ABSTRACT

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This study investigated the effects of a 10-week resistance training program on muscular strength and self-efficacy in 22 Phase III female cardiac rehabilitation patients. Subjects (Ss) were randomly assigned to an experimental ($N = 12$) or control ($N = 10$) group. The experimental group lifted 3 days per week in addition to their regular aerobic exercise program. Patients performed 2 sets of 12-15 repetitions on 5 upper and 4 lower body exercises at 50% of 1 RM for the first 4 weeks. During weeks 5-7, Ss utilized self-selected weight loads which allowed them to perform 2 sets of 10-12 repetitions. Weeks 8-10 consisted of weight loads which allowed Ss to perform 2 sets of 8-10 repetitions. In addition to strength testing, all Ss completed a self-efficacy questionnaire consisting of 8 domains which were divided into 3 categories: ambulatory (walking distance, walking time, climbing stairs); strength (lifting objects, lifting and carrying, carrying a laundry basket, handling groceries); and personal appearance. It was found that compared to the controls, the experimental group had significantly ($p < .05$) greater improvements in both upper body (39 vs. 5%) and lower body (101 vs. 14%) strength. The experimental group also had 24, 22, and 60% greater ($p < .05$) improvements in ambulatory, strength, and personal appearance self-efficacy scores, respectively, compared to the controls. Thus it appears that Phase III female cardiac patients can significantly improve muscular strength and related self-efficacy measures with a combined strength and aerobic training program.

EFFECTIVENESS OF A 10-WEEK RESISTANCE
TRAINING PROGRAM IN FEMALE
CARDIAC PATIENTS

A MANUSCRIPT STYLE THESIS PRESENTED
TO
THE GRADUATE FACULTY
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OF THE REQUIREMENTS FOR THE
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BY
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THESIS FINAL ORAL DEFENSE FORM

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We recommend acceptance of this thesis in partial fulfillment of this candidate's requirements for the degree:

Master of Science- Adult Fitness/Cardiac Rehabilitation

The candidate has successfully completed the thesis final oral defense.

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INTRODUCTION

Cardiac rehabilitation has been widely accepted for years due to the impact aerobic exercise has had on the cardiac patient. The primary benefits of cardiac rehabilitation are to enhance the quality of one's life, to modify coronary artery disease risk factors, and to return the patient back to activities of daily living (work or recreational) as soon as possible.

Many patients lack the self-confidence and the physical strength to perform activities of daily living after a cardiac episode.¹ Improvements in upper and lower body muscular strength and muscular endurance enable the patient to perform the required everyday tasks of lifting, carrying, and moving at lower energy costs and with increased efficiency of movement.¹ Since muscular strength and muscular endurance are required to perform these activities of daily living, it is important that resistance training be added to the existing cardiac rehabilitation aerobic endurance program. Recently, this concept has been recognized and supported by the following major organizations: the American College of Sports Medicine, the American Heart Association, the American Association of Cardiovascular and Pulmonary Rehabilitation, and the Surgeon General.²⁻⁸

Resistance training is becoming increasingly more popular due to its role in developing muscular strength, power, endurance, and muscle mass.⁹⁻¹⁰ Additional benefits of resistance training for the cardiac patient include: reduced body fat,

increased functional capacity, increased self-confidence or self-efficacy, decreased blood pressure, increased bone density, increased self-image, and increased balance.¹¹ These benefits encourage resistance training as a supplement to, but not a replacement for, cardiorespiratory fitness. Pollock and Evans add that not only is resistance training important in terms of health and disease prevention, but that it is safe for the elderly, frail, and cardiac patients.¹²

Resistance training was traditionally thought to be unsafe for coronary artery disease patients in the past.¹¹ This was due in part to the large increases in heart rate and/or blood pressure associated with lifting weights.¹³⁻¹⁴ This pressor response during resistance training was believed to result in an undue demand on the heart and, therefore increase the incidence of arrhythmias and ischemia.¹⁵ However, many recent studies have shown resistance training programs of low, moderate, and high levels to be safe and effective for strength gains in patients with coronary artery disease with little chance of untoward events.¹⁶⁻³¹ Cardiac patients who have implemented resistance training programs in addition to simultaneous aerobic training, have had significant strength gains and did not experience any cardiovascular complications during their resistance training program.

Most resistance training studies have been done solely on male cardiac patients^{18,19,21-31} or have included only a few female patients.^{16,17,20} There have not been any studies done looking at the effects of resistance training in female patients alone. An investigation of such importance could unveil vital information for prescribing a safe and effective resistance training program for females with cardiac disease. The purpose of

this study was to examine the effects of a 10-week resistance training program on muscular strength and self-efficacy in female Phase III cardiac rehabilitation patients.

METHODS AND PROCEDURES

Subject Selection

All Phase III female patients from the Franciscan Skemp Healthcare cardiac rehabilitation program in La Crosse, WI received an informative handout (see Appendix A) and a patient survey (see Appendix B) prior to the study. Therefore, all were given an equal opportunity to participate. Twenty-two women (mean age 74 ± 4 years and mean time in rehabilitation 26 ± 20 months) volunteered to participate in the study. The subjects had at least one of the following cardiac events: myocardial infarction, coronary artery bypass graft surgery, percutaneous transluminal coronary angiography, angina, arrhythmia, congestive heart failure, or cardiomyopathy. Prior to participation, the subjects signed an informed consent form (see Appendix C) and had completed a health history/physical activity form through Franciscan Skemp Healthcare at the start of their Phase III program. Participants were also required to receive medical clearance (see Appendix D) from their physician prior to participating in any of the testing or training procedures. Ten subjects were then randomly assigned to the control group and 12 to the experimental group. None of the patients had ever participated in a resistance training program before and all of the patients were clinically stable, functionally able to participate, and met the guidelines set forth by the American College of Sports Medicine, the American Heart Association, and the American Association of

Cardiovascular and Pulmonary Rehabilitation.²⁻⁷ The following exclusion criteria were applied:

1. abnormal hemodynamic responses or ischemic changes documented during their current cardiac rehabilitation exercise sessions
2. ejection fraction of ≤ 30 representing poor left ventricular function
3. a functional capacity of < 4.5 METS
4. uncontrolled angina, hypertension, dysrhythmias, or heart failure
5. severe coronary artery disease
6. severe aortic stenosis
7. orthopedic or cardiovascular limiting symptoms
8. characteristics that may increase the risk of a cardiac event with exercise

Orientation Procedures

All subjects were required to attend at least one of the three orientation classes held one week prior to pretesting. This orientation was mandatory as it served as an informative session on the logistics of the study. Subjects were told which group they were randomly assigned to and what their commitment to the study entailed. Graduate student staff supervised these sessions and instructed the subjects on proper lifting and breathing techniques on each piece of equipment that would be used in the study. The participants were also taught the one repetition maximum (1 RM) test method, which made it a more familiar and accurate test during the next week of pretesting. All final questions were answered and an informed consent was completed and turned in along

with a copy of their health history/physical activity questionnaire. Subjects were then allowed to practice each exercise using low weights, followed by stretching exercises led by the graduate student staff.

Testing Procedures

Self-Efficacy

The self-efficacy scale (see Appendix E) used in this study was a modified version of the scale used in the study done by Foster et al.³² The scale was used to measure the subjects self-perceived ability to perform the following ambulatory and strength activities: walking distance, walking time, climbing stairs, lifting objects, lifting and carrying, carrying a laundry basket, and handling groceries. In addition, the subjects also rated their personal appearance. Each activity was scaled with 4-8 levels of increasing difficulty to perform each task. For example, walking distance (at a comfortable pace) had seven levels of difficulty ranging from walking 1 block to walking 5 miles. Subjects were asked to rate how confident they were able to perform each of the levels of activity by using a number ranging from 0-100 (not at all confident: 0-10; a little confident: 20-30; moderately confident: 40-50; quite confident: 60,70,80; or extremely confident: 90-100) on the column provided. A subject's score was the sum of the confidence ratings for each category divided by the number of levels of difficulty for that category.

Muscular Strength

The pretest was scheduled for both groups 1 week after the orientation sessions were completed. Subjects were allowed a 5-10 minute warm-up consisting of light

aerobic (i.e., treadmill walking or airdyne cycling) and stretching exercises. They were then tested using the 1 RM method on the following exercises: biceps curl, leg press, triceps extension, leg extension, shoulder press, leg curl, chest press, calf raises, and one arm pull. The 1 RM method has become a practical measuring standard to assess muscular strength and to determine appropriate levels of training in exercise prescription.³³ The 1 RM method determines the maximal amount of weight that can be lifted one time through a full range of motion. Shaw et al.³³ studied 83 elderly subjects on five different upper and lower extremity 1 RM tests to evaluate the rate of injury associated with 1 RM testing.³³ Only 2% of their subjects were injured in response to the 1 RM testing, both of which did not have any previous experience with weight training. Therefore, their findings showed that with proper preparation and instruction, the 1 RM method could be performed safely in the elderly as a strength assessment tool.

