

To the Graduate Council:

I am submitting herewith a dissertation written by Niles Jay Lundt entitled "An Examination of the Efficacy and Safety of Low Intensity Weight Training in Phase II Cardiac Patients." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

Edward T. Howley
Edward T. Howley, Major Professor

We have read this dissertation
and recommend its acceptance:

Bill C. Wallace

Wendell L. Smith

Mary Sue Younger

Ralph E. Jones

Accepted for the Council:

Lowminkel
Vice Provost
and Dean of the Graduate School

AN EXAMINATION OF THE EFFICACY AND SAFETY OF
LOW INTENSITY WEIGHT TRAINING IN
PHASE II CARDIAC PATIENTS

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ABSTRACT

Resistance training for cardiac patients has traditionally been discouraged. The purpose of this study was to assess the safety and efficacy of a three day/week, six week low intensity strength training program in 33 stable phase II cardiac rehabilitation patients. Subjects were randomly assigned to arm training (n=11), leg training (n=11), and control (n=11) groups prior to study participation. All subjects engaged in traditional aerobic exercise (treadmill, arm ergometer, bicycle ergometer, and steps). In addition to aerobic exercise, arm training subjects performed 20-25 repetitions of unilateral arm curl exercise at 30-40% of one repetition maximum (1 RM) while leg training subjects performed 20-25 repetitions of seated leg extension exercise at 30-40% of 1 RM. Ten RM arm curl and leg extension strength assessment was conducted for all subjects before and after six weeks of training. ECG, heart rate (HR), and systolic blood pressure (SBP) were monitored during all activities. Self-efficacy scores for arm and leg tasks were also determined for resistance training groups before and after training.

Results indicated that 10 RM arm curl strength scores for the arm training group significantly ($p < .01$) increased 67% following resistance training while 10 RM leg extension strength also significantly ($p < .01$) increased 53.8% for the

leg training group after resistance training. No signs or symptoms of ischemia or abnormal HR or SBP responses were observed during the strength training program. Results showed no significant ($p > .05$) correlation between strength increase and enhanced self-efficacy scores as a result of participation in resistance training. It was concluded that low intensity weight training is hemodynamically safe for phase II patients and resulted in significant ($p < .01$) increases in upper and lower extremity muscular strength when compared with traditional aerobic exercise training.

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CHAPTER I

INTRODUCTION

I. Resistance Training for Cardiac Patients

Although training methods have changed over time, the primary focus of cardiac rehabilitation has long involved the restoration of patients with cardiac disease to active and productive lives.¹ Early cardiac rehabilitation programs were designed for patients recovering from an acute myocardial infarction (MI).² However, with the advent of new medical procedures and technology, programs have been expanded and exercise techniques altered to include other coronary heart disease (CHD) patients such as those recovering from coronary artery bypass graft surgery (CABG) or percutaneous transluminal angioplasty (PTCA).² Current rehabilitative services are also frequently modified to meet the needs of patients with other forms of stable cardiac disease such as stable angina pectoris and uncomplicated cardiac surgical procedures including heart valve replacement and heart transplantation.²

In spite of the fact that contemporary rehabilitation programs provide services to a larger and more varied patient population, the primary goals of cardiac rehabilitation continue to involve the restoration of

patient functional capacity, enhanced psychosocial functioning, and the return to normal daily activities.³ In an era of rapidly evolving training methodology to accommodate a more diverse patient population, it is necessary to more closely examine the role of resistance training in rehabilitation programs designed to accomplish the aforementioned goals.

Both healthy individuals and cardiac patients share minimal strength requirements for activities of daily living.⁴ However, phase II cardiac patients have frequently been advised to refrain from the lifting of weights during exercise training due to the belief that these activities dramatically elevate the rate pressure product (heart rate x systolic blood pressure) and put individuals with compromised coronary circulation unnecessarily at risk of myocardial ischemia.⁵ Accordingly, phase II cardiac rehabilitation programs have traditionally involved predominantly aerobic activities such as walking, stepping, bicycle ergometer, and arm ergometer exercise.⁶ Phase II rehabilitative programs are generally hospital based outpatient services which commence as soon as possible after hospital discharge and last for approximately 8-24 weeks or until patients return to work or enter self-monitored maintenance exercise programs.²

Unfortunately, many daily activities require that cardiac patients perform lifting tasks. In addition,

inactivity and disease-related decline in upper and lower extremity strength have been associated with impaired functional capacity.⁷ Although lifting tasks may be avoided in the rehabilitative setting, they most certainly will occur at home or work.⁵ Therefore, it is necessary to further investigate the problem of strength training in cardiac patients.

Although the literature includes several recent examinations of strength and hemodynamic responses in phase III cardiac patients while performing circuit-type weight training exercise,⁸ previous investigators have not adequately examined the incorporation of relatively low intensity weight lifting activity into standard phase II aerobic conditioning regimens. Phase III maintenance exercise programs are generally community based and serve clinically stable cardiac patients who are at least 12 weeks posthospitalization.²

Information exists to indicate that low intensity weight lifting may be appropriate for phase II patients.⁹ However, specific training recommendations and documented evidence of the effects of strength training in phase II patients do not appear in the current literature.¹⁰ The addition of weight lifting activity to existing phase II protocols may ameliorate strength decline in patients without radical modification of existing exercise programs.

The incorporation of weight lifting activity into existing phase II programs is of critical economic importance in an era of rapidly rising health care costs. The feasibility of implementing separate circuit-type weight training programs for phase II patients must be questioned when existing aerobic programs are threatened due to reduced third-party reimbursement.¹¹ In addition, many phase II patients are unable to take advantage of resistance training opportunities available in phase III programs due to a return to work at the conclusion of phase II participation.

An examination of the effectiveness of incorporating low intensity weight lifting activity into a standard phase II cardiac rehabilitation program is warranted. Although previous investigators have reported circuit weight training to be a hemodynamically safe and effective form of exercise for phase III patients,⁸ the training responses to higher intensity weight lifting exercise exhibited by phase III patients may differ from those which occur in entry level phase II patients who possess a more limited exercise capacity.⁶

A preliminary investigation of cardiovascular responses in phase II patients during upper extremity weight lifting and traditionally prescribed arm ergometer exercise has indicated that low intensity weight lifting activity is appropriate for entry level phase II participants.¹² However, the efficacy of hemodynamically safe weight

training activity for the development of upper and lower extremity muscular strength in phase II participants has not been adequately examined.

II. Statement of the Problem

The principal aim of this investigation was to examine the efficacy of six weeks of low intensity weight training for the development of upper and lower extremity muscular strength in phase II cardiac rehabilitation patients in excess of strength improvement which may be expected to occur following the performance of traditional aerobic activity. A pretest - posttest control group experimental design was utilized with an upper or lower extremity isotonic strength training regimen as the experimental variable. Ten repetition maximum arm flexion and leg extension strength measures were the physiological parameters analyzed for both experimental and control groups. A comparison of pre- and post-training upper and lower extremity muscular strength measures in phase II patients following participation in low intensity weight lifting and standard aerobic exercise training may further delineate the utility of weight training with phase II patients.

Additional examination of cardiovascular responses (rate pressure product) during weight lifting and aerobic

(ergometer) upper and lower extremity exercise in phase II patients is also warranted and was conducted in this study.

The descriptive survey method was also employed in order to examine possible change in arm and leg self-efficacy judgements following participation in resistance exercise training. Strength change scores from arm and leg training groups were correlated with self-efficacy change scores in order to determine if specific gains in strength are positively correlated with enhanced self-efficacy judgements for arm and leg tasks.

CHAPTER II

REVIEW OF LITERATURE

A substantial body of literature has been generated that has examined the physiological, psychosocial, and vocational benefits that result from participation in cardiac rehabilitation programs. The primary aim of this review is to focus on the research which investigates the particular benefits that result from participation in cardiac rehabilitative services which include a resistance training component.

The first section of this review includes a brief overview of the major goals of cardiac rehabilitative services as they relate to the training benefits reported in the literature. The second section focuses on studies that have investigated the cardiovascular responses which occur in cardiac patients during the performance of weight lifting activity. In the final section, the existing literature which describes the efficacy and program design of resistance exercise training for cardiac rehabilitation patients will be examined in detail.

I. Goals and Benefits of Cardiac Rehabilitation

The principal purpose of cardiac rehabilitative services is centered on the restoration of patients with cardiac disorders to active and productive lives within the limitations imposed by their disease process for as long a period of time as possible.² Specific goals which must be met in order to accomplish the stated purpose of cardiac rehabilitation include the provision of services which enable patients with cardiac disease to return to their optimal physiologic, psychosocial, and vocational status.¹³ A good deal of literature exists to examine the efficacy of cardiac rehabilitation programs in meeting the aforementioned goals.

Physiological Benefits

The value of early mobilization and progressive exercise training for patients with myocardial infarction or following cardiac surgery in ameliorating the detrimental effects of extended bed rest is well documented.¹⁴ Some of the deleterious effects reported to result from bed rest include reduced physical work capacity, moderate tachycardia, reduced pulmonary function, loss of postural vasomotor reflexes resulting in orthostatic hypotension, decreased circulatory blood volume, and most significant from a resistance training standpoint, skeletal muscle

wasting with an associated loss of strength.² Another major factor which limits physical work or functional capacity as determined by maximal oxygen uptake levels in cardiac patients is a reduction in cardiac output. This reduction has been reported to be due to a decrease in maximal stroke volume related to the extent of myocardial damage following a myocardial infarction.¹⁵

The literature indicates that cardiac patients typically show a significant improvement in maximal oxygen uptake and physical work capacity following participation in cardiac rehabilitation.² The increase in maximal oxygen uptake in myocardial infarction (MI) patients has been reported to range from 11-56% and in coronary artery bypass graft (CABG) patients from 14-66% after three to six months of aerobic exercise training.¹⁶ The greatest percentage improvement was observed in those patients with the lowest initial maximal oxygen uptake levels.

