CARDIOVASCULAR RESPONSE TO A CARDIAC REHABILITATION EXERCISE PROGRAM

by

Anne Marie Gassmann

A Thesis Submitted to the Faculty of the

COLLEGE OF NURSING

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 7 6

STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Anne Marie Gassmann

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

Alice J. Longman
ALICE J. LONGMAN
Associate Professor of Nursing

February 18, 1976
Date

ACKNOWLEDGMENTS

This paper is dedicated to all persons with cardiac problems with the hope that nursing research will add to the body of knowledge that will improve their level of health.

I would like to thank my committee, Dr. Alice Longman, R. N., Dr. Karen Sechrist, R. N., and Dr. Larry Buckels, M. D., for their generous support and encouragement. A special note of appreciation also goes to the staff and patients at the Cardiac Rehabilitation Center at Saint Joseph's Hospital.

TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

LIST OF TABLES

ABSTRACT

The relationship between three months' participation in a cardiac rehabilitation exercise program and cardiovascular function, as measured by a treadmill exercise stress test, was studied. The purpose of this investigation was to evaluate the cardiovascular conditioning response to an existing program. Nurses and other members of the health team can use this information to provide more comprehensive care to patients with cardiac problems.

The sample consisted of 36 subjects who had a treadmill exercise stress test, participated for three months in an exercise program, and then had a repeat treadmill exercise stress test. Information regarding the cardiovascular parameters of heart rate, blood pressure, electrocardiogram, and maximal double product was obtained from the records of both sets of tests, and the relationships between the values at the time of the first test and the second test were analyzed.

The diastolic blood pressure at three minutes post-exercise was significantly lower after participation in the exercise program. The pre-exercise resting heart rate, systolic and diastolic blood pressures, as well as the post-exercise systolic blood pressure decreased. Significant increases in duration of exercise and exercise stage achieved were demonstrated. The increase in maximal double product was attributed to its measurement at the increased exercise levels. Some improvement in electrocardiograms as measured by the Minnesota Code was shown.

CHAPTER 1

INTRODUCTION

Heart disease is the leading cause of death in the United States. For those whom it does not kill, coronary heart disease can cause great physical and emotional dysfunction. Coronary heart disease is caused by an individual's combination of certain factors. Reduction and prevention of coronary heart disease depends on effective management of these risk factors, including cigarette smoking, obesity, hyperlipidemia, hypertension, insufficient regular exercise, diabetes mellitus, and personality.

Health professionals have a great responsibility to develop effective preventive and therapeutic coronary heart disease control measures. Cardiac rehabilitation programs have been designed to meet this need. Naughton (1975:51) has defined cardiac rehabilitation as "that process by which a patient is restored to and maintained at optimal physiologic, psychologic, social, and vocational status."

In order to meet all of the needs of these patients, a cardiac rehabilitation program must be comprehensive. Among the services to be included are cardiac evaluation, education, and an exercise program. Cardiac evaluation is accomplished by an exercise stress test in order to detect coronary heart disease and to assess cardiovascular fitness. Educational programs are aimed at reducing risk factors and preventing heart disease. Exercise programs are designed to include cardiac patients, high risk factor patients, and interested normal subjects. Cardiac patients include those with arteriosclerotic heart disease, stable angina pectoris, previous myocardial infarction, and post-operative cardiac surgical patients. The purposes of exercise training programs are to prevent deterioration of the patient's physical condition during the convalescent phase and to increase physical work capacity. This would enhance the quality of life by increasing the patient's capabilities for work and leisure activities. Exercise programs are also aimed at increasing cardiac performance and reducing coronary risk. In addition, such programs restore self-confidence and reduce fear and apprehension in cardiac patients. Hellerstein (1968: 1029) summarized these purposes in stating that cardiac rehabilitation programs can "add life to years and perhaps add years to life."

Cardiac rehabilitation is accomplished through a team effort, involving the patient and health professionals, and nurses are an integral part of this team. The chief nursing roles are patient and family education and counseling. In addition to utilizing technical skills, nurses in these settings are able to recognize and alleviate emotional distress and to reinforce feelings of confidence and competence. Perhaps the nurse is the staff member whom the patient encounters most frequently and thus is best able to provide continuity of care.

Problem

What is the relationship between three months' participation in a cardiac rehabilitation exercise program and cardiovascular function, as measured by a treadmill exercise stress test?

Statement of Purpose

The purpose of this study was to evaluate the effectiveness of an existing cardiac rehabilitation exercise program. Only one aim of the program, cardiovascular conditioning, was examined.

The information obtained can be useful in several ways. First, the patients in the program would have evidence of their progress, and thus their confidence and incentive can be increased. Secondly, the results would provide the directors of the program with information as to whether or not they were accomplishing their aims for the program. The results of this study might also point out to other health professionals and to the public the importance and usefulness of such an exercise program.

Definitions

1. A <u>cardiac rehabilitation exercise program</u> is a physician supervised, individually prescribed regime of regular exercise, consisting of walking or jogging, three times a week. A target pulse rate is set as the target and limit for exercise, and telemetry monitoring is maintained.
2. <u>Cardiovascular function</u> consists of the following parameters:
   a. Pulse rate is the heart rate in number of beats per minute.
   b. Blood pressure is the pressure exerted by the blood on the wall of the brachial artery as measured in millimeters of mercury. The diastolic blood pressure is that existing during the relaxation phase. The systolic blood pressure

is that created by the ejection phase of left ventricular contraction.

c. A standard 12-lead electrocardiogram records the electrical impulses that stimulate the heart to contract.

d. The maximal double product is the product of the maximal recorded systolic blood pressure times the maximal recorded heart rate times 10^{-2}.

3. A <u>treadmill exercise stress test</u> is a multistage test in which the subject performs graded levels of activity of gradually increasing intensity on an electrically-driven treadmill until a predetermined endpoint is reached.

Limitations

1. No attempts were made for randomization of subjects.
2. Data were collected through a retrospective review of information recorded on subjects' charts.
3. Some parameters of cardiovascular function were not measured.
4. Other types of response to the exercise program, including metabolic, psychological, and neuromuscular, were not measured.

Theoretical Framework

The physiology of exercise consists of those chemical and physical processes which occur to transform chemically bound energy into mechanical energy. The main sources of energy are carbohydrate and fat. The carriers of energy within the cell are adenosine triphosphate (ATP) and creatine phosphate. Glycogen is a third source of energy. The cell's primary source of energy is the terminal phosphate group of ATP. The energy released from these sources is transformed into mechanical work, that is, the contraction of skeletal muscle fibers.

According to Phillips (Zohman and Phillips 1973:7), there are three phases of exercise in relation to energy production. The first phase of exercise depends on phosphagenic energy. With strenuous exercise, phosphagen stores are significantly reduced, and after 15 seconds they are largely expended, particularly creatine phosphate. This type of energy is used for short-term exercise. To continue exercise, energy from other sources must be used.