Subjects started with an initial submaximal lift that was determined by the graduate student staff. The resistance was gradually increased by 2-10 pounds depending on the subjects difficulty to lift the previous weight. Every effort was made to reach the 1 RM within 4-5 attempts.

The identical posttest was done on both groups during the week immediately following the completion of the training regimen. Again, the same self-efficacy scale was administered and 1 RM was re-tested on all of the exercises utilized in the study. These results were then compared to the baseline (pretest) findings and thus reflected improvements made during the study period.

Training Methods

Subjects in the experimental group participated in a 10-week intensity resistance training program that met 3 days per week for approximately 1 hour. Participants completed an individualized weight training program on each of the previously described exercises after a brief 5-10 minute light aerobic warm-up. To minimize the effects of fatigue, exercises were alternated between upper and lower body and patients were allowed a 1-minute rest interval between sets and 2 minutes rest in between machines. Intensity of the weight lifted was based on the initial 1 RM tests. The first 4 weeks of the program were at two sets of 12-15 repetitions and 50% of the initial 1 RM test. Weeks 5-7 and 8-10 were at a self selected weight load that enabled two sets of 10-12 repetitions and two sets of 8-10 repetitions, respectively.

RESULTS

Descriptive data for the subjects involved in the study are presented in Table 1. There were no significant differences in age, height, weight, diagnoses, or time in rehabilitation between the experimental and control groups. Overall compliance for the 10-week study was 82% with an average of 23 training sessions attended out of a possible 28 per participant. There were no adverse hemodynamic, musculoskeletal, or cardiovascular effects throughout the study.

Table 1. Subject Characteristics ($N = 22$), Including Their Primary Diagnosis

Subjects	Age (yrs)	Height (in)	Weight (lbs)	Diagnosis	Time in Rehab (mths)
Experimental					
#1	74	65	177	MI	1
#2	71	67	168	Arrhythmia	75
#3	75	69	170	CABG	27
#4	73	63	140	CABG	6
#5	72	60	125	Angina	2
#6	77	63	165	MI	25
#7	69	63	199	CABG	6
#8	68	64	235	PTCA	11
#9	71	63	206	Cardiomyopathy	35
#10	76	70	155	Angina	6
#11	72	62	162	CHF/Stroke	53
#12	76	69	219	Pacemaker	23
	72.8 ± 2.86	64.8 ± 3.08	176.8 ± 32.35		22.5 ± 22.77
Control					
#1	81	66	146	MI	30
#2	67	62	123	Angiogram	36
#3	71	69	193	CABG	14
#4	72	64	175	CABG	33
#5	74	63	209	CABG	3
#6	81	61	159	CABG	35
#7	69	65	180	MI	21
#8	73	65	210	CABG	30
#9	84	62	120	CABG	66
#10	82	63	122	CABG/CHF	21
	75.4 ± 6.06	64.0 ± 2.36	163.7 ± 35.10		28.9 ± 16.67

The pretest and posttest results from the 1 RM testing in both the control and experimental groups are presented in Table 2. The experimental group improved significantly ($p < .05$) more than the control group on all exercises except for the bicep curl. The only significant increase ($p < .05$) for the control group was on the leg

extension exercise. When combining the increases for the upper extremity and lower extremity exercises, the experimental group increased by an average of 39 and 101%, respectively. The control group improved by an average of 5 and 14%, respectively, for the same measures.

Table 2. Mean and Standard Deviations of Strength Gains in Female Cardiac Patients

Exercise/Group	Pretest	Posttest	Percent Change
Chest Press			
Experimental	55.5 ± 12.14	75.0 ± 10.72*	35%
Control	52.0 ± 16.87	51.0 ± 14.49	-1%
Leg Press			
Experimental	96.7 ± 45.74	215.0 ± 50.68*	122%
Control	111.5 ± 51.10	124.5 ± 50.25	12%
Shoulder Press			
Experimental	9.5 ± 2.49	13.1 ± 2.87*	38%
Control	7.8 ± 3.98	8.3 ± 3.79	6%
Leg Extension			
Experimental	32.7 ± 15.46	55.2 ± 20.77*	60%
Control	22.0 ± 10.12	28.5 ± 20.79*	30%
Biceps Curl			
Experimental	13.3 ± 2.50	15.6 ± 2.55	17%
Control	9.8 ± 3.62	10.5 ± 3.21	7%
Leg Curl			
Experimental	28.8 ± 10.85	45.0 ± 13.40*	56%
Control	19.0 ± 9.44	19.5 ± 9.19	5%
Tricep Press			
Experimental	11.9 ± 2.91	16.2 ± 1.86*	36%
Control	9.2 ± 3.19	9.7 ± 3.23	5%
Calf Raises			
Experimental	75.8 ± 27.46	200.0 ± 42.72*	164%
Control	96.0 ± 42.22	106.0 ± 48.35	10%
One Arm Pull			
Experimental	16.0 ± 3.17	26.8 ± 4.05*	68%
Control	13.9 ± 6.21	14.7 ± 6.87	6%

*Indicates a significant difference compared to pretest values ($p < .05$).

Pretest and posttest results from eight different domains of self-efficacy are presented in Table 3. The experimental group had significant improvements in the following domains of self-efficacy: walking distance, walking time, climbing stairs, lifting objects, and personal appearance. The control group, however, did not increase significantly on any of the self-efficacy domains. The eight domains were also grouped into three categories: ambulatory (walking distance, walking time and climbing stairs), strength (lifting objects, lifting and carrying, carrying a laundry basket, and handling groceries), and personal appearance. The experimental group increased significantly more for all three categories compared to the control group (ambulatory: average of 24%; strength: average of 22%; and personal appearance: average of 60%).

Table 3. Mean and Standard Deviations of Self-Efficacy Gains in Cardiac Patients

Domains	Pretest	Posttest
Walking Distance		
Experimental	64.9 ± 33.89	75.2 ± 28.81*
Control	64.1 ± 29.98	55.7 ± 25.10
Walking Time		
Experimental	66.6 ± 31.15	77.3 ± 29.27*
Control	67.4 ± 27.55	62.2 ± 20.57
Climbing Stairs		
Experimental	50.5 ± 24.77	70.2 ± 21.31*
Control	48.0 ± 25.18	50.8 ± 16.11
Lifting Objects		
Experimental	44.9 ± 17.28	61.8 ± 21.59*
Control	42.8 ± 26.20	32.9 ± 20.96
Lifting and Carrying		
Experimental	48.3 ± 30.56	60.6 ± 26.26
Control	36.8 ± 22.25	31.9 ± 20.65
Carrying a Laundry Basket		
Experimental	82.3 ± 23.51	93.5 ± 11.60
Control	81.9 ± 19.92	80.1 ± 21.04
Handling Groceries		
Experimental	88.0 ± 16.90	98.0 ± 4.68
Control	92.5 ± 13.59	93.5 ± 11.38
Personal Appearance		
Experimental	47.2 ± 22.20	75.5 ± 14.81*
Control	70.5 ± 28.41	69.6 ± 17.02

*Indicates a significant difference ($p < .05$) by comparison with pretest values.

DISCUSSION

Resistance training is becoming increasingly more popular among cardiac populations. Although traditionally thought to be unsafe in coronary artery disease patients, several recent studies have shown resistance training to be safe and effective for increasing strength in cardiac patients.¹⁶⁻³¹ However, most of these studies have been done solely on male cardiac patients^{18,19,21-31} or have included only a few female patients.^{16,17,20} Adams et al.¹⁶ and Fragnoli-Munn et al.²⁰ conducted studies on both male and female cardiac patients. Adams et al.¹⁶ found that the males and females responded similarly to the weight training program, however, the females experienced greater increases in upper (21%) and lower (20%) body strength compared to the males (16 and 14%, respectively). Fragnoli-Munn et al.²⁰ reported similar findings with their male and female cardiac subjects. Women had greater increases than the men did in both upper and lower body strength gains (29 versus 10% in the bench press, and 66 versus 29% increases in the leg extension, respectively). In the present study, we found that female cardiac patients improved upper body strength by an average of 39% and lower body strength by an average of 101%.

