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# Effects of a conditioning program on subjective and physiological indicators of stress in cardiac rehabilitation patients

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# EFFECTS OF A CONDITIONING PROGRAM ON SUBJECTIVE AND PHYSIOLOGICAL INDICATORS OF STRESS IN CARDIAC REHABILITATION PATIENTS

by

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An Abstract

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ABSTRACT

This study was concerned with changes in heart rate, blood pressure, and rating of perceived exertion occurring in cardiac patients as a result of a 9-week program of cardiovascular conditioning. The 15 subjects exercised at an individualized exercise prescription of between 60% and 85% of maximum heart rate using a walk, jog, or combination walk-jog for 30 to 70 minutes, twice weekly. Data were collected for all subjects both at rest and during exercise. The resting parameters measured included heart rate and blood pressure. The exercising parameters measured were heart rate and Borg rating of perceived exertion scores, both of which were taken halfway through each exercise session and again upon completion of the exercise session. Data were collected for the initial, median, and terminal sessions of the 9-week investigation period. Analysis of variance tests showed no significant ($p < .05$) changes in the two resting variables from the initial to the terminal point. Neither were there any significant changes, from the initial to the terminal point, in the exercising variables taken halfway through the exercise sessions, nor at the conclusion of the exercise sessions. These results were in disagreement with much of the available literature. Possible explanations included an insufficient number of subjects, an insufficient number of training sessions, changes in exercise prescriptions, inaccurately reported Borg scores, and breaks in exercise continuity.

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A Thesis Presented to the Faculty of

the Division of Health, Physical

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In Partial Fulfillment of the

Requirements for the Degree

Master of Science

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December 1989

Ithaca College
Division of Health, Physical Education, and Recreation
Ithaca, New York

CERTIFICATE OF APPROVAL

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MASTER OF SCIENCE THESIS

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This is to certify that the Master of Science Thesis of

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submitted in partial fulfillment of the requirements for the degree of Master of Science in the Division of Health, Physical Education, and Recreation at Ithaca College has been approved.

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# DEDICATION

"If one advances confidently in the direction
of his dreams and endeavors to live the life
which he has imagined, he will meet with a
success unexpected in common hours."

-Thoreau-

This is dedicated to Patricia and John Hanson, my mother and father, who have always shown their confidence in me and their love for me. They have always encouraged me to follow my dreams and aim for the highest goals. I love you, Mom and Dad!

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## INTRODUCTION

Interest in exercise as a means of promoting health dates from ancient times. It was not until the 20th century, however, that scientific efforts were devoted to investigation and interpretation of physiological responses and adaptations to the stress of exercise. Since then our knowledge of exercise physiology has continued to grow and expand, providing a more rational basis for application of habitual aerobic activity in the healthy individual as well as in the treatment of those afflicted by cardiac disease (Wilmore, 1977).

Cardiac rehabilitation is a type of progressive and comprehensive care through which patients are either restored to or brought to and maintained at their optimal medical, physiological, psychological, social, vocational, and recreational status. Secondary prevention of the underlying disease process is implicit in the concept, as is acceleration of the patient's return to a "pre-illness" level of activity, or an improved level of "health."

Until recently, cardiac rehabilitation was generally associated only with the long-term care of survivors of a myocardial infarction. This limitation may have been due to the fact that many of the techniques and principles that characterize cardiac rehabilitation evolved from investigations dealing with problems of coronary heart disease and myocardial infarction. However, the principles and techniques are applicable to the care of patients with other cardiac disorders as well, including congenital lesions, angina pectoris, aorta-coronary bypass surgery, and cardiomyopathy.

The leading cause of physical impairment and disability in the United States is myocardial infarction (Naughton, 1977). Related problems include reduction and/or loss of physical working capacity as a result of reduced myocardial reserve and overall physical deconditioning, as well as possible increases in psychological symptoms that are directly related to a loss of performance capacity. Although 80% of the survivors of myocardial infarction should be able to return to work and/or near normal levels of activity, many do not because of the presence of symptoms directly related to their physical deconditioning (Wenger, Hellerstein, & Blackburn, 1973). A cardiac rehabilitation program can provide physical and psychological abilities and confidence to patients so that they can resume normal, healthy lifestyles.

The components of cardiac rehabilitation include optimal medical care; periodic evaluation of adaptation to the stress of symptom-limited activities; participation in lifelong, graduated, prescribed physical activity; adequate psychological support; and patient and spouse education (Naughton, 1977).

This investigation concentrates on measurements of adaptation to the submaximal stress of symptom-limited work capacity. Generally in cardiac rehabilitation programs these adaptations are measured solely through such physiological vital signs as heart rate, pulse rate, and blood pressure. It is the intent of this investigator to determine the effectiveness of using the revised Borg rating of perceived exertion scale as an additional means of monitoring the level of exercise intensity and the physiological stress evoked.

## Scope of the Problem

Subjects for this study were 15 adults enrolled in a Phase III (see Definition of Terms) cardiac rehabilitation program at Monroe Community College, Rochester, New York. Each participant had a history of cardiovascular disease and was under medical care during the study. The program continued, unchanged, with no intervention by the investigator. The investigator only observed the subjects as they participated in prescribed activities. Data for the study were supplied by the director of the program. This information included weight, resting and exercising heart rate, resting blood pressure, and a Borg score for each subject. Changes from the initial to the terminal readings for Borg scores and physiological parameters were studied.

## Statement of the Problem

The intent of this study was to investigate the effects of a 9-week cardiac rehabilitation program on resting blood pressure, resting heart rate, exercising heart rate, and rating of perceived exertion during exercise. Comparisons of graphed data were also made between resting mean blood pressure and resting mean heart rate, between mean heart rate and mean Borg score at the halfway point of the exercise sessions, and between mean heart rate and mean Borg score at the end of the exercise sessions.

## Null Hypotheses

1. There will be no significant changes in either resting heart rate or resting blood pressure from the initial to the median to the terminal readings of a 9-week exercise program.

2. There will be no significant changes in exercise heart rates and Borg scores taken at the halfway point of the exercise sessions from the initial to the median to the terminal readings of a 9-week exercise program.

3. There will be no significant changes in the exercise heart rates and Borg scores taken at the completion of the exercise sessions from the initial to the median to the terminal readings of a 9-week exercise program.

## Assumptions

The following assumptions were established for this study:

1. Any outside activity engaged in by subjects was considered to have no significant influence upon results.

2. Absences due to illness, vacations, or other reasons did not have an effect on training results.

3. Perceived exertion was not altered by familiarity with the rating scale.

4. All subjects were truthful in their estimations and feelings of perceived exertion.

## Definition of Terms

The following terms have been defined for the purpose of this study:

1. Borg score is a number representing the subject's rating of perceived exertion during exercise.

2. Cardiovascular exercise is an aerobic (oxygen-consuming) type of exercise that is done continuously for a specific length of time. The cardiovascular exercises used in this investigation were a walk, jog, or combination walk-jog.

3. Cardiovascular exercising heart rate is determined at the halfway point of the cardiovascular exercise period and again as the subject completes the final lap of exercise.

4. Perceived exertion is the subjective rating of how difficult a task is at a specific workload.

5. Phase I cardiac rehabilitation occurs in the intensive care unit.

6. Phase II cardiac rehabilitation is an outpatient program conducted in a hospital setting and follows Phase I.

7. Phase III cardiac rehabilitation follows Phases I and II, but is not hospital-based. It is designed as a structured holisitic program of physical conditioning and patient and family education. The emphasis is on lifelong conditioning and exercise.

8. Resting blood pressure is determined with a blood pressure cuff. It is the pressure exerted by blood against the artery wall and is measured in millimeters of

mercury (mm Hg). The measurement is taken while the subject is seated, before the start of the exercise.

9. Resting heart rate is determined by the number of beats per minute felt at either the carotid or radial artery. The measurement is taken while the subject is seated, before the start of exercise.

10. Warm-up exercises consists of stretching movements followed by walking and /or easy jogging to prepare the muscular and cardiovascular systems for more intense, sustained exercise.

## Delimitations

The following delimitations were appropriate for this study:

1. The subjects for this study were 15 adults, 2 female and 13 male, selected from those participating in the Phase III cardiac rehabilitation program at Monroe Community College (Rochester, New York). All subjects had a history of cardiovascular disease.