The second phase of exercise utilizes aerobic energy. ATP is resynthesized from adenosine diphosphate (ADP) and adenosine monophosphate (AMP) by the energy derived from oxidative phosphorylation. The energy from oxidative processes makes a significant contribution to sustained muscular contraction after about 10 to 15 seconds. This slow increase in oxygen uptake at the beginning of exercise is due to the sluggish adjustment of the oxygen transporting systems. For light to moderate exercise, energy during the first minutes of exercise can be delivered aerobically. The necessary oxygen is stored in the muscles bound to myoglobin and in the blood perfusing the muscles. The energy derived reaches a peak in about three minutes at any submaximal level of sustained effort. At this point, oxygen uptake equals the oxygen used by the tissues, and a steady state is reached. Steady state work may be carried out for prolonged periods of time without an oxygen lack developing.

The attainment of maximal work requires maximum oxygen uptake, which equals the maximal aerobic power of an individual. Maximum oxygen uptake equals the point at which oxygen consumption plateaus. At this steady state of oxygen uptake, there is no further increase in oxygen uptake despite further increases in work load. The maximal oxygen uptake (VO_2 max) is a function of the maximal capacity to transport oxygen to the tissues. A well-trained individual can maintain a steady state at relatively high work loads because of more efficient oxygen transport and utilization in working muscles.

The third phase of exercise derives its energy from anaerobic processes. Through the process of glycolysis, ADP is rephosphorylated and lactate is produced. Lactate production from glucose makes no significant contribution to heavy muscular effort in the first 15 seconds but reaches a peak in about 35 seconds. The rate of glycolysis is directly proportional to the amount of work, up to a maximal level. Lactic acid formation can lead to acidosis. The accumulation of lactate in working muscle decreases the effectiveness of contraction, therefore rest periods between work levels allow time for lactate to diffuse into the total body pool and increase exercise tolerance. During very severe exercise, muscle may use lactate as a fuel substrate, and the heart is particularly effective in utilizing lactate as a direct energy source.

There is an interplay between aerobic and anaerobic processes in varying levels of exercise; any given work load requires a specific amount of energy. With light exercise, aerobic processes can provide the energy. With more severe exercise, anaerobic processes supply part of the energy during the early phase of work and continuously throughout exercise. The heavier the work load, the more important is the anaerobic energy contribution. Blood lactate concentration increases and lowered pH affects muscle tissue and respiration. The work becomes subjectively more strenuous.

The circulatory system performs several functions in maintaining physical activity. These include delivery of metabolic substrates, removal and redistribution of metabolites, transport of hormones, heat dissipation, and oxygen transport.

According to Astrand and Rodahl (1970:153), there are four stages of circulatory response to exercise. At rest, skeletal muscles receive about 15 percent of the minute blood flow, and their arterioles are constricted and few capillaries are open. The heart rate is kept down by vagal tone. When or just before exercise begins, parasympathetic activity is inhibited and sympathetic activity increased. Heart rate increases and arterioles dilate. Blood flow to the abdomen and skin is decreased. Venous constriction, muscle pumping, and forced respiration increase venous return. Heart rate and cardiac output generally increase in proportion to the work load. Systolic blood pressure rises in proportion to the intensity of exercise, with a plateau after several minutes. Diastolic blood pressure is usually unchanged or slightly decreased. In the third stage, appropriate adjustments occur. In the working muscles, arterioles dilate and capillaries open. In the resting muscles, arterioles constrict. Finally, skin vessels dilate to dissipate the produced heat.

One of the beneficial responses to exercise conditioning is a more efficient aerobic metabolism. Certain parameters of cardiovascular function can be examined to measure this response. Heart rate is a measure of maximal oxygen consumption. At higher ranges of maximal oxygen uptake, there is a direct linear relationship between heart rate and level of physical exercise and to maximal oxygen uptake itself. With physical conditioning, an individual can perform a given work load at a lower pulse rate. The increase in myocardial oxygen requirement during exercise is measured by the product of heart rate and systolic blood pressure. The ability to perform exercise depends on the capacity of the myocardium to extract and utilize oxygen from the coronary arteries. In general, poorly conditioned individuals have a higher pressure-rate product at a given submaximal work load than conditioned individuals. The increase in heart rate with exercise causes rate-related changes in the repolarization events of the electrocardiogram. These changes are reflected in the S-T segment and T wave.

Assumptions

1. The treadmill exercise stress test is a reliable, valid test of cardiovascular response to exercise.
2. Subjects' participation in the exercise program was consistent enough to create a training effect.

Hypothesis

Three months' participation in a cardiac rehabilitation exercise program will significantly ($P < .05$) improve four parameters of cardiovascular function, consisting of heart rate, blood pressure, electrocardiogram, and maximal double product.

CHAPTER 2

REVIEW OF THE LITERATURE

Programs of regular physical exercise have been demonstrated to create a beneficial effect on cardiovascular functioning. Evidence of such has been provided from studies of both healthy individuals and subjects with coronary artery disease. However, the exact mechanisms through which this beneficial cardiovascular effect is accomplished have not yet been clearly recognized and various hypotheses have been suggested.

The lack of regular physical exercise has been recognized as a risk factor in the development of coronary artery disease (Committee on Exercise 1972). Knowledge of the influence of exercise and the lack of it on cardiovascular functioning has led to the development of cardiac rehabilitation exercise programs.

Healthy Subjects

In an early study of 500 apparently healthy males in the United States, Balke and Ware (1959) measured work capacity in treadmill tests with the criterion of maximum oxygen consumption. Their results showed that the heart rate at any given work load reflected most closely the status of the work capacity of the person, and that subjects with lower work capacities had higher systolic and diastolic blood pressures at comparable work loads than those with higher physical work capacities.

Other studies showed the effects of exercise conditioning programs on healthy subjects. Ekblom et al. (1968) studied eight healthy male students, ages 19 to 27, before and after a 16-week physical conditioning program. They found that the highest recorded heart rate during maximal exercise was unchanged after training, but that the group mean heart rate at fixed submaximal work loads decreased significantly from 170 to 144 beats per minute. Byrd, Smith and Shackleford (1974) studied 13 middle-aged men, with four as controls and nine as participants in a 12-week training program consisting of jogging. The mean heart rate at rest and during submaximal work decreased significantly in the trained subjects, decreasing by ten beats per minute at rest and by 13 during submaximal work. Hartley, Jones and Mason (1973) also demonstrated a lower heart rate at submaximal work loads in 12 subjects after taining. After six months of training, Skinner, Holloszy and Cureton (1964) tested 15 previously sedentary males with several exercise tolerance tests. During the bicycle ergometer test, these subjects were able to pedal for progressively longer periods against increasing resistance before reaching a heart rate of 150. Their mean heart rate was significantly lower at each work load by approximately ten beats per minute. Their post-exercise heart rate was significantly decreased after a modified Harvard five-minute step test but was unchanged after an "all-out" treadmill run test.

Ekblom et al. (1968) found no change in arterial systolic, diastolic, and mean blood pressures at rest after training, but significant increases at highest work loads. Skinner et al. (1964) showed a significant decrease in post-exercise systolic blood pressure, but no significant change in diastolic blood pressure. Hartley et al. (1973) demonstrated similar results at submaximal work loads after training.