Subject characteristics (age and diagnoses) and pretest 1 RM values in the present study were similar to those of the female subjects in the studies done by Adams et al.¹⁶ and Fragnoli-Munn et al.²⁰ The resistance training protocols were also similar, except for the number of exercises the subjects completed. The participants from the study by Adams et al.¹⁶ only performed five exercises (three upper body and two lower body) and subjects in the study by Fragnoli-Munn et al.²⁰ completed only six exercises (four upper

body and two lower body). Meanwhile, subjects in the current study performed nine exercises (five upper body and four lower body), thus possibly allowing for greater improvements. Another possible explanation for the greater improvements in the current study is the limitation the researchers had by not being able to control the subjects' leisure time (i.e., physical activity levels) away from the study.

Self-efficacy was also measured in the present study. Many patients lack the self-confidence to perform vocational or avocational activities after a cardiac event. It was hypothesized that by involving patients in a combined aerobic endurance and resistance training program, self-confidence would increase and therefore, allow them to return to work or activities of daily living as soon as possible. We found that increases in muscular strength following a 10-week resistance training program had a positive influence on the subject's self-perceived ability to perform various related tasks. In addition, it also influenced how they perceived their personal appearance.

Experimental subjects in the current study increased significantly for all self-efficacy categories (ambulatory: average of 24%; strength: average of 22%; and personal appearance: average of 60%). In contrast, the control group decreased their scores in all categories of self-efficacy (ambulatory: average of -5%; strength: average of -9%; and personal appearance: average of -1%).

Our findings were consistent with the studies done by Ewart et al.³⁴ and Stewart et al.²⁷ in that the subjects involved in the resistance training component of the studies improved their self-efficacy scores, while members of the control group actually decreased their self-efficacy scores. These results support the concept of the self-efficacy

theory that self-perceived ability changes in relation to acquiring new ability information. Programs offering a variety of exercise modalities promote patients to try new activities, which in turn increase their self-confidence. Patients then feel better (emotionally) about themselves and are motivated to perform more physical activity.

In conclusion, significant improvements in upper and lower body muscular strength can be achieved safely in female cardiac patients after performing a 10-week resistance training program. These increases in muscular strength are also associated with an increase in self-efficacy relating specifically to the domains involved with performing the new implemented activity. Together, increases in muscular strength (increased physical capabilities) and self-efficacy (positive self-confidence) should promote an earlier return to vocational and avocational activities.

REFERENCES

1. Verrill DE: Resistive exercise training in cardiac rehabilitation. *Med Sci Sports Exerc* 1996;6:1-7.
2. American College of Sports Medicine. Position stand: The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness in healthy adults. *Med Sci Sports Exerc* 1990;22:265-274.
3. American College of Sports Medicine: Guidelines for Exercise Testing and Prescription, ed 5. Philadelphia: Williams and Wilkins, 1995.
4. American College of Sports Medicine. Position stand on exercise and physical activity for older adults. *Med Sci Sports Exerc* 1998;30:992-1008.
5. Fletcher GF, Balady G, Froelicher VF, Hartley LH, Haskell WL, Pollock ML: Exercise standards: a statement for healthcare professionals from the American Heart Association. *Circulation* 1995;91:58-615.
6. Fletcher GF, Balady G, Blair SN, et al: Statement on exercise: benefits and recommendations for physical activity programs for all Americans: a statement for health professionals by the committee on exercise and cardiac rehabilitation of the Council Clinical Cardiology. American Heart Association. *Circulation* 1996;94:857-862.
7. American Association of Cardiovascular and Pulmonary Rehabilitation: Guidelines for Cardiac Rehabilitation Programs, ed 2. Champaign, IL: Human Kinetics, 1995.
8. U.S. Department of Health, and Human Services, Physical Activity, and Health: A report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion. 1996:22-29.
9. Fleck SJ, Kraemer WJ: Designing Resistance Training Programs, ed 2. Champaign, IL: Human Kinetics, 1997.
10. Tesch PA: Skeletal muscle adaptations consequent to long-term heavy resistance exercise. *Med Sci Sports Exerc* 1988;20(S132-S134).
11. Verrill DE, Ribisl PM: Resistive exercise training in cardiac rehabilitation. *Sports Med* 1996;21:347-383.

12. Pollock ML, Evans WJ: Resistance training for health and disease: introduction. *Med Sci Sports Exerc* 1998;24:10-11.
13. Haslam DRS, McCartney N, McKelvie RS, MacDougall JD: Direct measurements of arterial blood pressure during formal weightlifting in cardiac patients. *J Cardiopulm Rehabil* 1988;8:213-225.
14. MacDougall JD, Tuxen D, Sale DG, Moroz JR, Sutton JR: Arterial blood pressure response to heavy resistance exercise. *J Appl Physiol* 1985;58:785-790.
15. Atkins JM, Mathews DA, Blomqvist CG, Mullins CB: Incidence of arrhythmias induced by isometric and dynamic exercise. *Br Heart J* 1976;38:465-471.
16. Adams KJ, Barnard KL, Swank AM, Mann E, Kushnick MR, Denny MD: Combined high-intensity strength and aerobic training in diverse phase II cardiac rehabilitation patients. *J Cardiopulm Rehabil* 1999;19:209-215.
17. Beniamini Y, Rubenstein JJ, Faigenbaum AD, Lichtenstein AH, Crim MC: High-intensity strength training of patients enrolled in an outpatient cardiac rehabilitation program. *J Cardiopulm Rehabil* 1999;19:8-17.
18. Daub WD, Knapik GP, Black WR: Strength training early after myocardial infarction. *J Cardiopulm Rehabil* 1996;16:100-108.
19. Derman EW, Scales N, Clark DR, Mabin T, Noakes TD: Circuit weight training improves exercise tolerance of cardiac rehabilitation patients without causing left ventricular hypertrophy (Abstr). *Med Sci Sports Exerc* 1994;26:142.
20. Fragnoli-Munn K, Savage PD, Ades PA: Combined resistive-aerobic training in older patients with coronary artery disease early after myocardial infarction. *J Cardiopulm Rehabil* 1998;18:416-420.
21. Ghilarducci LE, Holly RG, Amsterdam EA: Effects of high resistance training in coronary artery disease. *Am J Cardiol* 1989;64:866-870.
22. Haennel RG, Quinney HA, Kappagoda CT: Effects of hydraulic circuit training following coronary artery bypass graft surgery. *Med Sci Sports Exerc* 1991;23:158-165.
23. Kelemen MH, Stewart KJ, Gillian RE, et al: Circuit weight training in cardiac patients. *J Am Coll Cardiol* 1986;7:38-42.

24. McCartney N, McKelvie RS, Haslam DRS, Jones NL: Usefulness of weightlifting training in improving strength and maximal power output in coronary artery disease. *Am J Cardiol* 1991;67:939-945.
25. Sparling PB, Cantwell JD, Dolan CM, Niederman RK: Strength training in a cardiac rehabilitation program: a six-month follow up. *Arch Phys Med Rehabil* 1990;71:148-152.
26. Squires RW, Muri AJ, Anderson LJ, Allison TG, Miller TD, Gau GT: Weight training during phase II (early outpatient) cardiac rehabilitation. *J Cardiopulm Rehabil* 1991;11:360-364.
27. Stewart KJ, Mason M, Kelemen MH: Three-year participation in circuit weight training improves muscular strength and self-efficacy in cardiac patients. *J Cardiopulm Rehabil* 1988;8:292-296.
28. Stewart KJ, McFarland LD, Weinhofer JJ, Brown C, Shapiro EP: Weight training soon after myocardial infarction (Abstr). *Med Sci Sports Exerc* 1994;26:32.
29. Stewart KJ, McFarland LD, Weinhofer JJ, Cottrell E, Brown CS, Shapiro EP: Safety and efficacy of weight training soon after acute myocardial infarction. *J Cardiopulm Rehabil* 1998;18:37-44.
30. Svedahl K, Haennel RG, Hudec R, Habib N, Gebhart V: The effects of circuit training on the physical fitness of post-myocardial infarction (MI) patients (Abstr). *Med Sci Sports Exerc* 1994;26:185.
31. Wilke NA, Sheldahl LM, Levandoski SG, Hoffman MD, Dougherty MS, Tristani FE: Transfer effect of upper extremity training to weight carrying in men with ischemic heart disease. *J Cardiopulm Rehabil* 1991;11:365-372.
32. Foster C, Oldridge NB, Dion W, et al: Time course of recovery during cardiac rehabilitation. *J Cardiopulm Rehabil* 1995;15:209-215.
33. Shaw CE, McCully KK, Posner JD: Injuries during the one repetition maximum assessment in the elderly. *J Cardiopulm Rehabil* 1995;15:283-287.
34. Ewart CK, Stewart KJ, Gillilan RE, Kelemen MH: Self-efficacy mediates strength gains during circuit weight training in men with coronary artery disease. *Med Sci Sports Exerc* 1986;18:531-540.

