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Effects of resistance training on physical function in older disabled women with coronary heart disease

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M. ELAINE CRESS,³ ERIC T. POEHLMAN,² MARC TISCHLER,¹ AND PHILIP A. ADES¹
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Brochu, Martin, Patrick Savage, Melinda Lee, Justine Dee, M. Elaine Cress, Eric T. Poehlman, Marc Tischler, and Philip A. Ades. Effects of resistance training on physical function in older disabled women with coronary heart disease. *J Appl Physiol* 92: 672–678, 2002; 10.1152/jappphysiol.00804.2001.—We studied whether disabled older women with coronary heart disease can perform resistance training at an intensity sufficient to improve measured and self-reported physical function [$n = 30$, 70.6 ± 4.5 (SD) yr]. Compared with the controls, the resistance-training group showed significant improvements in overall measured physical function score using the Continuous-Scale Physical Functional Performance Test (+24 vs. +3%). The Continuous-Scale Physical Functional Performance Test measures physical function for 15 practical activities, such as carrying groceries or climbing stairs. Resistance training led to improved measures for domains of upper body strength (+18 vs. +6%), lower body strength (+23 vs. +6%), endurance (+26 vs. +1%), balance and coordination (+29 vs. -2%), and 6-min walk (+15 vs. +7%). Women involved in the flexibility-control group showed essentially no improvement for physical function measures. No changes were observed for body composition, aerobic capacity, or self-reported physical function in either group. In conclusion, disabled older women with coronary heart disease who participate in strength training are able to train at an intensity sufficient to result in improvements in multiple domains of measured physical functional performance, despite no change in lean body mass.

aging; functional capacity; cardiac rehabilitation; randomized controlled study

CORONARY HEART DISEASE (CHD) is highly prevalent in women aged >65 yr and is a major cause of disability in the United States, with its most profound effects in older patients, particularly older women (21, 22). Data from the Framingham Disability Study document that 67% of women aged 55–69 yr with CHD are disabled (18). The proportion increases to 79% in women over the age of 70 yr and 88% in older women with angina or chronic heart failure (18). Furthermore, healthy older women have lower levels of habitual physical activity and lower levels of physical functioning than older men, due in part to their lower strength and muscle

mass (7, 20). The impact of CHD on disability rates in aging women is a major public health issue (17, 19). There has been little study of interventions to treat or prevent coronary disability in older women. Our laboratory has recently determined that lack of muscle strength is significantly correlated with low self-reported physical function in older women with CHD (3). This is due to the fact that most household activities, such as carrying groceries, cooking, cleaning, and climbing stairs, are more strength-related rather than related to aerobic exercise capacity. We, therefore, undertook the present investigation to determine whether disabled older women with CHD can perform resistance training at an intensity sufficient to affect measured and self-reported physical function favorably.

Most studies of disability in CHD patients have utilized self-reported assessment instruments (questionnaires) to measure physical function (2, 16, 18). These questionnaires are easy to administer and are clinically useful and reliable (4, 14). They are, moreover, very relevant to the issue of whether an individual patient requests home help for the performance of daily activities, such as preparing meals, shopping, or housework. However, as reported by Applegate et al. (4), self-reported assessment instruments are often insensitive to subtle but potentially important clinical changes and only measure the patient's subjective assessment of function rather than actual performance. Furthermore, CHD patients have been described as more likely to limit physical activity because of apprehension regarding safety (14) rather than because of the occurrence of cardiovascular symptoms. Thus they may have a malperception of their physical capacity. We hypothesized that disabled older women with CHD would be capable of strength training at an intensity sufficient to improve directly measured and observed physical performance using standardized criteria developed for older individuals [Continuous-Scale Physical Functional Performance Test (CS-PFP)] (7, 8) and self-reported physical function [Medical Outcomes

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Study 36-Item Short Form (MOS SF-36) questionnaire] (28) over a 6-mo intervention period.

METHODS

Subjects

The study population included 30 women with CHD (diagnosed for >6 mo) between 65 and 81 yr of age (mean \pm SD: 70.6 \pm 4.5 yr). Patients had definite CHD as defined by myocardial infarction ($n = 24$), coronary revascularization ($n = 16$), and chronic stable angina ($n = 5$). Diagnoses were not mutually exclusive, and some patients had more than one cardiac diagnosis. Criteria for inclusion include a physical function score <85 [definition of disability from the Framingham Disability Study (18)] assessed from the physical function section of the MOS SF-36 health status questionnaire (25, 28). To attain a score of <85, an individual would have to be at least "limited a little" for at least three of the following activities: pushing a vacuum cleaner, climbing several flights of stairs, walking more than a mile, lifting or carrying groceries, bending, or stooping. Exclusion criteria included 1) hospitalization for an acute coronary syndrome within 6 mo; 2) very-low-threshold angina (≤ 3 metabolic equivalent workload); 3) exercise-limiting noncardiac comorbidity (i.e., orthopedic, neuromuscular, peripheral vascular, cerebrovascular); 4) uncontrolled hypertension (resting, seated blood pressure >160 systolic or 90 diastolic); 5) sternal nonunion after coronary bypass surgery; 6) recent (≤ 3 mo) participation in an organized cardiac exercise program; 7) inflammatory arthritis; and 8) dementia. All participants were asked to sign an informed consent document. This study was approved by the Medical Sciences Committee on Human Research at the University of Vermont.

