12-2000

The Safety and Efficacy of Resistance Training for Chronic Heart Failure Patients

John B. Coleman
Western Michigan University

THE SAFETY AND EFFICACY OF RESISTANCE TRAINING FOR CHRONIC HEART FAILURE PATIENTS

by

John B. Coleman, Jr.

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Health, Physical Education,
and Recreation

Western Michigan University
Kalamazoo, Michigan
December 2000

ACKNOWLEDGMENTS

The task of completing this thesis project has been very challenging and insightful. I could not have accomplished this without the help of several caring individuals. I would like to thank Dr. Dawson and Dr. Zabik for their continuing guidance and unending patience through the course of this research. I am also grateful to all of the staff at the Borgess Health and Fitness Center for their support, insight, and help in collecting data from the CHF clinic patients. Those employees included: Julie Frawley, RN; Pat Collopy, RN; Susan Miller, RN; Vickie Asaro; Cile Bell; Julie Johnson; and Janeen Docsa.

John B. Coleman, Jr.

THE SAFETY AND EFFICACY OF RESISTANCE TRAINING FOR CHRONIC HEART FAILURE PATIENTS

John B. Coleman, Jr., M.A.

Western Michigan University, 2000

The purpose of this study was to determine the safety and efficacy of resistance training (RT) in chronic heart failure (CHF) patients. Two retrospective CHF patient groups were assessed pre and post 4-week participation at the Borgess Health and Fitness Center CHF Clinic. The first group participated only in monitored aerobic exercise (AG, $N = 10$), while the second group participated in monitored aerobic exercise along with the six experimental RT exercises (ARG, $N = 10$). The safety parameters measured during the aerobic and RT exercises were incidence of new onset arrhythmia and rate pressure products (RPP). The efficacy parameters measured were perceived self-efficacy and functional capacity. These were measured pre and post using the SF-36™ Health Questionnaire (SF-36) and 6 min walk test (6WT) scores, respectively. ANOVAs revealed significant differences ($p < .05$) on the subject score of the SF-36, vitality, and 6WT distance walked. No new onset arrhythmia were documented while performing the RT exercise; 22 new onset arrhythmia were noted during the aerobic exercise. The RPP was lower during the RT exercise as compared to the RPP measured during aerobic exercise and the 6WT. Results of this study suggest that RT is a safe and effective means of exercise therapy for CHF patients.

TABLE OF CONTENTS

Table of Contents—Continued

Table of Contents—Continued

LIST OF TABLES

List of Tables—Continued

CHAPTER I

INTRODUCTION

Chronic heart failure (CHF) is a disease where the heart's function cannot match the metabolic demands of the body. This mismatch in nutrient supply is primarily due to the decreased pumping capacity of the left ventricle. This results in a diminished ejection fraction, termed left ventricular dysfunction (LVD). LVD leads to symptoms such as dyspnea on exertion, excessive fatigue, decreased functional capacity, as well as pulmonary and peripheral edema. The most common causes of CHF are: (a) ischemic heart disease, (b) left ventricular hypertrophy, and/or (c) diabetes. CHF afflicts 4.7 million Americans, 15 million people worldwide, and is growing at a rate of 400,000 new cases per year (Balady & Pina, 1997). Upon diagnosis, as noted in the Framingham study from 1948 to 1988, the median survival time is 1.7 years in men and 3.2 years in women (Balady & Pina, 1997). Strategies to prevent CHF and its progression include intense pharmacotherapy in conjunction with exercise and lifestyle modification. It is theorized that LVD cannot be greatly improved with exercise, so the goal of secondary exercise interventions is to enhance the oxidative capacity of the peripheral systems. To date, the most common form of exercise therapy is monitored aerobic exercise. This presents a one-dimensional training effect. A primary complaint among CHF patients is persistent and excessive fatigue. This excessive fatigue is partially due to skeletal muscle tissue atrophy, primarily from disuse (Mancini, Walter, & Reichek, 1992). Previously, it was believed that any exercise therapy was contraindicative for CHF patients. Now,

aerobic exercise is a common treatment in CHF therapy. Resistance training (RT) was thought to be too demanding on the heart of the CHF patient and therefore contraindicative for CHF patients. Currently, there is little research available that has measured the physical and psychological effects and safety of RT in the CHF population. Resistance training in conjunction with aerobic exercise may provide a safe and effective means for slowing the deleterious effects of CHF.

Statement of the Problem

The problem in this study was to determine the safety and efficacy of RT as a component of the exercise therapy used with CHF patients. Blood pressure, heart rate, rate pressure product (RPP), incidence of arrhythmia, 6-minute walk test (6WT) scores and Short Form 36™ Health Survey (SF-36) self-efficacy questionnaire scores were the dependent variables used in the comparison of two retrospective CHF clinic patient groups.

Purpose of the Study

This research project was conducted to determine whether RT was a safe and effective component of exercise therapy for individuals with CHF. A major outcome of CHF is a decline in functional capacity. Due to the fragile nature of these patients, a true measure of absolute functional capacity, maximal aerobic capacity (VO_2 max), is difficult or impossible. One solution to this problem has been the use of submaximal testing, in particular VO_2 peak assessment. Measurement of the distance covered in a standard 6WT has proven to be a valid and reliable measure of functional capacity for cardiac patients (Hamilton & Haennel, 2000). The estimated METS achieved during a 6WT may be used to estimate VO_2 peak in CHF patients.

VO_2 peak is defined as the maximal oxygen consumption achieved during a graded exercise test that is terminated either by the subject or the test administrator prior to the achievement of VO_2 max. VO_2 peak is a good predictor of the one-year survival of CHF patients. VO_2 peak values greater than 14 ml O_2/kg/min are associated with a 90% one-year survival rate. VO_2 peak values lower than 10 ml O_2/kg/min are associated with a 24–77% one-year mortality rate (Meyer et al., 1998). In CHF patients it has been estimated that 50% of the decrease in VO_2 peak is due to skeletal muscle atrophy (Mancini et al., 1992). RT has been shown to result in an increase of 4–15% in VO_2 max (Fardy, Franklin, Porcari, & Verril, 1998). The most prevalent symptoms of diminished functional capacity are excessive fatigue, dyspnea, and low levels of physical activity. A leading cause of these symptoms in the CHF patients is skeletal muscle abnormalities. These abnormalities may lead to decreased oxygenation of the respiratory muscles during exercise, causing a decrease in endurance and strength. Selective RT of the respiratory muscles has proved successful in increasing VO_2 peak in chronic obstructive pulmonary disease patients and may prove beneficial in the CHF population as well (Mancini, Hanson, LaManca, Donchez, & Levine, 1995). Increases in skeletal muscle mass have been shown to cause increases in basal metabolic rates and leads to greater overall exercise tolerance. RT in cardiac patients has been shown to improve glucose tolerance and enhance insulin sensitivity as well as improve carbohydrate metabolism. In the past, practitioners have believed that RT was contraindicative for cardiac patients. It was thought RT placed to great a demand on the heart. However, the long-standing perception that RT was harmful, or at least not beneficial to cardiac patients was not supported by the scientific evidence (AACVPR, 1999). In fact, evidence is accumulating that unnecessary rest may increase disability. It appears that careful

application of an adapted, progressive, RT regimen, such as an individually tailored program using light resistance, can enhance quality of life and possibly improve CHF prognosis as well (Delagardelle, Feiereisen, Krecke, Essamri, & Beissel, 1999). In a study of 14 CHF patients with an average ejection fraction of 31%, Delagardelle et al. (1999) observed no major traumatic, orthopedic, or cardiovascular problems while performing RT exercises using a pulley system. Dellagardelle et al. also observed no inappropriate blood pressure responses. Further, isometric/isodynamic exercise may increase myocardial perfusion at rate pressure products that normally produce ischemic ECG changes during dynamic exercise. The increase in diastolic blood pressure and decrease in venous return and ventricular wall tension during isometric exercise may actually increase myocardial reperfusion and increase blood flow to collateral and stenotic areas during diastole, creating a faster return to daily activities for the patient (Fardy et al., 1998).

Within the social cognitive theory model, the most significant variable related to motivation is self-efficacy. Self-efficacy is defined as one's beliefs in one's own capacity to successfully execute the necessary courses of action to satisfy situational requirements. The level of self-efficacy one possesses in part determines the choice of activities one engages in, the amount of effort expended and the degree of persistence demonstrated in the face of failure or aversive stimuli. These efficacy expectations can effect anxiety, depression, self-esteem, and affect. The mastery of performance accomplishments has been most consistently demonstrated as the most influential factor (McAuley & Blissmer, 2000). In order to enhance self-efficacy within the scope of daily living activities the patient may participate in strength specific tasks that create confidence in lifting weighted objects (Fardy et al., 1998). RT may enhance the quality of life for the CHF patient by increasing efficacy expectations.

The SF-36 is a questionnaire used to assess the self-efficacy of cardiopulmonary rehabilitation patients. The SF-36 is the most common tool used for self-efficacy measurement in the field of cardiopulmonary rehabilitation.

Delimitations

The following delimitations were identified for the study:

1. All subjects were male or female 18 to 100 years old.

2. The subjects were participants of the Congestive Heart Failure Clinic of the Borgess Cardiopulmonary Rehabilitation Department at the Borgess Health and Fitness Center, Kalamazoo, MI.

3. The study included two retrospective groups: (1) an aerobic group (AG) which participated in the standard aerobic therapy, 30 min of exercise 2 days per week plus patient education sessions, offered in the CHF clinic; and (2) an aerobic plus RT group (ARG) which participated in standard aerobic therapy, patient education sessions plus the RT exercise therapy.