Cardiac Subjects

Hellerstein (1968), after studying 254 middle-aged men with coronary artery disease and 402 normal coronary-prone men, concluded that it is probable that similar adaptations after physical conditioning occur in normal persons and cardiac subjects. Naughton et al. (1966) reached similar conclusions after studying 24 men who had recovered from a myocardial infarction and 12 apparently healthy men. He stated that the cardiovascular response to physical conditioning for non-symptomatic post-myocardial infarction patients was consistent with that which occurred in apparently healthy men.

Naughton et al. (1966) found that, after eight months of training, the mean pulse rates while at rest and standing were lower in the trained cardiac subjects than in the control cardiac and normal subjects. Their pulse rates at each comparable oxygen requirement during treadmill walking were significantly decreased by 12 to 20 beats per minute, but there were no differences observed in the sedentary men. Sanne, Grimby and Wilhelmsen (as cited by Larsen and Malmborg 1971) studied 168 subjects with previous myocardial infarctions, half of whom participated in a physical training program. They showed no difference in mean maximal heart rate before and after training. The trained subjects were then divided into three groups according to the reasons for stopping at a work load of 600 kpm/min: angina, fatigue, and caution. The mean heart rate at this work load decreased by 16 beats per minute in the well-trained groups who stopped because of angina or fatigue. Bergstrom, Bjernulf and Erikson (1974) studied 63 males with previous myocardial infarctions, with 34 in the training group and 29 as reference subjects. These authors demonstrated a significant lowering of heart rates at the same work loads before and after training and at the same submaximal work load this change consisted of a decrease of 15 beats per minute. Detry and Bruce (1971) found significant decreases in heart rate only at submaximal exercise levels. Lower heart rates after training were also reported by Clausen, Larsen and Trap-Jensen (1969), Gottheiner (1968), Hellerstein (1968), and Varnauskas et al. (1966).

Clausen et al. (1969) studied eight of nine cardiac patients who participated in an exercise program. At rest, these subjects showed significant decreases in both systolic and diastolic blood pressures after training. During submaximal exercise, the brachial artery mean blood pressure was lower due to significant decreases in both systolic and diastolic blood pressures. The tension-time index was decreased significantly due to the decreases in systolic blood pressure and heart rate, therefore myocardial work was decreased during exercise at a given work load. Naughton et al. (1966) also reported significant decreases in systolic and diastolic blood pressures during treadmill walking in the trained cardiac subjects. Hellerstein (1968) found a significant decrease in exercise systolic blood pressure. Bjernulf (1973), reporting on the same subjects as Bergstrom et al. (1974), found significant decreases in systolic, mean, and diastolic blood pressures during exercise in the trained group. Gottheiner (1968) studied 3000 subjects for ten years, and 1103 of those with ischemic heart disease for five years. His results showed that the resting blood pressure tended to diminish after training when it had been elevated and that abnormally high rises or paradoxic falls of blood pressure during exercise gradually disappeared. Three of four mildly hypertensive patients studied by Heller (1967) exhibited an improvement in blood pressure which remained normal after three to six months in a training program.

Detry and Bruce (1971) reported a significant decrease after physical training of the heart rate times systolic blood pressure product during submaximal exercise, which is an index of estimated myocardial oxygen requirement. Hellerstein (1968) also demonstrated an improvement in this product in subjects who adhered to the exercise program.

According to Hellerstein (1968), 63 percent of his subjects with abnormal initial electrocardiograms showed an improvement after training in their exercise electrocardiogram, as measured by amount of S-T segment depression. S-T segment depressions during and after exercise disappeared or were diminished in previously affected leads and the amplitudes of the R and T waves were augmented in the trained cardiac subjects studied by Gottheiner (1968). Barry et al. (1966) and Tobis and Zohman (1970) also demonstrated improvements in the electrocardiograms of their subjects.

Detry and Bruce (1971) found a significant decrease in S-T segment depression only at submaximal exercise levels in 14 subjects studied. They concluded that the relationship between the magnitude of

S-T segment depression during exercise and the heart rate times blood pressure product used as an index of myocardial oxygen consumption was not changed by physical training. Because of that and because physical training did not alter the relationship between the magnitude of S-T segment depression and heart rate (or the heart rate times blood pressure product during multi-stage treadmill testing), the authors suggested that changes in S-T segment response to submaximal and maximal exercise after training resulted from changes in hemodynamic response to exercise rather than from changes in myocardial oxygen supply. Therefore, the quantitative modifications of S-T segment response to exercise after training probably resulted from changes in heart rate and blood pressure responses rather than from an improvement in the coronary circulation.

The results of most studies support the conclusion of Hellerstein (1968) that the training effect for patients with coronary artery disease who participate in an exercise program includes the ability to do more work with fewer heart beats and a lower blood pressure. The lowered heart rate and blood pressure reduce the oxygen consumption demands on the heart (Bjernulf 1973). Naughton et al. (1966) concluded that a lower heart rate at comparable oxygen demands indicates an improved oxygen pulse, which reflects an increased cardiovascular efficiency.

CHAPTER 3

RESEARCH DESIGN

This study was concerned with the relationship between three months' participation in a cardiac rehabilitation exercise program and cardiovascular function, as measured by a treadmill exercise stress test. A retrospective experimental design of the one-group, before-after type was selected in order to seek answers to this problem. Descriptions of the research design and the sample for this study are presented in this chapter.

Description of Sample

The population consisted of all subjects who participated in the cardiac rehabilitation exercise program of a cardiac rehabilitation center located in a general hospital in a southwestern city. The sample for this study consisted of all consenting subjects who completed three months in the program during the approximately one year the program has been in existence and whose treadmill exercise stress tests were conducted at this center. This sample was chosen because a repeat treadmill exercise stress test was conducted for all participants after the completion of three months in the program.

Potential participants in the exercise program first undergo a treadmill exercise stress test in order to assess cardiovascular response to exercise and to detect coronary heart disease. The information obtained was used to prescribe each individual's exercise regime. The types of isotonic exercise used in this program consist of walking and jogging around an outdoor track. Treadmills and bicycle ergometers are also available for indoor exercising. For subjects who cannot tolerate these exercises involving the lower extremities, weighted pullies are available for upper extremity exercising. The average exercise prescription consists of walking and/or jogging for seven minutes and resting for three minutes; this sequence is repeated three times. Patients visit the center three times per week. A target pulse rate is set as the target and limit for exercise. Telemetry monitoring is maintained for as many subjects as possible and participants are taught to count their own pulse rate after each period of exercise and rest. A physician, registered nurse, and cardiopulmonary technician are present during all exercise sessions. Participants are advised to continue their exercise regime by themselves on those days when they do not visit the center. Each participant's regime is gradually progressed as he can tolerate it. The target pulse rate is increased and the length of each exercise session is sometimes increased. After three months, each subject is reevaluated with a treadmill exercise stress test. The exercise prescription is accordingly adjusted and the number of weekly visits is often reduced to two.

