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The Exercise Component of Cardiac Rehabilitation

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THE EXERCISE COMPONENT OF CARDIAC REHABILITATION

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This Independent Study, submitted by Thomas H. Olson in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

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PERMISSION

Title	The Exercise Component of Cardiac Rehabilitation
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ABSTRACT

Heart disease is the leading cause of death among all persons in the United States today. Many other people suffer from heart problems or conditions and are fortunate enough to survive. For those who do have nonfatal initial heart problems and complications, exercise will be a significant part of their follow up comprehensive cardiac rehabilitation program.

The cardiac rehabilitation program is determined by many medical professionals all of whom carry various responsibilities and participate in particular stages of a patient's overall program. The physical therapist is a member of the cardiac rehabilitation team and is generally in charge of the exercise portion of the program.

The purpose of this independent study is to explore the role of exercise, its importance, its prescription, and its implementation into the patient's comprehensive cardiac rehabilitation program. The information in this independent study will provide guidelines for the entry level or cardiac rehabilitation inexperienced physical therapist to better understand the scope and utilization of exercise as a component of comprehensive cardiac rehabilitation.

CHAPTER 1

INTRODUCTION

Coronary artery disease (CAD) is the number one killer in the United States and Western World today. Over a million persons will survive medical and surgical cardiac events each year in the United States alone. These cardiac events can include myocardial infarction (MI) which affects over 800,000 persons and angina pectoris, which is the overt manifestation of CAD affecting over 200,000 persons annually. More than 100,000 persons will undergo coronary artery bypass surgery (CABS) each year. Survivors are at high risk for a second, more serious event if medical intervention, including rehabilitation with exercise as an integral component, is not initiated after the initial event.[1,2]

The rehabilitation component of medical intervention is divided into three or four different phases, each of which builds a foundation and lays the ground work for advancement to the next phase. These phases focus upon the whole person through emotional, social, occupational, economical, medical educational and physical recovery through a multi-disciplinary approach. This integrated rehabilitation process provides baseline evaluation and surveillance of the medical status of the patient, progress assessment and emotional support components to aid the patient to recover to the fullest potential allowable according to the prognosis following the event.[2]

The traditional cardiac rehabilitation program generally focuses on services in three areas: exercise training, risk factor evaluation, and education/counseling. Other components within the entire program fall under these three categories.

There is much evidence to suggest that exercise/physical activity provides primary protection from the development of CAD and greatly influences the prognosis of persons who have CAD and many of those who have suffered a cardiac event. Clinically, it has been shown that exercise training can help lower resting and submaximal heart rates, decrease systolic blood pressure, increase a patient's functional capacity, improve lipid profiles, and psychologically guide the cardiac patient's self efficacy.[3]

This paper will focus upon the exercise component of the entire multi-disciplinary rehabilitation program and the general exercise progression of the cardiac patient through the comprehensive program phases.

CHAPTER 2

HISTORY OF CARDIAC REHABILITATION

In the years past there was much controversy as to whether exercise was important in the rehabilitation process of the cardiac patient. Mostly, it was not known whether exercise was beneficial or unhealthy for the patient. As far back as 1772, W. Heberden, a noted physician, published a report advocating the use of exercise for his patient with a chest disorder. The report described a six month program of exercise consisting of 30 minutes of daily sawing activity. In 1799, C.H. Parry described beneficial effects of physical activity performed by his patients suffering from chest pain.[5] These reports were written long before a formalized definition of coronary artery disease (CAD) was established.

In 1912, J.B Herrich gave his clinical description of an acute myocardial infarction (MI).[6] In that report he described the MI formally and also expressed concern that increased activity could cause greater risk for ventricular aneurysm rupture or arterial hypoxemia. Thus began the era of conservative management of heart patients.[5] Into the early decades of this century, heart patients were kept at complete bed rest for a minimum of 6-8 weeks. These patients were encouraged to minimize voluntary movements and they were subsequently fed, bathed and dressed by nurses. Hospitalization and bed rest for periods of up to four months were not uncommon in those days. Once many of these heart patients were released from the hospital they were still restricted to minimal physical activity levels and strenuous activity such as stair climbing was discouraged for at least one year. For most of these patients the resumption of a productive work life or normal life as they knew before the insult, especially as far as exertional activities were concerned, was not expected.[6] This approach to cardiac rehabilitation was further strengthened by studies by G. Malloy and P. D. White published in 1939. In these studies White and Malloy[7] proported the need for at least six weeks of bed rest for the necrotic tissue of the damaged heart to form a firm scar. They said, "To advise less than three weeks in bed is unwise, even for patients with the smallest myocardial infarcts." T. Lewis[8], in 1933, stated that 6-8 weeks of bed rest was necessary treatment and said, "During the whole of this period the patient is to be guarded by day and night nursing and helped in every way to avoid voluntary movement or effort."