4. Subject's functional aerobic capacity was assessed pre and post through the use of the 6WT performed on a Quinton CR 60 Medtrack treadmill (Quinton Instrument Company, Bothell, WA).

5. The subject's perceived self-efficacy was measured pre and post using the SF-36 (Medical Outcomes Trust).

6. Subjects in both groups attended two treatment sessions per week for 4 weeks.

7. The aerobic training sessions consisted of standard ECG telemetry monitored, aerobic exercise training lasting a maximum of 30 min per session.

8. The experimental RT regimen consisted of six pulley exercises performed in a circuit: (1) triceps pushdown, (2) biceps curl, (3) shoulder flexion, (4) shoulder extension, (5) latissimus dorsi pull, and (6) chest push. Subjects performed one set of 10 to 15 repetitions for each exercise starting at 3.5 lbs per exercise and titrated as tolerated.

9. The variables measured during the RT exercises were: (a) blood pressure, (b) heart rate, (c) incidence of arrhythmia, and (d) peak rate-pressure product (RPP).

Limitations

The following limitations could have affected the interpretation of the results of the study:

1. Because the nature of CHF causes frequent and recurrent hospitalizations, a small opportunistic sample was measured.

2. Duration of participation in the CHF clinic at the Borgess Health and Fitness Center was only 4 weeks.

Assumptions

The following assumptions were made for the study:

1. The equipment utilized in the data collection procedures operated within the specifications indicated by the manufacturers.

2. The subjects performed to the best of their ability during all training and testing sessions.

3. The individuals who helped in the data collection complied with the standard procedures established for the study.

Hypotheses

The following experimental hypotheses were formulated for this study:

1. Subjects in the ARG group will show greater increases in 6WT test distance than the AG group.

2. Subjects in the ARG group will show greater increases in self-efficacy than subjects in the AG group.

3. For the ARG group, the peak RPP measured during RT will be lower than the peak RPP measured during aerobic exercise sessions.

4. For the ARG group, the peak RPP measured during RT will be lower than the peak RPP measured during the 6WT.

5. Performance of the six experimental RT exercises will produce no new significant cardiac arrhythmias.

Definitions

The following definitions were specific to this study.

1. *Acute Congestive Heart Failure:* A condition characterized by weakness, breathlessness, abdominal discomfort or edema in the lower portions of the body resulting from venous stasis and reduced outflow of blood from the left side of the heart (Thomas, 1993).

2. *ACSM Titration Technique:* An RT acclimation technique for cardiac patients, which starts with the lightest weight or resistance on the resistive device. The patient is monitored for 10–12 repetitions to an RPE of 13–14 on the Borg category scale. If the patient is asymptomatic and tolerates the workload well, the resistance is increased to a higher workload every 1–2 weeks (Fardy et al., 1998).

3. *Chronic Heart Failure:* A clinical syndrome primarily due to LVD characterized by increased intracardiac pressures, decreased cardiac output, decreased peak VO_2 and is accompanied by signs and symptoms of dyspnea and fatigue (Balady & Pina, 1997).

4. *Dyspnea:* Shortness of breath resulting from insufficient oxygenation of blood from cardiac insufficiency (myocardial infarction and CHF), disturbances in the lungs, decreased oxygen pressure of air, circulatory disturbances, hemoglobin deficiency, acidosis, or excessive CO_2 levels in the blood (Thomas, 1993).

5. *Ejection Fraction:* The percentage of blood emptied from the left ventricle during contraction (Thomas, 1993).

6. *Functional Capacity:* The extent to which a person can increase exercise intensity and maintain those increased levels. It is determined by a person's maximal ability to convert chemical energy into mechanical energy. This is expressed most commonly as a metabolic equivalent (MET) and can be estimated by the distance walked on the 6WT (Balady & Pina, 1997).

7. *Hemodynamic Instability:* Uncontrolled hypertension: resting systolic blood pressure greater than 190mmHg, resting diastolic blood pressure greater than 90mmHg; unstable symptoms: malignant arrhythmia's causing decompensation of heart rate, blood pressure or respiratory rate, angina, or acute onset of dyspnea; severe valvular disease: a stenotic valve which compromises heart function.

8. *MET:* An abbreviation for a metabolic equivalent. One MET is equal to the oxygen consumption at rest (3.5 ml/kg/min) (Fardy et al., 1998).

9. *Rate Pressure Product (RPP):* The systolic blood pressure multiplied by the corresponding heart rate. This number represents an estimation of the myocardial oxygen demand (ACSM, 1998).

10. *VO_2 Peak:* The maximal oxygen consumption achievable for an individual due to limiting factors other than maximal fatigue such as shortness of breath or chest pain (ACSM, 1998).

CHAPTER II

REVIEW OF RELATED LITERATURE

Pathophysiology of CHF

Etiology of CHF

CHF is a very dehabilitating form of heart disease with very poor prognosis in which the pumping capacity of the heart is significantly diminished. Common causes of CHF are believed to be: (a) ischemic heart disease (67%), (b) left ventricular hypertrophy due to long standing uncontrolled hypertension, and/or (c) diabetes. The debilitating effects of this disease lead to a diminished functional capacity as evidenced by chronic fatigue, dyspnea, difficulty accomplishing daily living activities, and a decrease in physical self concept (Arnold, Ribeiro, & Colucci, 1990). Two primary physiological changes are thought to be associated with the causes of CHF: (1) central dysfunction, and (2) peripheral system changes. Central dysfunction is a combination of changes that include: (a) systolic dysfunction, (b) abnormal pulmonary hemodynamics, (c) diastolic dysfunction, and (d) neurohormonal mechanisms. These central factors are thought to be the primary determinants of peak performance and cardiovascular reserve. There is a strong correlation between decreases in VO_2 max and poor prognosis as a result of central dysfunction. Systolic dysfunction presents within the patient, most commonly as LVD, in which the left ventricle cannot pump adequately either due to pathologic increases in myocardial wall thickness or dilation the left ventricular chamber. Abnormal pulmonary

hemodynamics present physically in the form of ventilatory dysfunction. This is commonly seen as dyspnea on exertion or at rest. Dyspnea is due to some of the following factors: (a) increased dead space due to ventricular perfusion mismatch, (b) decreased lung compliance, (c) increased impedance to breathing due to chronic pulmonary hypertension, and (d) decreased nutrient flow to the respiratory muscles (Keteyian, Brawner, & Schairer, 1997). Ventilatory dysfunction includes heightened respiratory control due to a hyperventilatory response to increases in lactate, a ventilation-perfusion mismatch and an increase in physiologic dead space. Diastolic dysfunction occurs early in the disease process. This is seen when either the left or right atria become either dilated or thickened due to over-work, as seen in chronic pulmonary hypertension. The dysfunctional atria do not adequately fill the ventricles placing a great strain on the ventricular pumping ability, ultimately leading to LVD. Neurohormonal mechanisms respond to these changes by attempting to increase the diminished cardiac output by stimulating the release of catecholamines, mainly epinephrine and norepinephrine, resulting in a greater strain on the pumping heart due to the increase in sympathetic tone. Central dysfunction is primarily managed with medication and is not greatly altered through exercise therapy. These primary central changes lead to a cascade of secondary changes within the peripheral skeletal muscle tissue and related systems. These secondary peripheral changes include: (a) blood flow abnormalities, and (b) skeletal muscle biochemical changes. Specific blood flow abnormalities include: (a) decreased blood supply to skeletal muscle tissue, (b) increased blood lactate production and accumulation, and (c) increases in vasomotor tone. These changes result in a significant reduction in nutrient supply and waste product removal. Skeletal muscle biochemical changes include (a) decreases in mitochondrial mass, (b) decreases in Type I muscle fibers, and (c) increases in Type

II muscle fibers. The changes in skeletal muscle biochemistry result in a greater demand on the glycolytic (anaerobic) system. This leads to a decrease in oxidative phosphorylation and an abnormal increase in metabolic acidosis (Kenny, 1995). Since the primary mode for energy production in the CHF patient is by way of the anaerobic metabolic system, there is a decrease in oxidative capacity due to the excess depletion of the ATP-PC stores. This results in increased acidosis, a greater demand for ADP, and increased glycolysis. A decrease in B-hydroxyacyl-CoA, a mitochondrial based enzyme active in beta-oxidation, is also seen (Sullivan, 1989; Wilson & Mancini, 1993). The lack of physical activity brought about by these changes cause a decrease in mitochondrial volume and density in severely impaired individuals (Hanson, 1994). When discussing a loss in functional capacity, Arnold et al. (1990) stated that the loss in functional capacity is primarily due to three factors within the peripheral system: (1) decreased nutrient flow (blood flow abnormalities), (2) changes in muscle metabolism (biochemistry), and (3) histological muscle atrophy (disuse). All of these factors work together to produce a very disabled physical state. However, skeletal muscle tissue in the CHF patient adapts metabolically and functionally to training (Wilson & Mancini, 1993). The skeletal muscle of the CHF patient has shown the following increases in aerobic capacity: (a) increases in oxidative enzymes, (b) increases in skeletal muscle mitochondrial mass, and (c) increases in Type I skeletal muscle fibers. With this in mind, treatment goals are aimed towards making the above stated favorable peripheral changes.

Epidemiology and Economics

CHF is the leading cause of death and disability with a survival rate of only 40% beyond one year for those diagnosed with a New York Heart Association

(NYHA) Class III–IV condition (Keteyian et al., 1997). In the year 1991, 39,206 deaths were directly attributed to CHF, with another 250,000 deaths occurring with CHF as a related cause. The overall cost of medical treatment for CHF is about 10 billion United States dollars per year. Seventy-five percent of the cost is due to rehospitalization, which averages $6,429 per visit. The average CHF patient has 1.6 visits per year lasting about 6 days. This results in a nationwide cost of about 1 billion United States dollars per year (Balady & Pina, 1997).