Protection of Human Rights

The human rights of the subjects involved in this study were protected according to the guidelines of The University of Arizona. These rights include the rights to informed consent, confidentiality, and protection against risks.

Each subject had previously signed an informed consent form before each treadmill exercise stress test at the particular hospital (see Appendix A) which included the provision that the information obtained may be used for statistical purposes with the right of privacy maintained. The use of coded data and computer analysis were the means of providing confidentiality.

This study was designed to prevent any physical, psychological, or social risks to the participants. The information obtained had already been recorded on the subjects' records. The privacy and anonymity of the subjects was protected.

Data Collection Method

A retrospective experimental design of the one-group, before-after type was delineated. A subject data form (Appendix B) was formulated to collect the necessary data. All of the desired information was present in each subject's medical record. Cardiovascular function was evaluated by a treadmill exercise stress test before entrance into the exercise program and again after three months in the program. The cardiovascular parameters of heart rate, blood pressure while supine, and electrocardiogram classification in the pre-exercise resting period were recorded from both tests. Both exercise test responses, including stage achieved, total duration of exercise, maximum heart rate, blood pressure at the maximum rate, electrocardiogram classification, maximal double product, and the reason for stopping exercise, were also tabulated.

Blood pressures and electrocardiogram classifications in the post-exercise period were also recorded.

The treadmill exercise stress test was considered to be a reliable, valid test of cardiovascular response to exercise. A treadmill exercise stress test is a multistage test in which the subject performs graded levels of activity of gradually increasing intensity on an electrically-driven treadmill until a pre-determined endpoint is reached. The stages of exercise conducted at the participating center of the following:

Stage:		I	II	III	IV	V
Treadmill:	Grade	0%	10%	10%	15%	20%
	Speed	2 mph	2 mph	3 mph	3 mph	3 mph

These tests were conducted by a physician and a cardiopulmonary technician. They recorded the results of the tests in each subject's medical record.

The Minnesota Code was chosen as a standard classification method for recording electrocardiogram response. Thus the electrocardiogram results would be reported objectively and consistently (Blackburn et al. 1960, Rose and Blackburn 1968). S-T segment depression is considered to be the most significant indication of myocardial ischemia during exercise. Thus, for the purposes of this study, the S-T junction (J) and segment depression code for the resting electrocardiogram and the S-T items post-exercise (see Appendix C) were chosen for analysis. A code of zero was added to the post-exercise code as a category for those subjects with no codeable S-T items both pre-exercise and post-exercise.

Data Analysis

The chi square test and Pearson product-moment correlation coefficient were chosen as the statistical formulas for analyzing the data. Chi square is a non-parametric test of significance and is particularly useful when the data produced are in the form of nominal scales. It analyzes the significance of differences between groups being compared in terms of qualitative variables. It designates the significance between observed and expected frequencies of the variable being measured.

The Pearson product-moment correlation coefficient is a parametric test of association for pairs of measurements. It is used when the variables are quantitative and describes the degree of relationship between the variables. A positive value denotes a positive relationship, and a negative value reveals a negative relationship.

It was expected that cardiovascular function would be improved after three months' participation in the cardiac rehabilitation exercise program. When tested with the chi square test and Pearson product-moment correlation coefficient, the significance was expected to reach a level of .05.

CHAPTER 4

ANALYSIS OF DATA

The relationship between three months' participation in a cardiac rehabilitation exercise program and cardiovascular function was investigated. The purpose of this chapter is to present the characteristics of the sample for this study, the research findings, and an analysis of those findings.

Characteristics of Sample

The sample for this study consisted of 36 subjects--29 males and seven females. The mean age was 55 years, with a range of 40 to 67 years. Calculated from the maximum age-adjusted heart rate, the mean for this sample was 165.3, with a range of 153 to 180. The subjects were divided into categories according to diagnosis. There were six subjects with the diagnosis of arteriosclerotic heart disease, eight with a previous myocardial infarction, 12 who had previous cardiac surgery, and ten who were listed as having a routine indication for testing (see Table 1).

Information regarding adherence to the exercise program was available for 35 of the 36 subjects (see Table 2). The mean number of weeks of participation in the exercise program was 14.2, with a range of 12 to 22 weeks. The mean number of scheduled visits was 42.3, with a range of 26 to 66 visits. The mean number of visits missed was 6.7,

Table 1. Diagnosis or indication for treadmill exercise stress test.

Diagnosis or Indication	Number of Subjects
Arteriosclerotic Heart Disease	6
Previous Myocardial Infarction	8
Previous Cardiac Surgery	12
Routine	10
Total	36

Table 2. Adherence to the cardiac exercise rehabilitation program.

Exercise Schedule	Mean	Minimum	Maximum
Number of Weeks in Program	14.2	12	22
Number of Scheduled Visits	42.3	26	66
Number of Visits Missed	6.7	0	21
Number of Visits Made	35.5	24	55

with a range of zero to 21 visits. The mean number of visits made was 35.5, with a range of 24 to 55 visits.

Findings

In the pre-exercise resting period, the mean heart rate for the first test was 84, with a range of 60 to 110. The mean heart rate for the second test was 81.8, with the same range as the first test ($r = .247$; $P < .145$). The mean supine systolic blood pressure for the first test was 125, with a range of 90 to 160. For the second test, the mean supine systolic blood pressure was 122.5, with a range of 80 to 160 ($r = .235$; $P < .166$). The mean supine diastolic blood pressure for the first test was 80.8, with a range of 60 to 100; for the second test, the mean was 78.9, with a range of 50 to 100 ($r = .206$; $P < .227$). These pre-exercise resting measurements are shown in Table 3.

The pre-exercise resting electrocardiograms were grouped into three general categories (see Table 4). There were 15 subjects with a normal electrocardiogram before the first test, 22 before the second test, and one subject with a borderline abnormal electrocardiogram before each test. There were 20 subjects with an abnormal electrocardiogram before the first test and 13 before the second test ($X^2 = 1.722$; $P < .786$). Of the 15 subjects with a normal resting electrocardiogram at the time of the first test, five had an abnormal resting electrocardiogram before the second test. The subject with a borderline abnormal resting electrocardiogram before the first test had a normal resting electrocardiogram for the second test. Of the 20 abnormal resting electrocardiograms before the first test, 11 became normal, one was

Table 3. Mean pre-exercise resting measurements for test 1 and test 2.*

Mean	Pre-exercise Test 1	Pre-exercise Test 2
Heart Rate	84	81.8
Supine Systolic Blood Pressure	125	122.5
Supine Diastolic Blood Pressure	80.8	78.9

*Heart Rate: $r = .247$, $P < .145$

Supine Systolic Blood Pressure: $r = .235$, $P < .166$

Supine Diastolic Blood Pressure: $r = .206$, $P < .227$

Table 4. Cross-tabulation of pre-exercise resting electrocardiogram categories for test 1 and test 2.*

Pre-exercise Test 1	Pre-exercise Test 2 Normal	Borderline Abnormal	Abnormal	Total
Normal	10	0	5	15
Borderline Abnormal	1	0	0	1
Abnormal	11	1	8	20
Total	22	1	13	36

*$X^2 = 1.722$

$P < .786$

borderline abnormal, and eight remained abnormal at the time of the second test. The resting electrocardiograms were also categorized for S-T junction (J) and segment depression according to the Minnesota Code (see Appendix C). Data were available for 35 of the 36 subjects. There was one electrocardiogram in Code 1 for the first test and three for the second test; one in Code 2 for the first test and three for the second test; two in Code 3 for the first test and one for the second test; two in Code 4 for the first test and zero for the second test; and 29 in Code 9 for each test ($X^2 = 50.352$; $P < .000$).