2. Cardiovascular exercises used were limited to a walk, jog, or combination walk-jog.

3. Only physical activity done at the cardiac rehabilitation program was monitored.

4. Subjects participated on the average of two times per week, and attended from 6 to 9 weeks, yielding 12 to 18 sets of data for each subject.

5. Heart rate, blood pressure, and rating of perceived exertion were monitored to assess intensity of each subject's exercise regimen.

## Limitations

The following limitations existed for this sutdy:

1. Absence due to illness, vacations, or other intentions caused disruption in continuity for some subjects.

2. Participants were on varying types and dosages of prescribed medication, which may have affected performance levels and/or perception of performance.

3. Different results may occur using other types of cardiovascular exercises.

4. The results of this study may be due, in part, to unmonitored, outside exercise.

5. The results of this investigation only apply to this group of cardiac patients, due to individual variances of perception.

## Chapter 2

## REVIEW OF RELATED LITERATURE

The role of physical activity in cardiovascular health has received increasing attention in recent years. The type and extent of physical training or detraining has profound implications with regard to the ability of persons to perform comfortably, safely, and successfully in recreational or competitive athletic activities. Not only is physical training prophylactic in the healthy public, but it may also increase longevity in those already afflicted with coronary heart disease (CHD) (Tavel, 1975).

This review of literature will focus on three areas of concern. Exercise, as it relates to cardiovascular disease and cardiac rehabilitation, will be covered. Exercise prescription, as it relates to cardiac rehabilitation, will also be covered. Finally, rating of perceived exertion used as a way to monitor one's stress at a given work load, and how this is utilized in a cardiac rehabilitiation program, will be discussed.

### Exercise and Cardiovascular Disease

Disease of the heart and blood vessels is one of the most common causes of death in major industrial countries (Herd, 1975). Major risk factors of CHD and cardiovascular disease are hypertension, hyperlipidemia, cigarette smoking, and electrocardiograhic (ECG) abnormalities. Predisposing problems of CHD and cardiovascular disease are family history, a sedentary lifestyle, a Type A coronary-prone behavior pattern with a stressful occupation and lifestyle, diabetes mellitus, hyperuricemia, and obesity (American College of Sports Medicine, 1980). Some of these conditions may be due to the extremely stressful life style inherent in highly technological, industrial countries. However, some of the risk factors and predisposing problems can be changed in order to improve cardiovascular health.

The three major stages of CHD are development, appearance of clinical manifestations, and finally, rehabilitation and secondary intervention (Wilson, 1975). Stage 1, development, occurs from childhood to the onset of clinical manifestations. It is during this period that preventative measures, such as exercise, proper diet, and a healthy life style should be taken. Stage 2, appearance of clinical manifestations, is usually acute in onset and life threatening. Common manifestations or events due to CHD and cardiovascular disease are sudden death, myocardial infarction, angina pectoris, congestive heart failure, ventricular arrhythmias, or a complete heart block. Diagnosis and crisis intervention techniques are utilized to save the patient. Here, the post-event course is greatly affected by the muscle damage that results and by the type of care the patient receives. During the post-event years, the underlying arterial disease process continues to progress, putting the individual at high risk for recurrence of myocardial infarction or for occurrence of sudden death. To prevent further deterioration of the patient's health, some sort of intervention is necessary. The final stage, rehabilitation and secondary intervention, begins after recovery or stabilization from the acute event, and is required for return to optimal physiological, social, and vocational well-being. In addition, further progression of the underlying disease process may be deterred or possibly prevented (Wilson, 1975).

This final stage generally consists of an exercise program and usually some form of an educational program. It is generally agreed that exercise is beneficial to both healthy and afflicted individuals, therefore, exercise is used widely in the rehabilitation of CHD patients. With stressful exercise, the body's demand for oxygen is increased. To supply the extra demand, cardiac output must be increased. The most efficient way to achieve this is by an increased stroke volume, or amount of blood pumped with each beat. After a period of training, stroke volume is increased at all levels of activity. With an increased stroke volume, the body receives the amount of oxygenated blood it requires, so the heart can beat less often (Astrand & Rodahl, 1977; Tavel, 1975). A decreased heart rate yields a lower figure for the double product (heart rate times blood pressure). The double product can be used to estimate how much oxygen is required by the myocardium. A reduced double product (reduced oxygen requirement by the myocardium) can decrease the heart's vulnerability to incidence of ischemic stress that could result in angina pectoris, infarction, or sudden death (Tavel, 1975). After an exercise conditioning program, changes can also be seen in an individual's blood pressure (Ehsani, Heath, Hagberg, Sobel, & Holloszy, 1981), particularly in hypertensives (Bonanno & Lies, 1974). In the study done by Bonanno and Lies (1974), such individuals showed a reduction in systolic blood pressure averaging 13 mm Hg (millimeters of mercury). Lower pressure helps reduce myocardial oxygen requirements. It was also found that blood pressure response to any given work load is less after endurance training.

As noted earlier, obesity and sedentary life style are two predisposing problems of CHD. Proper exercise done regularly can aid in relieving these problems. Several authors (Astrand & Rodahl, 1977; Bonanno & Lies, 1974; McHenry, 1981) reported weight loss as a result of a regular exercise program.

Finally, physical conditioning also increases the cardiac patient's self-confidence and outlook on life (Tavel, 1975). A positive, healthy attitude can facilitate recovery to a "normal" lifestyle.

McHenry (1981) investigated the effects of a 12-week cardiac rehabilitation program on body composition, heart rate, and blood pressure. Twelve individuals with documented cardiovascular disease participated in the 12-week program 3 days per week, for 45 to 60 minutes per session. During the exercise sessions, walking and bicycle ergometry were used as modes to improve cardiovascular health. McHenry found the program to be effective in significantly reducing body weight as well as chest, arm, and abdominal skinfold measurements. There were decreases in both resting heart rate and resting blood pressure. Decreases were also found in maximal heart rate and blood pressure at given levels of exercise intensity.

Costill, Branam, Moore, Sparks, and Turner (1974) studied the effects of physical training on 68 men with some form of CHD. The subjects were divided into three groups. Group A ($n$ = 24) demonstrated ST-segment depression during a multistage treadmill test. Training consisted of 30-minute sessions of running or jogging 4 days per week for 12 weeks. Training intensity had been set by using 65% to 70% of the $VO_2$max (maximum oxygen uptake X $min^{-1}$) determined by the treadmill stress test. Data on subjects in Group A were recorded at 6- and 12-week intervals after initial testing. Subjects in Group B ($n$ = 20) were characterized by the presence of signs of ischemic heart disease. They participated in no cardiovascular training program. Data on Group B were recorded at the same intervals as for Group A. Subjects placed in Group C were categorized by the investigators as being of "low physical fitness" ($VO_2$max at maximum work load < 30 ml/kg x $min^{-1}$), yet showed no ST-segment depression during exercise. Group C trained in the same manner as Group A, at the same relative intensity (65% to 70% of $VO_2$max). The results, after 12 weeks of training, showed that for Groups A and C, $VO_2$ during maximal work increased 20% and 30%, respectively. Exercise capacity, as measured by the maximal duration of a treadmill test, was significantly greater ($p < .05$) after 6 and 12 weeks of training. Training produced a bradycardia (decreased heart rate) for all submaximal exercise levels, which permitted subjects to perform more work before the onset of angina pectoris and/or ST-segment depression (both of which occurred at the same heart rate before and after training).

Both studies by McHenry (1981) and Costill et al. (1974) demonstrated positive results due to cardiovascular training programs. Results reported by Costill et al. are of particular importance. It should be noted that although angina and/or ST-segment depression still occurred, it occurred at the same heart rate before and after training. Costill et al. noted that training did produce a bradycardia. This means that the subjects may still work at fairly intense levels, but because of a lower rate at such levels, no pain or danger is present. This is a major goal of cardiac rehabilitation.

## Exercise Prescription

### Prescription Determination

Cardiac rehabilitation programs rely on individualized exercise prescriptions (generally based on graded exercise tests administered by a doctor and/or laboratory technician) that can be used along with a patient's history as a guide to a level of exercise that is safe and will enhance physical fitness, particularly cardiovascular function. The level of training is established as a percentage of functional capacity, which is best estimated by the measurement of maximal oxygen uptake ($VO_2max$). This method is rather complex and not always possible to perform. Therefore, measurements of heart rate during exercise are frequently substituted.