A significant percentage of the improvement in heart patients following MI or CABG is reported to be due to the natural process of recovery and the return to usual routine physical activity.¹⁷ However, the additional increase in maximal oxygen uptake and physical work capacity induced by aerobic exercise training in cardiac patients is generally felt to occur as a result of peripheral training adaptations which result in an increase in the extraction and utilization of oxygen by trained skeletal muscle.

Peripheral training adaptations are reported to be indicated by the increased arteriovenous oxygen difference observed in aerobically trained cardiac patients.¹⁸

Although an improvement in maximal work capacity is the most frequently stated physiologic goal of rehabilitative aerobic exercise training, the primary benefit for most cardiac patients due to a higher maximal oxygen uptake may lie in an increased tolerance for normal daily activities.² Most activities of daily life do not require maximal physical performance but instead consist of repeated bouts of submaximal exertion.¹⁹ The performance of repeated submaximal efforts can be accomplished at a lower percentage of maximal work capacity by an endurance trained individual, resulting in greater endurance and less fatigue. Heart rate, systolic blood pressure, and rate pressure product (RPP) have also been noted to be generally lower during submaximal activity in aerobically trained patients, thereby reducing myocardial oxygen demands.¹⁶

Psychosocial Benefits

Another common rationale for exercise training of cardiac patients is to enhance psychosocial functioning. The literature reports a common belief among both health professionals and regular exercisers that physical activity produces psychosocial benefits such as a reduction in anxiety, muscular tension, and depression while promoting a

feeling of well being.²⁰ However, it is noteworthy that most of the positive reports of the psychosocial benefits of exercise in cardiac patients are reported to be based on clinical impression, anecdotal in nature, or attributed to studies which have serious methodological shortcomings.² A review of over 1000 studies of the psychological effects of exercise training conducted by Hughes²¹ indicated that only 12 met the criteria for well designed scientific studies. In addition, none of the properly designed studies reported significantly improved psychological functioning.

Blumenthal et al.²² specifically examined the psychosocial effects of 12 weeks of moderate vs. low intensity aerobic exercise training in cardiac rehabilitation patients. Consistent with the results of the Hughes analysis, no differences were found between groups in any measure of psychosocial functioning.

A more promising study concerning the psychosocial benefits of cardiac rehabilitation was conducted by Ewart et al.²³ This investigation involved the measurement of task specific self-efficacy perceptions in 40 men with coronary artery disease who participated in a rehabilitation program that included both aerobic and resistance exercise training. Twenty subjects participated in a combination of aerobic exercise and circuit weight training, while 20 subjects performed only aerobic activity. Task specific self-efficacy estimates were assessed following baseline strength

testing for all subjects and at the conclusion of ten weeks of aerobic or resistance exercise training. Participation in circuit weight training was reported to result in greater strength gains than aerobic training alone, and these changes were also noted to be accompanied by increased self-efficacy in resistance trained subjects for activities resembling the training tasks.

Regardless of the aforementioned positive results, it is generally concluded in the literature that there is inadequate scientific evidence to support the role of exercise for improving the psychological well being of cardiac patients.²⁴ Further study seems to be necessary in this area.

Vocational Benefits

Although not all cardiac patients choose to go back to work following an event such as a MI or CABG surgery, a return to the performance of normal daily activities, including work, is the primary goal for many patients involved in cardiac rehabilitation programs.²⁵ The proportion of patients who return to work following a MI has been reported to range from 49% to 93%.²⁶ Although physical, psychosocial, and clinical characteristics all influence resumption of work after a cardiac event,²⁷ cardiac rehabilitative services may exert an independent influence on earlier return to work through increased

patient functional capacity. Exercise training has been demonstrated to increase functional capacity, which for some patients may enhance their ability to resume work.

Schiller and Baker,²⁸ reported that the rate of employment was higher in a group of 101 men treated with cardiac rehabilitation than in a control group of 103 untreated men. The study included 204 men under the age of 65 who had a diagnosis of MI. It was noted that 80 subjects in the treatment group returned to work following participation in cardiac rehabilitation, while only 70 control group subjects resumed employment. In addition, of the subjects who returned to work, it was observed that eight of the control group did not remain employed, while only one of the treatment group did not remain at work following recovery from MI.

The role enhanced functional capacity plays in the return to work following a cardiac event highlights the importance of weight lifting activity in cardiac rehabilitation programs. Many activities at home and work require that cardiac patients perform lifting tasks. Furthermore, inactivity and disease-related decline in upper and lower extremity strength have been associated with decrement in functional capacity.¹⁰ Unfortunately, phase II cardiac patients have frequently been advised to refrain from the lifting of weights due to the belief that these activities dramatically elevate the rate pressure product

and put individuals with compromised coronary circulation unnecessarily at risk of myocardial ischemia.²⁹ Rate pressure product (heart rate x systolic blood pressure) is reported to be a major determinant of myocardial oxygen requirements during activity.¹⁶

II. Cardiovascular Responses During Weight Training In Cardiac Patients

Although in 1973 Mullins and Blomqvist³⁰ documented large increases in systemic blood pressure and the occurrence of complex ventricular arrhythmias with isometric handgrip exercise in cardiac patients, recent investigators have demonstrated the hemodynamic safety of acute circuit weight training sessions at 40-60% of maximal voluntary contraction in phase III cardiac patients.

Butler et al.⁵ conducted an investigation to determine if a program of upper-body strengthening could be safely performed by phase III cardiac rehabilitation patients. The cardiovascular responses of 13 men with known coronary artery disease were evaluated during a regimen of upper-body circuit weight training and traditional aerobic exercise. Changes in heart rate (HR), blood pressure (BP), and electrocardiogram (ECG) were compared for aerobic and resistance exercise. Circuit weight training consisted of eight exercise stations. All subjects completed two

circuits of ten repetitions per exercise station at 40-60% of one movement maximum. Aerobic exercise consisted of 35 minutes of treadmill activity at 85% maximal HR. No ischemic ECG responses were observed to occur during either type of exercise training. Similar increases in HR were reported during weight training and aerobic exercise (33 ± 4 and 39 ± 3 beats/min, respectively (mean $\pm$ SEM)). During aerobic exercise systolic and diastolic BP were observed to increase by 37 ± 4 and 12 ± 3 mm Hg, respectively. No significant changes in BP during circuit weight training were reported. The authors concluded that circuit weight training at 40-60% of 1 RM compared favorably with traditional aerobic exercise in terms of hemodynamic safety.

Vander et al.³¹ also evaluated the safety of circuit weight training in 21 phase III cardiac patients. Acute hemodynamic and ECG responses to circuit weight training were assessed and compared to those obtained during maximal aerobic exercise testing. Circuit exercise stations included five lower extremity and six upper extremity stations. Mean weight loads during weight lifting were estimated at 40-60% of maximal voluntary contraction. Upper and lower extremity weight lifting exercises were reported to elicit small increases in HR and rate pressure product (RPP). However, peak HR and RPP during weight lifting were reported to be only 56-64% and 44-62% of aerobic values, respectively. The authors concluded that resistance

exercise training using light to moderate loads is relatively safe in phase III cardiac patients.

Haslam et al.³² conducted direct measurements of arterial blood pressure during weight lifting in phase III cardiac patients. The previously mentioned Butler and Vander investigations measured BP values indirectly with a cuff immediately after the actual lifting. It is theorized that such a strategy would not allow the measurement of the elevated BP that occurs during the performance of exercise and then rapidly declines at the cessation of activity.³³ The direct measurement of arterial pressure in the Haslam et al. study was intended to eliminate this problem. Intra-arterial BP and ECG responses were monitored in eight male cardiac patients during progressive weight lifting activity. Repetitions of single arm curls and double and single leg presses were performed at 20, 40, 60, and 80% of maximum.

It was concluded that although direct arterial BP measurements during weight lifting activity were higher (30-40 mm Hg) than those values reported in earlier indirect investigations, weight lifting exercises that used a resistance between 40-60% of maximum resulted in clinically acceptable arterial BP and ECG responses.

Although the previous investigations of cardiovascular responses during weight lifting in cardiac patients were conducted with phase III patients, Lundt and Williamson¹² have specifically examined hemodynamics during upper

extremity weight lifting and aerobic exercise in phase II cardiac rehabilitation patients. Four male and two female stable phase II patients were studied in order to compare HR and systolic blood pressure (SBP) responses to weight lifting and arm ergometer exercise. Weight lifting consisted of 25-30 repetitions of dumbbell arm flexion and shoulder abduction exercise at 40-50% of estimated one repetition maximum. Arm ergometer activity involved five minutes of exercise at 60-70% of symptom limited maximum HR. HR and SBP values were measured immediately after weight lifting and aerobic exercise. Immediate post-exercise RPP values were analyzed and found to be significantly ($p < .05$) lower following weight lifting activity than after aerobic exercise. These findings indicated that low intensity weight lifting may result in lower hemodynamic responses and myocardial oxygen demand in phase II cardiac patients than aerobic arm ergometer exercise.