Diagnosis and Classification of CHF Severity

In general, CHF is diagnosed in patients who have one or more of the following cardiac parameters: (a) a resting stroke volume below 50 ml, (b) a cardiac index less than 2.5 L/min/m2, (c) a resting heart rate of 75–105 bpm, (d) a left ventricular ejection fraction less than 35–40%, and (e) a 5.6 cm end-diastolic left ventricle size (Keteyian et al., 1997). There are two major CHF classification measures, the Weber Class System and the New York Heart Association (NYHA) System. These are based on a measure of VO_2 peak levels and a judgment of the ability to carry out daily activities, respectively. The Weber and NYHA classes reported by Keteyian et al. (1997) are summarized in Table 1.

CHF Responses to Acute Exercise

In the CHF patient, overall peak exercise tolerance is 45% lower than normal, VO_2 peak is 44% lower, stroke volume is 55% lower, maximal heart rate responses to exercise are 20% lower, and the average VO_2 peak is 8-21 ml/kg/min (Keteyian et al., 1997). During submaximal exercise the following responses are common in those with CHF: (a) higher heart rates; (b) lower stroke volume; (c) lower oxygen

Table 1

CHF Severity Classifications

Weber Class	Peak VO_2	NYHA Class	Class Description
A	> 20	I	No dyspnea with exertion
B	16–20	II	Dyspnea with maximal exertion
C	10–16	III	Dyspnea with minimal exertion
D	<10	IV	Dyspnea at rest

Note. Peak VO_2 measured in ml/kg/min.

extraction; and (d) increased plasma norepinephrine, which increases sympathetic tone. These factors all contribute to the overall decrease in exercise tolerance and in activities of daily living.

Psychosocial Aspects

In the context of this study, self-efficacy was defined as an individual's perceived ability to carry out diverse physical daily activities. This level of certainty in one's own ability has a summative effect. This summative effect leads to an increase or decrease in confidence regarding judgments for completion of tasks of increasing difficulty within a specific behavior domain (Ewart, 1989). The concomitant decrease in functional capacity in the CHF patient affects their mentality leading to thoughts of hopelessness, uselessness, and many times fear. The CHF patient commonly shows signs of emotional distress, anxiety, and depression (Squires, 1998). Exercise has

been shown to have a positive effect on the CHF patient's mental state. Exercise can reduce or enhance stress-producing states, such as anxiety and anger, as well as enhance emotional well-being. Exercise also increases cognitive ability, decreases cardiovascular reactivity to stress, produces positive changes in diet, and may result in smoking cessation (Emery, Pinder, & Blumenthal, 1989). Increased levels of self-efficacy have been shown to increase levels of exercise compliance (Vidmar & Rubinson, 1994). These mental affects may, at times, greatly outweigh the physical effects of the disease.

Safety Considerations

The subjects were under constant supervision using ECG telemetry monitoring and were observed by American Heart Association Advanced Cardiac Life Support trained staff. During RT, modest heart rate and systolic blood pressure increases have been observed (Squires, 1998). The RPP was used to estimate myocardial oxygen demand. Vander, Franklin, Wrisley, and Rubenfire (1986) calculated the RPP during RT and compared it to peak workload RPPs achieved during the standard aerobic exercise. The RPP was significantly lower during RT versus workloads performed during graded physical exercise. While participating in RT exercises, fewer cardiac patients had deterioration of the left ventricular wall motion as opposed to those participating in aerobic exercise (Daub, Knapik & Black, 1996). It is the position of the American College of Sports Medicine (ACSM) that less myocardial ischemia and arrhythmias occur with RT as compared to endurance exercise at the same RPP (Kenny, 1995). In a study of seven stable heart failure patients with an ejection fraction averaging 22%, the RPP was lower during RT than during the graded exercise test they had undergone, and no adverse symptoms or

significant ECG changes occurred (Falconer, Logan, Stone, & Haennel, 1998). Another study of 10 CHF patients with an average ejection fraction of 27% compared the intrabrachial artery pressure and left ventricular responses to 10 repetitions at 70% of a one repetition maximum (1RM) of a single leg press RT exercise. Heart rate, cardiac output, and RPP were all significantly higher during cycling than the single leg press RT exercise. The diastolic blood pressure response was higher during the single leg press RT exercise, but no difference was seen in end-diastolic volume, end systolic volume, or ejection fraction. The myocardial oxygen demand was lower during the single leg press RT exercise and the left ventricular response was similar (McCartney, 1999).

Summary of RT for CHF Patients

Previously, it was believed that exercise therapy was contraindicated for CHF patients. The CHF population faces a great loss in functional capacity due to a sedentary lifestyle. RT provides a means for slowing the deleterious effects of lack of physical activity. In general, it has been shown that cardiac patients who participate in RT can expect to achieve the following benefits: (a) increased strength, (b) enhanced balance, (c) increased functional capacity, and (d) increased in bone density (Fardy et al., 1998). RT exercise also promotes enhanced self-efficacy, small decreases in body fat, lower resting and submaximal heart rates, increases in resting and exercise stroke volumes, maximal cardiac output, and a 4–15% increase in VO_2 max (Fardy et al., 1998). Since many occupational and recreational activities require significant levels of muscular endurance, strength, and power, RT will enhance activities of daily living (Daub et al., 1996). These improvements are primarily due to peripheral adaptations (Magnusson et al., 1996). Exercise training has been shown to increase the exercise

capacity without deterioration of left ventricular function or a significant number of side effects (Kostis, Rosen, Cosgrove, Shindler, & Wilson, 1994). Since usage of a single muscle group places a lower demand on the heart than whole body work, low level resistance training places less stress on the left ventricular wall than aerobic exercise (Magnusson et al., 1996). A study of the total thigh cross sectional area of 100 male patients with chronic heart failure (left ventricular ejection fraction [LVEF] of 26%) showed significant signs of wasting, primarily due to disuse atrophy (Harrington et al., 1997). Another study of 36 CHF patients (LVEF of 23.3%) showed a strong correlation between peak oxygen consumption and quadriceps cross-sectional area. Changes in skeletal muscle were independent of blood flow (Volterrani et al., 1994). Magnusson et al. (1996) found that high intensity knee extensor training caused increases in mitochondrial enzyme activity which enhanced the utilization of fatty acids and reduced the accumulation of lactic acid. A study of 38 cardiac patients who trained at 70–80% of 1RM showed significant increases in muscular strength without any signs of ischemia or arrhythmias (Beniamini, Rubenstein, Faigenbaum, Lichtenstein, & Crim, 1999).

CHAPTER III

METHODS AND PROCEDURES

Introduction

This chapter will explain the methodology used to determine the safety and efficacy of RT in CHF patients. This study investigated the safety and effectiveness of RT exercise therapy on the functional capacity and perceived self-efficacy of CHF patients. Two retrospective CHF patient groups, AG and ARG, were assessed. Both groups were patients of the CHF clinic at the Borgess Health and Fitness Center, Kalamazoo, MI, who either participated in the standard aerobic therapy (AG) or aerobic therapy plus RT group (ARG). All methods and procedures have been approved by the Western Michigan University Human Subjects Institutional Review Board (Appendix A), the Borgess Medical Center Institutional Review Board (Appendix B), the legal department of the Borgess Medical Center (Appendix C), and the Clinical Manager at the Borgess Health and Fitness Center (Appendix D). This chapter includes the following procedural steps: (a) selection of subjects, (b) instrumentation, (c) testing procedures, (d) 4-week training protocol, and (e) data analysis.

Subjects

All subjects were patients admitted to the Borgess Medical Center with a primary diagnosis of CHF. Upon admission to the Borgess Medical Center, all CHF

patients were evaluated by a cardiac nurse practitioner that works in cooperation with the CHF clinic at the Borgess Health and Fitness Center. The cardiac nurse practitioner screens and recruits patients for CHF clinic therapy at the Borgess Health and Fitness Center. The above process is standard hospital procedure. A goal of 15 to 45 subjects was expected. At the time of recruitment the patient had the right to refuse clinic therapy. A retrospective study was conducted comparing patient data previously collected by the Borgess Medical Center's CHF clinic staff on patients who participated in aerobic exercise therapy but did not participate in RT therapy, defined as the AG group, with data collected on patients who did participate in RT therapy in conjunction with the aerobic therapy, defined as the ARG group.

Instrumentation

The equipment used for the 6WT included a Quinton CR60 Medtrack treadmill (Quinton Instrument Company, Bothell, WA), the Hewlett Packard 78560A telemetry system (Hewlett Packard Company, Palo Alto, CA) and a standard sphygmomanometer. Assessment of self-efficacy was conducted using the SF-36™ Health Survey (SF-36) (Medical Outcomes Trust). During the RT exercise sessions, patients were monitored using the Hewlett Packard 78560A telemetry system. The RT exercises were performed on the Rehab Pulley System (Cardon Rehabilitation Production Incorporation, Niagara Falls, NY).

Testing Procedures

6WT Assessment Procedure

The procedural steps for the 6WT test were as follows. The patient was instructed to sit and rest for 5 min. Subsequently, a resting blood pressure and resting telemetry strip were obtained. The patient was then asked to walk on the treadmill for 6 min at a comfortable, self-determined pace, achieving no greater than a 13 on the Borg's rating of perceived exertion (RPE). At the end of 6 min a telemetry ECG strip was obtained, an RPE assessment was taken, the belt was stopped, and the patient was asked to sit down. At this time a blood pressure measurement was taken (with the patient in a seated position). The patient was then instructed to sit for another 5 min after which a cool-down blood pressure and ECG telemetry strip were obtained. Distance was measured in thousandths of a mile by the treadmill computer and converted into feet (5280 × distance attained). Pre and post distance achieved was used to show changes in functional capacity.