The ideal level of training based upon oxygen consumption is between 57% and 78% of $VO_2max$. This is comparable to a training level based on a heart rate of 70% to 85% maximal heart rate (Hellerstein, 1973; Wilson, Fardy, & Froelicher, 1981). The relationship between oxygen consumption and heart rate as a percentage of the maximum has been found to be consistent for normal individuals, athletes, and cardiac patients. This relationship is consistent, as well, for exercise involving either upper or lower extremities (Wilson et al., 1981).

Adherence to exercise heart rate prescription is necessary to maximize exercise benefits and ensure a safe training environment. Individuals with latent or overt CHD (including angina pectoris and previous infarctions) should be medically supervised, particularly during the initial phases of an exercise program (Tavel, 1975). Heart rate determinations should be taken at regular intervals throughout the exercise session. Heart rate can be obtained manually at the carotid or radial artery, with an ECG recorder, or with an accurate type of cardiotachometer (Wilson et al., 1981). Short ECG rhythm strips should be taken periodically, as they can provide accurate heart rates as well as important information about myocardial irregularities such as ventricular dysrhythmia, conduction defects, and ST-segment changes (Wilson et al., 1981).

Blood pressure also should be closely monitored. Normally, the systolic blood pressure rises in direct proportion to the intensity of exercise. When 70% of maximum heart rate is reached, the systolic blood pressure ranges from 150 mm Hg to 170 mm Hg. With levels of exertion producing 85% maximal heart rate, systolic pressure rates from 170 mm Hg to 190 mm Hg (Tavel, 1975). Indications of danger levels of blood pressure include a systolic pressure of 250 mm Hg or above, a diastolic pressure of 110 mm Hg to 120 mm Hg, or more than 20 mm Hg change in diastolic pressure (American College of Sports Medicine, 1980). Such changes necessitate cessation of the exercise.

Extreme levels of exercise also may be limited by pain or myocardial arrhythmias. If patients are closely monitored, such events can be detected and a change in exercise prescription made. Certain components of an exercise prescription may be altered to adjust the work load as necessary.

Components of Exercise Prescription

The exercise prescription takes into account an individual's present physiological condition and adjusts any of four of the five major components of exercise prescription. The five major components are type of activity, intensity, duration, frequency, and rate of progression (American College of Sports Medicine, 1980; Tavel, 1975; Wilson et al., 1981)

While the principal thrust of a cardiac rehabilitation program is directed towards enhancing cardiovascular conditioning, all-around physical conditioning, including strength, muscular endurance, and flexibility, also must be considered. The type of activities most recommended are those that use large muscle groups (preferably the lower extremities) in aerobic-type exercises (American College of Sports Medicine, 1980; Fardy & Ilmarinen, 1975). Commonly used exercise includes bicycling, running or jogging, and swimming.

Authorities differ on what is considered to be the optimal training intensity. According to the American College of Sports Medicine (1980), the activity should be of an intensity to produce 60% to 90% of maximal heart rate or 50% to 85% of $VO_2$max. However, Wilson et al. (1981) and Hellerstein (1973) stated that an exercise must produce a minimum of 60% maximal heart rate, while the optimal level is between 70% and 85% of maximal heart rate, or 57% and 78% of $VO_2$max. These authors believed the optimal level of intensity should produce sweating, an increase in rate and depth of ventilation, and a brief sense of mildly "uncomfortable" fatigue.

The third component of exercise prescription is the duration of training. There is some debate as to the minimal exercise duration that produces favorable physiological changes. Fardy and Ilmarinen (1975) and Roskamm (1967) observed that shorter sessions, between 5 and 10 minutes, produced favorable cardiovascular results, particularly for individuals with a low level of physical fitness at the outset. According to studies done by Blackburn (1971), Tavel (1975), Tooshi (1971), Wilmore, Royce Girandola, Katch, and Katch (1970), and Zohman and Gualtiere (1970), the duration of exercise necessary for training adaptations of the cardiovascular system was between 20 and 30 minutes per session. A more recent study was conducted by Ehsani et al. (1981) in which favorable results were found with initial 30-minute exercise sessions after which duration was progressively increased until patients were working continuously for 50 to 60 minutes.

It should be noted that the studies that showed 5 to 10 minutes as sufficient to produce cardiovascular changes used "healthy" subjects. Exercise is greatly influenced by a person's present level of condition (see Table 1). This may account for the differences of opinion.

The fourth component of exercise prescription is frequency, which would be the last to be altered if change is necessary. Although frequency appears less important than type, intensity, or duration, there is apparently a minimum number of days per week necessary to improve and sustain a certain level of cardiovascular fitness. There is disagreement in the literature concerning frequency of exercise training. Recommended frequencies range from as little as 2 nonsuccessive days per week (Fox, Naughton, & Gorman, 1972b; Fox, Naughton, & Haskell, 1971; Pollock, 1969; Pollock, Cureton, & Greninger, 1969) to 3 to 5 days per week (Ehsani et al., 1981; Pollock, Gettman, Milesis, Bah, Durstine & Johnson, 1977) in order to achieve cardiovascular improvements. In order to maintain a specific level of cardiovascular fitness, exercising 2 to 3 days per week was found to be necessary (American Heart Association, 1972; Blackburn, 1971; Brynteson & Sinning, 1973).

The final component, rate of progression, is obviously not something that anyone can change directly. The other four components may be altered to improve

Table 1

Sample Exercise Requirements for Achieving Cardiovascular Changes

| Subject | Intensity | Duration | Frequency |
| --- | --- | --- | --- |
| Highly Trained | 85-90% max HR[a] | 1-2 hours | 5-7 days |
| Sedentary & Cardiacs | 60-85% max HR | 15-45 min. | 3-5 days |

Note. Adapted from Blackburn (1971) and Brynteson & Sinning (1973).

[a]max HR = Maximal heart rate.

a patient's fitness level. As the level of fitness increases, so does the patient's ability to handle a greater work load. Generally, the most significant training effects are observed during the first 6 to 8 weeks of a conditioning program (American College of Sports Medicine, 1980). Therefore, periodical evaluations (a graded exercise test or an evaluation of exercise performance during the exercise sessions) should be made. These evaluations should consider a patient's history, the present physical condition, and all five of the previously mentioned components of exercise prescription: type of activity, intensity, duration, frequency, and rate of progression.

## Rating of Perceived Exertion

The concept of perceived exertion is credited to Gunnar Borg, from the Institute of Applied Psychology at the University of Stockholm, Sweden. Rating of perceived exertion is a method of selfmonitoring, which involves a subjective estimation of exertional costs of work effort (Borg & Noble, 1974). During exercise an individual reports a numeral from the Borg RPE scale (see Appendix B) that best represents his or her subjective sensation of the work intensity experienced in the current activity.

The first studies incorporating rating of perceived exertion (RPE) were done by Borg in 1970, followed by additional studies done later. A close relationship has been found to exist between heart rate and RPE (ranging from .80 to .90) (Borg, 1973; 1982a). Heart rate increases are linearly related to increases in exercise intensities. Because of such a strong relationship of heart rate and RPE, Borg orginally designed the RPE scale on this same linear basis. According to this scale (a category-ratio scale) intervals between ratings increased in equal units from an absolute 0.

Soon after Borg's scale was established, other investigations concerning its validity and reliability were conducted. One such study was carried out by

Skinner, Hutsler, Bergsteinova, and Buskirk (1973)'s. The subjects were eight lean and eight obese individuals. The training used bicycle ergometry as the method of cardiovascular exercise. Two different protocols were used: one administered normally (intensities increasing with each successive workload) and the second using randomly ordered intensities. Reliability was determined by testing each subject twice with each protocol. The testing order was of the two protocols, as well as the randomly ordered test, were assigned using a Latin square design. The recorded information for both tests were compared. There were no significant differences at the .05 level in any of the physiological and perceptual variables between the two testing protocols. These results confirmed the reliability and validity of the Borg RPE scale.