During the first treadmill exercise stress test, there were two subjects who exercised to stage 1, 14 to stage 2, 16 to stage 3, and four to stage 4. During the second test, there were seven subjects who exercised to stage 2, 18 to stage 3, 9 to stage 4, and two to stage 5 ($X^2 = 37.02$; $P < .000$). The exercise stages achieved are shown in Table 5. The mean duration in minutes of exercise for the first test was 6.3, with a range of three to 11 minutes. For the second test, the mean duration of exercise was 7.7, with a range of four to 14 minutes ($r = .597$; $P < .0001$). The mean duration of exercise is shown in Table 6.

The mean maximum heart rate recorded during exercise was 145 in the first test, with a range of 105 to 164. The mean maximum heart rate in the second test was 146.4, with a range of 102 to 165 ($r = .442$; $P < .006$). The mean systolic blood pressure recorded when the maximum heart rate was achieved was 164 for the first test, with a range of 125 to 210. The mean systolic blood pressure at the maximum heart rate for the second test was 166.1, with a range of 130 to 210

Table 5. Cross-tabulation of exercise stages achieved in test 1 and test 2.*

Exercise Stages in Test 1	Exercise Stages in Test 2 1	2	3	4	5	Total
1	0	2	0	0	0	2
2	0	4	10	0	0	14
3	0	1	8	7	0	16
4	0	0	0	2	2	4
5	0	0	0	0	0	0
Total	0	7	18	9	2	36

*$X^2 = 37.02$

$P < .000$

Table 6. Mean duration of exercise in minutes for test 1 and test 2.*

Mean	Test 1	Test 2
Minutes of Exercise	6.3	7.7

*$r = .597$

$P < .0001$

($r = .371$; $P < .028$). The mean diastolic blood pressure at the maximum heart rate was 82.2 for the first test, with a range of 60 to 110. For the second test, the mean diastolic blood pressure at that point was 83, with a range of 50 to 100 ($r = .154$; $P < .389$). The mean maximal double product during the first exercise test was 227.1, with a range of 132 to 300. During the second test the mean was 233, with a range of 140 to 300 ($r = .224$; $P < .194$).

S-T items at peak exercise just prior to stopping were classified according to the Minnesota Code for post-exercise records. Electrocardiograms at this point in the first test were available for 35 of the 36 subjects. There were 14 electrocardiograms in Code 0, ten in Code 1, three in Code 2, zero in Code 3, two in Code 4, three in Code 5, one in Code 6, two in Code 7, zero in Code 8, and zero in Code 9. Data were available for 36 subjects for the second test. There were 14 subjects in Code 0, six in Code 1, three in Code 2, zero in Code 3, six in Code 4, two in Code 5, one in Code 6, four in Code 7, zero in Code 8, and zero in Code 9 ($X^2 = 88.848$; $P < .000$). The codes for each subject in both tests are listed in Table 7.

At the first test, there were 24 subjects who stopped exercising because they had reached their 90 percent maximum age-adjusted heart rate, three because of arrhythmias, one because of an abnormal blood pressure response, and eight because of a positive test in terms of ST-T segment response. For the second test, there were 27 subjects who stopped because they reached 90 percent of their maximum predicted heart rate, two because of chest pain, two because of arrhythmias, and five because of a positive test (see Table 8).

Table 7. Minnesota Code for S-T items at peak exercise for test 1 and test 2.

Subject	Test 1	Test 2
1	2	0
2	1	2
3	0	4
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	-	4
10	0	4
11	1	2
12	7	7
13	5	7
14	1	1
15	1	1
16	7	7
17	1	7
18	0	0
19	1	5
20	1	1
21	6	6
22	4	4
23	2	0
24	0	0
25	0	0
26	1	1
27	2	2
28	0	0
29	4	0
30	0	4
31	1	4
32	1	1
33	0	0
34	0	0
35	5	5
36	5	1

Table 8. Cross-tabulation of reasons for stopping exercise for test 1 and test 2.

Test 1	Test 2: 90 Percent Maximum Heart Rate	Arrhythmias	Abnormal Blood Pressure Response	Positive Test	Chest Pain	Total
90 Percent Maximum Heart Rate	19	1	0	3	1	24
Arrhythmias	2	1	0	0	0	3
Abnormal Blood Pressure Response	1	0	0	0	0	1
Positive Test	5	0	0	2	1	8
Chest Pain	0	0	0	0	0	0
Total	27	2	0	5	2	36

The mean supine systolic blood pressure three minutes after exercise was 131 for the first test, with a range of 110 to 180. For the second test, the mean supine systolic blood pressure at that point was 127.4, with a range of 95 to 160 ($r = .234$; $P < .169$). The mean supine diastolic blood pressure three minutes after exercise was 80.5 for the second test, with a range of 56 to 100. For the second test the mean was 78.5, with a range of 58 to 104 ($r = .494$; $P < .002$).

Post-exercise records for the Minnesota Code were available for 35 of the 36 subjects after the first test and for all 36 subjects after the second test. Three minutes after exercise, there were 20 electrocardiograms in Code 0 for the first test, three in Code 1, two in Code 2, zero in Code 3, one in Code 4, four in Code 5, two in Code 6, two in Code 7, zero in Code 8, and one in Code 9. After the second test, there were 22 electrocardiograms in Code 0, two in Code 1, three in Code 2, zero in Code 3, two in Code 4, one in Code 5, one in Code 6, five in Code 7, zero in Code 8, and zero in Code 9 ($X^2 = 57.322$; $P < .057$). The codes for each subject after both tests are shown in Table 9.

Analysis

In the pre-exercise resting state, the mean heart rate, supine systolic blood pressure, and supine diastolic blood pressure were lower at the time of the second test when compared to the first test. These improvements, however, were not significant.

There were seven more subjects with normal resting electrocardiograms at the time of the second test, one subject each time with a borderline abnormal electrocardiogram, and seven less with an abnormal

Table 9. Minnesota Code for S-T items three minutes post-exercise for test 1 and test 2.

Subject	Test 1	Test 2
1	0	0
2	1	2
3	4	4
4	0	0
5	0	0
6	9	0
7	2	0
8	0	0
9	-	0
10	0	0
11	0	2
12	7	7
13	5	7
14	0	1
15	0	6
16	7	7
17	1	7
18	0	0
19	0	7
20	6	0
21	5	0
22	1	4
23	0	0
24	0	0
25	0	0
26	0	1
27	0	0
28	0	0
29	2	0
30	0	0
31	0	0
32	6	2
33	0	0
34	0	0
35	5	5
36	5	0

resting electrocardiogram at the second test. Because of crossing over among the groups, however, these changes were not significant statistically.

