (check if yes)
   ___Pain in your heart or chest  ___Coughing of blood
   ___Heart Attack                 ___Anemia
   ___Rheumatic Fever              ___Diabetes
   ___Diseases of the arteries     ___Epilepsy
   ___Varicose veins               ___Bronchitis
   ___Heart Murmur                 ___Asthma
   ___Any heart problems           ___Pneumonia
   ___Abnormal EKG                 ___Abnormal chest x-ray
   ___Extra or skipped heart beats ___Other lung diseases
   ___Phlebitis                    ___Nervous/emotional stress
   ___Dizziness or fainting spells ___Injuries to back, arm, legs, or joints
   ___Stroke                      ___Back Pain
   ___High blood Pressure          ___Swollen, stiff or painful joints
   ___Badly swollen ankles         ___Arthritis of arms or legs
   ___Cough on exertion            ___Scarlet Fever

Explanation or Comments_________________________________________________________

2. List any medicines or drugs you are now taking___________________________________

3. Date of last complete medical exam____ Were results normal____
   If no explain____________________________________________

4. Do you know of any medical problems that might make it dangerous or unwise to participate in vigorous exercise__________ If yes, explain______________________________________________________________
5. Have any of your blood relatives had any of the following?

- Heart attack
- Stroke
- High blood pressure
- Elevated cholesterol
- Congenital heart disease
- Heart operations
- Diabetes
- Obesity

6. Have you ever smoked:

- cigarettes ___ Age started ___ Age quit ___ No. per day ___
- cigars ___ Age started ___ Age quit ___ No. per day ___
- pipe ___ Age started ___ Age quit ___ No. per day ___

7. What is your weight now ___ at age 21 ___ what is the most you have ever weighed ___ at what age ___ What do you consider a good weight for yourself ___?

8. Are you currently involved in a regular exercise program? If yes, indicate type and amount of exercise. __________________________
   __________________________

Do you regularly walk or run one or more miles continuously? ___
Do you frequently participate in sports? ___ If yes, which one(s) __________________________

___ Did you participate in high school or college varsity sports
___ If yes, which ones __________________________

Do you experience discomfort, shortness of breath or pain with moderate exercise? ___

9. Explain any other significant medical problems you consider it important for us to know. __________________________
   __________________________

__________________________________________
signature

__________________________________________
witness

__________________________________________
date
APPENDIX C

Borg Scale of RPE
BORG RATINGS OF PERCEIVED EXERTION

At various times throughout your bicycle ride I will hold up this scale and ask you to select the number that best represents how hard you feel the work is for you at that time. As you can see, this scale ranges from a low of 6 to a high of 20. The higher the number, the harder you feel the effort is for you. The highest number (20) should represent the maximum effort and fatigue level you have ever felt while riding). There is no right or wrong answer. Just try to estimate your total feeling of exertion and effort as honestly and accurately as you possibly can.

BORG SCALE OF PERCEIVED EXERTION

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, 1970, p.93)
APPENDIX D

Bicycle Ergometer
BICYCLE ERGOMETER

In order to determine your initial fitness level, you will be performing a maximal exercise test on the Monark Bicycle.

The seat will be adjusted to your height and will allow you the optimal use of the pedal stroke. You will be required to grasp the handle bars and remain on the seat at all times.

You will be pedalling in beat to a metronome at a rate of 50rpm. At the sound of the metronome, you should be on the down portion of the pedal stroke.

There will be a three minute warm up with little or no resistance. The first two minutes the nose clip will not be on. The third minute of warm up, the nose clip will be placed on your nose. This aids in pushing out the trapped air in the hose and Beckman. The test will begin at the completion of the third minute and the workload will be increased every two minutes.

I want you to pedal until you can no longer continue. During the test I will be taking your blood pressure. Please turn your palm to the ceiling and straighten your arm at that time. I will be encouraging you to a maximal effort however, the completion of the test is in your control. I will need thirty seconds for the final readings. Please indicate this to me.

Do you have any questions?
Monark Bicycle Protocol

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pre O₂   post O₂
pre CO₂  post CO₂
APPENDIX F

Training Heart Rates
### Training Heart Rates

**Program-12**

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Training Heart Rates
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