In addition, a preliminary investigation of cardiovascular responses during low intensity weight lifting and aerobic exercise in phase II cardiac patients was conducted prior to the initiation of the present study. Seven male and three female phase II patients were studied in order to compare HR and SBP responses to upper and lower extremity weight lifting and traditionally prescribed arm and bicycle ergometer exercise. Weight lifting activity consisted of 25-30 repetitions of upper extremity (dumbbell

arm curl) or lower extremity (squat while holding dumbbells) exercise. Training loads were set at a weight equal to approximately 40-50% of each patient's estimated 1 RM. Aerobic activity involved five to seven minutes of arm and bicycle ergometer exercise at 60-70% of symptom limited maximum heart rate reserve. Subjects were randomly assigned to upper (n=5) and lower (n=5) extremity groups for weight lifting and RPP monitoring. HR and SBP values were measured immediately after weight lifting and aerobic exercise.

Immediate post-exercise mean RPP values were analyzed and found to be significantly ($p < .05$) lower following weight lifting activity than after aerobic exercise for both upper and lower extremity groups.

The preceding literature indicates that low intensity weight lifting activity is hemodynamically appropriate for stable phase II and III cardiac rehabilitation patients. However, further investigations must be reviewed in order to determine the efficacy of low intensity weight training for the development of muscular strength in cardiac patients.

III. The Efficacy of Resistance Exercise Training for Cardiac Patients

Although limited information has been available regarding the benefits and management of strength conditioning for cardiac patients, the literature includes

several recent examinations of the effectiveness of low intensity weight training for developing muscular strength in phase III patients.

Keleman et al.⁴ conducted one of the initial training studies designed to evaluate the safety and efficacy of weight training in cardiac patients. The study involved a randomized evaluation of the effects of ten weeks of circuit weight training in male phase III cardiac patients aged 35 to 70 years. Circuit weight training was defined as the performance of a series of arm and leg weight lifting exercises using a light to moderate load with high repetitions. During circuit weight training the participant typically moves to an exercise station, performs the exercise, and then moves on to the next station to exercise again. A weight training circuit may consist of 10-15 different arm and leg exercise stations, with the participant completing the circuit one to three times. Circuits usually consist of resistive weight machines at each station, although free weights (barbells and dumbbells) are also used. All subjects had participated in an aerobic cardiac rehabilitation program for a minimum of three months prior to the study. Twenty control subjects continued with their regular aerobic exercise regimen while twenty experimental subjects participated in circuit weight training in addition to the standard aerobic activity. Circuit weight training consisted of two sets of 12-15

repetitions of arm and leg exercise at 40% of one repetition maximum (1 RM) for each resistance exercise station. Training was conducted three times weekly throughout the ten week study period. At the conclusion of the ten week training period muscular strength in the experimental group was reported to have increased by an average of 24%. No change was noted in the control group. The authors concluded that compared with participation in only a traditional aerobic program, circuit weight training significantly ($p < .05$) improved arm and leg strength and was performed safely by all subjects.

Keleman and associates⁸ also conducted a follow-up examination of three year participation in circuit weight training activity. Changes in muscular strength over a three year period were studied in 25 male phase III cardiac rehabilitation patients. All subjects regularly performed aerobic exercise training consisting of walking or stationary cycling. Seventeen subjects also performed circuit weight training while eight subjects served as controls. Muscular strength was reported as the sum of one repetition maximum lifts on six arm and two leg resistance exercise stations. Circuit weight training consisted of 12-15 repetitions at 40% of 1 RM for each arm and leg station. Two circuits were performed during each exercise session with three sessions scheduled per week. The circuit weight training group significantly ($p < .05$) increased 13% in arm

strength and 40% in leg strength over the three year period. No increase in strength was reported to occur in the control group.

Sparling et al.³⁴ conducted an examination of the management and potential benefits of strength conditioning for cardiac patients. The investigators studied the effects of a 26 week resistance training program on muscular strength in 22 male phase III cardiac rehabilitation patients. All subjects performed aerobic exercise training. In addition to aerobic training, a treatment group of 16 subjects also engaged in circuit weight training throughout the study period. Circuit training consisted of one set of 8-12 repetitions at 30% of 1 RM for each arm and leg exercise station. Exercise training was conducted three times weekly. The authors reported that the circuit weight training group exhibited significant ($p < .01$) improvement in both arm and leg muscular strength measures following the 26 week training period. No significant improvement was reported for the aerobic exercise group.

Haslam et al.³⁵ compared the effects of ten weeks of combined weight lifting and aerobic activity with aerobic training alone on indices of muscular strength in 18 aerobically trained cardiac patients. Ten subjects performed combined weight training and aerobic activity while eight patients served as controls. Initial strength performance was reported to be similar between groups.

However, following ten weeks of exercise training, one repetition maximum strength measures for arm curl and knee extension exercise were reported to significantly ($p < .01$) increase by 43% and 24%, respectively, in the weight trained group. No increase was reported for controls. The authors concluded that weight training was a more effective method of increasing muscular strength in cardiac patients than aerobic training alone.

The effects of higher resistance weight training have also recently been examined in phase III cardiac patients. Ghilarducci et al.³⁶ assessed the safety and efficacy of a three day per week, ten week strength training program in nine aerobically trained male cardiac patients. The strength training program consisted of weight lifting activity with 80% of 1 RM loads for five upper and lower extremity exercise stations. ECG was monitored during the performance of maximal lifts while HR and BP were monitored during all activity. One repetition maximum strength measures were reported to be significantly ($p < .01$) increased by 19% and 53%, respectively, for arm curl and leg extension exercise at the conclusion of the training period. No signs or symptoms of abnormal HR or BP responses were reported to occur during the strength training program. The investigators concluded that resistance training at 80% of 1 RM appeared to be both safe and effective in stable, aerobically trained cardiac patients.

A consensus from the preceding literature indicates that one set of resistance exercise training conducted at 30-60% of 1 RM for 12-15 repetitions per upper and lower extremity exercise station is both effective and safe for the development of muscular strength in phase III cardiac patients.³⁷ However, the existing body of literature includes no documentation of the efficacy of low intensity resistance training for developing upper and lower extremity muscular strength in stable phase II patients.

CHAPTER III

METHODS

I. Selection of Subjects

Twenty-three male and ten female (ages 37-77, mean $\pm$ S.D. age 60.76 ± 11.77 years) stable phase II cardiac rehabilitation patients volunteered for this study.

Subjects included twenty CABG patients, five MI patients, one MI+CABG patient, two stable angina patients, one PTCA patient, two MI+PTCA patients, one valve repair patient, and one heart transplant patient. Subjects for this study were participants in the Park West Hospital phase II outpatient cardiac rehabilitation program.

All patients underwent symptom-limited 12-lead graded exercise testing prior to participation in rehabilitation and the study. Patients were excluded from the study for any of the following reasons: unstable angina, uncontrolled hypertension (systolic blood pressure >200 mm Hg or diastolic blood pressure >100 mm Hg), uncontrolled arrhythmias (ventricular tachycardia (three or more consecutive premature ventricular contractions (PVCs))), frequent (>10 beats/min) PVCs, multifocal (>4 beats/min) PVCs, R on T PVCs, atrial fibrillation, exercise induced second or third degree heart block, exercise induced left or

right bundle branch block, or left ventricular dysfunction indicative of congestive heart failure (ejection fraction of $<.50$).

Program and study participation were also contingent upon the approval of the patient's referring physician. The exercise prescription was formulated under the referring physician's supervision and he was regularly updated as to the progress of his patients throughout the training period. Each subject read and signed an informed consent form (Appendix A) prior to study participation.

II. Strength Testing Protocol

Pre-training strength measurement was conducted for all subjects prior to study participation. Consistent with current recommendations for cardiac patients,³⁴ one repetition maximum strength testing was avoided. Submaximal strength assessment methods were conducted according to existing standards.³⁴ The upper extremity evaluation procedure involved seated unilateral arm flexion (curl) testing with 5, 8, 10, 12, 15, 17, 20, or adjustable 20-40 lb. dumbbell weights. The lower extremity evaluation procedure involved bilateral leg extension testing on a seated leg extension bench using 2.5, 5, 10, and 25 lb. free weight plates. The greatest weight at which each patient was able to perform ten repetitions of each movement (arm

curl and leg extension) was used to determine estimated one repetition maximum values.

Following pre-training strength assessment, subjects were randomly assigned (allowing for orthopedic limitations) to one of the following three treatment groups: arm training, leg training, or control. Post-training strength assessment was conducted according to the aforementioned procedures for all subjects at the conclusion of the training period.

Self-Efficacy Assessment

All study participants completed written self-efficacy scales designed to measure self-perceived ability to perform arm and leg activities (Appendix B). Self-efficacy assessments were conducted in order to examine possible change in arm and leg self-efficacy judgements following participation in resistance exercise training. The written scales were administered to all subjects immediately following pre-training and post-training strength measurement.