Self-Efficacy Testing Procedure

The SF-36 was used as a measure of self-efficacy. The SF-36 is the standard tool used to assess self-efficacy within the field of cardiopulmonary rehabilitation. The SF-36 is a subjective questionnaire, which measures general health perception. This test is made up of standard choices covering nine health concepts: (1) physical functioning, (2) role functioning, (3) bodily pain, (4) general health, (5) vitality, (6) social functioning, (7) role emotional, (8) mental health, and (9) reported health transition. The SF-36 is scored on a scale of 0–100 and was used to compare individual and group improvement. Jette and Downing (1994) reported a test-retest

reliability of the SF-36 of .70 to .84. A reliability score for internal consistency was reported by Jette and Downing as measured by Cronbach's Alpha of .72 to .85. This tool is considered by the field of cardiac rehabilitation as useful for measuring psychological well-being, as well as physical and social function (Jette & Downing, 1994). Subjects answered this questionnaire before and after the 4-week training period. The pre- and posttest scores were calculated by the Orion Outcomes Software used by the clinical staff and assessed to determine the effectiveness of RT training on self-efficacy.

4-Week RT Training Protocol

The ARG group participated in the experimental RT in addition to the standard biweekly 30 min aerobic training sessions 2 days per week for a period of 4 weeks, which is the standard length of stay for CHF patients in the CHF clinic. The RT exercise was performed in a 6 station, upper body circuit manner. Blood pressure and ECG strips were obtained while the subject performed the RT exercises. The patient rested as long or as little as needed between stations. RT performed in a circuit training protocol using a pulley system is considered safer than free weights and is easier to learn. This form of exercise elicits significant gains in muscular strength and lean body mass, enhances bone mineral content, increased range of motion and cardiovascular endurance (Fardy et al., 1998).

Daily Exercise Log

Subjects' performance over the 4-week training program was tracked in an exercise log 2 days per week during the exercise therapy treatments. The data entered included the following: (a) daily body mass, (b) resting heart rate, (c) resting blood

pressure, (d) resting one lead telemetry ECG, (e) exercise time, (f) modality, (g) workloads, (h) perceived exertion, (i) peak workload ECG, and (j) peak exercise blood pressures (see Appendix E). Data were entered into the log by one of the following staff members: (a) cardiopulmonary nurses, (b) exercise physiologists, or (c) clinical exercise specialists. Data were then taken from the exercise log by a nonbiased staff member of the rehabilitation department and then transferred to a data collection sheet for statistical analysis.

Aerobic Training

The standard aerobic therapy conducted in the CHF clinic was composed of a goal of 30 min of aerobic therapy at an RPE of 11 to 13, as tolerated by the subject. Each subject had the choice of using one of the following modalities for training, in combination or singularly for a goal of 30 min of total exercise: (a) a treadmill, (b) a recumbent bicycle, (c) an airdyne bicycle, (d) an upper body ergonometer, or (e) a NuStep recumbent stepper.

Resistance Training

The RT protocol consisted of six upper body pulley exercises. RT exercises were conducted in the Phase II Cardiopulmonary monitored exercise room of the Borgess Health and Fitness Center. The exercises performed were as follows: (1) triceps extension, (2) biceps curl, (3) shoulder flexion, (4) shoulder extension, (5) latissimus dorsi pull, and (6) chest press. The weight setting for each pulley exercise started with a workload of 3.5 lb The entire pulley system consisted of seven 3.5 lb plates, totaling 24.5 lb per pulley system. The intensity of the exercise was determined using the ACSM titration technique. Patients were instructed to exercise

within an RPE range of 11–13 for a workload of 10–15 repetitions for one set (Fardy et al., 1998). Blood pressures were assessed in the left arm of each patient while performing the exercise. At the same time a telemetry ECG strip was obtained to determine a concomitant heart rate. Once the subject comfortably trained at a given weight at an RPE of 11 or less while performing 15 repetitions, an increase of 3.5 lb in workload occurred.

RT Exercise Instructions

The seven instructions for the RT patients to follow during training were as follows:

1. Participate in an aerobic exercise session previous to RT.
2. Breathe normally or exhale during muscle contraction. Do not hold your breath.
3. Maintain a loose, comfortable grip during muscle contraction on each piece of equipment.
4. Perform lifting movements through a complete range of motion.
5. Lift the weight in a smooth, slow and controlled manner.
6. Learn and practice proper technique and form for each piece of equipment.
7. Terminate RT if you develop symptoms of intolerance such as chest pain, dizziness, faintness or unusual fatigue. The criteria for termination of a RT session can be found in Appendix F.

Data Analysis

Descriptive statistics were used to describe the characteristics of the ARG and AG using the data obtained from the daily exercise log for the following variables:

(a) incidence of arrhythmia; (b) peak workloads during aerobic training sessions; (c) body mass changes; (d) blood pressure; (e) heart rate; and (f) rate pressure products during the aerobic, RT, and 6WT. At the beginning and end of the training period each subject underwent a 6WT and completed an SF-36 questionnaire to estimate functional capacity and self-efficacy. A split plot factorial ANOVA design was used to assess significant differences for the 6WT, 8-day exercise log and the SF-36 variables among groups ARG and AG at the .05 level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

Results

In this study the researcher investigated the safety and efficacy of RT in CHF patients. Efficacy was determined by analysis of changes in functional capacity and perceived self-efficacy scores over the course of CHF clinic participation. Safety was determined by totaling the number of new onset arrhythmias during exercise and comparison of peak exercise RPPs. Retrospective data on 20 Borgess Cardiopulmonary CHF Clinic patients were assessed. All patients participated in 4 weeks of monitored aerobic exercise, and 10 of these patients also participated in the experimental RT exercises. Function capacity was assessed in two ways: (1) 8-day exercise log data, and (2) 6WT assessment. The 8-day log documented: (a) total daily exercise time, (b) peak systolic blood pressure, (c) peak diastolic blood pressure, (d) peak heart rate, (e) peak RPP, (f) total incidence of arrhythmia, and (g) peak RPE. The second measure of functional capacity was assessed pre and post by measuring the following 6WT variables: (a) peak heart rate, (b) peak blood pressure, (c) peak RPE, (d) peak RPP, and (d) distance covered in 6 minutes. Perceived self-efficacy was assessed pre and post through the SF-36 with the following variables: (a) physical functioning, (b) role physical, (c) bodily pain, (d) general health, (e) vitality, (f) social functioning, (g) role emotional, (h) mental health, and (i) reported health transition. RT exercise data were presented in descriptive form

with the following variables: (a) peak heart rate, (b) peak systolic blood pressure, (c) peak diastolic blood pressure, and (d) peak RPP. Results were discussed under the following subheadings: (a) subject demographics, (b) functional capacity, (c) perceived self-efficacy, (d) RT exercise data, and (e) safety parameters. A split plot factorial ANOVA design was used to evaluate significant differences for the 6WT, 8-day exercise log, and the SF-36 variables between groups, ARG and AG, at the .05 level of significance. RT and incidence of arrhythmia data were presented in descriptive form.

Subject Demographics

Data on 20 retrospective patients were assessed, 10 in the AG and 10 in the ARG group. The AG group consisted of 6 males and 4 females with an average age of 62.3 years and average EF of 28.85%. The ARG group consisted of 8 males and 2 females with an average age of 61.9 years and an average EF of 25.57%.

Functional Capacity

Eight Day Exercise Log

A split plot factorial ANOVA design was calculated for the following variables: (a) total daily exercise time, (b) peak diastolic blood pressure, (c) peak systolic blood pressure, (d) peak heart rate, (e) peak RPP, and (f) peak RPE. The independent variables for the design were groups with two levels, AG and ARG, and 8 days with eight exercise sessions.

Daily Exercise Time. The ANOVA summary for daily exercise time is presented in Table 2. The results were:

Table 2

ANOVA Summary Table for Daily Exercise Time

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	39.01	1	39.01	0.32	.58
Subj. w. Groups	2221.96	18	123.44		
Within Subjects					
Days (D)	917.19	7	131.03	5.70	.00
G × D	84.74	7	12.11	0.53	.81
D × Subj. w. Groups	2898.94	126	23.01		

1. No significant difference was found between groups, $F(1,18) = 0.32$, $p = .58$. The means for the AG and ARG groups were 25.04 and 26.03 min, respectively.

2. A significant difference was found among the 8 exercise days, $F(7, 126) = 5.70$, $p = .00$. The means for the consecutive exercise days were: 21.00, 22.65, 24.40, 26.50, 27.65, 27.70, 27.50 and 26.85 min, respectively.

3. The first order interaction effect, groups by days, was not significant, $F(7, 126) = 0.53$, $p = .81$.

Daily Diastolic Blood Pressure. The ANOVA summary for daily diastolic blood pressure is presented in Table 3. The results were:

1. No significant difference was found between groups, $F(1,18) = 3.76$, $p = .07$. The means for the AG and ARG groups were 66.83 and 73.70 mmHg, respectively.

Table 3

ANOVA Summary Table for Daily Diastolic Blood Pressure

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	1890.63	1	1890.63	3.76	.07
Subj. w. Groups	9062.85	18	503.49		
Within Subjects					
Days (D)	1044.38	7	149.20	1.64	.13
G × D	337.58	7	48.23	0.53	.81
D × Subj. w. Groups	11484.55	126	91.12		

2. No significant difference was found among the 8 exercise days, $F(7, 126) = 1.64$, $p = .13$. The means for the consecutive exercise days were: 73.3, 73.7, 70.2, 71.4, 69.9, 70.3, 68.0, and 65.3 mmHg, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(7, 126) = 0.53$, $p = .81$.