Twenty-nine subjects in each test had no codeable S-T junction (J) and segment depression in their resting electrocardiograms according to the Minnesota Code. This information served as a basis for classifying changes in the exercise and post-exercise electrocardiograms.

The subjects exercised to a significantly further stage in the second test and they also exercised a significantly longer period of time in minutes.

The mean maximum heart rate recorded during exercise was significantly greater during the second test. The mean systolic and diastolic blood pressures recorded at that point also increased, as did the maximal double product. The increase in mean systolic blood pressure was significant, but the other changes were not.

There were 22 subjects whose Minnesota Code classification for S-T items at peak exercise did not change in the second test. There were nine (25.4 percent) subjects whose electrocardiograms improved and four subjects (11.5 percent) whose electrocardiograms worsened.

The majority of subjects in both tests stopped because they had reached their 90 percent maximum predicted heart rate. The next largest group of subjects at both tests stopped because of a positive test in terms of ST-T segment response. There were small numbers of subjects who stopped because of arrhythmias, abnormal blood pressure response, or chest pain.

The mean systolic blood pressure three minutes post-exercise was lower after the second test, but it was not significant. The mean diastolic blood pressure three minutes after the second exercise test was significantly decreased.

In the post-exercise period, there were 19 subjects whose Minnesota Code classification did not change in the second test. There were nine subjects whose electrocardiograms improved (25.4 percent) and seven (20.1 percent) whose electrocardiograms worsened.

CHAPTER 5

CONCLUSIONS, SUMMARY AND RECOMMENDATIONS

A retrospective study was conducted to evaluate cardiovascular response to a cardiac rehabilitation exercise program. Information regarding 36 subjects was reviewed after three months' participation in the exercise program. In this chapter, the conclusions drawn from this study will be presented, along with a summary and recommendations for further study.

Conclusions

The cardiovascular parameter of mean diastolic blood pressure at three minutes post-exercise was significantly lower after participation in the exercise program. Clausen et al. (1969) also found a significant decrease in resting diastolic blood pressure after training. This finding has important implications for the treatment of hypertension, in which the diastolic blood pressure elevation is most crucial. Gottheiner (1968) found that the resting blood pressure tended to diminish after training when it had been elevated and Heller (1967) showed an improvement in blood pressure in three of four mildly hypertensive patients after exercise training.

Other significant improvements shown in this study were the increases in duration of exercise and exercise stage achieved. After a period of physical training, these subjects were able to tolerate a greater work load before needing to stop. Bergstrom et al. (1974) and others have reported significant increases in work capacity after training. The majority of subjects in this study stopped exercising because they had reached their 90 percent maximum predicted heart rate, therefore for those subjects who reached this heart rate in both tests there was a capacity in the second test for an increased work load at the same heart rate, reflecting a cardiovascular conditioning response.

It was expected that the exercise systolic and diastolic blood pressures, as well as the maximal double product, would decrease. In this study, however, they increased, and the changes in mean systolic blood pressure and mean maximum heart rate were significant. These findings can be attributed to the fact that the subjects exercised significantly longer and at higher work loads. The heart rate, blood pressure, and maximal double product data were those obtained at the maximum level of exercise achieved by each subject. With the design of this study, there was no way to determine heart rate and blood pressure at equivalent submaximal exercise levels. If these data were available, a valid comparison of these parameters during exercise would be possible. Sanne, Grimby and Wilhelmsen (as cited by Larsen and Malmborg 1971) showed no difference in mean maximal heart rate before and after training, but Bergstrom et al. (1974) demonstrated a significant lowering of heart rates at the same work loads after training.

With the Minnesota Code classification of S-T items, it was possible to demonstrate electrocardiographic improvement or worsening, but it was not possible to quantitate that change. The chi square analysis of the Minnesota Code demonstrated the chance that the observed frequencies would be found in the general population. The Minnesota Code, therefore, was an inadequate method of measuring electrocardiographic response to exercise training. Quantitative data regarding S-T segment response to exercise might provide more valuable information about this cardiovascular parameter.

Information regarding adherence to the exercise program was collected in order to consider other variables affecting the sample and its response to the exercise program. The subjects attended approximately 85 percent of their scheduled visits and this would indicate good adherence to the program. This adherence rate should have a positive influence on cardiovascular conditioning. The nurse may play an important role in motivating the patients to adhere to their program.

It was hypothesized that three months' participation in a cardiac rehabilitation exercise program would significantly ($P < .05$) improve four parameters of cardiovascular function, consisting of heart rate, blood pressure, electrocardiogram, and maximal double product. The only statistically significant cardiovascular improvement demonstrated was that of a lower post-exercise diastolic blood pressure ($P < .002$).

Summary

Cardiac rehabilitation programs have been developed as a means of preventing and treating coronary heart disease. Such programs provide cardiac evaluation, education, and an exercise program, and are accomplished through a health team effort, in which nurses play an integral role.

The purposes of cardiac exercise training programs are to prevent deterioration of the patient's physical condition during the convalescent phase, to increase physical work capacity, to increase cardiac performance, to reduce coronary risk, and to restore self-confidence and reduce fear and apprehension. In order to evaluate the effectiveness of an existing cardiac rehabilitation exercise program, the relationship between three months' participation in the program and cardiovascular function, as measured by a treadmill exercise stress test, was studied.

A retrospective experimental design of the one-group, before-after type was selected in order to seek answers to this problem. Data were obtained from the medical records of 36 consenting subjects who had undergone a treadmill exercise stress test, participated for three months in an individualized exercise program of walking and jogging, and then had a repeat treadmill exercise stress test. The treadmill exercise stress test was considered to be a reliable, valid test of cardiovascular response to exercise. Information regarding the cardiovascular parameters of heart rate, blood pressure, electrocardiogram, and maximal double product was obtained from both tests and the relationships analyzed.

Cardiovascular conditioning through exercise training was examined. According to Phillips (Zohman and Phillips 1973:7), there are three phases of exercise in relation to energy production: phosphagenic, aerobic, and anaerobic. Phosphagenic energy is used for short-term exercise. An interplay between aerobic and anaerobic processes is involved in varying levels of exercise, with any given work load requiring a specific amount of energy. One of the beneficial responses to exercise conditioning is a more efficient aerobic metabolism. The four parameters of cardiovascular function examined in this study were used to measure this response. It was hypothesized that three months' participation in a cardiac rehabilitation exercise program would significantly ($P < .05$) improve all four parameters. This hypothesis was only partially borne out.

Heart rate is a measure of maximal oxygen consumption, and with physical conditioning an individual can perform a given work load at a lower pulse rate. The mean resting heart rate for this group was lower after three months in the program, but it was not significant.

The mean diastolic blood pressure at three minutes post-exercise was significantly lower after participation in the exercise program. The pre-exercise resting mean systolic and diastolic blood pressures and the post-exercise mean systolic blood pressure were also lower.