The scales utilized in this study were adapted from self-efficacy scales developed and published by Ewart and Taylor.³⁸ Each activity was scaled by presenting subjects with a list of increasingly more difficult levels of arm and leg behavioral tasks. Subjects were asked to indicate how certain they were that they could perform each of the task

levels by writing opposite each one a number ranging from 0 (completely uncertain) to 100 (completely certain). The arm exertion task was lifting heavy objects (12 levels, 10-120 lbs.) while the leg exertion tasks were climb stairs without stopping (8 levels, 1-8 flights) and walk at a steady two to three mile per hour pace (10 levels, 1/2-5 miles). A subject's score on each scale was determined by dividing the sum of the confidence estimates given for each task by the number of levels on the scale.

III. Exercise Training Protocol

Exercise training for all subjects included multiple short duration (5-10 min.) bouts of aerobic circuit exercise that utilized the following stations: treadmill, bicycle ergometer, steps, and arm ergometer. A two minute recovery period followed each bout of exercise. Patients exercised at a target heart rate reserve intensity range of between 60-70% of the maximum heart rate attained on the graded exercise test. Exercise intensity at each station was controlled through the adjustment of speed and resistance settings on each piece of equipment. The order of exercise performance was randomly determined by patient selection throughout the training period. Exercise training was performed three times weekly (M-W-F). Each patient's

exercise prescription was evaluated and updated following each exercise session.

In addition to the aerobic circuit exercise routine, arm training subjects performed 20-25 repetitions of seated or standing bilateral dumbbell arm curl exercise while leg training subjects performed 20-25 repetitions of bilateral seated leg extension exercise.³⁴ Control group subjects performed only aerobic circuit exercise.

Due to the fact that the current literature includes no specific recommendations for resistance exercise training in phase II patients, the weight training protocol utilized in this study was adapted from phase III methods. In order to ensure the safety of weight lifting activity for phase II patients, the training protocol was selected from the lowest range of the intensity continuum established for phase III patients.

Consistent with existing standards, the upper extremity weight lifting protocol utilized in this study involved the initial use of 2-10 lb. weights, progressing to a maximum of no more than 10-20 lbs. per limb before completion of the study.¹⁰ The lower extremity protocol involved the initial use of 10-30 lb. loads, progressing to a maximum of no more than 30-50 lbs. before completion of the study. Initial training loads were set at a weight equal to approximately 30% of each patient's estimated one repetition maximum. Estimated one repetition maximum values were derived from

measured ten repetition maximum scores with the use of a predicted percentage chart published by Fleck and Kraemer.³⁹ Following the initial three weeks of resistance training, training loads were increased to a weight equal to approximately 40% of each patient's estimated 1 RM.

In light of the fact that overhead lifting has been associated with exaggerated blood pressure responses,⁴⁰ all overhead lifting was avoided during upper extremity training.

Lifting rate (20 lifts/min.) was controlled through the use of an electronic metronome. Each subject was taught the correct exercise and breathing techniques for all stations prior to the initiation of exercise training. The study was conducted over a six week period of time. All exercise testing and training took place in the Optimal Health Center at Park West Hospital.

IV. Patient Monitoring

Throughout all weight lifting and aerobic activity, single lead ECG (via telemetry) was monitored on lead two for abnormal ST segment responses to exercise. Two millimeters horizontal or downsloping ST segment depression, or ST segment elevation during exercise resulted in cessation of activity. Subjects also terminated exercise in the event of excessive fatigue, lightheadedness, cyanosis,

or nausea. Heart rate values during exercise were recorded from the telemetry system. Staff members experienced in the measurement of blood pressure (BP) used a standard sphygmomanometer cuff and mercury manometer to obtain BP measurements.

Blood pressure and heart rate were monitored during each exercise session as follows: (a) resting measurement for all subjects prior to the start of exercise; (b) immediately after completion of arm ergometer exercise for the arm training group and following bicycle ergometer exercise for the leg training group; (c) immediately after completion of weight lifting exercise for arm and leg training groups; and (d) five minutes into cool-down and recovery period for all subjects. According to methods published by Butler et al.,⁵ blood pressure was measured within ten seconds after the cessation of exercise. Peak exercise heart rate during weight lifting and ergometer exercise was multiplied by immediate post-exercise systolic BP values in order to determine the rate pressure product ($RPP = HR \times SBP$) achieved by patients during exercise performance. RPP was monitored in order to provide an indication of the myocardial oxygen demand imposed upon subjects by weight lifting activity.⁴

V. Statistical Analysis

Comparisons of 10 RM pre- and post-training arm and leg strength gain (posttest minus pretest) measures were made between treatment groups using one-way analysis of variance with each subject's gain score as the dependent variable.⁴¹ There were three levels of training groups. Tukey's studentized range test was used in order to compare differences between treatment group means.

Statistical analysis of cardiovascular data included calculations of means and standard deviations. A Student's t test for paired observations was used to examine differences between select cardiovascular variables (RPP during arm ergometry and arm curl exercise for the arm training group and RPP during cycle ergometry and leg extension exercise for the leg training group).

The Pearson product-moment correlation coefficient (Pearson r) for continuous data was utilized to correlate strength change scores (post-pre) with self-efficacy change scores (post-pre) in order to determine if specific gains in arm and leg strength were positively correlated with changes in self-efficacy judgments for arm and leg tasks.⁴²

For all statistical analyses the null hypothesis was rejected if the significance level was less than 0.05.

CHAPTER IV

RESULTS

I. Strength Measurements

The analysis and results which follow represent data collected from the 33 subjects who participated in the study. Individual strength data are included in Appendix C. Subjects completed an average of 12 (range 10 to 14) of a possible 18 exercise training sessions (67% compliance).

Arm Strength Measurements

Ten RM arm curl strength scores for the arm training, leg training, and control groups increased by 67%, 18.8%, and 19.4%, respectively, following six weeks of exercise training (Figure 1). Analysis of variance indicated significant ($p < .0001$) differences in 10 RM arm curl gain scores between treatment groups (Table 1). Tukey's studentized range test was used in order to examine the differences between treatment group means (Table 2). Combined right and left arm strength scores for the arm training group increased significantly ($p < .01$) greater than scores for either the leg training or control group. No significant ($p > .05$) difference was indicated in arm strength gain scores between the leg training and control groups.

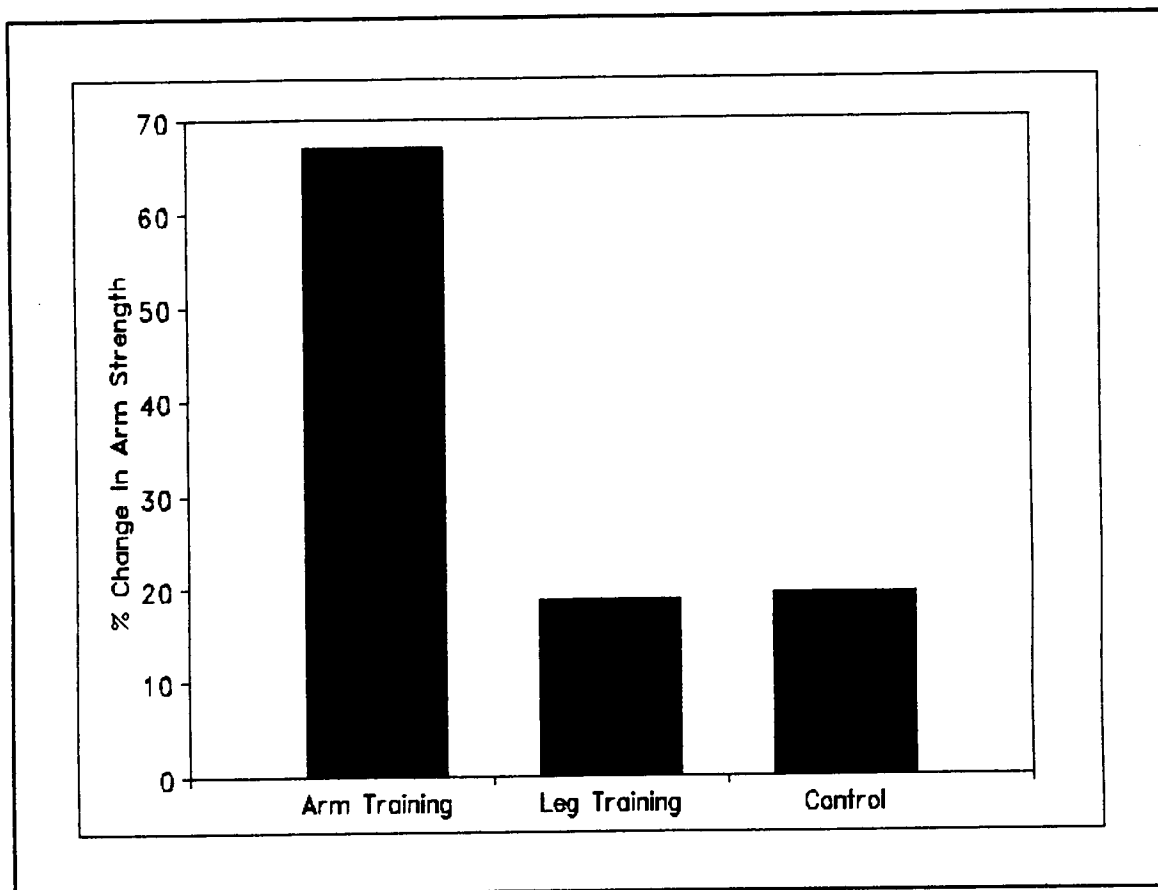


Figure 1. Arm Strength Change Following Exercise Training.