APPENDIX A
INFORMATIVE HANDOUT

INFORMATIVE HANDOUT

To Whom It May Concern:

We are current Adult Fitness/Cardiac Rehabilitation students at the University of Wisconsin-La Crosse interested in working with female cardiac rehabilitation patients. In partial fulfillment of our Masters Degree we have chosen to study 10 weeks of resistance training on Phase III patients. We are seeking 30 to 40 women to randomly assign into either a control or experimental group for the 10 weeks. The women will be asked to participate three days a week for an hour. This will be in addition to their current training program. Our study is going to observe the effects on strength and functional abilities of the women before and after the 10-week period.

Strength will be assessed on:

Biceps curl
Triceps extension
Shoulder press
Chest press
One arm pull
Leg press
Leg extension
Leg curl
Calf raises

Functional abilities will be assessed by:

Chair sit-to-stand
Single leg Stand
Functional reach
Up-and-go
Floor rise
Grocery Carry
Step test

Tentative testing will begin in October with the training beginning soon after. Training sessions will be supervised and will possibly meet Monday, Wednesday, and Friday mornings. Here is a tentative schedule of events:

- Week 1 (M, W, F)-Orientation for all participants
- Week 2 (one day)-Pretesting of all participants
- Week 3 (M, W, F)- First week of training for experimental group
- Weeks 4-12 (M, W, F)-Continuation of training for experimental group
- Week 13 (one day)-Posttesting for all participants*

*Participants in the control group will receive personalized training upon completion of the study.

If you have any questions, please contact Carla Theusch (787-0696), Stefanie Hatcher (784-9896), or Dr. John Porcari (785-8684).

APPENDIX B
PATIENT SURVEY

Looking for a new addition to your workout?

Do you want to have a more complete exercise program?

Would you be interested in adding weight training to your cardiovascular program?

Yes!

We are looking for women already involved in the Phase III cardiac program at Franciscan Skemp Hospital to participate in a supervised 10 week weight training program.

Previous studies on cardiac patients and weight training have shown to be safe and effective. Numerous benefits have been seen: increased muscular endurance, reduced body fat, increased self confidence, increased self image, decreased resting blood pressure, decreased insulin requirements, increased bone density, and increased ability to perform activities of daily living (house work, walking, shopping, etc.).

We are current Adult Fitness/ Cardiac Rehabilitation students at the University of Wisconsin-La Crosse interested in working with female cardiac rehabilitation patients. We are working with the Franciscan Skemp staff in implementing weight training into their current cardiac rehabilitation program.

Enclosed you will find a questionnaire related to the new program. We appreciate you taking time to consider participating and would like to hear your responses by completing this form. If you have any questions or comments please ask the cardiac rehab staff or feel free to contact us.

Thank you for your time and we look forward to hearing from you!
Carla Theusch 787-0696
Stefanie Hatcher 784-9896

Name _____

Date _____

1. Are you willing to participate in a weight training program?

Yes

No

2. If yes, are you available to meet Monday, Wednesday, and Friday between 9 am and 11 am for a period of 10-weeks (October through December)?

Yes

No

3. If no, are you willing to be tested without participating in the weight training? The testing will require a couple of hours in October and January.

Yes

No

4. Are you currently participating in any form of weight training?

Yes

No

5. What time are you currently participating in cardiac rehabilitation?

* If you are not available for the 10 weeks of training, but would like to participate in the testing, we will also offer personalized training after the initial 10 week program has been completed.

Thank you for taking time to fill out this questionnaire. If you have expressed interest in the program we will be in contact with you in the near future. Please call us with any questions or concerns.

Carla Theusch
787-0696

Stefanie Hatcher
784-9896

APPENDIX C
INFORMED CONSENT

INFORMED CONSENT

EFFECTIVENESS OF A 10-WEEK RESISTANCE TRAINING PROGRAM IN FEMALE CARDIAC PATIENTS

I, _____ (print name), voluntarily consent to participate in a study to investigate the effects of a 10-week resistance training program on muscular strength and functional abilities. As a participant in this study, I will be randomly assigned to either a control or experimental group. If I am assigned to the experimental group, I will undergo a series of muscular strength and functional ability tests and participate in a 10-week moderate intensity weight training program. If I am assigned to the control group, I will participate in the muscular strength and functional ability testing only. Testing for the control and experimental groups will require two, one hour sessions at the beginning and end of the study period.

Testing

All testing will take place in the Physical Therapy Department (across the hall from Cardiac Rehab) at Franciscan Skemp Healthcare. Participants will be tested for maximal strength (the most weight which can be lifted once) before and after the training program on the following exercises:

1. Triceps extension	6. Chest press
2. Biceps curl	7. One arm pull
3. Leg press	8. Shoulder press
4. Leg extension	9. Calf raises
5. Leg curl	

Functional testing is required for all participants as well and will take place on a separate day. The majority of the functional tests will be timed and will evaluate the performance of common activities of daily living such as:

1. Chair sit-to-stand	5. Single leg stand
2. Floor rise	6. Functional reach
3. Up-and-go	7. Step test
4. Grocery carry	

Training

The training program will be 10 weeks in duration, meeting on Monday, Wednesday, and Friday mornings in the Franciscan Skemp Healthcare Physical Therapy Department. Each session will last approximately one hour, and will include the weight training exercises described above. The workload of the exercises will be individually determined from the initial strength testing. Initially, training will include performing two sets of 12-15 repetitions on each exercise. The weight load will progressively increase resulting in a decrease in the number of repetitions (i.e. two sets of 8-10 repetitions).

I have been informed that all testing and training sessions will be scheduled at my convenience and will be conducted by Stefanie Hatcher (784-9896) and Carla Theusch (787-0696), graduate

students from the University of Wisconsin-La Crosse Adult Fitness/Cardiac Rehabilitation program. These students are under the supervision of John P. Porcari, Ph.D. If any questions arise during the testing or training, Dr. Porcari can be contacted at (608) 785-8684.

I have been informed that the following benefits are often associated with a properly performed resistance training program: increased muscular strength and endurance, reduced percent of body fat, increased self-confidence, increased self-image, decreased resting blood pressure, decreased insulin requirement, increased bone density, and increased ability to perform activities of daily living (walking, carrying groceries, etc.).

I have also been informed that there are possible risks and discomforts associated with participating in any exercise testing and training program. These include musculoskeletal injuries and possible irregularities in heart beat, heart rate, blood pressure, and heart rhythm. Dizziness, lightheadedness, syncope, heart attack, stroke, or death are also possible risks. Every effort will be made to minimize these risks by evaluation of my previous medical and exercise history. I have been instructed to report any signs and symptoms, or other discomforts that occur during testing or training to the researchers. Permission will also be obtained from my personal physician before I participate in the study. In addition, trained personnel and emergency equipment are available if an emergency situation should arise. I also understand that Franciscan Skemp Healthcare will not be held liable for any adverse consequence that may occur and my personal medical insurance will be responsible for all necessary coverage.

I consent to the publication of the results of this study so long as the information is anonymous and disguised so that no identification of individual subjects can be made. I have been informed that although a record will be kept of my participation in this study, all data collected from my participation will be identified by number only.

I consider myself to be in good health and to my knowledge I am not infected with a contagious disease or have any musculoskeletal limitations that would preclude my participation in the described study.

I have been informed that any questions I have concerning the research study or my participation in it, before or after my consent, will be answered by John Porcari Ph.D., 141 Mitchell Hall, UW-L, La Crosse, Wisconsin, 54601, (608) 785-8684. Questions regarding the protection of human subjects may be addressed to Dr. Garth Tymeson, Chair, UW-La Crosse, IRB for the protection of human subjects (608) 785-8155.

I have read the above information. The nature, demands, risks, and benefits of the project have been explained to me. I knowingly assume the risks involved, and understand that I may withdraw my consent and discontinue participation at anytime without penalty or loss of medical care at Franciscan Skemp Healthcare. In signing this form I am waiving any legal claims, rights, or remedies. A copy of this consent form will be given to me for my records.

Signed: _____
 Witness: _____

Date: _____
 Date: _____

APPENDIX D
MEDICAL CLEARANCE

MEDICAL CLEARANCE

University of Wisconsin-La Crosse
La Crosse, WI 54601

Title: Effectiveness of a 10-Week Resistance Training Program in Female Cardiac Patients

Principle Investigators: Stefanie Hatcher and Carla Theusch

Dear Dr. _____,

We are writing to ask your permission to allow your patient _____ to participate in a moderate intensity resistance training program. The study to be conducted will be our master's theses for the Adult Fitness/Cardiac Rehabilitation program at the University of Wisconsin-La Crosse.