In the late 1930's, the New York State Employment Service became concerned about an increasing number of men on disability and decided to investigate the matter. They found, through a survey, that approximately 80% of those disabled individuals were coronary patients who had never been able to return to their respective occupations. They further found that very few of those men had tried or had had the opportunity to re-educate for another occupation or even been given the opportunity to change jobs within their previous area of employment. In 1940, prompted by these findings, the New York State Employment Service in conjunction with New York Heart Association established the work classification unit or work evaluation unit. It's purpose served three functions. First, to establish the work capacity of the cardiac patient and offer the appropriate job placement accordingly. Second, to educate training physicians and inform the general public. Lastly, to research cardiac patients looking at causes of cardiac disease in relationship to ability to work. Although exercise was not a part of this program, the project is considered an early approach to cardiac rehabilitation as we know it today.[5]

The 1940s began to see more people in the medical community questioning the restrictions to activity commonly prescribed to heart patients. At this time, S. Levine[9] began a new change in cardiac patient treatment by recommending what is now known as the "chair treatment" for his patients. This new approach was seen as revolutionary at the time. The treatment consisted of allowing the patients to sit up in a chair for one to two hours beginning the first day after their infarction. Levine believed this to benefit patients by increasing peripheral venous pooling and reducing preload on the heart. Levine felt that "long continued bed rest saps morale, provokes desperation, unleashes anxiety and ushers in hopelessness of the capacity of resuming a normal life."[9]

Others at that time such as W. Dock[6] began to deny the practice of long periods of bed rest. Dock emphasized that long term bed rest increased the risk of thromboembolism, led to increased bone demineralization and muscle wasting, digestive and urinary tract problems and vasomotor instability. He also was against the use of bed pans and promoted the use of bedside commodes for his coronary patients due to the decreased energy expenditure and less likelihood of the use of the valsalva maneuver on this device as opposed to the bed pan.[6]

The decade of the 1950s began to see a new, liberalized attitude toward cardiac rehabilitation emerging. At the Thirteenth Scientific Session of the American Heart Association in Chicago in 1953, Louis Katz[10], a prominent physician of the times, told his medical colleagues at the convention that "physicians must be ready to discard old dogma when they are proven false and accept new knowledge." Other physicians at the time including D. Turrell and H. Hellerstine[5] pushed for a new more positive philosophy and a more comprehensive approach to the treatment of cardiac patients. Still yet, the medical community as a whole was reluctant to accept this new concept. Research in the area continued to be published and reported to a doubting medical community which refused to embrace it. It wasn't until Dwight D. Eisenhower, the President of the United States, suffered a heart attack while in office, did the tide begin to turn toward believing in the new approach. After his cardiac event, Eisenhower's physician, the respected and noted Paul D.

White, who was a proponent of exercise, prescribed graded levels of exercise for the ailing President which included swimming, walking and playing golf. Many of White's colleagues viewed this approach as reckless and inappropriate for such a noted patient, let alone the common heart patient. However, the program was successful and because of its positive effects on the President, Eisenhower created the President's Youth Fitness Council, better known today as the President's Fitness Council, renamed later by President J. F. Kennedy.[5]

Because of the aforementioned research conducted in the 1950s and the efforts of others at the time such as N. Wenger, B. Saltin, L. Zotman and J. Tovis and R. Bruce, the decade of the 1960s began to see a formalized shift towards inpatient cardiac rehabilitation programs. Many reports in the sixties proported progressive activity for the rehabilitation of the coronary patients including earlier discharge home from the hospital. Many studies of that era demonstrated that the risks of early activity such as ambulation were minimal and progressive activity during early stage acute myocardial rehabilitation was encouraged.[11]

Regardless of the progress being made in the field, the 1970s still saw varied approaches to cardiac rehabilitation being undertaken with little congruency. Many physicians still felt that the best course for patients with even uncomplicated myocardial infarctions was that of prolonged bed rest and hospitalization. Bed rest from one day to four weeks and hospital stays of up to six weeks were still commonly prescribed. The most recent data at the time however, showed that most of the serious complications after an acute MI usually occurred within the first days of hospitalization, and that those patients with uncomplicated MIs had little or no mortality and few complications in the later stages of hospitalization.[3] Thus, unless the patient suffered from recurrent cardiac pain, cardiac decompensation, serious rhythm disorders, or other major complications, early activity and shorter hospital stays were slowly coming to be the trend.[6]

The recently past decade of the 1980s saw many advances in the realm of cardiac rehabilitation. Advanced testing/diagnostic equipment allowed for better risk stratification of coronary patients and better identification of low risk cases earlier in the course of hospitalization. With these advances physicians and other rehabilitation personnel could prescribe activity for the coronary patients and tailor it to their particular case. Exercise rehabilitation as a component of the comprehensive cardiac rehabilitation process was individually prescribed based on the patients' clinical status' and rehabilitative prognosis and goals.[6] Continued advances are being made in the cardiac rehabilitation scene and the 1990s will continue to see refinement in the field as research continues to enforce the importance and necessity for exercise related activity as a part of the entire rehabilitation process.[3]

CHAPTER 3

PRE-EXERCISE CANDIDACY SCREENING

Before the exercise component of a patient's cardiac rehabilitation program is implemented, that patient must first be cleared by his/her primary physician as an exercise candidate. This entails a thorough examination and screening process. This is accomplished through taking a thorough history, chart review, a patient interview and an extensive physical examination.