Daily Systolic Blood Pressure. The ANOVA summary for daily systolic blood pressure is presented in Table 4. The results were:

1. No significant difference was found between groups, $F(1,18) = 2.51$, $p = .13$. The means for the AG and ARG groups were 130.74 and 146.13 mmHg, respectively.

2. No significant difference was found among the 8 exercise days, $F(7, 126) = 1.78$, $p = .10$. The means for the consecutive exercise days were: 142.4, 139.7, 139.7, 138.6, 141.3, 139.1, 136.6, and 130.1 mmHg, respectively.

Table 4

ANOVA Summary Table for Daily Systolic Blood Pressure

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	9471.01	1	9471.01	2.51	.13
Subj. w. Groups	68020.86	18	3778.94		
Within Subjects					
Days (D)	2006.29	7	286.61	1.78	.10
G × D	1690.84	7	229.98	1.43	.20
D × Subj. w. Groups	20315.24	126	161.23		

3. The first-order interaction effect, groups by days, was not significant, $F(7, 126) = 1.43$, $p = .20$.

Daily Exercise Peak Heart Rate. The ANOVA summary for daily exercise peak heart rate is presented in Table 5. The results were:

1. No significant difference was found between groups, $F(1,18) = 0.04$, $p = .85$. The means for the AG and ARG groups were 97.45 and 98.75 bpm, respectively.

2. A significant difference was found among the 8 exercise days, $F(7, 126) = 2.05$, $p = .05$. The means for the consecutive exercise days were: 102.55, 101.8, 98.8, 98.25, 93.50, 94.75, 97.00, and 98.15 bpm, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(7, 126) = 0.62$, $p = .74$.

Table 5

ANOVA Summary Table for Daily Exercise Heart Rate

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	67.60	1	67.60	0.04	.85
Subj. w. Groups	32993.05	18	1832.95		
Within Subjects					
Days (D)	1352.00	7	193.14	2.05	.05
G × D	406.20	7	58.03	0.62	.74
D × Subj. w. Groups	1185.55	126	94.09		

Daily Exercise Peak RPP. The ANOVA summary for daily exercise peak RPP is presented in Table 6. The results were:

Table 6

ANOVA Summary Table for Daily Exercise RPP

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	1.1×10^8	1	1.1×10^8	1.34	.26
Subj. w. Groups	1.4×10^9	18	8.0×10^7		
Within Subjects					
Days (D)	5.8×10^7	7	8.3×10^6	2.15	.04
G × D	3.7×10^7	7	5.3×10^6	1.37	.22
D × Subj. w. Groups	4.8×10^8	126	3.8×10^6		

1. No significant difference was found between groups, $F(1,18) = 1.34$, $p = .26$. The means for the AG and ARG groups were 12778.68 and 14414.43, respectively.

2. A significant difference was found among the 8 exercise days, $F(7, 126) = 2.15$, $p = .04$. The means for the consecutive exercise days were: 14633.50, 14348.35, 13830.40, 13598.6, 13186.30, 13127.1, 13307.70, and 12740.5, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(7, 126) = 1.37$, $p = .22$.

Daily Peak RPE. The ANOVA summary for daily peak RPE is presented in Table 7. The results were:

1. No significant difference was found between groups, $F(1,18) = 0.34$, $p = .57$. The means for the AG and ARG groups were 12.34 and 12.51, respectively.

Table 7

ANOVA Summary Table for Daily RPE

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	1.23	1	1.23	0.34	.57
Subj. w. Groups	65.13	18	3.62		
Within Subjects					
Days (D)	15.10	7	2.16	1.54	.16
G × D	9.58	7	1.37	0.98	.45
D × Subj. w. Groups	176.08	126	1.40		

2. No significant difference was found among the 8 exercise days, $F(7, 126) = 1.54$, $p = .16$. The means for the consecutive exercise days were: 12.35, 13.00, 12.00, 12.25, 12.25, 12.70, 12.20, and 12.65, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(7, 126) = 0.98$, $p = .45$.

6WT Assessment

A split plot factorial ANOVA design was calculated for the following variables: (a) heart rate, (b) systolic blood pressure, (c) diastolic blood pressure, (d) RPP, (e) RPE, and (f) distance. The independent variables for the design were groups with two levels, AG and ARG, pre and post CHF clinic participation.

6WT Heart Rate. The ANOVA summary for 6WT heart rate is presented in Table 8. The results were:

1. No significant difference was found between groups, $F(1,18) = 1.21$, $p = .29$. The means for the AG and ARG groups pre and post were 101.15 and 94.10 bpm, respectively.

2. No significant difference was found between the pre and posttest, $F(1, 18) = 0.03$, $p = .86$. The means for the pre and posttest were: 97.25 and 98.00 bpm, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(1, 18) = 0.03$, $p = .87$.

6WT Systolic Blood Pressure. The ANOVA summary for 6WT systolic blood pressure is presented in Table 9. The results were:

Table 8

ANOVA Summary Table for 6WT Heart Rate

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	497.03	1	497.03	1.21	.29
Subj. w. Groups	7381.85	18	410.10		
Within Subjects					
Days (D)	5.63	1	5.63	0.03	.86
G × D	4.23	1	4.23	0.03	.87
D × Subj. w. Groups	2952.65	18	164.04		

Table 9

ANOVA Summary Table for 6WT Systolic Blood Pressure

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	2755.60	1	2755.60	2.54	.13
Subj. w. Groups	19558.00	18	1086.56		
Within Subjects					
Days (D)	435.60	1	435.60	2.44	.14
G × D	78.4	1	78.4	0.44	.52
D × Subj. w. Groups	3214.00	18	178.56		

1. No significant difference was found between groups, $F(1,18) = 2.54$, $p = .13$. The means for the AG and ARG groups pre and post were 117.30 and 133.90, mmHg, respectively.

2. No significant difference was found between the pre and posttest, $F(1, 18) = 2.44$, $p = .14$. The means for the pre and posttest were: 128.90 and 122.30 mmHg, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(1, 18) = 0.44$, $p = .52$.

6WT Diastolic Blood Pressure. The ANOVA summary for 6WT diastolic blood pressure is presented in Table 10. The results were:

1. No significant difference was found between groups, $F(1,18) = 1.23$, $p = .28$. The means for the AG and ARG groups pre and post were 62.60 and 67.60, mmHg respectively.

2. No significant difference was found between the pre and posttest, $F(1, 18) = 2.58$, $p = .13$. The means for the pre and posttest were: 67.20 and 63.00 mmHg, respectively.

Table 10

ANOVA Summary Table for 6WT Diastolic Blood Pressure

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	250.00	1	250.00	1.23	.28
Subj. w. Groups	3669.60	18	203.87		
Within Subjects					
Days (D)	176.40	1	176.40	2.58	.13
G × D	0.40	1	0.40	0.01	.94
D × Subj. w. Groups	1231.20	18	68.4		

3. The first-order interaction effect, groups by days, was not significant, $F(1, 18) = 0.01, p = .94$.

6WT RPP. The ANOVA summary for 6WT RPP is presented in Table 11. The results were:

1. A significant difference was found between groups, $F(1,18) = 0.31, p = .00$. The means for the AG and ARG groups pre and post were 11884.70 and 12574.25, respectively.

2. No significant difference was found between the pre and posttest, $F(1, 18) = 0.20, p = .66$. The means for the pre and posttest were: 12423.35 and 12035.60, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(1, 18) = 0.75, p = .40$.

Table 11

ANOVA Summary Table for 6WT RPP

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	4.8×10^6	1	4.8×10^6	0.31	.00
Subj. w. Groups	2.8×10^8	18	1.5×10^7		
Within Subjects					
Days (D)	1.5×10^6	1	1.5×10^6	0.20	.66
G × D	5.7×10^6	1	5.7×10^6	0.75	.40
D × Subj. w. Groups	1.4×10^8	18	7.6×10^6		

6WT RPE. The ANOVA summary for 6WT RPE is presented in Table 12. The results were:

1. No significant difference was found between groups, $F(1,18) = 0.43$, $p = .52$. The means for the AG and ARG groups pre and post were 12.00 and 11.70, respectively.

2. A significant difference was found between the pre and posttest, $F(1, 18) = 15.36$, $p = .00$. The means for the pre and posttest were: 11.05 and 12.65, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(1, 18) = 0.24$, $p = .63$.

Table 12

ANOVA Summary Table for 6WT RPE

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	0.90	1	0.90	0.43	.52
Subj. w. Groups	38.2	18	2.12		
Within Subjects					
Days (D)	25.6	1	25.6	15.36	.00
G × D	0.40	1	0.40	0.24	.63
D × Subj. w. Groups	30.00	18	1.67		

6WT Distance. The ANOVA summary for 6WT distance is presented in Table 13. The results were:

1. A significant difference was found between groups, $F(1,18) = 5.21$, $p = .04$. The means for the AG and ARG groups pre and post were 734.65 and 958.90 ft, respectively.

2. A significant difference was found between the pre and posttest, $F(1, 18) = 27.72$, $p = .00$. The means for the pre and posttest were: 708.65 and 993.9 ft, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(1, 18) = 1.39$, $p = .25$.

Table 13

ANOVA Summary Table for 6WT Distance

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	717972.03	1	717972.03	5.21	.04
Subj. w. Groups	2482099.85	18	137894.44		
Within Subjects					
Days (D)	1142101.03	1	1142102.03	27.72	.00
G × D	57229.23	1	57229.23	1.39	.25
D × Subj. w. Groups	741544.25	18	41196.90		

Perceived Self-Efficacy

SF-36™ Health Survey

A split plot factorial ANOVA design was calculated for the following variables: (a) functional capacity, (b) role physical, (c) bodily pain, (d) general health,

(e) vitality, (f) social functioning, (g) role emotional, (h) mental health, and (i) reported health transition. The independent variables for the design were groups with two levels, AG and ARG, pre and post CHF clinic participation.