Borg & Noble (1974) conducted another study investigating the test-retest reliability of measurements of physical working capacity based on heart rate (Whr) compared to measurements based on rating of perceived exertion (Wrpe). The subjects used were a group of 9 male and 10 female cardiac patients and a group of 12 male and 5 female healthy individuals. A test using varying intensities on a cycle ergometer was administered initially to all subjects and again to all subjects 2 to 4 weeks later. Results from both groups showed high reliability coefficients between heart rate and RPE. The Whr130 (work load yielding a heart rate of 130 beats per minute) and Whr170 test-retest coefficients were .93 and .98, respectively, for the cardiac patients, and .88 and .97, respectively, for the healthy subjects. Wrpe 13 (work load yielding a rating of perceived exertion as 13) and Wrpe17 coefficients were .80 and .94, respectively, for cardiac patients, and .91 and .98, respectively, for healthy subjects. On the basis of these coefficients, Borg & Noble (1974) concluded that reproducibility, based on repeated measures, was as good for the working capacities based on heart rate as for working capacities based on RPE scores.

Borg (1982a) later constructed a new scale to be used for rating of perceived exertion (see Appendix B). According to this more recent work, RPE cannot be based on a ratio scale in which intervals between successive increments are exactly equal. Borg designed his new scale to show subjective ratings according to a positively accelerated function of physical working load. In other words, there are smaller intervals at the low-exertion end of the scale; as the work load increases, so do the intervals of the ratings.

Borg knew his new scale was valid and reliable when used with exercises of medium to long duration (based on the studies done to construct the scale). In 1982, Borg conducted a study to determine the validity and reliability of using the new RPE scale to rate intensities for work of short duration. The Wingate cycle test, which was administered in 30-second bouts of exercise, was given to 20 volunteer subjects (11 males, 9 females) who were accustomed to exercise and familiar with the Borg RPE scale. A Pearson correlation was run between maximum performances for 30 seconds and the ratings obtained during those same performances. The reliability coefficients ranged from .78 to .96. Borg concluded, therefore, that both reliable and valid ratings may be obtained during exercise of such a short duration as 30 seconds (Borg, 1982b).

Work on perceived exertion has been conducted primarily in order to attempt to improve human efficiency in performance. For example, RPE can be used in cardiac rehabilitation programs to measure patients' work capacities. The scale has diagnostic value in medicine and exercise prescription. The intensity of work or treatment can be regulated by the subject's perception of fatigue, exertion, pain, discomfort, or satisfaction. Subjects or patients can be exercised at their appropriate level, and goals can be regulated for maximum efficiency without risk of physiological damage (Borg & Noble, 1974).

## Summary

In recent years people have begun to realize the importance of exercise for a healthy life. Exercise can affect one's health at any stage; healthy people benefit as well as those afflicted with cardiovascular disease.

The best time to begin an exercise program is during young, healthy years. However, it is possible, and highly recommended, that a supervised exercise program be started after the occurrence of CHD, cardiovascular disease, or acute coronary event. Such rehabilitation programs include exercise sessions as well as educational sessions. Exercise is prescribed individually based on a cardiac stress test performed before entering the program. Once exercise has begun the patient is carefully monitored by ECG, heart rate, and/or blood pressure. Another method of monitoring patients is the rating of perceived exertion, developed by Gunnar Borg. This is a subjective measure of how hard the level of work is for a patient. By using the Borg RPE scale, the patient can subjectively rate how intensely he/she is exercising.

At any time in life exercise is important. It is particularly important to a cardiac patient in order to restore the condition of the afflicted heart muscle.

# Chapter 3

## METHODS AND PROCEDURES

The following chapter considers all the methods and procedures involved in this investigation of perceived exertion: selection of subjects, exercise program, testing instruments, treatment of data, and summary.

### Selection of Subjects

The subjects used in this study were 15 cardiac patients who were participating in the cardiac rehabilitation program at Monroe Community College, Rochester, New York. All subjects had a history of cardiovascular disease and were under their doctor's care. All subjects had completed Phase I and Phase II cardiac rehabilitation programs. Subjects were present at least 6 of the 9 weeks during which data collection took place and attended, on the average, two times per week. Informed consent forms were signed by all subjects (see Appendix A).

### Exercise Program

#### Methods

The cardiac rehabilitation program at Monroe Community College was established with the intent of designing for each patient an exercise routine constructed according to his/her individual abilities and needs. The program deals with psychosocial as well as physical needs of the participants in order to help them regain their confidence and build their physical ability to resume a normal lifestyle. The program is set up on a yearly basis, each year divided into two 6-month sessions. Session One consists of classes held twice weekly. The classes include orientation and education seminars concerning medication, smoking, food preparation, group exercise, and other related topics in cardiac rehabilitation. Session Two is a 6-month program structured for those persons who have completed

Session One. The emphasis is shifted from group exercise toward a lifelong, home plan for fitness and health.

Procedures

Subjects attended exercise classes an average of twice a week. Generally they were weighed on the 1st day of the week in which they attended the program. Immediately after this a resting blood pressure and heart rate were taken for each participant.

After the resting, or baseline, data were obtained, an exercise warm-up period took place. This lasted approximately 10 to 15 minutes and consisted of various walk-jog movements and arm, leg, and whole body stretches to prepare the muscular and cardiovascular systems for the cardiovascular exercise period. At the end of the exercise warm-up, a heart rate was recorded, as was a Borg score for this bout of exercise. (All subjects were familiar with using the Borg RPE scale, as it had been explained to them upon entering the program.)

Most of the time in the class sessions was spent on cardiovascular exercise. The method of doing laps around the gym (a walk, jog, or walk-jog program), the work load, and the duration were prescribed by the program director and the patient's physician. The work load prescriptions were based on a stress test administered before the patient entered the program. Through the stress test, a maximum heart rate was determined and a percentage of the maximum was calculated, yielding the exercise prescription. Most patients exercised at a work load resulting in 60% to 80% of maximum heart rate. The duration of this cardiovascular exercise period varied from subject to subject, ranging between 35 and 72 minutes. A cardiovascular exercising heart (pulse) rate and Borg score were taken halfway through the exercise period (according to distance), and again as the last lap was being completed. Upon completion of the cardiovascular exercise bout, the subjects completed two or three cool down, easy walking laps. Each class ended with a brief lecture period. Lectures dealt with various aspects of cardiovascular disease, exercise, diet, and other topics.

For the purposes of this investigation, all data were copied and made available to the investigator, who could not be present at all class sessions.

## Testing Instruments

The Borg RPE scale was first developed as a subjective method of determining work intensity with regard to oxygen consumption and heart rate (Borg, 1970). This scale has been shown to correlate with heart rate ($r$ = .85) (Borg & Noble, 1974). However, this scale did not follow the true growth of perceived intensities with increased work loads. Therefore, there have been several revisions of the Borg RPE scale, the most recent being the one used in this study (see Appendix B) (Borg, 1982a; Noble, Borg, Jacobs, Ceci, & Kaiser, 1983). Despite the fact that the new scale is not a linear scale, it has been found that ratings are related linearly to heart rate as it responds to increasing levels of exercise (Noble et al., 1983).

## Treatment of Data

Analysis of variance (ANOVA) was used to test for any significant physiological changes or changes in Borg RPE over the course of a 9-week cardiac rehabilitation program. The variables analyzed included resting heart rate, resting blood pressure, exercising heart rate halfway through the cardiovascular conditioning period, heart rate at the end of the cardiovascular conditioning period, Borg RPE score halfway through the cardiovascular conditioning period, and Borg RPE score at the end of the cardiovascular conditioning period. All variables were recorded for the initial, median, and terminal sessions attended by each subject. Statistical significance was set at $p < .05$.

## Summary

Fifteen participants of Monroe Community College's cardiac rehabilitation program (Rochester, New York) served as subjects for this study. Over a 9-week period, data were collected on resting heart rate, resting blood pressure, exercising heart rates, and Borg rating of perceived exertion scores during exercise. The data were analyzed using analysis of variance to determine statistically significant changes in variables over time.

## Chapter 4

## RESULTS

The purpose of this study was to investigate the effects of 9-week cardiac rehabilitation program on resting blood pressure, resting heart rate, exercising heart rate, and rating of perceived exertion during exercise. The data collected in this study were gathered on 15 members selected form those participating in the cardiac rehabilitation program at Monroe Community College (Rochester, New York). Thirteen men and two women served as subjects for this sutdy. These sets of data were recorded. The first set was for each participant's initial exercise session, set two was for the median session, and set three for the terminal session. The data collected were analyzed statistically, and the results are presented in this chapter.

### Resting Variables

An analysis of variance (ANOVA) was utilized for each of the variables to test for any significant changes in the values for resting parameters (see Tables 2 and 3) These resting parameters included resting heart rate and mean blood pressure. All hypotheses here and through out the study were tested at the .05 level of significance.