The initial priority of the physician is to determine if the patient's CAD or other heart condition is stable. The physician can generally determine this by obtaining a thorough patient history. This history should reveal information concerning whether the patient is threatened by inordinate myocardial oxygen requirements including unstable angina and reduced myocardial reserve and ventricular function. It should also identify the medications the patient is taking which could have hemodynamic consequences effecting training capabilities. Lastly, other systemic diseases or disorders which might contraindicate physical activity in the cardiac rehabilitation program should be discovered.[11,12,13]

Following the history screening, the physician then performs an extensive physical examination of the patient. The cardiovascular system is the main focus of this examination. The physician should also be able to easily detect other problems such as hypothyroidism, congestive heart failure or abdominal aortic aneurysm. The physician must also be on the lookout for more subtle lesions which can be detected through inspection and palpation of peripheral arteries, palpation and auscultation of the heart and a thorough examination of the eye grounds.[12] The physician should also do complete lung/breathing sound evaluations and blood pressure screenings.[11]

Following the history and physical examination of the coronary patient the physician should then order any particular laboratory tests he deems necessary. Essential tests for pre-exercise screening include a resting electrocardiogram (ECG), a chest roentgenogram and particular blood chemistry tests.[12]

The ECG, taken at rest, is a recording of the patient's electrical activity and conduction system of the heart. Results of this test are used to evaluate cardiac rhythm and electrical conduction. The results can also be used to detect specific heart chamber enlargement, myocardial ischemia or myocardial infarction.[14] Any evidence of increasing ischemia, unsuspected or undetected infarction or specific arrhythmias would be considered contraindications to exercise training. A detected combination of bundle branch block and CAD would be considered high risk or possibly contraindicate exercise training.[12]

After the ECG testing, the patient will under go a chest X-ray or roentgenogram. This test yields information about the size of the heart and is also a fairly simple indicator of reduced cardiac reserve. X-ray and fluoroscopic examination of coronary arteries can also detect severe atherosclerotic obstruction which is considered an exercise risk factor.[15]

The physician also utilizes the findings from particular blood chemistry tests for screening purposes. Blood tests including blood sugar levels, electrolyte levels and myocardial enzyme levels are routinely helpful in the screening process.

There are other factors the physician will take into consideration for the patient before clearance for cardiac rehabilitation exercise training. These would include the patient's motivation, elimination of undue risk factors and the potential benefit of exercise training to the patient.

Motivation is a major factor in patient adherence to the cardiac rehabilitation program and to the attainment of patient goals, and it is important for the individual patient's safety. Factors the physician will look for to determine the patient motivation level would include the patient's past history of regular exercise, patient personality traits, the patient's desire to return to good health and well being, the patient's fear of incapacitation and whether the patient enjoys exercise without it becoming boring.[12]

Upon completion of the history and physical evaluation of the coronary patient, the physician can then utilize the information gathered to assess the patient's risk factors and proceed to determine if exercise would be harmful to the patient.[12] Specific benefits, contraindications and risk stratification for exercise for cardiac patients is presented in Tables 1-3.

TABLE 1
Benefits of Exercise for the Cardiac Patient[24]

1.	Improved functional capacity
2.	Improved cardiovascular efficiency
3.	Reduced detrimental effects of prolonged bed rest
4.	Increased psychological outlook and improved well-being
5.	Improved coronary circulation
6.	Decreased resting systolic blood pressure
7.	Stress reduction/outlet
8.	Reduced chance of CAD events from recurring
9.	Decreased atherogenic factors of CAD
10.	Improved quality of life

TABLE 2
Contraindications to Exercise for Cardiac Patients[11]

1. Hypertension uncontrolled above 200 mm Hg systolic or above 110 mm Hg diastolic blood pressure resting
2. Unstable angina pectoris
3. Unstable cardiac conditions or recent MI
4. Second or third degree heart block
5. Serious ventricular or atrial arrhythmias
6. Thrombophlebitis
7. Recent systemic or pulmonary embolism
8. Body temperature above 100° F
9. Uncompensated heart failure
10. Acute pericarditis or myocarditis
11. Aortic stenosis (Severe or idiopathic)
12. Acute systemic illness
13. Uncontrolled diabetes
14. Overt psychosis
15. Exercise induced arrythmia (uncontrolled)

TABLE 3
Risk Stratification Levels and Characteristics of Cardiac Patients for Cardiac Rehabilitation Exercise.[11,21]

LOW LEVEL	INTERMEDIATE LEVEL	HIGH LEVEL
Uncomplicated hospital stay	Flat or downsloping ST segment	Ejection fraction less than 35% at rest
No myocardial ischemia	Reversible thallium defects	Prior MI or infarct involving 35% left ventricle
Functional capacity above or equal to 7 METs	Left ventricular function ejection fraction 35-49%	Systolic BP falls or fails to rise 10 mm Hg during exercise test
Normal left ventricular function (above 50%)	New or changing patterns of angina pain	Ischemic pain that is constant or recurring after 24 hours hospitalization
No significant ventricular ectopy evident		Functional capacity below 5 METs with complications
		High-grade ventricular ectopy
		CHF syndrome during hospitalization

Finally the physician must determine the patient's prognosis and thus the potential benefit the patient could receive as a result of exercise training. Exercise training has been proven to benefit patients with problems such as severe valvular aortic stenosis, idiopathic hypertrophic subaortic stenosis and other forms of cardiomyopathy all of which should have been red-flagged as a result of the physician's screening process.[11]

Not all coronary patients require cardiac rehabilitation exercise training, although many can benefit from it. Thorough screening and examination are necessary to determine patient candidacy for exercise training. However, it is not common to exclude patients from exercise training in a cardiac rehabilitation program. Even patients with some of the major contraindications to exercise (see Table 2) can be in exercise programs. However, these patients will need individualized exercise training and particular precautions must be followed according to the type of contraindication the patient displays.[11] These patients would not be candidate for general group cardiac exercise therapy. In all cases it is the decision of the primary physician to select patients for exercise training and make the referral to a cardiac rehabilitation program for exercise training appropriate to the patient.[11,12,13]

CHAPTER 4

EARLY AMBULATION AND ACTIVITY

There are specific goals and therapeutic strategies for the exercise component of the cardiac rehabilitation program. These include goals and strategies to improve exercise capacity and endurance, improve the quality of life and prepare the patients for return to normal life activities including occupational tasks. However, exercise in the initial stages of Phase I of the cardiac rehabilitation program of the uncomplicated post myocardial infarction or CABG is undertaken with the achievement of a separate set of goals in mind, namely, to overcome the detrimental effects of prolonged bedrest and inactivity.