The purpose of the study is to investigate the effects of a 10-week resistance training program on muscular strength and endurance and functional abilities of female Phase III cardiac rehabilitation participants. Few studies have been done that specifically target the female cardiac patient in regards to resistance training and functional abilities. The results will be used by Franciscan-Skemp Healthcare to determine if resistance training will be implemented into their current cardiac rehabilitation program.

Each subject participating in the study will be randomly assigned to a control or experimental group and will continue with their current exercise prescription. The experimental group will undergo a series of muscular strength and functional ability tests and participate in a 10-week moderate intensity resistance training program. The control group will participate in the muscular strength and functional ability testing only. Testing will require two, one-hour sessions at the beginning and end of the study. One week of orientation will be included to allow the participants to become acquainted with proper lifting and breathing techniques. All subjects in the control and experimental groups will complete informed consent forms. These will be collected at the Franciscan-Skemp

Healthcare cardiac rehabilitation office before any participation in the experiment, including orientation week, has begun.

Testing

The majority of the functional tests will be timed and will evaluate the performance of common activities of daily living such as:

1. Chair sit-to-stand	5. Single leg stand
2. Floor rise	6. Functional reach
3. Up-and-go	7. Step test
4. Grocery carry	

Training

The training program will be 10 weeks in duration, meeting on Monday, Wednesday, and Friday mornings. Each session will last approximately one hour, and will include the weight training exercises described below:

1. Triceps Extension	6. Chest Press
2. Biceps Curl	7. Shoulder Press
3. Leg Press	8. Calf Raises
4. Leg Extension	9. One Arm Pull
5. Leg Curl	

The workload of the exercises will be individually determined from the initial strength testing. Initially, training will include performing two sets of 12-15 repetitions at 50% 1RM on each exercise. The weight load will progressively increase, resulting in a decrease in the number of repetitions (i.e. two sets of 8-10 repetitions).

Each testing and training session will be supervised and emergency equipment will be available if an emergency situation should arise. Each subject will be made aware of the possible risks involved and will be instructed to report to us any signs, symptoms or other discomforts that occur during testing or training. The orientation will be used to familiarize the subjects with the equipment and proper lifting procedures. An emphasis will be placed on proper breathing techniques to avoid any adverse cardiovascular

changes. Previous literature has shown resistance training to be very safe and effective for cardiac patients when executed properly.

The possible benefits to a resistance training program are: increased muscular strength and endurance, reduced percent of body fat, increased self-confidence, increased self-image, decreased resting blood pressure, decreased insulin requirement, increased bone density, and increased ability to perform activities of daily living (walking, carrying groceries, etc.).

I give my permission for my patient _____, to participate in the aforementioned resistance training study.

Dr. _____

Date _____

Please return this signed form to the Cardiac Rehabilitation Office of Franciscan-Skemp Healthcare, La Crosse, WI, by Thursday, October 21, 1999. Thank you.

APPENDIX E
SELF-EFFICACY QUESTIONNAIRE

SELF-EFFICACY QUESTIONNAIRE

Self-efficacy is measured by how much confidence you have in performing physical activity. Please mark in the column provided, a number between 0 and 100 that best reflects your level of confidence to perform each of the following activities. (Not at all confident: 0-10; A little confident: 20-30; Moderately confident: 40-50; Quite confident: 60, 70, 80; Extremely confident: 90-100)

Level of Confidence
(0-100)

Walking Distance (at a Comfortable Pace)

I feel confident I could:

Walk 1 block (approximately 150 steps)

Walk 2 blocks

Walk 4 blocks

Walk 8 blocks

Walk 12 blocks (approximately 1 mile)

Walk 2 miles

Walk 5 miles

Walking Time (at a Comfortable Pace)

I feel confident I could:

Walk for 10 minutes

Walk for 15 minutes

Walk for 20 minutes

Walk for 30 minutes

Walk for 45 minutes

Walk for 60 minutes

Walk for 90 minutes

Handling Groceries

I feel confident that I could:

Push groceries in a cart

Unload groceries into car

Carry groceries into house (10-15 lbs. each)

Lift groceries onto kitchen counter

Lifting Objects

I feel confident I could:

Lift a 5-lb. object

Lift a 20-lb. object

Lift a 30-lb. object

Lift a 40-lb. object

Lift a 50-lb. object

Lift a 60-lb. object

Lifting and Carrying

I feel confident I will be able to carry a box 10 times across a room and place it on a shelf at shoulder height if it weighs:

5 lbs.

10 lbs.

20 lbs.

30 lbs.

40 lbs.

Carrying a Laundry Basket

I feel confident that I could carry:

With the basket almost empty

With the basket 1/2 full

With the basket full

With the basket heaping full

Climbing Stairs (Without resting)

I feel confident I could:

Climb 1/2 flight of stairs (5-6 stairs)

Climb 1 flight of stairs (10-12 stairs)

Climb 2 flights of stairs

Climb 3 flights of stairs

Climb 4 flights of stairs

Climb 5 flights of stairs

Climb 6 flights of stairs

Climb 7 flights of stairs

Personal Appearance

I feel confident:

My muscles are firm and toned

About my appearance when I look in the mirror

The clothes I wear are comfortable and reveal my figure

I am in control of my body appearance

With my ability to lift weights

What goals do you wish to accomplish through participation in this resistance training program?

Thank you for taking time to participate in this questionnaire. You will not be scored or compared to other participants in the program. We will use this input to compare to *your* mid- and post-questionnaires only.

APPENDIX F

ONE REPETITION MAXIMUM (1 RM) DATA COLLECTION SHEET

1 RM DATA COLLECTION SHEET

Name _____

Date _____

	1 st	2 nd	3 rd	4 th	Max
Chest Press					
Leg Press					
Shoulder Press					
Leg Extension					
Biceps					
Leg Curl					
Triceps					
Calf Raises					
One Arm Pull					

APPENDIX G
RESISTANCE TRAINING LOG

APPENDIX H

REVIEW OF RELATED LITERATURE

REVIEW OF RELATED LITERATURE

Introduction

A major component of the normal aging process is a reduction in muscle mass. The 1998 American College of Sports Medicine position stand on Exercise and Physical Activity for Older Adults reports that approximately 30% of muscular strength is lost between the ages of 50-70 years and it appears that the most dramatic loss in muscle strength occurs after 70 years of age.¹ Since muscular strength is necessary and responsible for one's performance of activities of daily living (ADLs), it is expected then that ADLs are also reduced with age, which in turn allows this population to become more sedentary and less active. Additionally, reduced muscle strength is also associated with an increased likelihood of injury and disability. Therefore, improvements in upper and lower body muscular strength and muscular endurance could reverse this age associated decline and enable the patient to perform the required everyday tasks of lifting, carrying, and moving at lower energy costs, with increased efficiency of movement, and decreased risk of injury.²

Many cardiac patients also lack the self-confidence to perform ADLs after a cardiac episode.² In addition, patients may be afraid to do too much. It is important that healthcare professionals are aware of the current self-efficacy (SE) levels of their patients so that they can address these psychological barriers if they exist. Levels of self-confidence can be measured by using SE scales as an assessment tool before the start of a cardiac rehabilitation program (CRP).

This review will discuss literature related to the effects of weight training on strength gains and SE in male and female cardiac patients. It will also show that there is a lack of research investigating the effects of weight training exclusively on female cardiac patients, thus the purpose for this study. Topics to be discussed include the following: 1) safety of resistance training in cardiac patients, 2) resistance training studies in male cardiac patients, 3) resistance training studies involving male and female cardiac patients, and 4) the effects of resistance training on SE in cardiac patients.

Safety of Resistance Training in Cardiac Patients

Resistance training has been thought to be hemodynamically unsafe for coronary artery disease (CAD) patients in the past.³ This was due in part to the large increases in heart rate and/or blood pressure associated with lifting weights.^{4,5} These large increases were thought to put an undue stress on the heart, thus putting the patient's safety in jeopardy.

Haslam et al.⁴ studied eight cardiac patients during three weight lifting exercises (one upper body and two lower body) at four different intensities: 20, 40, 60, and 80% of one repetition maximum (1 RM). Intra-arterial pressures and electrocardiographic responses were measured and researchers reported a prominent increase in the peak diastolic blood pressure at 80% of 1 RM during the single-arm curl. The highest heart rate and arterial blood pressures were seen on the double leg press, also at 80% of 1 RM. They also found that during the other three intensities studied, blood pressures remained similar, over the same number of repetitions on all three exercises. Therefore, it was

concluded that resistance training is safe and should not pose an undue stress on the cardiovascular system at intensities below 80% of 1 RM.