Resting heart rate increased somewhat from the initial to the median readings, then decreased slightly from the median to the terminal readings (see Table 2). This change, however, was not statistically significant (See Table 3).

Resting mean blood pressure was the second resting variable considered. This was calculated as follows:

DIASTOLIC + (SYSTOLIC - DIASTOLIC) / 3.

A decrease from the initial to median readings was found, followed by a slight increase from the median to terminal readings (see Table 2). These were not

Table 2

Descriptive Statistics for Resting Variables

| Reading | Variables | M | SD |
|---|---|---|---|
| Initial | RHRate [a](beats/min) | 73 | 15 |
| | BPMean [b](mm Hg) | 95 | 9 |
| Median | RHRate (beats/min) | 77 | 21 |
| | BPMean (mm HG) | 89 | 11 |
| Terminal | RHRate (beats/min) | 76 | 17 |
| | BPMean (mm Hg) | 90 | 12 |

[a]Resting heart rate.
[b]Mean Blood pressure.

Table 3

ANOVA Table for Resting Variables

| Variable | Source of Variatiion | SS | df | MS | F |
|---|---|---|---|---|---|
| RHRATE[a] | Treatment | 88.7 | 2 | 44.3 | .8 |
| | Error | 1471.3 | 13 | 52.5 | |
| BPMean[b] | Treatment | 366.9 | 2 | 183.5 | 2.6 |
| | Error | 1471.5 | 13 | 52.5 | |

[a]Resting heart rate.
[b]Mean blood pressure.

statistically significant (see Table 3). Results of these data indicate that the hypothesis of no significant changes in either resting heart rate or resting blood pressure from initial to median to terminal readings of the 9-week exercise program should be accepted.

Exercising Variables

An ANOVA was also run with each subject's initial, median, and terminal values for exercising variables (see Tables 4-6). The exercising variables used in this study were heart rate and Borg score, both of which were taken halfway through each exercise session and at the end of each session.

Exercising heart rate halfway through exercise sessions showed a decrease from the initial to median values, followed by a slight increase from median to terminal values. Final heart rate decreased progressively (see Table 4). Neither of these changes, however, was statistically significant (see Tables 5 and 6).

Initially, the results from Borg scores at the halfway point and upon completion yielded an *F* value so close to 0 that it was hypothesized the assumption of homogeneity of variance was not being met. A Hartley's *F*-max test was performed, and results indicated that what had been hypothesized was correct. The ANOVA was then altered to perform calculations on the square root of each Borg score. Still, there was so little variation in Borg scores that no statistically significant changes could be found (see Tables 5 and 6).

Results of these data indicate that the hypothesis of no significant changes in exercise heart rates and Borg scores taken halfway through exercise sessions from the initial to the median to the terminal readings of the 9-week exercise program should be accepted. The hypothesis that stated that there would be no significant changes in exercise heart rates and Borg scores taken at the completion of the exercise sessions from the initial to the median to the terminal readings of the 9-week exercise program was also accepted.

Table 4

Descriptive Statistics for Exercising Variables

| Reading | Phase of Exercise | Variable | M | SD |
|---|---|---|---|---|
| Initial | Halfway | HRate[a] (beats/min) | 116.0 | 24.0 |
| | Halfway | Borg Score | 3.6 | .4 |
| | Final | HRate (beats/min) | 117.0 | 24.0 |
| | Final | Borg Score | 4.2 | .5 |
| Median | Halfway | HRate (beats/min) | 113.0 | 20.0 |
| | Halfway | Borg Score | 3.6 | .3 |
| | Final | HRate (beats/min) | 116.0 | 18.0 |
| | Final | Borg Score | 4.1 | .4 |
| Terminal | Halfway | HRate (beats/min) | 117.0 | 22.0 |
| | Halfway | Borg Score | 4.0 | .1 |
| | Final | HRate (beats/min) | 112.0 | 22.0 |
| | Final | Borg Score | 4.2 | .2 |

[a]Heart rate.

Table 5

ANOVA Table for Exercising Variables Halfway through Exercise Sessions

| Variable | Source of Variation | SS | df | MS | F |
|---|---|---|---|---|---|
| HRate[a] | Treatment of Variation | 3.2 | 1 | 3.2 | .06 |
| | Error | 754.9 | 14 | 53.9 | |
| BorgSQRT[b] | Treatment | .163 | 1 | .163 | 2.5 |
| | Error | .915 | 14 | .654 | |

[a]Heart rate.

[b]Square root of the Borg score.

Table 6

ANOVA Table for Exercising Variables

upon Completion of Exercise Sessions

| Variable | Source of Variation | SS | df | MS | F |
|---|---|---|---|---|---|
| RHRate[a] | Treatment | 73.3 | 2 | 36.6 | .27 |
| | Error | 5847.1 | 13 | 208.8 | |
| BorgSQRT[b] | Treatment | .4 | 2 | .2 | .16 |
| | Error | 2.3 | 13 | .8 | |

[a]Heart rate.
[b]Square root of the Borg score.

## Analysis of Figures

As stated, no statistically significant changes were found for any single variable. Therefore, comparisons were made between the patterns of mean heart rate and resting mean blood pressure, mean heart rate and mean Borg score at the halfway point of the exercise sessions, and mean heart rate and mean Borg score at the end of the exercise session as they were plotted over the data collection period. These comparisons are illustrated in Figures 1, 2, and 3.

An inverse pattern was seen in the relationship between the resting variables (see Figure 1). From the initial reading to the median, as heart rate increased, blood pressure decreased. From the median to the terminal reading, as heart rate decreased, blood pressure increased. Overall, from initial to terminal readings there was a slight increase in heart rate and a slight decrease in blood pressure.

Figure 2 shows no similarities between heart rate and Borg score recorded for the halfway point of the exercise session. The heart rate decreased from initial to median reading, then increased from median to terminal. The Borg score gradually increased from initial to median to terminal readings. Overall, from initial to terminal, there was a slight increase in both variables.

Neither were there any similarities between heart rates and Borg scores taken upon completion of the exercise sessions (see Figure 3). As heart rate decreased, both from initial to median and from median to terminal, the average of recorded Borg scores remained relatively constant.

## Summary

Analyses of both resting and exercising variables showed no statistically significant changes from the initial to the median to the terminal readings from the 9-week cardiac rehabilitation program. Some slight changes were detected by graphing the mean values of the resting and exercise variables for the initial, median, and terminal readings. However, no consistent patterns were found among any of the variables.