The ill effects of prolonged bedrest and inactivity include orthostatic hypotension, decreased functional capacity, increased risk of thromboembolism, pulmonary system complications, metabolic alterations and general musculoskeletal atrophy.[11,16] Thus, activity is initiated as early as day one post MI or CABG, generally in the Coronary Care Unit (CCU) or in the Intensive Care Unit (ICU), if the patient's condition is classified as uncomplicated.[16] An uncomplicated condition means the absence of disturbances in cardiac rhythm, congestive heart failure, persistent or recurrent chest pain, hypotension or clinical shock.[17] Early mobilization guidelines state that the activity be dynamic at a low intensity of no more than 1 to 2 METs. (A MET equals 3.5 mL oxygen consumption at rest per kilogram of bodyweight per minute and is known as a Metabolic Equivalent. This is the average oxygen consumption at rest.)[2]

Patients must be supervised and monitored in all activity for individual responses to that activity. These responses are monitored with an Electrocardiography (ECG) monitor or telemetry and a blood pressure sphygmomanometer. Activity end points are dictated by the patient's symptoms of angina, severe dyspnea, dizziness or light-headedness, as well as the monitored responses of the BP and ECG readings which include detection of hypotension, arrhythmias or other abnormalities.[16] The activity level is increased gradually if no abnormal responses are encountered; activity level is only increased by the supervising individual after a review of the patient's symptoms and responses to previous activity. Many times requirements of 1 to 2 METs energy expenditure are met by the patient simply performing self care activities such as feeding, bathing or bedside commode use. Other minor activities such as sitting at the edge of the bed or in a chair and selected upper or lower extremity flexibility or range of motion (ROM) activities can meet this output level as well. The appropriate response to these low intensity dynamic activities is a heart rate increase of less than 20 beats per minutes, with a maximal heart rate of 120 beats per minute. This level of activity usually produces heart rates from 80 to 120 beats per minute. If the patient is on drugs which alter heart rate or blood pressure (i.e. beta blockers, calcium channel blockers, ACE Inhibitors, etc.) these values will be significantly lower; the general guideline for patients on this drug regime is a heart rate increase not to exceed 15 to 20 beats per minute above the resting heart rate. Other appropriate responses include absence of chest pain or discomfort, palpitations or exercise fatigue, no arrhythmias, no increase in ECG monitored ST segment displacement indicative of myocardial ischemia and lastly, increases in systolic BP of no more than 15 to 20 millimeters mercury (mm Hg). The systolic BP should never fall below starting values.[6,18] If self care activity responses do not exceed any of the aforementioned criteria, early ambulation will be the next line of progression.

Early ambulation consists of walking with progressive increases in pace and distance and is performed several times daily with rest periods between sessions. Ambulation output levels are gradually increased toward the level of 2 to 3 METs desired by discharge from the acute care hospital Phase I. Achievement of this level of activity allows the patient to be functional in home activities at that approximate level.

Early activity and ambulation for appropriate patients provides many benefits beyond those of off-setting detrimental physiologic effects of bedrest and prolonged inactivity. Early low-level activity provides patients with confidence that they can resume active lives and decreases their sense of depression due to fears of becoming invalid or of dying. This improves self confidence and self image and increases their acknowledgment of the physician's assertion that they can resume work and many of the normal life activities enjoyed before their hospitalization. Early activity and ambulation also helps decrease the period of stay in the hospital, thus less medical expenses are incurred by the patients and the potential for the use of hospital beds is also increased.[6,17]

Another important benefit of early activity and ambulation is the fact that it makes predischarge exercise testing viable. (It would be inappropriate for the patient who had been on prolonged bed rest or inactivity.) Thus, because of the benefits of early mobilization patients' functional capacities through graded exercise testing (GXT) can be assessed appropriately and a prognosis and risk stratification derived. Data for exercise prescription in the outpatient phase(s) of patients' cardiac rehabilitation programs can also be obtained.[6,18]

CHAPTER 5

THE GRADED EXERCISE TEST

After the patients have successfully completed the medical screening process and have been cleared for the exercise portion of their rehabilitation program by their doctor, the next step in preparation for exercise is the exercise stress testing. The patients may undergo various exercise tests to determine specific information about their present cardiac condition as well as current fitness levels. Variables such as aerobic capacity through peak or optimal oxygen uptake (VO_2 max), blood pressure (BP) and heart rate (HR) responses due to hemodynamic changes can be evaluated with these tests. Also clinical signs and symptoms which could be limiting to the exercise program, such as angina pectoris and associated electrical function activity changes in the heart as well as other factors, can be detected with these tests. Primarily, exercise testing goals are to determine the patients' cardiac responses at given levels of effort and to correlate these responses to probable performance demands in life and occupational situations.[6] Data gathered from these tests can be used in a multitude of ways including the determination of physical work capacity; the determination of prognosis; the degree of patient recovery; the evaluation of progress during rehabilitation; the monitoring and detection of dysrhythmias; and for patient motivation according to progress.[13]