Table 1. ANOVA For Arm Strength Change

Source	SS	df	MS	F	p>F
Model	1312	2	656	19.4	<.0001
Error	1014	30	34		
Total	2326	32			

Table 2. Tukey's Studentized Range for Arm Strength Change

Group	Arm	Leg	Control
Mean	18.86	<u>5.18</u>	<u>5.82</u>

Note: Underlined means are not significantly different at $p<.05$.

Leg Strength Measurements

Ten RM leg extension strength scores for the arm training, leg training, and control groups increased by 20.4%, 53.8%, and 20.1%, respectively, following six weeks of exercise training (Figure 2). Analysis of variance indicated significant ($p < .0001$) differences in 10 RM leg extension gain scores between treatment groups (Table 3). Tukey's studentized range test was used to examine the differences between treatment group means (Table 4). Leg strength scores for the leg training group increased significantly ($p < .01$) greater than scores for either the arm training or control group. No significant ($p > .05$) difference was indicated in leg strength gain scores between the arm training and control groups.

II. Cardiovascular Responses

Statistical analysis of cardiovascular data included the calculation of means and standard deviations for RPP ($HR \times SBP$) following weight lifting and aerobic activity in the arm and leg training groups. HR and SBP were assessed immediately following arm ergometry and arm curl exercise for the arm training group and immediately post bicycle ergometer and leg extension exercise for the leg training group. The aforementioned cardiovascular variables were

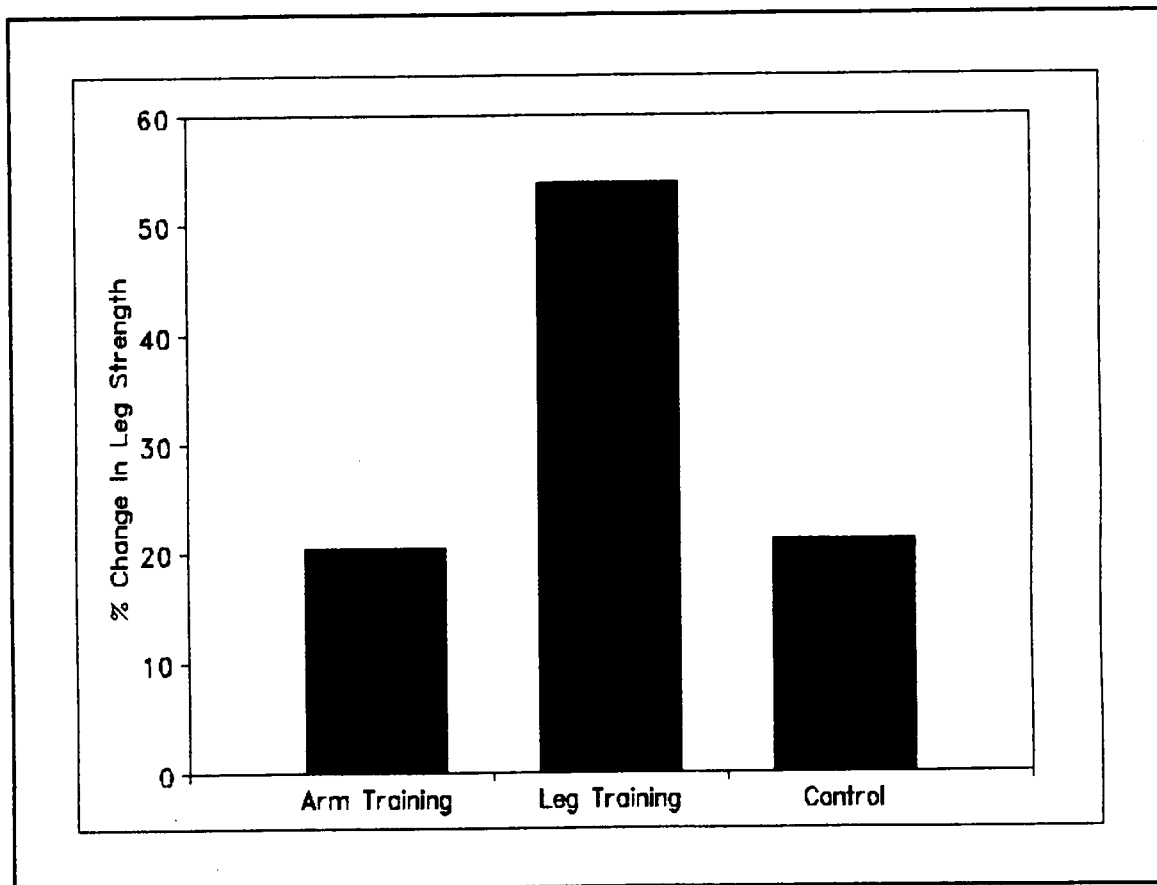


Figure 2. Leg Strength Change Following Exercise Training.

Table 3. ANOVA For Leg Strength Change

Source	SS	df	MS	F	p>F
Model	2037	2	1019	13.63	<.0001
Error	2242	30	75		
Total	4279	32			

Table 4. Tukey's Studentized Range for Leg Strength Change

Group	Leg	Arm	Control
Mean	30.27	<u>13.9</u>	<u>13.32</u>

Note: Underlined means are not significantly different at $p<.05$.

monitored and grand means determined for all exercise sessions attended throughout the course of the study.

A Student's t test for paired observations indicated that mean RPP values following arm ergometer activity were significantly ($p < .001$) greater (21%) than values recorded after arm curl activity in the arm training group (Figure 3). Statistical analysis also indicated that mean RPP values following cycle ergometer exercise were significantly ($p < .001$) greater (22%) than RPP values measured after leg extension activity in the leg training group (Figure 4).

A greater increase in both HR and SBP occurred during aerobic activity in the arm training group when compared with weight lifting (118 ± 15 versus 103 ± 15 beats/min and 142 ± 12 versus 127 ± 10 mm Hg, respectively (mean $\pm$ SD)). Similarly, greater increases in HR and SBP occurred during aerobic activity in the leg training group when compared with weight lifting (119 ± 14 versus 104 ± 16 beats/min and 161 ± 18 versus 144 ± 18 mm Hg, respectively).

III. Self-Efficacy Scores

The Pearson product-moment correlation coefficient (Pearson r) for continuous data was utilized to correlate strength change scores (posttest minus pretest) with self-efficacy change scores (posttest minus pretest) in order to determine if specific gains in arm and leg strength were

correlated with changes in self-efficacy judgements for arm and leg tasks. Results indicated that gains in arm and leg strength were not significantly ($p > .05$) correlated with gains on any of the self-efficacy scales (Tables 5 and 6).

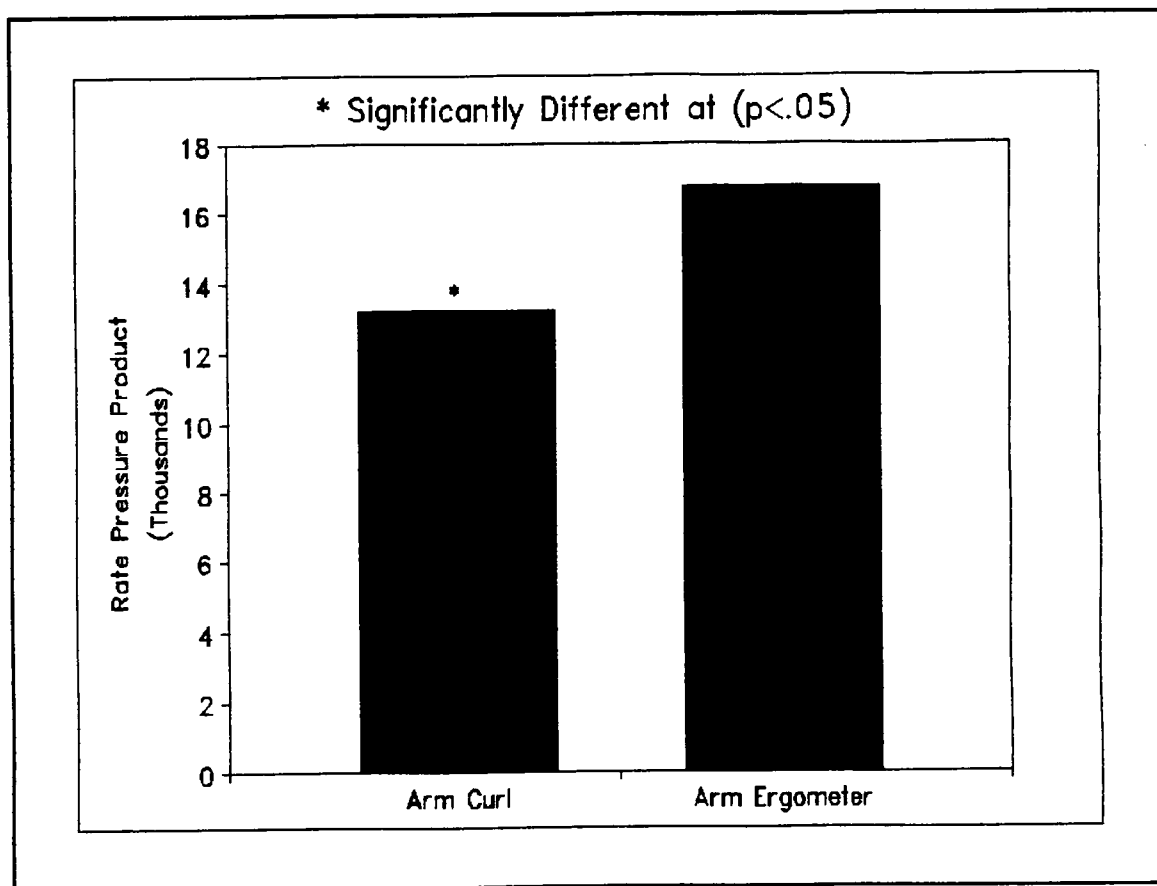


Figure 3. Mean RPP Following Arm Exercise Training.