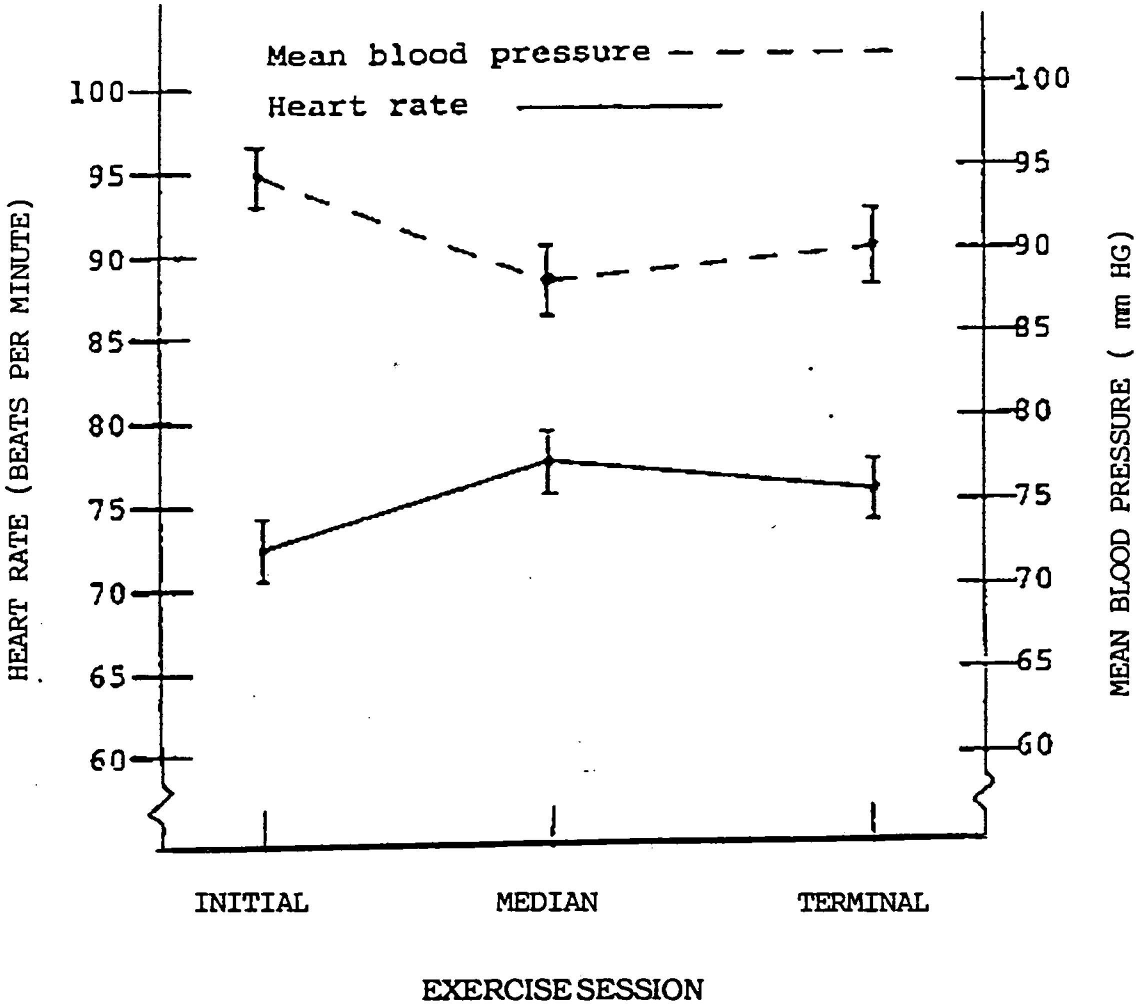


Figure 1. Resting heart rates and blood pressures over 9 weeks.

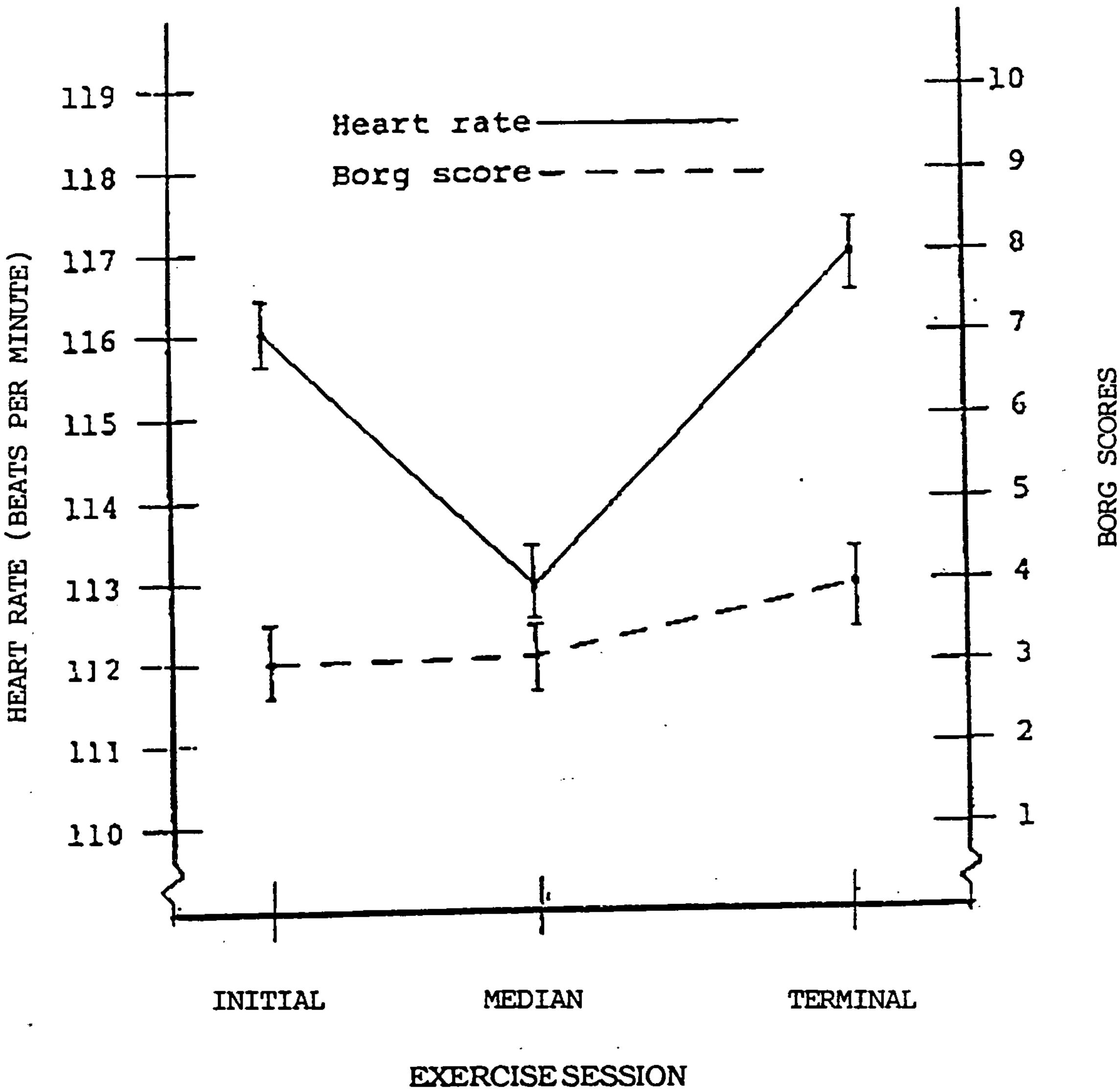


Figure 2. Heart rates and Borg scores halfway through exercise periods over 9 weeks.