Physical Functioning. The ANOVA summary for physical functioning is presented in Table 14. The results were:

1. No significant difference was found between groups, $F(1,18) = 4.02$, $p = .06$. The means for the AG and ARG groups pre and posttest were 42.45 and 58.20, respectively.

2. A significant difference was found between the pre and posttest, $F(1, 18) = 7.02$, $p = .02$. The means for the pre and posttest were: 45.70 and 55.45, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(1, 18) = 0.73$, $p = .40$.

Table 14

ANOVA Summary Table for SF-36 Physical Functioning

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	2640.63	1	2640.63	4.02	.06
Subj. w. Groups	11823.65	18	656.87		
Within Subjects					
Days (D)	950.63	1	950.63	7.02	.02
G × D	99.23	1	99.23	0.73	.40
D × Subj. w. Groups	2437.65	18	135.43		

Role Physical. The ANOVA summary for role physical is presented in Table 15. The results were:

1. No significant difference was found between groups, $F(1,18) = 0.21$, $p = .65$. The means for the AG and ARG groups pre and post were 32.50 and 28.25, respectively.

2. A significant difference was found between the pre and posttest, $F(1, 18) = 10.08$, $p = .01$. The means for the pre and posttest were: 14.75 and 46.00, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(1, 18) = 0.02$, $p = .90$.

Table 15

ANOVA Summary Table for SF-36 Role Physical

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	180.63	1	180.63	0.21	.65
Subj. w. Groups	15626.25	18	868.13		
Within Subjects					
Days (D)	9765.63	1	9765.63	10.08	.01
G × D	15.63	1	15.63	0.02	.90
D × Subj. w. Groups	17431.25	18	968.40		

Bodily Pain. The ANOVA summary for bodily pain is presented in Table 16. The results were:

1. No significant difference was found between groups, $F(1,18) = 0.42$, $p = .53$. The means for the AG and ARG groups pre and post were 69.35 and 75.45, respectively.

2. A significant difference was found between the pre and posttest, $F(1, 18) = 4.54$, $p = .05$. The means for the pre and posttest were: 66.50 and 78.30, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(1, 18) = 2.35$, $p = .14$.

Table 16

ANOVA Summary Table for SF-36 Bodily Pain

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	372.10	1	372.10	0.42	.53
Subj. w. Groups	16078.50	18	893.25		
Within Subjects					
Days (D)	1392.40	1	1392.40	4.54	.05
G × D	722.50	1	722.50	2.35	.14
D × Subj. w. Groups	5526.10	18	307.01		

General Health. The ANOVA summary for general health is presented in Table 17. The results were:

1. No significant difference was found between groups, $F(1, 18) = 1.43$, $p = .25$. The means for the AG and ARG groups pre and post were 47.50 and 57.80, respectively.

2. A significant difference was found between the pre and posttest, $F(1, 18) = 4.44$, $p = .05$. The means for the pre and posttest were: 49.95 and 55.35, respectively.

3. The first-order interaction effect, groups by days, was significant, $F(1, 18) = 10.25$, $p = .01$.

Table 17

ANOVA Summary Table for SF-36 General Health

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	1060.90	1	1060.90	1.43	.25
Subj. w. Groups	13339.20	18	741.07		
Within Subjects					
Days (D)	291.60	1	291.60	4.44	.05
G × D	672.40	1	672.40	10.25	.01
D × Subj. w. Groups	1181.00	18	65.61		

Vitality. The ANOVA summary for vitality is presented in Table 18. The results were:

1. A significant difference was found between groups, $F(1, 18) = 5.10$, $p = .04$. The means for the AG and ARG groups pre and post were 40.00 and 56.50, respectively.

2. A significant difference was found between the pre and posttest, $F(1, 18) = 16.64$, $p = .00$. The means for the pre and posttest were: 41.00 and 55.50, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(1, 18) = 0.18, p = .68$.

Table 18

ANOVA Summary Table for SF-36 Vitality

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	2722.50	1	2722.50	5.10	.04
Subj. w. Groups	9605.00	18	533.61		
Within Subjects					
Days (D)	2102.50	1	2102.50	16.64	.00
G × D	22.50	1	22.50	0.18	.68
D × Subj. w. Groups	2275.00	18	126.39		

Social Functioning. The ANOVA summary for social functioning is presented in Table 19. The results were:

1. No significant difference was found between groups, $F(1,18) = 0.05, p = .83$. The means for the AG and ARG groups pre and post were 65.70 and 67.40, respectively.

2. A significant difference was found between the pre and posttest, $F(1, 18) = 7.91, p = .01$. The means for the pre and posttest were 58.15 and 74.94, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(1, 18) = 0.25, p = .62$.

Role Emotional. The ANOVA summary for role emotional is presented in Table 20. The results were:

Table 19

ANOVA Summary Table for SF-36 Social Functioning

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	28.90	1	28.90	0.05	.83
Subj. w. Groups	11165.00	18	620.28		
Within Subjects					
Days (D)	2822.40	1	2822.40	7.91	.01
G × D	90.00	1	90.00	0.25	.62
D × Subj. w. Groups	6419.60	18	356.64		

Table 20

ANOVA Summary Table for SF-36 Role Emotional

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	455.63	1	455.63	0.17	.69
Subj. w. Groups	49723.85	18	2762.44		
Within Subjects					
Days (D)	5452.23	1	5452.23	5.28	.03
G × D	455.63	1	455.63	0.44	.52
D × Subj. w. Groups	18581.65	18	1032.31		

1. No significant difference was found between groups, $F(1, 18) = 0.17$, $p = .69$. The means for the AG and ARG groups pre and post were 58.40 and 57.65, respectively.

2. A significant difference was found between the pre and posttest, $F(1, 18) = 5.28$, $p = .03$. The means for the pre and posttest were: 43.35 and 66.70, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(1, 18) = 0.44$, $p = .52$.

Mental Health. The ANOVA summary for mental health is presented in Table 21. The results were:

1. No significant difference was found between groups, $F(1, 18) = 0.72$, $p = .41$. The means for the AG and ARG groups pre and post were 66.50 and 72.60, respectively.

2. No significant difference was found between the pre and posttest, $F(1, 18) = 3.11$, $p = .10$. The means for the pre and posttest were: 66.70 and 72.40, respectively.

Table 21

ANOVA Summary Table for SF-36 Mental Health

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	372.10	1	372.10	0.72	.41
Subj. w. Groups	9285.80	18	515.88		
Within Subjects					
Days (D)	324.90	1	324.90	3.11	.10
G × D	12.10	1	12.10	0.12	.74
D × Subj. w. Groups	1881.10	18	104.50		

3. The first-order interaction effect, groups by days, was not significant, $F(1, 18) = 0.12, p = .74$.

Reported Health Transition. The ANOVA summary for reported health transition is presented in Table 22. The results were:

1. No significant difference was found between groups, $F(1, 18) = 0.93, p = .35$. The means for the AG and ARG groups pre and post were 2.30 and 1.85, respectively.

2. A significant difference was found between the pre and posttest, $F(1, 18) = 9.51, p = .01$. The means for the pre and posttest were: 2.45 and 1.7, respectively.

3. The first-order interaction effect, groups by days, was not significant, $F(1, 18) = 2.07, p = .17$.

Table 22

ANOVA Summary Table for SF-36 Reported Health Transition

Source	*SS*	*df*	*MS*	*F*	*p*
Between Subjects					
Groups (G)	2.03	1	2.03	0.93	.35
Subj. w. Groups	39.25	18	2.18		
Within Subjects					
Days (D)	5.63	1	5.63	9.51	.01
G × D	1.23	1	1.23	2.07	.17
D × Subj. w. Groups	10.65	18	0.59		

Daily RT

A total of 15 measurements were taken while the CHF clinic patients were participating in the experimental RT. The results were: (a) average diastolic blood pressure was 78.67 mmHg, (b) average systolic blood pressure was 140.53 mmHg, (c) average heart rate was 98.87 bpm, (d) average RPP was 12765.84, and (e) the total incidence of arrhythmia was 0.

Incidence of Arrhythmia

A total of 22 new onset arrhythmias were seen during the aerobic training portion of the CHF clinic for the 20 patients measured. The AG group presented 12 new onset arrhythmias and the ARG presented 10 new onset arrhythmias. All new onset arrhythmias observed were an increased frequency of unifocal PVCs. No new onset arrhythmias were documented during the RT exercise or the 6WT assessment.

Discussion

This study adds to only a handful found within the scientific literature to explore the safety and efficacy of RT with CHF patients. Over the course of 4 weeks, eight total exercise training sessions, both the AG and ARG showed favorable increases in functional capacity and self-efficacy. No serious exercise-related complications occurred in either group. Delagardelle et al. (1999), in studying 14 CHF patients, found no major traumatic, orthopedic, or cardiovascular problems while performing RT exercise, which was supported by this research. The ARG has shown several significant improvements in comparison to the AG group in functional capacity, self-efficacy, and safety parameters.

Functional Capacity

Functional capacity progress was measured using data obtained over the course of the 8 exercise days as well as performance pre and post on the 6WT.