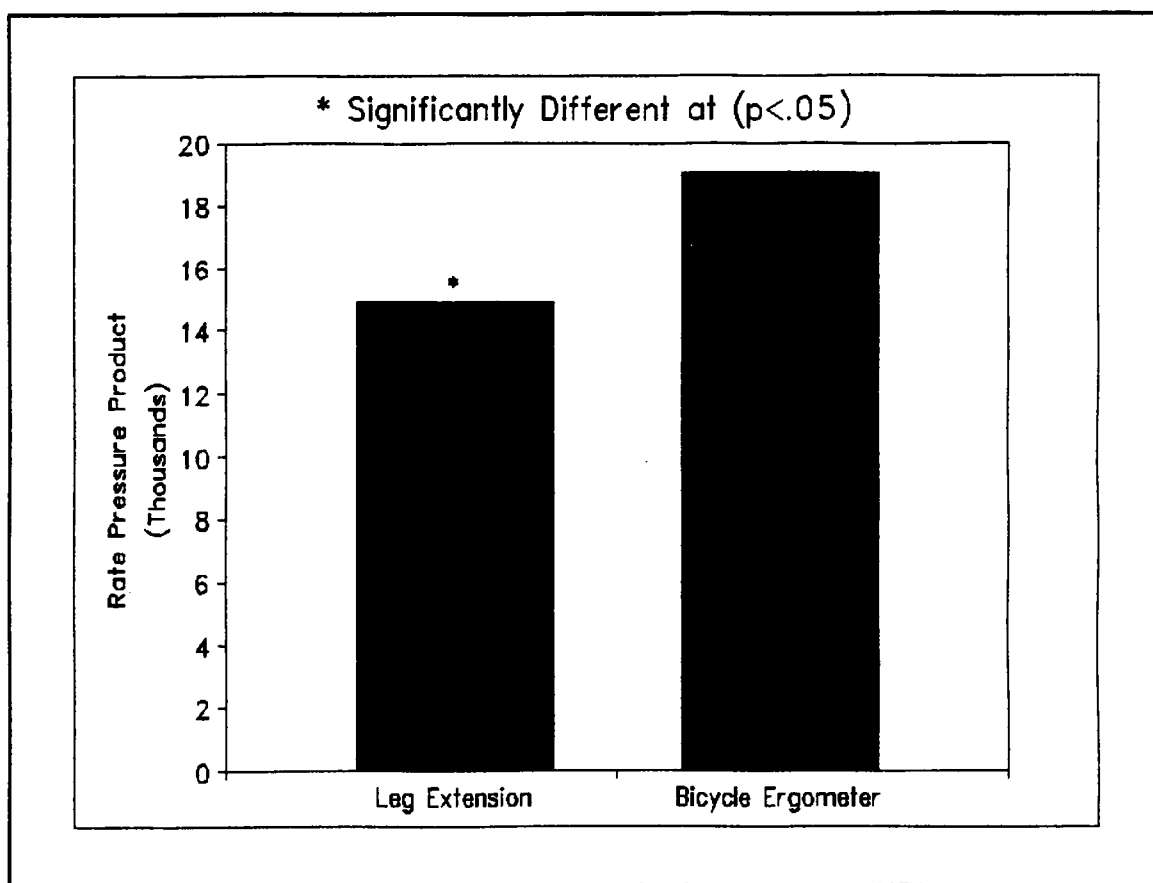


Figure 4. Mean RPP Following Leg Exercise Training.

Table 5. Pearson r Correlations Between Arm Strength Change Scores and Self-Efficacy Change Scores

	Lift Change	Climb Change	Walk Change
Strength Change	.41	.34	.23

Note: No significant correlations at $p < .05$.

Table 6. Pearson r Correlations Between Leg Strength Change Scores and Self-Efficacy Change Scores

	Lift Change	Climb Change	Walk Change
Strength Change	-.27	-.14	-.06

Note: No significant correlations at $p < .05$.

CHAPTER V

DISCUSSION

I. Strength Change

The principal aim of the present investigation was to examine the efficacy of low intensity weight lifting for the development of muscular strength in phase II cardiac patients in excess of strength improvement which may be expected to occur following the performance of traditional aerobic activity.

A significant percentage of the physiological improvement observed in cardiac patients following participation in cardiac rehabilitation programs has been noted to be due to the natural process of recovery and the resumption of regular physical activity.¹⁷ In addition, the literature also indicates that the performance of solely aerobic activity results in significant increases in muscular strength for phase II patients.¹⁰

Therefore, even though it is reported in the literature that the primary effect of low intensity resistance training is the enhancement of muscular strength,⁴³ it was not known if the low intensity training deemed hemodynamically safe for phase II patients would result in significantly greater

improvement in upper and lower extremity muscular strength than the performance of aerobic training alone.

Analysis of the data indicated that significant ($p < .01$) differences in 10 RM arm curl and leg extension strength improvement did occur between the treatment and control groups as a result of six weeks of resistance exercise training.

Furthermore, the effects of resistance training specificity were also demonstrated in the present study. Specificity has been reported to be a major tenet of resistance training.³⁹ Specificity theory assumes that muscles demonstrate the greatest evidence of strength improvement for activities similar to the resistance training performed. Results from strength training literature have also been reported to generally show a lack of transfer of arm and leg training effects.⁴⁴ Therefore, in subjects trained with upper extremity resistance exercise, leg performance should demonstrate little or no improvement over that of controls and vice versa.

In fact, combined right and left arm strength scores for the arm training group did increase significantly ($p < .01$) greater than scores for either the leg training or control group. No significant ($p > .05$) difference was indicated in arm strength gain scores between the leg training and control groups.

Conversely, leg strength scores for the leg training group increased significantly ($p < .01$) greater than scores for either the arm training or control group. No significant ($p > .05$) difference was indicated in leg strength gain scores between arm training and control groups.

Ten RM arm curl strength scores for the arm training, leg training, and control groups increased by 67%, 18.8%, and 19.4%, respectively, following six weeks of resistance exercise training. The 67% increase in 10 RM arm curl strength observed in this study was greater than arm strength improvements reported by other investigators of resistance training for cardiac patients. Ghilarducci et al.³⁶ and Keleman et al.⁴ reported arm curl strength improvement of 19% and 11.8%, respectively, in phase III patients following participation in circuit weight training.

The greater percentage improvement noted in the present study may be due to the fact that all subjects were phase II participants with lower initial exercise capacities than the aerobically trained phase III subjects examined in earlier investigations. It has been reported that the greatest percentage improvement in physical capacity following exercise training for cardiac patients is observed in patients with lowest initial fitness levels.² In addition, seven of the eleven arm training subjects were CABG patients who possessed a low initial upper body exercise tolerance because of incision discomfort. A combination of the

natural process of recovery and the rapid improvement observed in CABG patients following initial exercise training⁴⁵ would indicate the likelihood of a greater percentage increase in arm strength for subjects from this study.

It is noteworthy that a majority of subjects in the present investigation (20 of 33) were CABG patients with low initial upper body exercise tolerance. Additionally, it has been reported that subjects who begin with low initial performance scores can demonstrate improvement more easily than those who begin with higher entry levels of performance.⁴¹ However, strength change percentage increases observed for both the control group and untrained limbs in the arm and leg training groups were similar, indicating the independent influence of weight lifting activity for the improvement in muscular strength of resistance trained subjects.

Ten RM leg extension strength scores for the leg training, arm training, and control groups increased by 53.8%, 20.4%, and 20.1%, respectively, following six weeks of resistance training. The 53.8% increase in leg extension strength observed in this study was consistent with the 53% and 52% leg strength improvement scores reported by Ghilarducci et al.³⁶ and Keleman et al.,⁴ respectively.

II. Cardiovascular Responses

As noted by Franklin et al.,⁴⁴ weight lifting exercises have traditionally not been included in most cardiac rehabilitation programs, since it was felt that they produced excessive hemodynamic responses which may result in ischemic changes and increased myocardial irritability. Recent investigations have not shown low intensity weight training to be more dangerous than traditional aerobic training for cardiac patients.³¹

However, a significant increase in blood pressure with moderate to heavy static (isometric) exercise has been reported.⁴⁶ Furthermore, increases in blood pressure with resistance training have also been indicated to be related to the maximum amount of muscle mass being innervated during activity.⁴⁷ For example, using a weight for the muscles involved in the performance of wrist flexion movement which is similar to the weight used with the muscles involved in elbow flexion would show a markedly higher increase in blood pressure for the smaller muscle mass (wrist flexion) activity.