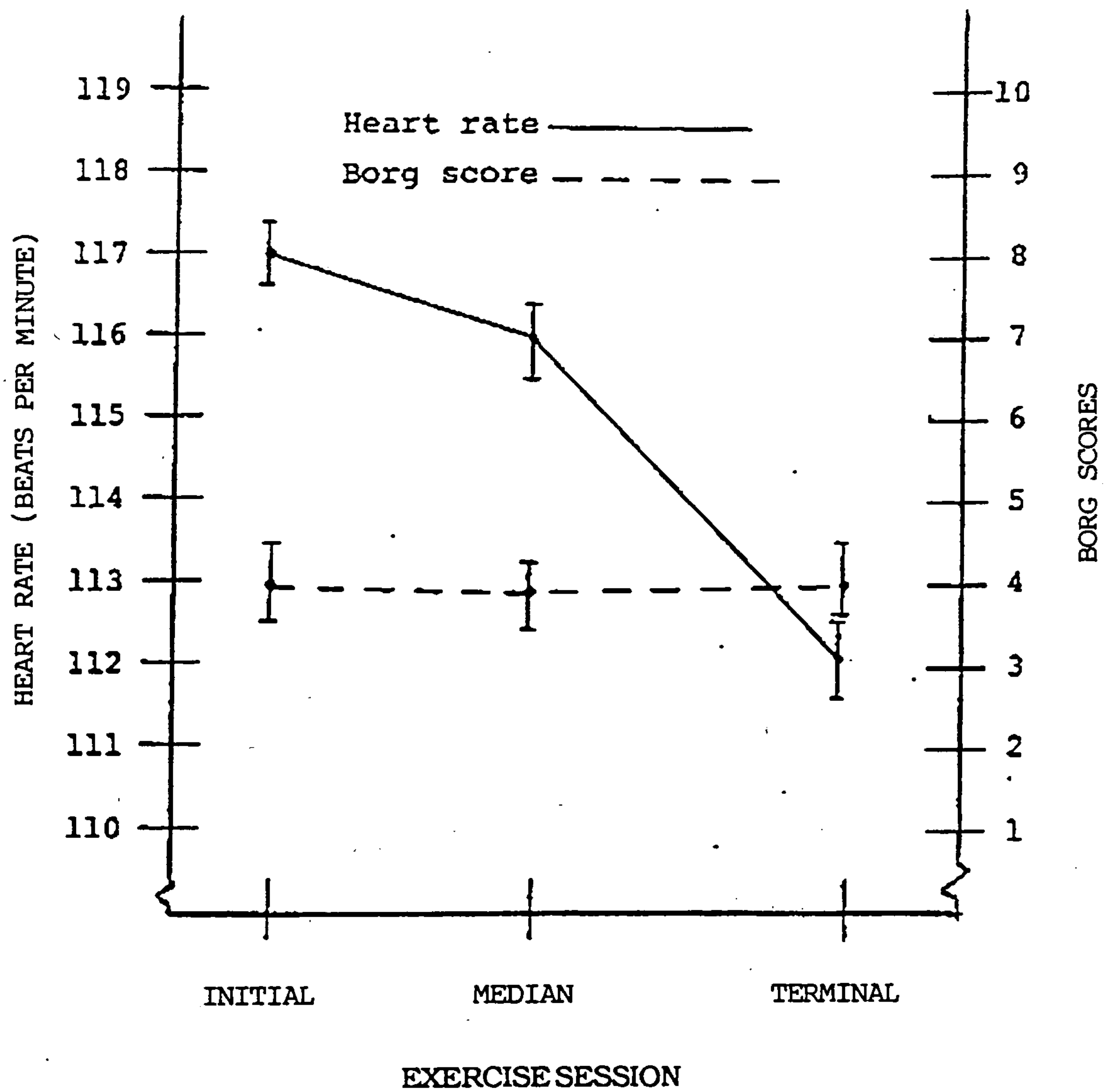


Figure 3. Heart rates and Borg scores upon completion of exercise periods over 9 weeks.

## Chapter 5

## DISCUSSION OF RESULTS

The purpose of this study was to investigate the effects of a 9-week cardiac rehabilitation program on cardiac patients with documented cases of cardiovascular disease. The 15 subjects were participating in an established cardiac rehabilitation program at the onset of the data collection period used for this study. Readings were taken for resting heart rate, resting blood pressure, exercising heart rate, and rating of perceived exertion during exercise at the initial, median, and terminal points of the 9-week period. The mean for all 15 subjects, at each of the three points for each of the variables, was then used to examine the changes which resulted.

For this study statistical significance was set at the .05 level. Although changes were seen in all except one of the means of the variables, none of the changes showed statistical significance at the level set. Ideally, the effect of aerobic conditioning over a period of time would be to reduce both the resting and exercising variables studied in this investigation. Results of resting and exercising variables are reviewed, followed by possible explanations of the results.

### Resting Variables

Means and standard deviations of the resting variables were presented in Table 2, and these two variables were compared graphically in Figure 1. Resting heart rate showed an increase from the initial to the median readings that was followed by a decrease from the median to the terminal readings, resulting in an overall slight increase. Blood pressure followed a pattern opposite that of heart rate. A decrease from the initial to the median readings was followed by an increase from the median to the terminal readings, resulting in an overall slight decrease.

According to Tavel (1975) and Bonanno and Lies (1974), a decrease in both heart rate and blood pressure should be seen as a result of a cardiovascular training program. A decrease in the double product (heart rate times blood pressure) decreases myocardial oxygen requirements which, in turn, decreases the heart's vulnerability to ischemic stress and possible infarction. The results of this study, however, show no similarity between resting heart rate and resting blood pressure and no continuous decreases in either resting heart rate or blood pressure. Had there been some parallelism between heart rate and blood pressure it would have been possible to make deductions consistent with earlier findings. Due to the inverse relationships, however, these are not possible.

Exercising Variables

The exercise program used in this study incorporated two methods of evaluating levels of work intensity: an exercising heart rate and Borg RPE scores. Regarding data taken halfway through exercise sessions (see Table 4 and Figure 2), no similarities were found between exercising heart rates and Borg scores. Heart rate showed a decrease from the initial to the median reading, followed by an increase from the median to the terminal reading. Borg scores increased from initial to median, and increased still more from the median to terminal readings. Both variables resulted in overall slight increases.

Regarding data taken upon completion of the exercise sessions (see Figure 3), there was again no similar pattern found between exercising heart rates and Borg scores. While a continuous decrease was recorded for heart rates, almost no changes occurred in Borg scores taken upon completion of the exercise sessions. While it was encouraging to see a decrease in exercising heart rate taken at the end of the exercise sessions, this did not correspond either to that of the Borg scores at the end of the exercise session or to those found for heart rate and Borg scores taken halfway through the exercise sessions.

Possible Explanations

On the basis of results from other studies, a decrease in the means of all variables (for the initial reading through the median to the terminal) was anticipated. Such results did not occur with any consistency among variables in this study. While decreases in any variable may be explained as a training effect of the cardiovascular conditioning program, contrary results regarding the variables are subject to conjecture; the following will present possibilities.

The number of subjects ($n$ = 15) may have been insufficient to yield results which agree with most reported literature dealing with a similar topic. Secondly, on the average, subjects attended classes two times per week. According to some investigators (Fox, Naughton, & Gorman, 1972a; Fox et al., 1971; Pollock, 1969; Pollock et al., 1969) 2 days per week is sufficient to see such physiological changes as decreased heart rate and blood pressure. However, a later study by Pollock et al. (1977) revealed that 3 to 5 days per week is required to yield cardiovascular improvements.

Another possible reason for the unexpected results relates to changes in exercise prescription. An increase (or decrease) in duration or intensity could have a significant effect on the recorded variables. During the course of the 9-week data collection period, changes in exercise prescriptions were made by the director of the rehabilitation program. These were beyond the control of the investigator. Of the 15 subjects, 6 were given an increase, 4 a decrease, and 5 remained the same. It is impossible to know to what extent the changes of the 10 exercise prescriptions influenced the outcome of this study.

Results of this study would have been affected if inaccurate Borg scores were reported by the subjects. The subjects were all very familiar with the Borg rating of perceived exertion scale. All patients knew there was supposed to be a close relationship between heart rate and Borg score. All patients had target heart rates (i.e., heart rates at which they should be exercising). It may have been possible that, knowing these things, patients automatically reported the same Borg score each time it was taken without giving careful consideration to its accuracy.

Finally, absenteeism could have been an influencing factor. Continuity is one criterion necessary for a training effect; this condition was not met by all subjects participating in this study. Due to illness, vacation, or other such reasons, subjects occasionally missed classes. It is possible that this condition may be partially responsible for unexpected results.

## Summary

This investigator can only conjecture as to why the results found in this study vary so greatly from those found in other studies. Possible explanations include an insufficient number of subjects, a training frequency level too low to yield significant results, changes in exercise prescriptions, inaccurately reported Borg scores, and breaks in exercise continuity due to absences. Any or all of these conditions may have contributed to the unanticipated results found in this study. There is always the possibility that other conditions, unknown to this investigator, also could have contributed to the results.

Chapter 6

# SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER STUDY

## Summary

The investigator used 15 cardiac patients participating in a cardiac rehabilitation program at Monroe Community College (Rochester, New York) as subjects. Data were collected on resting heart rate and blood pressure, and on exercising heart rate and Borg RPE. Readings were taken at the initial, median, and terminal points of a 9-week period. Resting rates were taken at the beginning of each exercise session. Exercise heart rate and RPE were taken both halfway through and upon completion of each session.

Data were analyzed by analysis of variance (ANOVA). No statistically significant changes were found for any of the resting variables. Resting heart rate increased only slightly from the initial to the median readings, then decreased somewhat less from median to terminal readings, with an overall slight increase. Resting blood pressure values showed a decrease from the initial to the median readings, then a slight increase form the median to the terminal readings, with an overall slight decrease. When comparisons were made between resting mean heart rate and resting blood pressure, an inverse pattern was seen.

Results of the exercising variables showed no significant change either. Exercising heart rate halfway through exercise sessions showed a slight decrease from the initial to the median readings, followed by an increase from the median to the terminal readings, with a slight increase overall. Borg scores taken halfway through the exercise sessions showed a progressive increase from the initial through the median to the terminal readings.

Exercising variables recorded at the end of exercise sessions also showed no statistically significant changes. Heart rate did, however, decrease progressively from the initial to the terminal readings. Recorded Borg scores remained relatively constant.

According to authoritative literature, there should have been decreases in resting blood pressure, resting and exercising heart rates, and ratings of perceived exertion. It is possible that these changes did not reach statistical significance in this study for a number of reasons: an insufficient number of subjects, a training frequency level too low, changes in exercise prescription, inaccurately reported Borg scores, and breaks in exercise continuity due to absences.