8-Day Exercise Performance

Both groups showed similar characteristics of performance during the 8-day exercise sessions. Peak heart rate, peak systolic and diastolic blood pressure, peak RPP, total daily exercise time, and RPE responses to exercise were the same over the course of the CHF clinic. Incidence of new onset arrhythmias was about the same for both groups (AG = 12, ARG = 10) during the aerobic exercise portion of the program. The average peak RPP for the AG and ARG groups during the aerobic exercise was 12778.68 and 14414.43, respectively, as compared to the average peak RPP of 12765.87 for the ARG group during RT exercise. These findings support the data presented by Vander et al. (1986), Kenny (1995), McCartney (1999), and Falconer et al. (1998) stating that the peak RPP calculated during RT will be lower than the peak RPP during aerobic exercise. This supports the hypothesis that the myocardial oxygen demand of RT is lower than the myocardial oxygen demand for aerobic exercise. Therefore, the overall cardiac demand is lower while performing RT exercise at low levels, supporting the statement by the AACVPR that the long-standing perception that RT was harmful, or at least not beneficial for cardiac rehabilitation patients was not scientifically supported.

6WT Assessment Results

Results pre and post for the 6WT showed great improvement for both groups as a result of the 8 training session days. No differences were found between groups' peak heart rate, peak systolic or diastolic blood pressure, or RPE performance during the 6WT. A significant difference was found in the distance walked during the 6 min. This test is a direct measure of ones functional capacity and can be used to estimate VO_2 peak. The AG group walked an average of 734.65 ft and the ARG group walked an average of 958.90 ft. These results show a favorable increase in functional capacity as a result of the RT exercise regimen above that of aerobic training alone. According to Daub et al. (1996), RT closely mimics the requirements of daily living activities, thus increasing functional capacity in a practical manner.

Perceived Self-Efficacy

Both groups showed favorable increases in self-efficacy as a result of the exercise training. No difference between groups was seen in perceived levels of (a) physical functioning, (b) role physical, (c) bodily pain, (d) general health, (e) social functioning, (f) role emotional, (g) mental health, or (h) reported health transition. A significant difference between groups was found in the perceived level of vitality with an average AG score of 40.00 and an average ARG score of 55.50. According to the designers of this assessment tool, Medical Outcomes Trust, *vitality* is defined as, "Feeling energetic and full of pep versus feeling tired and worn out. Low scores indicate tired and worn out all the time while high scores indicate feeling full of pep and energy all of the time." These results show increased perceived levels of overall energy for daily activities as a direct result of the RT exercise regimen.

These findings support the statements of Fardy et al. (1998) that in order to enhance self-efficacy within the scope of daily living activities the patient must participate in strength specific tasks that create confidence in lifting weighted objects.

Safety Parameters

Incidence of New Onset Arrhythmias

Both groups presented with relatively the same number of new onset arrhythmias (increased unifocal PVC frequency) during the aerobic exercise. However, during RT, no new onset arrhythmias were documented. These findings support the ACSM position statement that less myocardial ischemia and arrhythmias occur with RT as compared to endurance exercise (Kenny, 1995).

RPP Comparison

The RPP was lower during the RT exercise than the daily aerobic exercise. This supports the hypothesis that RT exercise places less stress on the left ventricular wall than the aerobic therapy (Magnusson et al., 1996). With a lower myocardial oxygen demand, the probability for adverse reactions is much lower thus making RT a safe and effective means of training CHF patients. The reasons stated for this phenomena are that single muscle usage, as seen in RT, is less demanding than the whole body requirements of aerobic exercise.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this research paper was to assess the safety and efficacy of RT in the higher risk cardiac population of CHF patients. The research was discussed under the following chapter headings: (a) summary, (b) findings, (c) conclusions, and (d) recommendations.

Summary

The safety and efficacy of RT in CHF patients was assessed in three ways: (1) functional capacity improvements, (2) changes in perceived self-efficacy, and (3) safety parameters. Functional capacity was measured in two ways: (1) daily exercise performance, 2 days per week, over the course of 4 weeks; and (2) pre and post 6WT assessment scores. Perceived self-efficacy was measured by way of the SF-36 pre and post. The two safety parameters measured were: (1) incidence of new onset arrhythmia, and (2) peak RPP. A split plot factorial ANOVA was used to assess differences for the 6WT, SF-36 and 8-day exercise log. Incidence of arrhythmia and RT physiologic responses were stated in descriptive format.

Findings

With the exception of the hypothesis stating the RPP for the 6WT would be higher than the RPP during RT, the research hypotheses were supported. The ANOVA for the dependent variable 6WT distance revealed a significant difference

for distance walked pre and post, $F(1, 18) = 5.21, p < .05$. The average daily aerobic RPP was higher than the average peak RT RPP, 13596.56 and 12765.87, respectively. The ANOVA for the dependent variable perceived self-efficacy revealed a significant difference in 1 of the 9 SF-36 scores, vitality, $F(1, 18) = 5.10, p < .05$. During the RT exercise no new onset arrhythmias were documented as compared to a total of 22 for the daily aerobic exercise training.

Conclusions

Based on the results of this study, it was concluded that RT was both a safe and effective mode of exercise training for CHF patients. The ARG CHF patients showed significant improvements in functional capacity and perceived levels of daily energy (vitality) compared to the AG CHF patients. This was accomplished without any documented adverse effects and a lower myocardial oxygen demand for RT exercise.

Recommendations

Several ideas warrant mention in regard to recommendations for further research as well as implications for RT as a mode of exercise therapy for the CHF patient. The RT workload placed on the CHF patients was very low, starting at 3.5 lb and increased to a maximum of 7 lb over 4 weeks. In order to fully appreciate the physiologic and psychological implications of RT on CHF patients, one would need to use a more extensive full body routine for a longer period of time, such as 8–12 weeks. This study did not attain physiologic measurements on every RT exercise every day. This would be required in the future for greater statistical strength. Also,

pre and post strength measurements were not taken. A method of measuring either direct strength gains or a specific daily activity test would prove worthwhile.

These data can also be used to improve training techniques for future CHF patients. Though the 4-week training protocols have shown some improvements, the CHF patients would benefit greatly from an extended period of monitored training, such as the 12 weeks used for high risk Phase II cardiac rehabilitation patients. During this period of time they can take advantage of the first 2 weeks to adapt aerobically as well as assess CHF status and then progress to a much more rigorous RT program as they increase in strength. This population has proved a challenge to study but has much potential for improvement and can achieve great gains in strength and aerobic power similar to those of healthy individuals.

Appendix A

Protocol Clearance From the Western Michigan University Human Subjects Institutional Review Board

Human Subjects Institutional Review Board

Kalamazoo, Michigan 49008-3899

WESTERN MICHIGAN UNIVERSITY

Date: 30 November 1999

To: Roger Zabik, Principal Investigator
John Coleman, Jr., Student Investigator for thesis

From: Sylvia Culp, Chair Sylvia Culp

Re: HSIRB Project Number 99-07-03

This letter will serve as confirmation that your research project entitled "The Safety and Efficacy of Resistance Training in Chronic Heart Failure Patients" has been **approved** under the **full** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: 30 November 2000

Appendix B

Protocol Clearance From the Borgess Medical Center Institutional Review Board

The Institutional Review Board of Borgess Medical Center has received and reviewed the information related to this protocol which was presented to the committee at their 4-18-00 meeting. The information was accepted as presented, no action required.

Richard Lammers, MD

Richard Lammers, MD, Chairperson

BORGESS
Health &
Fitness Center

Dr. I
IRB
Borgess Medical Center

March 17, 2000

Subject: Graduate Thesis entitled: "The Safety and Efficacy of Resistance Training with Chronic Heart Failure Patients."

Dear Dr. Lammers:

In regards to the above titled research project being conducted at the CHF clinic of the Borgess Health and Fitness center I have had to make some changes. The experimental resistance training exercises have been implemented within the clinic as a standard of care. Due to this change, I have decided to use the existing patient data that is routinely charted during the monitored exercise sessions in retrospect. Each subject will be assigned a number and all data will be transferred to a data recording sheet. All subjects will remain anonymous. The study will now consist of two groups: (1) a retrospective control group, which will be past patients who have not participated in the experimental resistance training exercises and (2) an experimental group consisting of current patients who are now participating in the resistance exercises as a standard mode of treatment.

In essence, I will be doing nothing different with the CHF patients, however, I will be accessing their charts for the analysis of data. I have contacted the legal department at Borgess and they stated that I will need their approval before using the charts. I will begin analysis of the data upon your and the legal departments approval. I have also contacted the Western Michigan University Human Subjects Review Board and they will approve the changes upon receipt of a letter from Borgess allowing me to access patient charts for research purposes.

Please contact me at (616) 552-2215 if you have any questions or suggestions.

Thank you very much for your time,

Expedited Review — Approved
AZ 3/21/00

Yours in health,

John Coleman

Appendix C

Borgess Medical Center Legal Department
Letter of Approval

3025 Gull Road
Kalamazoo, MI 49001
(616) 552.BFIT

BORGESS
Health &
Fitness Center

June 8, 2000

To Whom It May Concern:

I have received word from our Legal Department that John Coleman has been approved to use data from our Congestive Heart Failure Clinic for his thesis study. He has my support to begin this research as soon as possible. I can be reached at 552-2300 if you have questions.

Sincerely,

Janeen Docsa

Janeen Docsa
Director

CONFIDENTIALITY AGREEMENT

I acknowledge that as a student at Western Michigan University in the Exercise Science curriculum, I may have access confidential patient information relating to the Borgess Health Alliance and its subsidiaries, related corporations and affiliates (hereinafter "Borgess").

I agree that I will hold all confidential information in the strictest confidence and will not disclose confidential information to any other person or entity except authorized personnel within Borgess. I understand that the unauthorized disclosure of confidential information is cause for immediate denial of access to patient records and termination of my status as a student at Borgess. I understand that this Agreement extends beyond the termination of my employment for any reason.