Clinical application of exercise testing is generally for diagnostic, functional or therapeutic objectives.[19]

A fairly standard, noninvasive exercise test that provides a wealth of information about patients is the graded exercise test (GXT). The GXT is generally administered on either a treadmill or a cycle ergometer, but it can also be conducted on steps or on an arm ergometer if patients' needs so indicate.[19,20] The GXT is the recommended precursor to formulating patients' exercise prescriptions. The exercise prescriptions will be based on the physiological responses of patients to the GXT. Guidelines for the administration of GXTs are outlined by either the American College of Sports Medicine (ACSM)[19] or the American Heart Association (AHA).[21]

The most commonly used dynamic testing method for administration of the GXT at present in the United States is the treadmill stress test.[11] During this test an attempt is made to provoke and electrocardiographically document exercise-induced myocardial ischemia and to correlate these changes with patient symptoms.[22] The treadmill stress test performance begins with first obtaining a resting baseline ECG, HR and BP. These parameters are then continually monitored throughout the testing at set intervals. There are various exercise test protocols which are successful with the treadmill stress tests. These include, but are not limited to the Bruce and Modified-Bruce Protocols, the Balke-Naughton Treadmill Protocol, the modified Balke Protocol, Branching Treadmill Protocols, the Ellestad Protocol, the Sheffield Protocol, and the modified Astrand Protocol.[19,22,23,26] Since these are all standardized protocols it is necessary to choose the proper protocol and utilize this through subsequent tests on the same patient in order to be consistent in comparisons. These protocols are all progressive, uninterrupted and the workload is increased in stages.[24]

The most widely used treadmill protocol is the Bruce Protocol. In this test the speed and grade (incline) of the treadmill are changed every three minutes. It is a relatively brief protocol with five stages, (the Modified-Bruce Protocol has seven stages), although most nonconditioned patients rarely exceed stage three. Its brevity is its major advantage. It is not recommended for cardiac patients with low anginal thresholds, however, nor is it recommended for post myocardial infarction predischarge exercise testing.[19] The Balke-Naughton Treadmill Protocol uses constant walking speeds of 2.0 to 3.3 miles per hour with only grade increases every two to three minutes. The modified Balke Protocol is a more applicable method for testing cardiac patients who have limited exercise capacities due to the test's gradual incremental increases.[19] See Table 4 for protocol comparisons.[27]

The treadmill utilized in the testing should be equipped with front and side hand rails for the patients to steady themselves, but not to be held on to constantly. Instead the patients should make a light fist and extend the index finger to touch the front rail to steady themselves when beginning walking until comfortable then let the arms swing at their side naturally during the test.

TABLE 4
Comparison of Common Treadmill GXT Protocols Used in Cardiac Rehabilitation[27]

Stage	Modified-Bruce Time/Elevation/Speed	Modification-Balke Time/Elevation/Speed	Ellestad 1 Time/Elevation/Speed	Naughton Time/Elevation/Speed
1	3.0/10/1.7	2.0/02/3.3	3.0/10/1.7	3.0/0/2.0
2	3.0/12/2.5	2.0/04/3.3	2.0/10/3.0	3.0/3.5/2.0
3	3.0/14/3.4	2.0/06/3.3	2.0/10/4.0	3.0/7.0/2.0
4	3.0/16/4.2	2.0/08/3.3	2.0/10/5.0	3.0/10.5/2.0
5	3.0/18/5.0	2.0/10/3.3	2.0/15/6.0	3.0/14.0/2.0
6	3.0/20/5.5	2.0/12/3.3	2.0/15/7.0	3.0/17.5/2.0
7	3.0/22/6.0	2.0/14/3.3	2.0/15/8.0	3.0/21.0/2.0
8	------------	2.0/16/3.3	------------	------------
9	------------	2.0/18/3.3	------------	------------
10	------------	2.0/20/3.3	------------	------------

Time = Minutes   Elevation = % Grade   Speed - MPH

Grasping the hand rail will decrease oxygen uptake and work and increase exercise time and ECG muscle artifact. Any other type of isometric work should be avoided as well. The patients should be taught how to maintain a steady pace as they walk and to avoid turning their heads or trunks so as not to interfere with balance. These things may be demonstrated to the patients before testing begins.[11,19]

For patients who have orthopedic problems or instabilities which might contraindicate treadmill walking, the cycle ergometer is a useful alternative exercise modality for the GXT. The cycle ergometer is not as easily regulated to changing workload demands as is the treadmill, however, so if the patients slow down the pedaling pace, there is a decrease in the administered workload. Also the patients must be relaxed in the upper extremities and avoid an isometric "tight" grip on the handlebars as this will increase their work output. Cycle ergometer protocols generally begin with no load on the pedals for a two minute warmup period and then progress 25 to 50 watts in workload every two minutes. HR and BP are monitored every minute and ECG readings are taken after each two minute interval. Cycle ergometry induced HR values are generally about the same as treadmill values, but BP values generally tend to be somewhat higher and VO_2 max levels somewhat lower than in the treadmill tests.[19]