Therefore, it is recommended that strength training for cardiac patients should use dynamic exercise of large muscle groups (such as the arms and legs) and avoid isometric small muscle group activity (such as hand gripping).⁴⁵ Accordingly, this investigation utilized only dynamic

exercise of large muscle groups. One RM testing was also not conducted because of the greater isometric component associated with maximal effort.

In order to further ensure the safety of study participants, HR and SBP were monitored immediately following arm ergometer and arm curl exercise for the arm training group and post bicycle ergometer and leg extension exercise for the leg training group. Mean RPP post-exercise values were determined and analyzed for treatment group subjects in order to provide an indication of the myocardial oxygen demand imposed upon them by weight lifting activity.

RPP values for arm training subjects were significantly (21%) higher during the performance of aerobic exercise when compared with weight lifting activity. RPP values for leg training subjects were also significantly (22%) higher during aerobic exercise when compared with weight lifting. Telemetry ECG monitoring conducted throughout the study indicated that no ischemic ECG responses, as indicated by ST segment depression, or significant arrhythmias occurred for subjects in either of the treatment groups.

These findings were consistent with cardiovascular values reported by previous researchers⁵ and suggest that low intensity upper and lower extremity weight lifting activity is as hemodynamically appropriate for phase II patients as traditionally prescribed arm or bicycle ergometer exercise.

It is important to mention that blood pressure measurement in this study was conducted via indirect methods at the conclusion of lifting activity. It has been noted that indirectly measured BP levels may underestimate values that occur during the actual performance of weight lifting exercise. However, Haslam et al.³² directly measured intra-arterial blood pressure levels in cardiac patients during weight lifting activity and concluded that although direct measurements were higher (30-40 mm Hg) than values reported in indirect investigations, arm curl and leg extension exercises that used a resistance less than 60% of 1 RM resulted in clinically acceptable BP and ECG responses.

III. Self-Efficacy Change

Another common rationale for exercise training of cardiac patients is to enhance psychological functioning. However, it is generally concluded in the literature that there is inadequate scientific evidence to support the role of exercise for improving the psychological well being of cardiac patients.²⁴

Although most of the current literature deals with the psychological effects of aerobic training, it does include one investigation of the effects of weight lifting activity on self-efficacy in phase III cardiac rehabilitation patients.²³ Self-efficacy is defined as an individual's

level of certainty that he or she can perform a given behavioral task.⁴⁸ It is noteworthy that cardiac patients' perceptions of their physical capabilities have been reported to exert as great an influence over their return to normal activities as does their actual physiological capacity.⁴⁸ The literature also suggests that the most effective way to enhance self-efficacy for specific activities is to provide exercise experiences that are similar to the activities in which increased self-efficacy is desired.⁴⁸

The Ewart et al.²³ study involved the measurement of task specific self-efficacy perceptions in 40 male cardiac patients who participated in a phase III cardiac rehabilitation program that included both aerobic and resistance exercise training. Twenty subjects participated in a combination of aerobic exercise and circuit weight training, while 20 subjects performed only aerobic activity. Participation in circuit weight training was reported to result in significant strength gains which were accompanied by increased self-efficacy scores in resistance trained subjects for activities resembling the training tasks.

This investigation utilized the self-efficacy scales developed by Ewart et al. in an attempt to examine self-efficacy changes that may occur following resistance training in phase II patients. Strength change scores were correlated with self-efficacy change scores in order to

determine if specific gains in arm or leg strength were correlated with changes in self-efficacy judgements for arm and leg tasks. Results showed that gains in arm strength were not positively correlated with changes in self-efficacy scores for lifting ($r=.41$, $p>.05$), stair climbing ($r=.34$, $p>.05$), and walking ($r=.23$, $p>.05$). It is interesting to note that results from the Ewart et al. study reported identical correlation coefficients for arm strength change with lifting self-efficacy change ($r=.41$) and stair climbing self-efficacy change ($r=.34$) as were found in the present study. These correlation coefficients were reported to be statistically significant at $p<.01$ and $p<.04$, respectively. Similar correlation coefficients may have achieved statistical significance in the Ewart et al. study as it included a larger sample size ($n=20$) than the present study ($n=11$). Results from both this study and the Ewart et al. investigation indicated that changes in leg strength were not significantly correlated with gains on any self-efficacy scales.

The self-efficacy scales were also analyzed in order to assess changes in task specific confidence ratings following participation in resistance exercise training. The performance of physical activity similar in nature to the scale task in question has been reported to result in enhanced self-perceived ability ratings.⁴⁸

The frequency distributions of completely certain (100) lifting and stair climbing ability ratings were plotted for the arm and leg training groups, respectively, before and after participation in six weeks of weight lifting activity (Figures 5 and 6).

The number of completely certain ability ratings for the lifting scale increased by 54% in the arm training group following participation in resistance training, suggesting that self-perceived ability ratings may improve following participation in weight lifting activity. A 26% increase in the number of completely certain ratings for the stair climbing scale was also noted in the leg training group following participation in weight lifting activity.

In spite of the aforementioned information, it is important to re-emphasize that correlational statistical analysis indicated that gains in arm and leg strength were not significantly ($p > .05$) correlated with gains on any of the self-efficacy scales.

Therefore, self-efficacy results from this investigation support the general consensus in the existing literature that although exercise participants may report feelings of enhanced strength and physical ability following participation in exercise training, there is inadequate scientific evidence to support such claims.

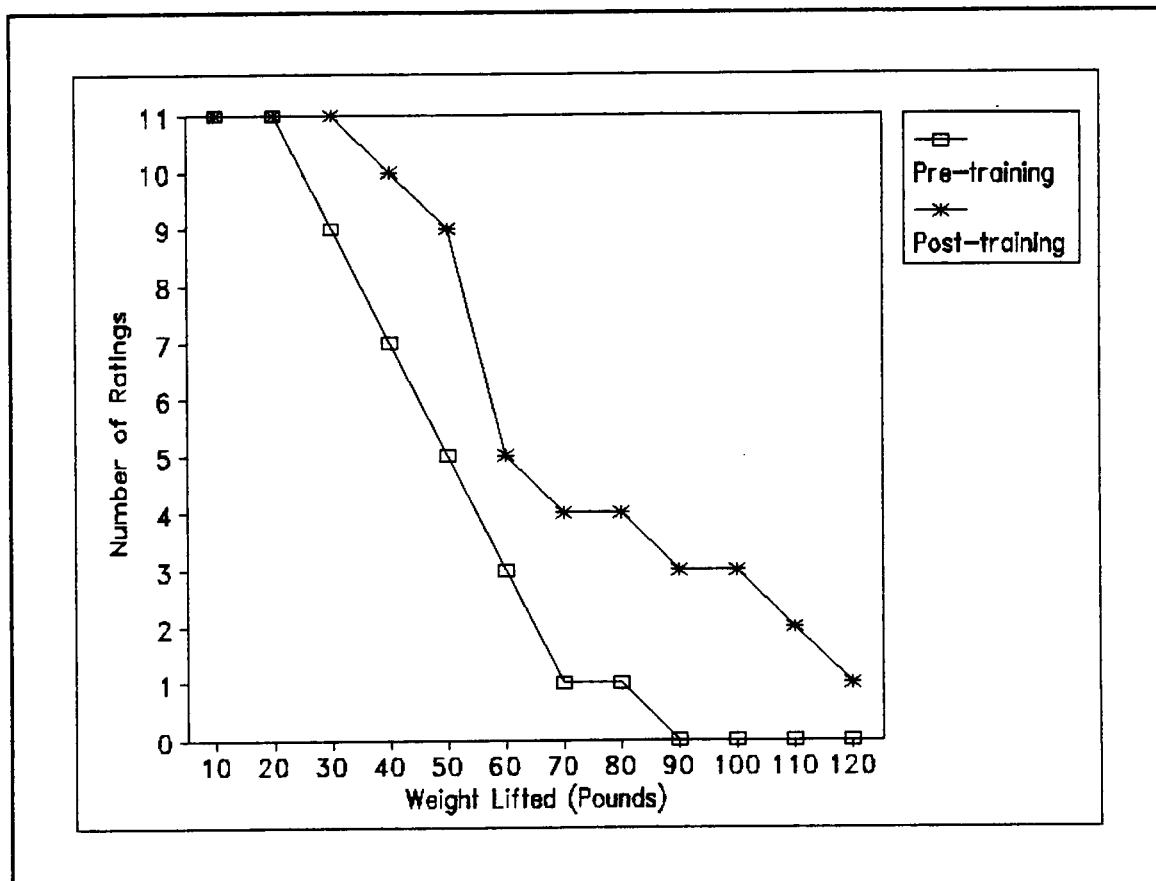


Figure 5. Frequency Distribution of Completely Certain Lifting Ratings for Arm Training Subjects.