In 1985, MacDougall et al.⁵ studied the blood pressure response of heavy weight lifting exercise on five experienced male body builders. Subjects performed single arm curls, overhead presses, and both single- and double-leg presses to fatigue at 80, 90, 95, and 100% of maximum. The researchers found that systolic and diastolic blood pressures increased dramatically to extremely high levels during the concentric phase of each exercise. The highest peak pressures were noted during the double-leg press where the group mean value was 320/250 mmHg. However, even peak pressures in the smallest muscle group, measured by the single-arm curl, generated extreme pressures where the group mean value was 255/190 mmHg. The authors concluded that weight lifting using small and large muscle groups at high intensities elicited a potent pressor response that resulted in up to a fourfold elevation in systolic and diastolic blood pressures in young healthy male body builders.

An earlier study correlated isometric exercise (i.e., sustained handgrip) with a higher incidence of cardiac dysrhythmias and ventricular decompensation in patients with impaired left ventricular function or CAD.⁶ The authors studied the occurrence of arrhythmias during isometric sustained handgrip exercise and bicycle exercise in 45 patients with heart disease not currently taking any antiarrhythmic medication. They found that atrial arrhythmias were just as common during handgrip (11%) as bicycle (9%) exercise. Ventricular arrhythmias, however, were more common during handgrip exercise. Thirty-eight percent of the patients completing handgrip exercise developed ventricular

arrhythmias, with ventricular tachycardia accounting for 15% of these episodes.

Meanwhile only 22% of the bicycle exercise group developed any ventricular arrhythmias.

The authors concluded that CAD patients and/or patients with depressed left ventricular function (low ejection fraction) developed twice the incidence of ventricular arrhythmias during isometric exercise than during dynamic exercise.

While the above studies have shown an increased risk for ventricular arrhythmias and elevated hemodynamic responses, the vast majority of studies have not shown any cardiovascular or sternotomy complications. It appears that the benefits outweigh the potential risks. Thus, the following major organizations currently provide guidelines and recommend that resistance training for cardiac patients should be added to the existing cardiac rehabilitation aerobic endurance program: the American College of Sports Medicine, the American Heart Association, the American Association of Cardiovascular and Pulmonary Rehabilitation, and the Surgeon General.^{1,7-12}

Resistance Training Studies in Males Soon After Cardiac Event

Current research involving similar studies on non-sustained isometric or isodynamic weight training exercises show that programs using low, moderate, and high intensity levels are both safe and effective for the development of strength in the male CAD patient.¹³⁻¹⁸ Subjects were 2-16 weeks post event (i.e., myocardial infarction or coronary artery bypass graft surgery) and none of them experienced any cardiovascular or sternotomy complications.

Daub et al.¹³ studied 57 male patients 6-16 weeks post myocardial infarction (MI) for a duration of 10 weeks. Patients completed two upper body weight training circuits of

7-20 repetitions at 20-60% of 1 RM combined with aerobic exercise at 70-85% of maximal heart rate (HRmax). Strength increased by an average of 12% and aerobic capacity was improved by an average of 9%.

Haennel et al.¹⁴ studied eight male patients 9-10 weeks post coronary artery bypass graft surgery (CABG) for a total of 8 weeks of weight training (intensity was not identified). Three sets of 8-16 repetitions were completed and strength gains of 18% and 22% were seen in upper and lower body strength, respectively. Subjects also improved their aerobic capacity by 11% without any aerobic activity as part of their training. Researchers believe this improvement was from an increase in maximum stroke volume and cardiac output, and lower submaximal exercise heart rates.

Squires et al.¹⁵ conducted a study using 13 male patients who were only 5-6 weeks post event (MI or CABG). Four of the 13 patients involved had an ejection fraction of 40% or less. Training included 24 weeks of aerobic exercise and one set of a weight load that allowed them the ability to perform 10-14 repetitions. An average increase of 25% was noted in upper and lower body strength. Aerobic capacity was not measured. Again, no cardiovascular or sternotomy complications were cited throughout the study, even in those with the lowest ejection fractions.

In 1994, Stewart et al.¹⁶ evaluated eight male MI patients and had them start resistance training just 2 weeks post event. Subjects trained three times a week, for 10 weeks, completing two circuits of resistance training (12-15 repetitions at 40% of 1 RM) combined with aerobic exercise. Upper and lower body strength improved by 22% and 29%, respectively and aerobic capacity increased by 15%.

Another study by Stewart et al.¹⁷ was done in 1998 using 23 male cardiac patients between 4-6 weeks post MI. These subjects participated in 10 weeks of either combined cycle and weight training or cycle training alone. The cycle training consisted of exercising at 70-80% HRmax and the weight training included two sets of 10-15 repetitions at 40% of 1 RM. VO_{2max} increased by 14% in the combined training group versus 8% in the cycle training group. Strength also increased more in the combined group than in the cycling group by 20 versus 10% in the upper body and 31 versus 16% in the lower body, respectively. Researchers concluded that weight training can be safely performed soon after a MI, and when done in combination with aerobic exercise, cardiovascular and muscular improvements are enhanced.

Lastly, Svedahl et al.¹⁸ studied 16 male MI patients with an average ejection fraction of 40-50%, 8-12 weeks post event. Each subject completed 12 weeks of hydraulic circuit weight training, exercising three times per week. Lower body strength increased by 23% and upper body strength increased by 29%. VO_{2max} also increased by 19% even though aerobic exercise was not a part of the subject's training protocol.

The authors of these studies concluded that weight training at low, moderate, and high intensity can be safely incorporated in male CAD patients soon after their cardiac event (MI or CABG). In order to promote greater improvements in both strength and cardiovascular endurance, weight training should be added as a supplement to aerobic exercise rather than performing aerobic activity alone.

Other Resistance Training Studies Which in Male Cardiac Patients

Other studies investigating the effects of weight training on male cardiac patients have been done where the patients were post cardiac event for a more extensive period of time and were involved in a CRP for at least three months prior to the research project.^{19,25} None of the studies found any major cardiovascular complications, with the exception of one study. Kelemen et al.²¹ had one patient become hypotensive and four patients developed bigeminy.

Derman et al.¹⁹ studied nine male CRP participants for 10 weeks of weight training and aerobic exercise (intensities not identified). Average strength gains of 19% were seen, but there was no change in $VO_2\text{max}$. The most likely explanation for this finding is that the patients had already been aerobically active for at least 3 months prior to the study. Subjects were, however, able to cycle 19% longer by the end of the study.

In 1989, Ghilarducci et al.²⁰ followed nine male cardiac patients with various diagnoses (i.e., MI, angina, or CABG) for 10 weeks. Subjects completed one set of 12-15 repetitions at 80% of 1 RM and aerobic exercise at 45-64% of HRmax. There was an average increase of 29% in upper and lower body strength. Aerobic capacity was not measured.

Kelemen et al.²¹ researched the effects of a 10 week weight training (two sets of 10-15 repetitions at 40% of 1 RM) and aerobic exercise (85% of HRmax) program on 20 male cardiac patients with CAD, CABG, angina, or MI. Upper and lower body strength increased by an average of 24% while treadmill time to exhaustion increased by 12%. As mentioned earlier, this was the only group that noted any cardiovascular complications.

McCartney et al.²² monitored 18 male CRP patients with CAD, CABG, angina, or MI for 10 weeks. Subjects performed either 2-3 weight training circuits of 10-15 repetitions at 40-80% of 1 RM and aerobic exercise at 60-85% of HRmax, or aerobic exercise alone. The group which performed aerobic training only increased single-arm curl strength by 13%, single leg press strength by 4%, and single knee extension by 5%. Meanwhile, the aerobic-weight trained group achieved increases of 43, 21, and 24%, respectively, for the same exercises. Maximal cycle ergometer power output was also measured in both groups, with the aerobic exercise group increasing by 2% and the aerobic-weight trained group increasing by 15%. Cycling time to exhaustion increased in the aerobic exercise group by 11%, but the aerobic-weight trained group increased by 109%. These researchers concluded that combined aerobic-weight training in male CAD patients is a more effective way to increase aerobic and strength performance compared to aerobic training alone.

In 1990, Sparling et al.²³ studied 16 male patients with coronary heart disease or who were at "high risk" for developing coronary disease according to the 1987 Georgia American Heart Association Guidelines for Cardiac Rehabilitation Programs. For 10 weeks, subjects completed one weight training circuit of 12-20 repetitions at 30-40% of 1 RM and aerobic exercise at 70-85% of HRmax. Aerobic capacity was not measured, but upper and lower body strength increased by an average of 22%.

Stewart et al.²⁴ performed a follow-up study on 17 of the original 20 male patients used in the study by Kelemen et al.²¹ Researchers found, 3 years later, that patients with the same diagnoses, performing the original circuit weight and aerobic training program,

had additional increases of 13 and 40% in upper and lower body strength, respectively.