Body Composition

Body weight (nearest 0.1 kg) and height (nearest 0.1 cm) were measured and used to calculate the body mass index (kg/m^2). Dual-energy X-ray absorptiometry (DEXA) (model DPX-L; LUNAR Radiation, Madison, WI) was used to measure body composition. DEXA measures included fat mass, lean body mass, bone mineral content, and percent body fat, as previously described (6, 11). Patients were positioned on the DEXA table with the upper extremity separated from the trunk to permit measurement of appendicular mass.

Peak O_2 Consumption

Patients performed a symptom-limited graded exercise test on treadmill using a modified Balke protocol before and after the rehabilitation program, as previously described (6). Standard 12-lead electrocardiograms were performed at the end of each 2-min stage. The occurrence of any untoward responses, such as low-threshold angina or ≥ 2 -mm ST segment depression, excluded patients from the training protocol. Patients performed this test taking their usual medications, which were not altered during the exercise training program. Peak O_2 consumption ($\dot{V}\text{O}_2$) (l/min) was considered to be the highest 30-s value obtained during the test. Expired gas was analyzed during the exercise protocol using a Sennormedics V29c metabolic cart (Yorba Linda, CA). Data collection included $\dot{V}\text{O}_2$ and respiratory equivalent ratio (CO_2 production/ $\dot{V}\text{O}_2$).

Measures of Physical Function

CS-PFP. The CS-PFP specifically targets older adults and has been validated over a broad range of functional levels to

assess overall physical performance (7, 8). It was administered at the University of Vermont General Clinical Research Center by an individual with experience in supervising cardiac exercise testing and training. The CS-PFP is based on ordinary activities of daily life, performed at maximal effort within the bounds of safety and comfort. It requires standard conditions and utilizes a scripted dialogue. All tasks are quantified by time, distance, or weight. Each task is scored 0–100, based on an empirically derived range from data gathered on older adults with a broad range of individual functional abilities (8). The test yields a total score (0–100) that is the average of the five separate physical domain scores: upper body strength, lower body strength, flexibility, balance and coordination, and endurance. The battery includes 15 everyday tasks, ranging from "easy" to "difficult." These include practical activities, such as carrying groceries, lifting heavy pots, loading and unloading a washing machine and dryer, climbing stairs, bed making, vacuuming, and a 6-min walk.

Physical function score. The MOS SF-36 questionnaire was used to assess the "self-reported" physical function score. This questionnaire has been extensively studied and validated in various populations (25, 27–29). The physical function component of the SF-36 was not shortened from the long-form instrument due to the importance of physical functioning to health-related quality of life. The MOS SF-36 includes scores in eight domains: 1) physical functioning, 2) role functioning, 3) bodily pain, 4) general health, 5) vitality, 6) social functioning, 7) mental health, and 8) reported health transition.

Geriatric Depression Questionnaire. The presence and severity of depression symptoms were measured using the Geriatric Depression Score, developed and validated by Yesavage et al. (30) in older populations and utilized by our research group in prior studies of coronary patients (2). The Geriatric Depression Questionnaire provides measurement of a depression score that is scaled 0 to 15, where a score of ≥ 5 signifies the presence of significant depressive symptoms.

Measures of Muscle Strength

Single-repetition maximal lift. For the first three sessions, subjects weight trained with a very light resistance to allow them to learn proper technique and minimize muscle soreness. At 1-wk, all patients were evaluated with a single-repetition maximum (1-RM) lift for the bench press and leg extension on a Universal Gym apparatus (Universal, Cedar Rapids, IA). The 1 RM is the maximum load that a subject can lift, using correct form, through a full range of motion for one repetition only. After a warm-up, the 1 RM was determined within four trials (with at least one trial in excess of maximum). Subsequently, women in the intervention group were retested monthly, and the controls were retested at the end of 6 mo.

Isokinetic strength test. Muscle strength was also measured utilizing an isokinetic dynamometer (Lido Active, Loredan Biomedical, W. Sacramento, CA). Measures of isokinetic peak torque and average force (in Newtons) at 30 and 120°/s were made for leg extension. The subjects were seated, and the legs and upper torso were strapped to the chair to prevent hip movement. The dominant leg was tested. After three practice trials, three maximal contractions were recorded, and the average was calculated. Sixty seconds of rest were allowed between trials.