Arm ergometry exercise testing is used as an alternative to the cycle and treadmill exercise tests for patients with problems such as peripheral vascular disease, musculoskeletal disorders or neurologic conditions which do not allow them to participate in leg exercise tests.[6,11,18] Arm ergometer protocols are generally continuous with a 25 watt workload increase every two minutes. Some arm ergometry test protocols allow for discontinuous stages; with each stage the workload increases 25 watts, but a rest period of one to two minutes is allowed between stages. This type of protocol is better tolerated by most patients and it also allows for easier monitoring of the patients' BP. Arm ergometer testing usually evokes lower VO_2 levels than does leg ergometry. HRs are usually equal to or slightly lower than those achieved by leg ergometry. BP responses are difficult to compare between the two.[19] Basically, the data collected through arm ergometry stress testing is satisfactory as an alternative mode of testing for myocardial ischemia, but it is not an acceptable test for aerobic capacity. Functional capacity testing with this method is not reliable.[25] Therefore, arm ergometry testing is a suitable, but not an equivalent alternative to leg exercise testing.[11]

ECG monitoring is a vital part of the GXT regardless of whether it is a functional or a diagnostic exercise test. Most ECG exercise monitoring systems utilize a 10 to 12 lead modified configuration for electrode placement, but many configurations and styles exist. Because the heart is a three dimensional anatomical structure, leads must also be placed in a three dimensional pattern to reflect the entire electrical progression of conduction within the heart. Therefore, many lead systems and configurations have been developed to meet the specific needs and situations which exist in monitoring. By increasing the number of leads, the sensitivity of the test is increased, but the selectivity of the test is then decreased. It has been shown that a minimum of three leads is necessary for clinical situations and that a single lead can detect approximately 80% of ST changes detected by multi-lead systems.[26] The key to satisfactory ECG monitoring is proper skin preparation prior to lead placement to eliminate noise in the signal.[19] Electrodes are placed in a variety of configurations depending upon the specific monitors used and the quality of the signal desired. Because the question of the number of leads truly needed for exercise testing is still not resolved, it is best to record as many leads as is economically and practically possible.[24]

The ECG data which is obtained from the exercise stress test is very helpful in designing the exercise program and also serves as a baseline for future comparisons throughout the patients' cardiac rehabilitation program.[20] The data is used to evaluate patients' suitability for exercise therapy as well as to help determine their prognosis. The data can be quantitatively used to evaluate patients' chronotropic capacity, aerobic capacity, myocardial aerobic capacity, and changes in the electrical functions of the heart.[26] The ECG data can also be used for many other diagnostic and functional purposes beyond the scope of this study.

Generally, normal GXT end-points for termination of the test include hyperpnea, symptoms of muscle fatigue, Rate of Percerved Exertion (RPE) greater than seven (very hard), and achievement of maximal predicted heart rate. All of these symptoms converge rapidly over a short time so careful monitoring is necessary to avoid overstress. The test may also be terminated if abnormal responses are observed such as angina, dyspnea, falling systolic BP, dizziness or indications of severe ischemia or left ventricular failure.[19]

The cardiovascular response to GXT should be a heart rate of no less than 85% predicted maximal heart rate for the GXT to be considered maximal and valid. Blood pressure values vary widely from 160-200/50-90 mm Hg. Discontinuation of the test should be initiated when a systolic BP of 250 mm Hg or more or a diastolic BP is greater than 120 mm Hg is achieved.[11,19]

CHAPTER 6

EXERCISE PRESCRIPTION PHASES I-IV

The cardiac patients' exercise prescriptions are generally formulated by an exercise specialist (i.e. physical therapist or exercise physiologist) and the patients' physicians. It is formulated based on results of evaluations and tests mentioned in previous chapters of this study. Many factors contribute to the determination of the dosage or amount of exercise prescribed for the patient. These factors include frequency, intensity, duration, mode and rate of progression. Other factors which influence the exercise prescription are the patients' personality types, interests, needs, background and their current health status.[6,22,24,25] In definition, the exercise prescription is "the process for recommending a regime of physical activity in a systematic and individualized manner to help the patient to achieve optimal physiologic benefit from exercise training, enhance physical fitness, promote health by reducing risk for further development or recurrence of disease and ensure safety during exercise participation."[6] Exercise prescription for cardiac patients should be approached with caution and respect the same as would any prescribed medication in order to minimize complications and maximize benefits to the patient.[28]

Because exercise begins early in the cardiac patient's overall rehabilitation process, the exercise prescription must meet goals specific to the current stage of rehabilitation and focus on its needs. The rehabilitation process must be viewed as a continuous and logical process that begins as early as CCU or ICU, as mentioned in Chapter IV, and optimally becomes a life long habit. The exercise demands must be continually adjusted to the patient's stage of rehabilitation. Generally there are four stages of the Cardiac Rehabilitation Program: 1) Phase I is the inpatient hospital stage; 2) Phase II is the early outpatient phase after hospital discharge; 3) Phase III the later outpatient phase, and; 4) Phase IV is the life long maintenance stage.[28] The goals of each stage require the exercise prescription to be flexible and modifiable to meet the needs of the patients at that time.