The increase in myocardial oxygen requirement during exercise is measured by the product of heart rate and systolic blood pressure. The mean maximal double product for this group increased after training, and a decrease had been expected. This finding, however, was attributed to the fact that the subjects exercised significantly longer and at higher work loads. These subjects exercised under a heavier work load before driving their 90 percent maximum predicted heart rate and maximal double product, which indicates a positive cardiovascular conditioning response.

The increase in heart rate with exercise causes rate-related changes in the repolarization events of the electrocardiogram. S-T segment depression is considered to be the most significant indication of myocardial ischemia during exercise. When classified according to the Minnesota Code, the majority of electrocardiograms did not change after training in this study.

Thirty-six subjects were studied after three months' participation in a cardiac rehabilitation exercise program. Cardiovascular conditioning, as reflected by a lower resting heart rate and blood pressure, was partially demonstrated.

Recommendations

1. A similar study could be conducted with a larger sample and over a longer period of time.
2. A prospective study could be designed to evaluate cardiovascular response to a cardiac rehabilitation exercise program.
3. A method for quantitating electrocardiographic response to exercise, such as measuring millimeters of ST-T segment depression, could be formulated as an alternative to the Minnesota Code.
4. Heart rate, blood pressure, and their product could be measured at equivalent submaximal levels of exercise and the results analyzed.
5. With a larger sample, certain subgroups, such as subjects with angina, could be analyzed to determine trends for that particular subgroup.

6. The response of subjects with hypertension to a program of regular exercise could be studied.

7. The role of the nurse in cardiac rehabilitation programs could be examined.

APPENDIX A

SUBJECT CONSENT FORM

ST. JOSEPH'S HOSPITAL
Tucson, Arizona
CARDIAC REHABILITATION CENTER

INFORMED CONSENT FOR EXERCISE STRESS TESTING

In order to determine an appropriate plan, in my medical management, I hereby consent to voluntarily engage in an exercise test to determine my heart and circulation response to exercise. The information thus obtained will help my physician in advising me regarding activities and/or medications, as indicated.

Before I undergo the test, I will have an interview with a physician. This physician will attempt to determine if there are any conditions which would indicate that I should not engage in this test.

The test which I will undergo will be performed on a Treadmill or bicycle, with the amount of effort increasing gradually. This increase in physical effort will continue until a pre-determined heart rate is achieved, symptoms such as fatigue, shortness of breath, or chest discomfort may appear, and then the exercise test will be terminated.

During the performance of the test, a physician and a trained observer, will keep under surveillance my electrocardiogram and blood pressure.

There exists the possibility of certain changes or complications occurring during the test. They include, but are not limited to, abnormal blood pressure, fainting, disorders of heart beat, which may be too rapid or too slow, and rare instances of heart attack and death. Every effort will be made to minimize these changes by the preliminary interview and observations during the exercise stress test. Emergency equipment and trained personnel are available to deal with unusual situations which may arise.

The information which is obtained will be treated as privileged, and confidential and will not be released or revealed to any person without my express written consent. The information obtained, however, may be used for statistical purpose with my right of privacy retained.

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

____
Patient

____
Witness

____________________ ____________________
Date Witness

APPENDIX B

SUBJECT DATA

1-3	________	Subject	
4	________	Sex	1. Male 2. Female
5	________	Indications/ Diagnosis	1. Arteriosclerotic Heart Disease 2. Previous Myocardial Infarction 3. Previous Cardiac Surgery 4. Risk Factors 5. Apparently Healthy 6. Other

Adherence

6-7	________	Number of weeks in program
8-10	________	Number of scheduled visits
11-13	________	Number of visits missed

<u>Pre-exercise Resting (Test #1)</u>

14-16	________	Heart Rate	
17-19	________	Blood pressure systolic (supine)	
20-22	________	Blood pressure diastolic (supine)	
23	________	EKG Classification	1. Normal EKG 2. Borderline normal EKG 3. Abnormal EKG
24	________	Minnesota Classification S-T Junction and Segment 1 Class 2 Class 3 Class 4 Class (9 N.A.)	

Exercise Test Response (Test #1)

25 __________ Stage Achieved

26-27 __________ Total Duration of Exercise (minutes)

28-30 __________ Maximum age-adjusted heart rate

31-33 __________ 90 percent Maximum age-adjusted heart rate

Vital Signs at Peak Exercise

34-36 __________ Maximum heart rate recorded

37-39 __________ Systolic blood pressure at maximum rate

40-42 __________ Diastolic blood pressure at maximum rate

43 __________ Minnesota Code
S-T items

44-46 __________ Maximal double product

47 __________ Reason for Stopping Exercise

1. 90 percent Maximum Heart Rate
2. Chest pain
3. Dyspnea
4. Leg pain
5. Neurological signs
6. Arrhythmias
7. Abnormal blood pressure response
8. Other

Post-exercise Period (Test #1)

48-50 __________ Systolic blood pressure 3 minutes after exercise (supine)

52-53 __________ Diastolic blood pressure 3 minutes after exercise (supine)

54 __________ Minnesota Code
S-T items

Pre-exercise Resting (Test #2)

55-57 __________Heart Rate

58-60 __________Blood pressure systolic (supine)

61-63 __________Blood pressure diastolic (supine)

64 __________EKG Classification
1. Normal EKG
2. Borderline normal EKG
3. Abnormal EKG

65 __________Minnesota Classification
S-T Junction and Segment
1 Class
2 Class
3 Class
4 Class

(9 N.A.)

Exercise Test Response (Test #2)

66 __________Stage Achieved

67-68 __________Total Duration of Exercise (minutes)

69-71 __________Maximum age-adjusted heart rate

72-74 __________90 percent Maximum age-adjusted heart rate

Vital Signs at Peak Exercise

75-77 __________Maximum heart rate recorded

78-80 __________Systolic blood pressure at maximum rate

81-83 __________Diastolic blood pressure at maximum rate

84 __________Minnesota Code
S-T items

85-87 __________Maximal double product

88 __________ Reason for Stopping Exercise

1. 90 percent Maximum Heart Rate
2. Chest pain
3. Dyspnea
4. Leg pain
5. Neurological signs
6. Arrhythmias
7. Abnormal blood pressure response
8. Other

Post-exercise Period (Test #2)

89-91 __________ Systolic blood pressure 3 minutes after exercise (supine)

92-94 __________ Diastolic blood pressure 3 minutes after exercise (supine)

95 __________ Minnesota Code S-T items

APPENDIX C

MINNESOTA CODE ITEMS*

Minnesota Code for Resting Electrocardiograms

S-T Junction (J) and Segment Depression

4-1 S-T-J depression 1.0 mm or more and S-T segment horizontal or downward sloping in any of leads I, II, aVL, aVF, V1, 2, 3, 4, 5, 6.

4-2 S-T-J depression at least 0.5 mm and less than 1.0 mm and S-T segment horizontal or downward sloping in any of leads I, II, aVL, aVF, V1, 2, 3, 4, 5, 6.

4-3 No S-T-J depression as much as 0.5 mm, but S-T segment downward sloping and segment of T wave nadir at least 0.5 mm below P-R baseline in any of leads I, II, aVL, V2, 3, 4, 5, 6.