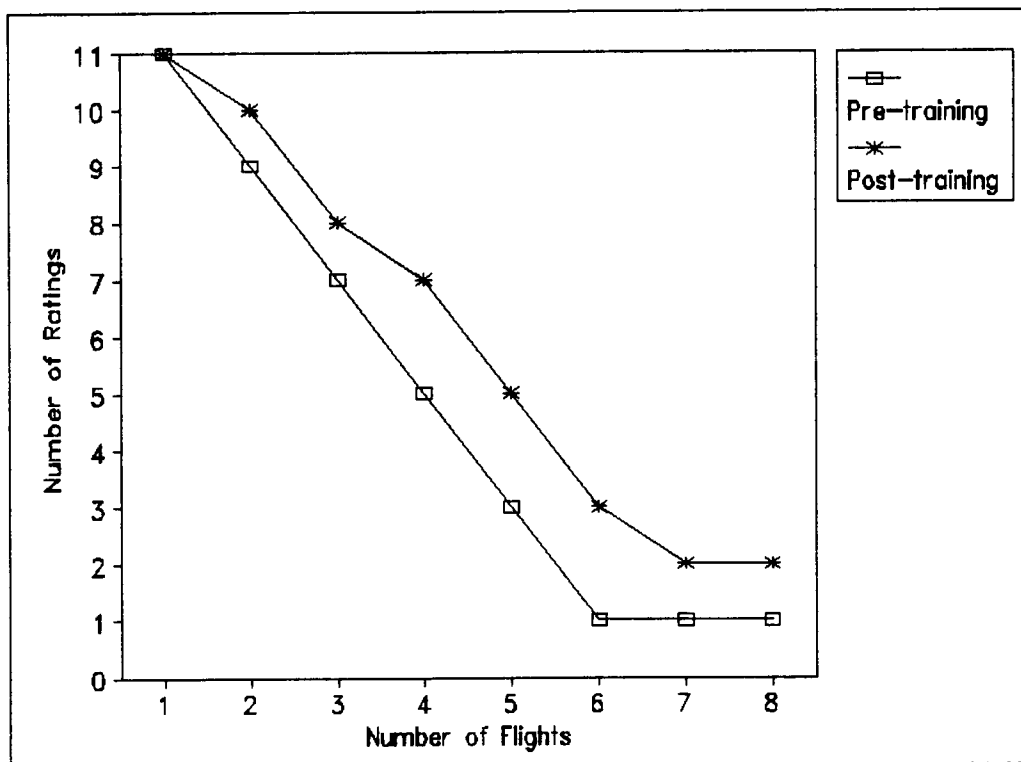


Figure 6. Frequency Distribution of Completely Certain Stair Climbing Ratings for Leg Training Subjects.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Analysis and interpretation of the results obtained from this study lead to the following conclusions and recommendations:

- (1) The data support the hypothesis that low intensity weight training results in greater upper and lower extremity muscular strength improvement in phase II cardiac rehabilitation patients than participation in aerobic activity alone.
- (2) The data support the specificity principle of resistance exercise training as arm trained subjects demonstrated the greatest improvement in arm strength and leg trained subjects exhibited the greatest increase in leg strength.
- (3) Low intensity weight lifting activity is as hemodynamically appropriate as aerobic exercise training for phase II cardiac patients.
- (4) Participation in upper and lower extremity weight lifting activity by phase II cardiac patients did not result

in enhanced self-efficacy perceptions for either arm or leg tasks.

(5) More specific resistance training guidelines for phase II patients must be formulated and reported in the cardiac rehabilitation literature. Although an adequate amount of phase III strength training literature exists, scientific documentation for current phase II recommendations is lacking.¹⁰ More specific phase II information is necessary as most cardiac patients perform only phase II activity. Less than 20% of phase II patients are reported to continue exercise participation in cardiac rehabilitation programs to the phase III level.⁴⁹ This investigation indicates that low intensity weight lifting activity is hemodynamically appropriate and effective for improving muscular strength in phase II patients. It seems wise to further document and standardize resistance training guidelines for phase II programs.

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APPENDIXES

APPENDIX A

CONSENT FORM

DESCRIPTION OF THE PROJECT

This study is designed to examine heart rate, blood pressure, and strength training responses in cardiac rehabilitation patients during low intensity weight lifting and standard aerobic exercise. All participants will perform the normally prescribed exercise routine. In addition to the standard aerobic routine, some individuals will also perform low intensity arm or leg weight lifting exercise. If you perform weight lifting exercise during this study your blood pressure and heart rate will be measured immediately following your lifting activity and also following arm or bicycle ergometer exercise. Heart rate and blood pressure measurements will be conducted during each regularly scheduled exercise session (3 days/wk) over a six week period of time.

Submaximal muscular strength assessment will be conducted for all participants prior to and immediately following the six week training period.

All study participants will also complete written self-efficacy scales designed to measure your self-perceived ability to perform arm and leg activities. You will complete each self-efficacy scale prior to and following study participation.

POSSIBLE RISKS AND DISCOMFORTS

The exercises you will perform are designed to improve cardiovascular and muscular fitness. All exercises will be prescribed by your cardiologist in conjunction with the exercise therapist. The exercise prescription will be based upon your general health status, fitness level, and physical impairments in order to avoid undue discomfort or fatigue.

During exercise your heart rate and rhythm, blood pressure, and in some cases level of blood oxygen, will be closely monitored in order to predict an abnormal response to exercise. These responses may include a change in blood pressure or heart rate/rhythm, ineffective heart pumping, difficulty in breathing, and in rare instances, heart attack. Emergency equipment and trained personnel are available to respond to any life threatening situation that may occur.

In the event of physical injury or illness because of my participation in this study, financial compensation is not available and medical treatment is not provided free of charge. I have read the above statement and understand my role in the experiment and the risks involved. The procedures have been explained to me and my questions have been answered to my satisfaction. In addition I am aware that:

- (1) My scores and name will remain confidential;

- (2) I am entitled to have any further inquiries answered regarding the experiment;
- (3) I may withdraw from this study at any time without penalty or prejudice toward me;
- (4) I do not expect any personal benefit beyond a report of my cardiovascular and strength responses to exercise.

Signature:

Date:

Witness:

Date:

Niles Lundt

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APPENDIX B

ARM ACTIVITY QUESTIONNAIRE

Please indicate how certain you are that you could perform each of the following activities by writing on the blank opposite each activity a number ranging from 0 (completely uncertain) to 100 (completely certain).

Lift a heavy object weighing:

10 pounds	_____
20 pounds	_____
30 pounds	_____
40 pounds	_____
50 pounds	_____
60 pounds	_____
70 pounds	_____
80 pounds	_____
90 pounds	_____
100 pounds	_____
110 pounds	_____
120 pounds	_____

LEG ACTIVITY QUESTIONNAIRE

Please indicate how certain you are that you could perform each of the following activities by writing on the blank opposite each activity a number ranging from 0 (completely uncertain) to 100 (completely certain).

Climb stairs without stopping.

- 1 flight _____
- 2 flights _____
- 3 flights _____
- 4 flights _____
- 5 flights _____
- 6 flights _____
- 7 flights _____
- 8 flights _____

LEG ACTIVITY QUESTIONNAIRE

Please indicate how certain you are that you could perform each of the following activities by writing on the blank opposite each activity a number ranging from 0 (completely uncertain) to 100 (completely certain).

Walk at a steady pace for a distance of:

1/2 mile	_____
1 mile	_____
1 1/2 miles	_____
2 miles	_____
2 1/2 miles	_____
3 miles	_____
3 1/2 miles	_____
4 miles	_____
4 1/2 miles	_____
5 miles	_____

APPENDIX C

Table C-1. Individual Strength Data

ID #	AGE	SEX	GROUP	ARMPRE	ARMPOST	LEGPRES	LEGPOST
1	46	M	ARM	34	64	80	105
2	45	F	ARM	16	30	60	80
3	55	M	ARM	40	70	85	115
4	75	F	ARM	13	22	35	40
5	68	M	ARM	34	55	60	75
6	46	F	ARM	18	34	50	55
7	73	M	ARM	24	40	60	70
8	76	M	ARM	32	48	70	75
9	51	M	ARM	40	74	90	110
10	68	M	ARM	34	45	60	73
11	57	F	ARM	32	42	55	60
12	71	M	LEG	30	34	45	75
13	77	F	LEG	16	18	25	38
14	58	M	LEG	24	34	70	115
15	53	M	LEG	27	34	50	75
16	63	M	LEG	40	50	75	120
17	51	F	LEG	22	22	60	85
18	76	M	LEG	37	42	60	90
19	59	F	LEG	32	32	70	105
20	71	F	LEG	20	24	35	60
21	54	M	LEG	32	43	80	125
22	41	F	LEG	20	24	50	65
23	60	M	CONTROL	27	37	80	100
24	45	M	CONTROL	40	45	70	82.5
25	75	M	CONTROL	40	40	75	90
26	67	M	CONTROL	30	36	55	67
27	37	M	CONTROL	40	50	85	100
28	62	M	CONTROL	40	45	75	90
29	74	F	CONTROL	20	24	40	50
30	67	M	CONTROL	24	34	50	60
31	52	M	CONTROL	30	37	65	80
32	56	M	CONTROL	40	43	80	97
33	76	M	CONTROL	30	34	50	55

VITA

Niles Jay Lundt was born in Marshalltown, Iowa on June 7, 1959. He was graduated from Gladbrook High School, Gladbrook, Iowa in May 1978.

Following graduation from Iowa State University in May 1983, he completed the Master of Science in Physical Education degree at Iowa State University in August 1986. He served as a graduate teaching assistant in physical education at Iowa State University.

In September, 1986 he accepted a graduate assistantship and began graduate studies at The University of Tennessee, Knoxville. He completed requirements for the Doctor of Philosophy degree with a major in Education and specialization in exercise physiology, in December, 1990.

The author currently is employed as Exercise Physiologist at Fort Sanders Parkwest Medical Center, Knoxville, Tennessee and is a member of the American College of Sports Medicine and the National Strength and Conditioning Association.