## Conclusions

Within the realm of this investigation, the following conclusions were drawn:

1. There were no significant changes in either resting heart rate or resting mean blood pressure from the initial to the terminal point of the 9-week period.

2. There were no significant changes in mean heart rates or Borg scores recorded halfway through exercise sessions from the initial to the terminal point of the 9-week period.

3. There were no significant changes in mean heart rates or Borg scores recorded at the completion of exercise sessions from the initial to the terminal point of the 9-week period.

## Recommendations for Further Study

Should further studies be done with similar purposes, the following recommendations are made:

1. Future studies should involve larger samples.

2. Subjects should participate three times a week throughout the data collection period.

3. Exercise prescriptions should remain constant for all subjects throughout the data collection period.

4. A study should be done to determine any significance in results for heart rates, blood pressures, and Borg scores at varying exercise intensities.

5. A study should be done comparing various modes of cardiovascular exercise for cardiac patients, such as bicycle ergometry, swimming, and a walk-jog program.

6. A study should be done with regard to weight and body composition changes in cardiac patients participating in a rehabilitation program.

7. A study should be done to determine the effects of exercise on different age groups involved in a cardiovascular training program.

## Appendix A

INFORMED CONSENT FORM

1. a) Purpose of the study: To investigate the effects of a 9-week cardiac rehabilitation program on resting blood pressure, resting heart rate, exercising heart rate, and rating of perceived exertion during exercise.

b) Benefits: Once this technique is learned the patient should be able to more accurately adjust the intensity of the exercise being performed. He/She may also be able to better judge increments of improvement as the rating of perceived exertion for any given level of exercise decreases.

2. Methods: After exercising for a specific amount of time, subjects will be asked to record a Borg score. A record will be kept of these scores and additional physiological information: body weight, blood pressure, heart rate, estimated heart weight, heart ratio, and estimated stroke volume. All information will be plotted to show any changes throughout the course of this investigation.

3. Will this hurt? The methods and procedures used in this study show no evidence of physical or psychological risks.

4. Need more information? Additional information can be obtained from either Marcianne Hanson (607) 272-0620 or Dr. Roscoe Hastings (424-5200, ext. 6108 or 6134). All questions are welcomed and will be answered.

5. Withdrawal from the study: Participation is voluntary. You are free to withdraw your consent and discontinue at any time.

6. Will the data be maintained in confidence? All data will be confidential. Once data are collected, names of subjects will be discarded and replaced by subject number (e.g., Subject 7). Data will be analyzed by group, not by individual subject.

7. I have read the above and I understand its contents and I agree to participate in the study. I acknowledge that I am 18 years of age or older.

____________________ Signature

____________________ Date

Appendix B

BORG RATING OF PERCEIVED EXERTION SCALE

| SCORE | INTERPRETATION | |
|---|---|---|
| 0 | Nothing at all | |
| 0.5 | Very, very weak | (just noticeable) |
| 1 | Very weak | |
| 2 | Weak | (light) |
| 3 | Moderate | |
| 4 | Somewhat strong | |
| 5 | Strong | (heavy) |
| 6 | | |
| 7 | Very strong | |
| 8 | | |
| 9 | | |
| 10 | Very, very strong | (almost maximal) |
| . | Maximal | |

Note. Information from Borg, 1982a.

Appendix C

RAW DATA

| Sub. # | Sys. BP | Dia. BP | Borg 1 | Borg 2 | RHR | HR1 | HR2 |
|---|---|---|---|---|---|---|---|
| 1 | 148 | 84 | 5.0 | 5.0 | 108 | 140 | 140 |
| 1 | 124 | 60 | 5.0 | 5.0 | 116 | 140 | 144 |
| 1 | 140 | 78 | 4.0 | 4.0 | 116 | 140 | 140 |
| 2 | 122 | 74 | 4.0 | 4.0 | 48 | 108 | 116 |
| 2 | 110 | 66 | 5.0 | 5.0 | 48 | 124 | 124 |
| 2 | 104 | 60 | 4.0 | 4.0 | 56 | 104 | 112 |
| 3 | 138 | 80 | 4.0 | 4.0 | 68 | 152 | 168 |
| 3 | 124 | 76 | 3.0 | 3.0 | 68 | 140 | 120 |
| 3 | 138 | 70 | 4.0 | 4.0 | 72 | 160 | 144 |
| 4 | 118 | 70 | 3.0 | 4.0 | 84 | 104 | 96 |
| 4 | 110 | 74 | 3.0 | 3.0 | 76 | 107 | 115 |
| 4 | 122 | 68 | 4.0 | 4.0 | 88 | 108 | 96 |
| 5 | 122 | 88 | 2.0 | 1.0 | 84 | 116 | 108 |
| 5 | 130 | 80 | 2.0 | 1.0 | 96 | 108 | 112 |
| 5 | 120 | 80 | 4.0 | 3.0 | 80 | 100 | 96 |
| 6 | 108 | 70 | 5.0 | 5.0 | 60 | 130 | 148 |
| 6 | 104 | 64 | 5.0 | 5.0 | 60 | 124 | 116 |
| 6 | 114 | 62 | 5.0 | 5.0 | 56 | 152 | 148 |
| 7 | 120 | 74 | 3.0 | 6.0 | 60 | 88 | 76 |
| 7 | 130 | 78 | 4.0 | 6.0 | 60 | 88 | 112 |
| 7 | 148 | 84 | 4.0 | 4.0 | 60 | 96 | 97 |

Appendix C (continued)

| Sub. # | Sys. BP | Dia. BP | Borg 1 | Borg 2 | RHR | HR1 | HR2 |
|---|---|---|---|---|---|---|---|
| 8 | 148 | 96 | 2.0 | 3.0 | 64 | 92 | 116 |
| 8 | 114 | 78 | 3.0 | 4.0 | 60 | 88 | 112 |
| 8 | 114 | 82 | 4.0 | 4.0 | 72 | 88 | 72 |
| 9 | 138 | 68 | 1.0 | 1.0 | 60 | 72 | 84 |
| 9 | 110 | 64 | 3.0 | 3.0 | 60 | 72 | 60 |
| 9 | 110 | 54 | 3.0 | 4.0 | 64 | 88 | 92 |
| 10 | 128 | 80 | 5.0 | 5.0 | 72 | 132 | 120 |
| 10 | 154 | 82 | 4.0 | 4.0 | 80 | 120 | 124 |
| 10 | 116 | 70 | 3.0 | 4.0 | 64 | 128 | 112 |
| 11 | 124 | 80 | 2.0 | 7.0 | 92 | 104 | 124 |
| 11 | 98 | 54 | 3.0 | 5.0 | 96 | 124 | 128 |
| 11 | 104 | 56 | 4.0 | 4.0 | 76 | 115 | 107 |
| 12 | 124 | 80 | 5.0 | 5.0 | 68 | 150 | 115 |
| 12 | 120 | 80 | 5.0 | 6.0 | 52 | 124 | 132 |
| 12 | 138 | 74 | 4.0 | 4.0 | 60 | 108 | 104 |
| 13 | 110 | 70 | 4.0 | 4.0 | 84 | 108 | 108 |
| 13 | 118 | 64 | 4.0 | 4.0 | 92 | 110 | 108 |
| 13 | 104 | 70 | 4.0 | 4.0 | 84 | 125 | 125 |
| 14 | 120 | 78 | 5.0 | 6.0 | 72 | 132 | 136 |
| 14 | 132 | 78 | 5.0 | 5.0 | 80 | 128 | 116 |
| 14 | 138 | 88 | 5.0 | 6.0 | 88 | 132 | 132 |
| 15 | 158 | 90 | 6.0 | 6.0 | 76 | 104 | 100 |
| 15 | 154 | 96 | 5.0 | 5.0 | 106 | 92 | 112 |
| 15 | 138 | 90 | 4.0 | 5.0 | 100 | 112 | 112 |

Appendix C (continued)

Note. Subject number is given three (3) times; the row corresponding to the first appearance represents data for the initial reading; the second appearance represents data for the median reading; the third appearance represents data for the terminal reading.

Note. Abbreviations: Sys.BP = Systolic blood pressure; Dia.BP = Diastolic blood pressure; Borg1 = Borg score reported halfway through exercise session; Borg2 = Borg score reported upon completion of exercise; HR1 = Heart rate recorded halfway through exercise session; HR2 = Heart rate recorded upon completion of exercise; RHR = Resting heart rate.

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