Unlike the previous study, aerobic capacity was not measured.

Lastly, Wilke et al.²⁵ studied 14 male patients with a diagnosis of MI, CABG, percutaneous transluminal coronary angioplasty (PTCA), angina, or valvular disease for 12 weeks. Subjects completed three sets of weight training at 40-70% of 1 RM and aerobic exercise at 70-85% of HRmax. Upper body strength increased by 30% and lower body strength increased by 35%. Aerobic capacity also increased by 14%.

The researchers, therefore, concluded that not only is weight training safe and beneficial for strength and aerobic capacity improvements in male cardiac patients after 3 months of cardiac rehabilitation, but that patients at "high risk" for coronary disease benefit from these programs as well. They also agree with the previous authors that greater improvements will be seen when weight lifting is performed in conjunction with aerobic exercise versus aerobic activity alone.

Resistance Training Studies that Included Both Male and Female Cardiac Patients

Most studies have been done solely in male cardiac patients or have included only a few female cardiac patients.²⁶⁻²⁸ Research from these studies conclude that it is safe to participate in low, moderate, and high intensity weight and aerobic training programs for both males and females and that both genders experienced improvements in cardiovascular endurance and significant strength gains. Also, none of the studies reported any cardiovascular complications in either sex.

Adams et al.²⁶ evaluated 61 Phase II CRP patients (46 males, 15 females) of low, moderate, and high risk after 8 weeks of high-intensity weight training (two sets of 8-12

repetitions at 60-80% of 1 RM). Subjects also engaged in aerobic exercise at 60-80% of HRmax. Significant gains were seen in both upper and lower body strength with average increases of 17 and 15%, respectively. Although the males and females responded similarly to the weight training program, the females experienced greater increases in upper (21%) and lower (20%) body strength compared to males (16 and 14%, respectively). Surprisingly, there were no significant changes in VO_2max .

In 1999, Beniamini et al.²⁷ studied the effects of a 12 week high-intensity (50-80% of 1 RM) weight training program on 29 male and 9 female phase II CRP patients. The subjects were 6-16 weeks post cardiac event (MI, CABG, PTCA, or angina) and continued with their current aerobic endurance exercise program at 65-80% of HRmax. Participants performed 1-2 sets of 8-12 repetitions and strength gains ranging from 100-200% were achieved by the females, while the men improved by 45-95%.

Fragnoli-Munn et al.²⁸ compared the effects of a combined aerobic-weight training program on older versus younger cardiac patients. Thirty-eight males and seven females 4-12 weeks post MI participated in the 12 week training program. Weight training consisted of one set of 10 repetitions at 50% of 1 RM. The aerobic portion involved exercise on a combination of the treadmill, cycle and arm ergometers at an intensity of 70-85% of HRmax. Both age groups increased similarly in strength with 35% lower body and 14% upper body increases in the older patients and 39% lower body and 14% upper body increases in the younger patients, respectively. Women had greater increases than the men in both lower and upper body strength gains (66 versus 29% increases in the leg extension, and 29 versus 10% in the bench press, respectively).

Therefore, the authors found that older cardiac patients can improve in strength in a similar fashion to younger cardiac patients and that women tend to achieve greater strength gains from weight lifting than men.

Self-Efficacy in Cardiac Patients

Self-efficacy is defined as, "one's level of certainty that one can perform a given task or behavior and is quantified by summing confidence judgements for tasks of increasing difficulty within a specified behavior domain".²⁹ Perceptions that CAD patients have on their physical capabilities or SE often influence their return to vocational or avocational activities more than their current medical status does. For example, a study reported that patients post uncomplicated acute MI frequently limit themselves more by fear of exertion than by their actual current medical status.³⁰ As mentioned earlier, most CAD patients lack the self-confidence to perform ADLs and thus resort to inactive lifestyles.

Increasing SE creates a positive impact on exercise by encouraging people to give exercise a try. Additionally exercise can be a positive factor for SE as it may induce mood changes that will further enhance physical capabilities or SE, and therefore motivate one to pursue more challenging exercise goals. It is important for healthcare professionals to assess their patients SE so that individuals can improve their psychological well-being and feel confident about their ability to perform exercise, thereby avoiding a sedentary lifestyle.

Self-efficacy theory believes that individuals actions are based on anticipated costs and benefits of acting.^{31,32} It also believes that it is equally important for one to

self-appraise their ability to perform actions in order to achieve desired outcomes. For instance one must not only believe that exercise produces beneficial results, but that one must also perceive themselves capable of performing the physical and social actions that an exercise program entails. When they can achieve this, they will increase their psychological well-being and have self-confidence to perform the activity, thereby decreasing inactivity and the risk for future cardiac episodes.

Self-efficacy theory also proposes a model to help reduce self-limiting fears (such as those experienced after an acute cardiac event) and motivates patients to return to ADLs.³¹ It states that SE is derived from the following four major sources (listed in order of importance): 1) *prior performance*; having performed the activity or one similar too before, 2) *social modeling*; observing someone similar perform the activity, 3) *persuasion*; from a respected authoritative position; and 4) *internal feedback*; ones physiologic response (i.e., feeling relaxed or nervous). It is recommended that the most effective way to encourage patients to become physically active in areas of exercise for which they lack SE or self-confidence is to gradually introduce them to increasing amounts of the recommended activity (performance), allow them to observe others similar to their condition perform the activity (social modeling), have respected healthcare professionals refer them and emphasize the importance of the activity (persuasion), and arrange for a relaxed, but motivating atmosphere in the setting where the activity takes place (internal feedback).

Effects of Resistance Training on Self-Efficacy in Cardiac Patients

Studies have been done in cardiac patients to check the validity of the different beliefs of the self-efficacy theory.^{24,33,34} One concept of the self-efficacy theory is the belief that subjects do not change their self-perceived ability to perform a given activity until they have acquired relevant new ability information by trying the specific task or a similar task. As discussed earlier, Stewart et al.²⁴ performed a follow-up study on 17 of the original 20 male cardiac patients used in the study by Kelemen et al.²¹ In addition to measuring the effects of weight training on muscular strength, Stewart et al. also measured the effects of weight training on SE. The aerobic exercise group actually had decreased their SE scores, while the weight training group improved. Additionally, the weight training group saw its greatest gains in SE in the newest activity exposed, the arm tasks. For these subjects, the arm tasks provided new ability information versus the leg exercises, since the patients were already familiar and involved in walking, jogging etc., thus allowing a larger area of improvement in the arm SE. The researchers concluded that their findings along with results from earlier studies by Ewart et al.³³ and Ewart et al.³⁴ were consistent with the concept that self-perceived ability changes in relation to new ability information. Thus CRP that offer a wide variety of exercise including weight training, will enhance the SE of the cardiac patient more than those composed of one activity.

Another way to look at this concept is by the familiar example of patients not willing to enroll in an exercise program due to fear of exertion. However, studies have shown that performing supervised exercise sessions on a treadmill can help remove the

fear or anxiety, and stimulate confidence which in turn enhances participation in an exercise program.^{33,34}

Specificity is another factor involved in SE. This concept states that SE of one type of task should generate changes of SE on other similar tasks, but have lesser effect on dissimilar tasks. Ewart et al.³³ tested this hypothesis on 40 males with CAD while investigating the relationship between circuit weight training (arm and leg strength exercises), volleyball, and SE. The researchers found that SE estimates were highly task-specific in that arm SE scores were closely related to the arm strength test performed and not at all related to the aerobic endurance test performed. Their findings also agreed with Stewart et al.²⁴ in relation to the new ability information concept discussed earlier. Only the patients involved in the newest activity, the circuit weight training program, improved their self-perceived ability to perform tasks associated with arm and leg strength. Participants in the circuit weight training program achieved greater improvements in both strength and endurance, than did the volleyball group. These changes were accompanied by an increase in SE in those tasks related to the circuit weight training program.

Ewart et al.³⁴ tested the self-efficacy theory that authoritative persuasion by a respected nurse or physician would increase previous ratings of SE for dissimilar tasks. They examined 40 male cardiac patients who first completed a pre-self-efficacy questionnaire, then performed a graded exercise test (GXT) followed by a counseling session with the attending cardiologist. The cardiologist thoroughly explained the results of the GXT and discussed with the patient their ability to perform various physical activities (i.e., walking, jogging etc.). The patient was then counseled by a nurse who

reinforced the doctors' recommendations and a post-self-efficacy questionnaire was given. Results showed that after the counseling sessions, SE scores for dissimilar tasks to the treadmill GXT (i.e., sexual activity, lifting and general exercise) improved dramatically. Their results also agreed with the specificity concept mentioned earlier tested by Ewart et al.³³ Therefore, the author concluded from this study that SE of a specific task was shaped by an individual's experience of performing that activity or one similar to it and that counseling with encouragement from a respected authoritative position increased SE levels of dissimilar tasks.