Phase I

In Phase I of patients' cardiac rehabilitation programs, exercise or activity is prescribed with goals different from those of later stages of the program. In this phase the major goal of activity/exercise is to forestall the deleterious effects of prolonged bedrest. Early exercise also gives the patients confidence that they can be active after their event and thus it helps decrease psychological side effects of anxiety and depression often brought on by prolonged bedrest once prescribed after a cardiac event. The goal is not aerobic conditioning at this point; the goals are to decrease physical deconditioning, prevent thrombosis and enhance the patients' well-being.[2,26]

In Phase I activity begins once the patients are medically stabilized and are free from life-threatening complications. Early activities include the use of a bedside commode, chair sitting and short walks about the room. By approximately day three post uncomplicated cardiac event the patients are gradually working up to short walks into the hallway. These walking sessions are short (generally of 5 to 20 minutes duration) and of low intensity. The heart rate should not exceed 20 beats per minute above the resting heart rate at any time during the session. At this stage of the program multiple short walks throughout the day are generally safer and less fatiguing than a single long walk. The patients should be closely monitored during this stage of rehabilitation. Generally HR, BP, and ECG responses to exercise, ambulation and other activities are keys to detecting problems such as myocardial ischemia and dysrhythmias.[2] The patients should also be taught to monitor their symptoms using the New Borg Rate of Perceived Exertion (RPE) Scale.[27] This is a numeric scale from 0 to 10 with word descriptors to rate a patients' perceptions of exertional levels. See Table 5. The Borg Scale relates well to physiological factors such as heart rate, oxygen consumption, and minute ventilation. It has been proven to be a valid and reliable indicator of a patient's level of physical exertion. In Phase I of cardiac rehabilitation the patient usually exercises to a rating of not more than four on the scale or "somewhat strong" exertion. This relates to a HR of no more than 20 beats per minute above the resting HR.[19,20,26]

TABLE 5
Borg Scale (Rate of Perceived Exertion)[27]

Numeric Value	Verbal Descriptor
10+	Maximal
10	Very, very strong
9	
8	
7	Very strong
6	
5	Strong
4	Somewhat strong
3	Moderate
2	Weak
1	Very Weak
0.5	Very, very weak
0	Nothing at all

Another method of prescribing exercise levels or intensity is to use the Metabolic Equivalent (MET) levels as defined in Chapter IV. Phase I cardiac patients usually carry out exercise at the low intensity 2 MET level in the early parts of Phase I and progress to the 3 to 4 MET level by discharge.[2] Activities at this higher level would include ROM activities (upper or lower extremity), sitting or standing intermittently, and short ambulation distances. Near the end of Phase I at approximately 6 to 8 days post event, stair climbing should also be added.[26]

Because hospital stays are much shorter now than they were in the past, rehabilitation efforts must be aimed at the important areas and not progressed in predefined stages over a period of days as was common in the not so distant past. Thus, the goal is to ambulate the patients as soon as is reasonable and safe in order to prepare the patients for a return to normal activities to enable them to go home.[2,3]

It is generally at this level, just prior to discharge from the hospital, that patients undergo the GXT in order to determine their current level of fitness and to help gather information for the Phase II exercise prescription. From this test the patients' upper limit target HR can be determined as well as their response to exertion at greater levels.[28] At this time it is also necessary to review the general components of the exercise prescription the patients will be following in Phase II of their program. These components include warm-up and cool-down periods, the exercise period, intensity of exercise, duration of the exercise sessions, frequency of exercise sessions, and the rate of progression of exercise in this phase.[6]

Phase II

Phase II of the cardiac rehabilitation program is the outpatient program. This stage is generally three months in duration or longer. It is considered a critical period in cardiac rehabilitation because it generally has the highest mortality rate of all phases. It is also a very vulnerable period for the patients due to their anxiety about the safety of resuming normal activities. Goals in this period should address the monitoring of patients' symptoms, creating a positive outlook in the patients, aiding the patients' return to work and leisure activities and continued education of the patients toward lifestyle modification and risk reduction. The patients should remain in frequent contact with health care personnel during the early stages of Phase II.[2] Most Phase II cardiac rehabilitation programs consist of structured exercise sessions which provide close medical supervision. Supervision of Phase II patients gives reassurance, allows for immediate identification of complications and also helps patients recognize or interpret new symptoms.[2,3] Activities in this phase should be safe, noncompetitive and goal oriented. Activities should always begin with a warm-up period, proceed to aerobic activity and then end with a definite cool-down period. All programs must have a cardiac cart with a DC defibrillator on site for any emergency that might arise. This device can also be used for monitoring patients' hearts if an ECG or telemetry unit is not available. It is advised that a telemetry unit be on site for Phase II programs.[29]

Phase II exercise prescriptions vary according to the patients' individual functional capacity. If patients at the Phase II level have a functional capacity (FC) of less than 5 METs, the guidelines for inpatient exercise prescription are still valid. For patients with a FC of greater than 5 METs, heart rate and RPE are the general guidelines for exercise intensity. Phase II exercise duration should, in the early stages, be about 10 to 15 minutes initially and gradually increase up to 30 to 60 minutes in later stages. The frequency of exercise should be 3 to 4 sessions per week. The intensity of exercise is monitored by the patients' HR and RPE score. These must be monitored regularly because various modes of exercise can evoke different responses. There are several different modes of exercise training available the Phase II patients. These include interval training and conditioning where exercise is followed by rest periods at specific intervals; circuit training, in which patients exercise on a variety of modalities with or without interspersed rest periods; circuit-interval training which combines the two aforementioned methods; and continuous conditioning, which requires continuous exercise throughout the training period.[19] These modes of exercise can be fulfilled using a multitude of different exercise types or modalities such as walking, jogging, circuit weight training, cycling, rowing, low-impact aerobics, etc.