4-4 S-T-J depression of 1.0 mm or more and S-T segment upward sloping, or U-shaped, in any of leads I, II, aVL, V1, 2, 3, 4, 5, 6.

Minnesota Code for Post-exercise Records

S-T Items Post-exercise

11-1 Change from no coded S-T item at rest to S-T item type 4-1 post-exercise.

11-2 Change from no coded S-T item at rest to S-T item type 4-2 post-exercise.

---

* Taken from Rose and Blackburn (1968, pp. 139, 141).

11-3 Change from no coded S-T item at rest to S-T item type 4-3 post-exercise.

11-4 Change from no coded S-T item at rest to S-T item type 4-4 post-exercise.

11-5 Change from one coded S-T item at rest to a lower numerical S-T item post-exercise (for example, 4-3 at rest to type 4-1 post-exercise).

11-6 Change from one coded S-T item at rest to a higher numerical S-T item post-exercise (for example, 4-3 at rest to type 4-4 post-exercise).

11-7 No change from resting coded S-T item (for example, 4-2 at rest and type 4-2 post-exercise).

11-8 Change from any coded S-T item at rest to no reportable S-T item post-exercise.

11-9 Questionable S-T depression post-exercise due to technical considerations.

SELECTED BIBLIOGRAPHY

Abdellah, Faye G. and Eugene Levine. Better Patient Care Through Nursing Research. New York: The Macmillan Company, 1965.

Astrand, Per-Olof and Kaare Rodahl. Textbook of Work Physiology. New York: McGraw-Hill Book Company, 1970.

Balke, Bruno and Ray W. Ware. "An Experimental Study of 'Physical Fitness' of Air Force Personnel." United States Armed Forces Medical Journal, 10, No. 6 (June, 1959), 675-688.

Barry, Alan J., James W. Daly, Esther P. R. Pruett, John R. Steinmetz, Newton C. Birkhead and Kaare Rodahl. "Effects of Physical Training in Patients Who Have Had Myocardial Infarction," American Journal of Cardiology, 17, No. 1 (January, 1966), 1-8.

Bean, Patricia. "The Nurse: Her Role in Cardiopulmonary Rehabilitation," Heart and Lung, 3, No. 4 (July-August, 1974), 587-591.

Bergstrom, Kjell, Arne Bjernulf and Uno Erikson. "Work Capacity and Heart and Blood Volumes Before and After Physical Training in Male Patients After Myocardial Infarction," Scandinavian Journal of Rehabilitation Medicine, 6, No. 2 (1974), 51-64.

Bjernulf, Arne. "Haemodynamic Effects of Physical Training After Myocardial Infarction," Acta Medica Scandinavica, Supplementum 548, 1973, 5-50.

Bjernulf, A., J. Boberg and S. Froberg. "Physical Training After Myocardial Infarction." Scandinavian Journal of Clinical and Laboratory Investigation, 33, No. 2 (April, 1974), 173-185.

Blackburn, Henry, Ancel Keys, Ernst Simonson, Pentti Rautaharju and Sven Punsor. "The Electrocardiogram in Population Studies," Circulation, 21, No. 6 (June, 1960), 1160-1175.

Byrd, Ronald J., Douglas P. Smith and Charles B. Shackleford. "Jogging in Middle-Aged Men: Effect on Cardiovascular Dynamics," Archives of Physical Medicine and Rehabilitation, 55, No. 7 (July, 1974), 301-305.

Clausen, Jan Praetorius, Ole Andree Larsen and Jens Trap-Jensen. "Physical Training in the Management of Coronary Artery Disease," Circulation, XL, No. 2 (August, 1969), 143-154.

Committee on Exercise. Exercise Testing and Training of Apparently Healthy Individuals: A Handbook for Physicians. New York: American Heart Association, 1972.

Detry, Jean-Marie and Robert A. Bruce. "Effects of Physical Training on Exertional S-T Segment Depression in Coronary Heart Disease," Circulation, 44, No. 3 (September, 1971), 390-396.

Ekblom, Bjorn, Per-Olof Astrand, Bengt Saltin, Jesper Stenberg and Brittmari Wallstrom. "Effect of Training on Circulatory Response to Exercise," Journal of Applied Physiology, 24, No. 4 (April, 1968), 518-528.

Ferguson, George A. Statistical Analysis in Psychology and Education. New York: McGraw-Hill Book Company, 1971.

Gottheiner, Victor. "Long-Range Strenuous Sports Training for Cardiac Reconditioning and Rehabilitation," American Journal of Cardiology, 22 (September, 1968), 426-435.

Granger, Judith W. "Full Recovery from Myocardial Infarction: Psychosocial Factors," Heart and Lung, 3, No. 4 (July-August, 1974), 600-610.

Hartley, L. H., L. G. Jones and J. Mason. "The Usefulness of Exercise Therapy in the Management of Coronary Heart Disease," Advances in Cardiology, Vol. 9, 1973, 174-179.

Heller, Maurice E. "Rehabilitation after Myocardial Infarction," Canadian Medical Association Journal, 97, No. 1 (July 1, 1967), 22-27.

Hellerstein, Herman K. "Exercise Therapy in Coronary Disease," Bulletin of the New York Academy of Medicine, 44, No. 8 (August, 1968), 1028-1047.

Larsen, O. Andree and R. O. Malmborg (eds.). Coronary Heart Disease and Physical Fitness. Baltimore: University Park Press, 1971.

Naughton, John. "The Contribution of Regular Physical Activity to the Ambulatory Care of Cardiac Patients," Postgraduate Medicine, 57, No. 5 (April, 1975), 51-55.

Naughton, John and Herman K. Hellerstein (eds.). Exercise Testing and Exercise Training in Coronary Heart Disease. New York: Academic Press, 1973.

Naughton, John, Kamal Shambour, Robert Armstrong, John McCoy and Michael T. Lategola. "Cardiovascular Responses to Exercise Following Myocardial Infarction," Archives of Internal Medicine, 117 (April, 1966), 541-545.

Rose, G. A. and H. Blackburn. Cardiovascular Survey Methods. Geneva: World Health Organization, 1968.

Skinner, James S., John O. Holloszy and Thomas K. Cureton. "Effects of a Program of Endurance Exercises on Physical Work," American Journal of Cardiology, 14, No. 6 (December, 1964), 747-752.

Tobis, Jerome S. and Lenore R. Zohman. "Rehabilitating the Coronary Patient," Postgraduate Medicine, 47, No. 2 (February, 1970), 139-145.

Treece, Eleanor Walters and James William Treece. Elements of Research in Nursing. Saint Louis: The C. V. Mosby Company, 1973.

Varnauskas, E., H. Bergman, P. Houk and P. Bjorntorp. "Haemodynamic Effects of Physical Training in Coronary Patients," Lancet, 2, No. 7453 (July 2, 1966), 8-12.

Zohman, Lenore R. and Raymond E. Phillips (eds.). Medical Aspects of Exercise Testing and Training. New York: Intercontinental Medical Book Corporation, 1973.