Vicki R Alsop, MA
Witness

John Coleman

5/10/00
Date

Appendix D

Borgess Health and Fitness Center
Clinical Manager Approval

3025 Gull Road
Kalamazoo, MI 49001
(616) 552.BFIT

BORGESS
Health &
Fitness Center

July 1, 1999

Human Subjects Review Board
Western Michigan University
Kalamazoo, MI 49008

To Whom It May Concern:

I am aware of and give consent for John Coleman to perform research for the masters thesis titled "The Safety and Efficacy of Resistance Training in Chronic Heart Failure Patients." I understand that patients of the Borgess CHF Clinic, which are seen within the Borgess Health and Fitness Center, will be asked to volunteer in this study.

If you have any questions I can be reached at (616) 552-2200.

Sincerely,

Janeen Docsa, MA
Clinical Manager

Appendix E

CHF Clinic Daily Exercise Log

BORGESS MEDICAL CENTER
CARDIAC REHABILITATION SERVICES

CHF CLINIC EXERCISE LOG

PHYSICIAN_____

NAME: RESTRICTIONS/LIMITATIONS:

Date: Visit #: Weight: lbs. Wt. Change lbs. Monitored By:

Min.	Clock	Mode	Workload	METs	HR	BP	PE	Comments
Rest								
5								
10								
15								
20								
25								
30								
Cool								

Nursing Assessment

Heart Tones_____

Lung Sounds_____

Edema_____

Other Symptoms_____

Comments_____

Heart rhythm: Rest _____ Exercise: _____

Date: Visit #: Weight: lbs. Wt. Change lbs. Monitored By:

Min.	Clock	Mode	Workload	METs	HR	BP	PE	Comments
Rest								
5								
10								
15								
20								
25								
30								
Cool								

Nursing Assessment

Heart Tones_____

Lung Sounds_____

Edema_____

Other Symptoms_____

Comments_____

Heart rhythm: Rest _____ Exercise: _____

Key: WU = Warm-up
WL = Workload
PE = Perceived exertion (Borgess scale 6-20)
BP = Blood pressure
HR = Heart rate

Mode Key: TM = Treadmill
AD = Airdyne
R = Row

Workload Key: TM = mph - % grade
AD = KPM
R = Watts

Appendix F

Criteria for Termination of RT Exercise

Criteria for Termination of RT Exercise

1. Acute MI or suspicion of MI
2. Signs of poor perfusion including pallor, cyanosis, or cold and clammy skin
3. Central nervous symptoms including ataxia, vertigo, visual or gait problems
4. Light-headedness, confusion, nausea, or severe peripheral circulating insufficiency
5. Onset of angina with resistive exercise
6. Drop in systolic BP accompanied by signs and symptoms (dizziness or lightheadedness) or a drop below standing resting pressure
7. Excessive BP rise measured during lifting: systolic greater than 220 mmHg or diastolic greater than 110 mmHg
8. Inappropriate bradycardia (decrease in HR greater than 10 bpm) during resistive exercise
9. SVT or exercise induced complex supraventricular dysrhythmias
10. Pronounced ST segment changes (greater than 2 mm) from rest on the basis of telemetry recording
11. Onset of frequent ventricular ectopy and/or ventricular tachycardia (3 or more consecutive PVCs)
12. Exercise induced left bundle branch block that cannot be distinguished from a wide complex tachycardia
13. Onset of dyspnea, wheezing or fatigue
14. Onset of second and/or third degree AV block from telemetry recording
15. New onset or aggravation of preexisting musculoskeletal problem that would prohibit continuation of resistive training

16. Failure to comply with exercise prescription or poor technique

17. Discomfort related to past surgery (CABG, rotator cuff) (Fardy et al., 1998)

BIBLIOGRAPHY

AACVPR guidelines for cardiac rehabilitation and secondary prevention programs (3rd ed.). (1999). Champaign, IL: Human Kinetics.

ACSM's reference manual for guidelines for exercise testing and prescription (2nd ed.). (1998). Baltimore: Williams and Wilkins.

Arnold, J. M. O., Ribeiro, J. P., & Colucci, W. S. (1990). Muscle flow during forearm exercise in patients with severe heart failure. *Circulation, 82,* 465–472.

Balady, G. J., & Pina, L. (Eds.). (1997). *Exercise and heart failure.* New York: Futura.

Beniamini, Y., Rubenstein, J., Faigenbaum, A., Lichtenstein, A., & Crim, M. (1999). High intensity strength training of patients enrolled in and outpatient cardiac rehabilitation program. *Journal of Cardiopulmonary Rehabilitation, 19,* 8–17.

Brooks, G., Fahey, T., & White, T. (1996). *Exercise physiology* (2nd ed.). Mountain View, CA: Mayfield.

Daub, W., Knapik, G., & Black, W. (1996). Strength training early after myocardial infarction. *Journal of Cardiopulmonary Rehabilitation, 16,* 100–108.

Delagardelle, C., Feiereisen, P., Krecke, R., Essamri, B., & Beissel. (1999). Objective effects of 6 months' endurance and strength training program in outpatients with congestive heart failure. *Medicine & Science in Sports and Exercise, 31*(8), 1102–1107.

Emery, C., Pinder, S., & Blumenthal, J. (1989). Psychological effects of exercise among elderly cardiac patients. *Journal of Cardiopulmonary Rehabilitation, 9,* 46–53.

Ewart, C. K. (1989). Psychological effects of resistive weight training: Implications for cardiac patients. *Medicine and Science in Sports and Exercise, 21,* 683–688.

Falconer, T., Logan, T., Stone, J., & Haennel, R. (1998). The safety and efficacy of resistance training in stable heart failure patients. *Journal of Cardiopulmonary Rehabilitation, 18*(5), 351.

Fardy, P., Franklin, B., Porcari, J., & Verril, D. (1998). *Training techniques in cardiac rehabilitation monograph #3.* Champaign, IL: Human Kinetics.

Hanson, P. (1994). Exercise testing and training in patients with chronic heart failure. *Medicine and Science in Sports and Exercise, 26,* 527–537.

Hamilton, D., & Haennel, R. G. (2000). Validity and reliability of the 6-minute walk test in a cardiac rehabilitation population. *Journal of Cardiopulmonary Rehabilitation, 20*(3), 156–164.

Harrington, D., Anker, S., Chua, T., Webb-Peploe, K., Ponikowski, P., Poole-Wilson, P., & Coats, A. (1997). Skeletal muscle function and its relation to exercise tolerance in chronic heart failure. *Journal of the American College of Cardiology, 30*(7), 1758–1764.

Jette, D., & Downing, J. (1994). Health status of individuals entering a cardiac rehabilitation program as measured by the medical outcomes study 36-item short-form survey (SF–36). *Physical Therapy, 74*(6), 521–526.

Kostis, J., Rosen, R., Cosgrove, N., Shindler, D., & Wilson, A. (1994). Nonpharmacologic therapy improves functional and emotional status in congestive heart failure. *Chest, 108*(4), 996–1001.

Kenny, L. (1995). *ACSM's guidelines for exercise testing and prescription* (5th ed.). Baltimore: Williams and Wilkins.

Keteyian, S. J., Brawner, C. A., & Schairer, J. R. (1997). Exercise testing and training in patients with heart failure due to left ventricular systolic deficiency. *Journal of Cardiopulmonary Rehabilitation, 17,* 19–28.

Magnusson, G., Gordon, A., Kaijser, L., Sylven, L., Isberg, B., Kerpakka, J., & Saltin, B. (1996). High intensity knee extensor training in patients with chronic heart failure. *European Heart Journal, 17,* 1048–1055.

Mancini, D. M., Hanson, D., LaManca, J., Donchez, L., & Levine, S. (1995). Benefits of selective respiratory muscle training on exercise capacity in patients with chronic congestive heart failure. *Circulation, 91,* 320–329.

Mancini, D. M., Walter, G., & Reichek, N. (1992). Contribution of skeletal muscle atrophy to exercise intolerance and altered muscle metabolism in heart failure. *Circulation, 85,* 1364–1373.

McAuley, E., & Blissmer, B. (2000). Self-efficacy determinants and consequences of physical activity. *Exercise and Sports Science Review, 28*(2), 85–88.

McCartney, N. (1999). Acute responses to resistance training and safety. *Medicine and Science in Sports and Exercise, 31*(1), 31–37.

Meyer, J., Gullestand, L., Vaselows, R., Bellin, J., Ross, H., & Fowler, M. (1998). Clinical, hemodynamic and cardiopulmonary exercise test determinants of survival in patients referred for evaluation of heart failure. *Circulation, 124*(4), 286–293.

Squires, R. W. (1998). *Exercise prescription for the high-risk cardiac patient.* Champaign, IL: Human Kinetics.

Sullivan, M. J. (1989, April). Exercise intolerance in CHF: Role of peripheral factors. *Cardiology,* 137–144.

Thomas, C. L. (1993). *Taber's cyclopedic medical dictionary* (17th ed.). Philadelphia: F. A. Davis.

Vander, L., Franklin, B., Wrisley, D., & Rubenfire, M. (1986). Acute cardiovascular response to nautilus exercise in cardiac patients: implications for exercise training. *Annals of Sports Medicine, 2*(4), 165–169.

Vidmar, P., & Rubinson, L. (1994). The relationship between self-efficacy and exercise compliance in a cardiac population. *Journal of Cardiopulmonary Rehabilitation, 14,* 246–254.

Volterrani, M., Clark, A. L., Ludman, P. F., Swan, J. W., Adamopoulos, S., Picpoli, M., & Coats, A. J. S. (1994). Predictors of exercise capacity in chronic heart failure. *European Heart Journal, 15,* 801–809.

Wilson, J. R., & Mancini, D. M. (1993). Skeletal muscle metabolic dysfunction. Implication for exercise intolerance in heart failure. *Circulation, 87,* VII104–VII109.