Phase II of the cardiac rehabilitation program has general guidelines for discharge but they are not standardized. Criteria which should be considered before progression to the Phase III community program include a functional capacity of no less the 5 METs, a stable medical status with a normal and unchanged ECG at peak exercise, normal hemodynamic responses to exercise, absent or stable angina and a physical fitness level adequate for daily activities and/or occupational duties.[19] When patients meet these requirements satisfactorily, they will then be discharged to the next phase of the program.

Phase III

Phase III of the cardiac rehabilitation program is either a community based program of group nature or an individualized home program. Either of these programs is tailored to be indefinite in duration. The exercise prescription in Phase III now becomes more like that prescribed a healthy adult, although the exercise intensity is somewhat lower. Generally the intensity is about 70% of maximal HR. This will be aimed towards the 85% mark as the patients progress through the program. Each session is usually 30 to 60 minutes in duration and the frequency is at least 3 to 4 times per week.[19,26] Specific goals in Phase III continue to aim towards enhancing functional capacity through exercise training, the identification of patients who may require additional interventions beyond rehabilitation such as surgery or angioplasty, the limitation of psychologic problems that could hinder functioning and lastly intensive risk factor modification to prevent the recurrence of further cardiac events.[2]

For patients who wish optimally to return to work it is necessary for them to work toward attaining a functional capacity of 8 to 9 METs as a threshold. The suggested minimal functional capacity for entering a community based program is generally 5 METs. Exercise intensity in Phase III should be based upon the patients' clinical status and pathological abnormalities. Once a functional capacity of 8 to 9 METs is achieved the goal should be aimed more toward a maintenance program. Although patients can continue to exercise at continually higher intensities and more frequently, it is not suggested that the duration of exercise bouts increase.[19]

Ultimately, Phase III programs should promote patients' adherence to the exercise prescription and other lifestyle modifications. This will then help the patients continue in lifelong exercise participation beyond the community based Phase III program.

The duration of Phase III is generally in the 6 to 12 month range and is dependent upon the local program guidelines. It is not unusual for patients who do not reach discharge criterion to remain in this phase for indefinite periods. Discharge criterion for leaving the community based Phase III program is not standardized, but the following criterion is the general discharge base information: Energy output levels of at least 5 METs are necessary for general daily activity in the home setting. Medical and physical fitness status for discharge are the same as for Phase II although it is hoped that patients who have participated in a community based Phase III program would exhibit greater functional capacity and be able to tolerate activities with higher metabolic demands.[2,19]

In addition to the exercise component of the Phase III program, of equal importance is the educational component and ongoing efforts to improve the patients' knowledge of their disease process and their role in health maintenance. This means continued adherence to behavioral modification in lifestyle such as diet, smoking, stress and weight control. All of these components in conjunction with regular exercise must remain consistent throughout the cardiac patients' lives.[2,18,19]

Activities in Phase III include walking, walk-jogging, jogging, cycling, rowing and resistance training to name a few. Distance goals, not speed, are important in this phase. Whatever the chosen mode of exercise in Phase III, the frequency, intensity, and duration of the patients' programs should be individualized to fit their capabilities and interests as well as their motivation levels. It is the maintenance of physical fitness that is the goal in this phase.[18]

Phase IV

Although not all programs have a Phase IV, for those that do, Phase IV is the ongoing maintenance phase where the goal is to continue the exercise program through a home program. It is also important for the patient to continue the high-level achievement of maintaining health risk-factor modification. Exercise levels of Phase III should be maintained in this phase. It is also recommended that these patients follow up with yearly GXTs and those patients with complications attain more frequent assessments.[2,22]

CHAPTER 7

SUMMARY

As this study pointed out, exercise plays an important role in the comprehensive cardiac rehabilitation program in two major ways. First, exercise is a vital part of the prognostic and diagnostic portion of the rehabilitation process through the GXT in its various applications. Secondly, exercise is the basis of treating patients in an attempt to improve their tolerance to the imposed demands of activities on the cardiovascular system such as normal daily lifestyle activities. Since the cardiovascular system has been altered due to the patients' cardiac events, exercise is a versatile tool in their cardiac rehabilitation. The patients can benefit from exercise according to the goals of the particular phase of the program. Early in the program the patients benefit from exercise by minimizing the ill effects of bedrest and prolonged inactivity. Later in the program, exercise becomes a tool to help decrease the risk of a recurrence of the initial event and exercise enables the patients to become as physically fit as is possible when all factors are taken into consideration.

Exercise testing is a useful diagnostic tool for determination of the cardiac patients' conditions and it helps to formulate their individual exercise prescriptions. The GXT allows the rehabilitation staff the ability to determine patients' cardiac conditions, and it is a valuable tool for following patients' progress in a standard and consistent manner. The GXT is also used in conjunction with other tests to further explore the patients' conditions.

Ultimately, the cardiac rehabilitation program is dependent on team work, but the base of the cardiac rehabilitation pyramid is the patients. The patients must understand why exercise is beneficial to them, how it can effect their condition and help them return to normal or near normal lives. Utmost however, the patients must be motivated to perform exercise and learn to change their lifestyles in order to reap the benefits cardiac programs offer. This must become a lifelong habit for the patients in order for it to be completely successful.

The four phased cardiac rehabilitation program provides cardiac patients with physical therapy, medical education and assessment, psychological support and education in lifestyle modification, all of which are continuous from the initial event and ultimately throughout the patients' lifetimes. It is effective for patients of all ages and for most cardiac patients. Ultimately, the patients must be motivated to participate to maximize their program benefits.

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