In conclusion, knowing SE levels are important for healthcare professionals so that they can provide an effective and comprehensive exercise prescription for their patients. Higher SE levels increase psychological well-being and in return allow the self-confidence and motivation to return to ADLs or achieve more challenging exercise goals, which more importantly reduce sedentary lifestyle. The studies reviewed recommend that CRP offer a wide variety of activities and encouragement to patients by giving them positive reinforcement and motivation to help increase their SE levels.

Summary

The above researchers studied the effects of low, moderate, and high intensity weight training programs on male and female patients with a variety of diagnoses. Several protocols were used involving different durations and intensity of the training. Some were soon after the cardiac event, while others later; and older cardiac patients were compared to younger cardiac patients. The researchers concluded that weight training is safe for all ages, genders, CAD risk categories, and can be started as soon as

2 weeks post event. Additionally, weight training appears to be safe without the occurrence of any adverse hemodynamic responses up to 80% of 1 RM.

It is, therefore, now recommended that CAD patients perform these activities in combination with aerobic exercise to improve muscular strength and promote earlier return to work since most vocational and avocational activities require performing lifting and pushing movements. Since many patients post cardiac event lack the self-confidence to perform these everyday activities, the SE studies mentioned earlier concluded that aerobic exercise be accompanied by weight training to help patients overcome the fears that prevent them from fully participating in their daily routines. Present findings also suggest that exercise programs will be most successful at increasing SE when they expose their patients to a variety of activities and encourage gradual performance goals.

It is well established, then, that weight training is safe for cardiac populations and improves their SE, however, current research lacks evidence exclusively on female cardiac patients and weight training. The purpose of this study was to fulfill this void and therefore provide healthcare professionals with the necessary data to help implement a beneficial weight training program when prescribing an exercise regimen for their female cardiac patients.

REFERENCES

1. American College of Sports Medicine. Position stand on exercise and physical activity for older adults. *Med Sci Sports Exerc* 1998;30:992-1008.
2. Verrill DE: Resistive exercise training in cardiac rehabilitation. *Med Sci Sports Exerc* 1996;6:1-7.
3. Verrill DE, Ribisl PM: Resistive exercise training in cardiac rehabilitation. *Sports Med* 1996;21:347-383.
4. Haslam DRS, McCartney N, McKelvie RS, MacDougall JD: Direct measurements of arterial blood pressure during formal weightlifting in cardiac patients. *J Cardiopulm Rehabil* 1988;8:213-225.
5. MacDougall JD, Tuxen D, Sale DG, Moroz JR, Sutton JR: Arterial blood pressure response to heavy resistance exercise. *J Appl Physiol* 1985;58:785-790.
6. Atkins JM, Mathews DA, Blomqvist CG, Mullins CB: Incidence of arrhythmias induced by isometric and dynamic exercise. *Br Heart J* 1976;38:465-471.
7. American College of Sports Medicine. Position stand: the recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness in healthy adults. *Med Sci Sports Exerc* 1990;22:265-274.
8. American College of Sports Medicine: Guidelines for Exercise Testing and Prescription, ed 5. Philadelphia: Williams and Wilkins, 1995.
9. Fletcher GF, Balady G, Froelicher VF, Hartley LH, Haskell WL, Pollock ML: Exercise standards: a statement for healthcare professionals from the American Heart Association. *Circulation* 1995;91:58-615.

10. Fletcher GF, Balady G, Blair SN, et al: Statement on exercise: benefits and recommendations for physical activity programs for all Americans: a statement for health professionals by the committee on exercise and cardiac rehabilitation of the Council Clinical Cardiology. American Heart Association. *Circulation* 1996;94:857-862.
11. American Association of Cardiovascular and Pulmonary Rehabilitation: Guidelines for Cardiac Rehabilitation Programs, ed 2. Champaign, IL: Human Kinetics, 1995.
12. U.S. Department of Health, and Human Services, Physical Activity, and Health: A report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion. 1996: 22-29.
13. Daub WD, Knapik GP, Black WR: Strength training early after myocardial infarction. *J Cardiopulm Rehabil* 1996;16:100-108.
14. Haennel RG, Quinney HA, Kappagoda CT: Effects of hydraulic circuit training following coronary artery bypass graft surgery. *Med Sci Sports Exerc* 1991;23:158-165.
15. Squires RW, Muri AJ, Anderson LJ, Allison TG, Miller TD, Gau GT: Weight training during phase II (early outpatient) cardiac rehabilitation. *J Cardiopulm Rehabil* 1991;11:360-364.
16. Stewart KJ, McFarland LD, Weinhofer JJ, Brown C, Shapiro EP: Weight training soon after myocardial infarction (Abstr). *Med Sci Sports Exerc* 1994;26:32.
17. Stewart KJ, McFarland LD, Weinhofer, JJ, Cottrell E, Brown CS, Shapiro EP: Safety and efficacy of weight training soon after acute myocardial infarction. *J Cardiopulm Rehabil* 1998;18:37-44.
18. Svedahl K, Haennel RG, Hudec R, Habib N, Gebhart V: The effects of circuit training on the physical fitness of post-myocardial infarction (MI) patients (Abstr). *Med Sci Sports Exerc* 1994;26:185.
19. Derman EW, Scales N, Clark DR, Mabin T, Noakes TD: Circuit weight training improves exercise tolerance of cardiac rehabilitation patients without causing left ventricular hypertrophy (Abstr). *Med Sci Sports Exerc* 1994;26:142.

20. Ghilarducci LE, Holly RG, Amsterdam EA: Effects of high resistance training in coronary artery disease. *Am J Cardiol* 1989;64:866-870.
21. Kelemen MH, Stewart KJ, Gillian RE, et al: Circuit weight training in cardiac patients. *J Am Coll Cardiol* 1986;7:38-42.
22. McCartney N, McKelvie RS, Haslam DRS, Jones NL: Usefulness of weightlifting training in improving strength and maximal power output in coronary artery disease. *Am J Cardiol* 1991;67:939-945.
23. Sparling PB, Cantwell JD, Dolan CM, Niederman RK: Strength training in a cardiac rehabilitation program: a six-month follow up. *Arch Phys Med Rehabil* 1990;71:148-152.
24. Stewart KJ, Mason M, Kelemen MH: Three-year participation in circuit weight training improves muscular strength and self-efficacy in cardiac patients. *J Cardiopulm Rehabil* 1988;8:292-296.
25. Wilke NA, Sheldahl LM, Levandoski SG, Hoffman MD, Dougherty MS, Tristani FE: Transfer effect of upper extremity training to weight carrying in men with ischemic heart disease. *J Cardiopulm Rehabil* 1991;11:365-372.
26. Adams KJ, Barnard KL, Swank AM, Mann E, Kushnick MR, Denny MD: Combined high-intensity strength and aerobic training in diverse phase II cardiac rehabilitation patients. *J Cardiopulm Rehabil* 1999;19:209-215.
27. Beniamini Y, Rubenstein JJ, Faigenbaum AD, Lichtenstein AH, Crim MC: High-intensity strength training of patients enrolled in an outpatient cardiac rehabilitation program. *J Cardiopulm Rehabil* 1999;19:8-17.
28. Fragnoli-Munn K, Savage PD, Ades PA: Combined resistive-aerobic training in older patients with coronary artery disease early after myocardial infarction. *J Cardiopulm Rehabil* 1998;18:416-420.
29. Ewart CK, Stewart KJ, Gillilan RE, Kelemen MH: Self-efficacy mediates strength gains during circuit weight training in men with coronary artery disease. *Medi Sci Sports Exerc* 1986;18:531-540.
30. DeBusk RF, Kraemer HC, Nash E: Stepwise risk stratification soon after acute myocardial infarction. *Am J Cardiol* 1983;52:1161-1166.
31. Bandura A: Self-efficacy: toward a unifying theory of behavioral change. *Psychol Rev* 1977;84:191-215.

32. Bandura A: Social Foundations of Thought and Action: A Social Cognitive Theory. Englewood Cliffs, NJ: Prentice-Hall, 1986.
33. Ewart CK, Stewart KJ, Gillilan RE, Kelemen MH: Self-efficacy mediates strength gains during circuit weight training in men with coronary artery disease. *Med Sci Sports Exerc* 1986;18:531-540.
34. Ewart CK, Taylor CB, Reese LB, DeBusk RF: Effects of early postmyocardial infarction exercise testing on self-perception and subsequent physical activity. *Am J Cardiol* 1983;51:1076-1080.