Isometric strength test. Isometric knee-extension strength was obtained at 55° extension. The patients were positioned as described and were instructed to attempt to straighten

their leg as forcefully as possible. After one practice trial, three maximal isometric contractions were recorded. The average of the three measures was used for statistical analysis.

Handgrip. A measure of handgrip strength was made with a handgrip dynamometer (Jamar, Jackson, MI) using the dominant hand. A mean of three measures was recorded as the handgrip strength measure.

Echocardiography

A two-dimensional echocardiography examination was performed with the subject supine, in the left lateral decubitus position, with a phased-array ultrasonoscope device (Acuson XP-10; Acuson, Mountain View, CA), using a 2.5-MHz transducer, as previously described (24).

Two-dimensional analysis. Three to five cardiac cycles were digitized at end systole (time of smallest cavity area) and end diastole (R-wave peak) with an off-line workstation (Imagevue, Nova Microsonics, Mahwah, NJ). End-diastolic volumes, left ventricular mass, and ejection fraction were calculated as previously described (12, 26), with the use of the short-axis area times length method.

Exercise Protocol

Subjects were first randomized to one of the two modalities of training. The randomization was stratified by the physical function score from the SF-36 such that groups were matched at baseline by this measure. Patients performed the exercise training program for 6 mo, meeting three times weekly. Body weight was followed on a weekly basis, with subjects instructed to maintain body weight throughout the program. Patients in both study groups were required to attend at least 54 of the 72 sessions over the 6-mo period to be considered in the study analysis. Study subjects were asked not to start an exercise program, other than the intervention program, during the 6-mo study period.

Resistance-training intervention. The exercise training program was established based on baseline 1-RM lifts and ratings of perceived exertion (1, 5). During *week 1* of the exercise program, before 1-RM testing, patients worked for three sessions at a very low intensity on the Universal weights, with free weights, and/or with elastic tubing. At 1 wk, patients performed 1-RM testing for each of two weight exercises: leg extension and bench press. After maximal testing, weight training began at 50% of 1 RM, and 2 wk later maximal strength was retested, and relative training intensity was gradually increased towards 80% of 1 RM, as tolerated. The resistance-training program was performed with Universal weights and dumbbells. The 1 RM was updated

monthly, and the progression of exercise was supplemented by perceived exertion scores, with patients increasing the resistance when perceived exertion scores dropped below a threshold value (14 on the Borg scale of 6–20) (5). The number of repetitions, the amount lifted, the number of sets completed, and any relevant comments were recorded in daily training logs. The eight exercises focused on leg, arm, and shoulder strength, such that strength increases may translate to improved mobility and lifting capacity. Exercises included 1) leg extensions (quadriceps), 2) leg press (gluteals, quadriceps), 3) leg curls (hamstrings), 4) shoulder press (deltoids, scapular, triceps), 5) arm curls (biceps), 6) lateral pulldown (latissimus, biceps), 7) bench press (pectoralis), and 8) tricep extension (triceps). Subjects began training with one set of 10 repetitions per station, gradually increasing to two sets of 10 repetitions with a 2-min rest in between each set. Each training session was under the supervision of an exercise physiologist experienced in coordinating weight-training programs in the healthy elderly and in CHD patients (10).

Control group. Control patients met three times per week for 30–40 min at the Cardiac Rehabilitation facility with the study coordinator and participated in a program of stretching, calisthenics, light yoga, and deep breathing-progressive relaxation exercises.

Statistical Analyses

Values in Tables 1–4 are presented as means \pm SD. The distribution of score for each variable was verified, and variables not normally distributed were log transformed before analysis [lean body mass before (Pre) and after exercise (Post), upper body flexibility Post, percent change for leg extension, torque at 30° Pre, and percent change for torque at 120°]. A nonpaired *t*-test was used for the comparison between groups at baseline and after 6 mo. Two statistical approaches were used to determine the effect of treatment. First, ANOVAs for repeated measures were used to determine the effect of treatment over the 6-mo period within each group. Second, a nonpaired *t*-test approach was used to compare changes between groups for percent changes after the program. Pearson correlations were used to measure association between variables of interest. A level of significance of $P < 0.05$ was used for hypotheses testing. All statistical analyses were carried out using the Stat View 4.01 (Stat View 5.0.1, SAS Institute, Cary, NC; 1992–1998) and Jump 3.1 (JUM 4.0.2, SAS Institute; 1989–2000) statistical software programs. A level of significance of $P < 0.05$ was used for hypotheses testing.

Table 1. Anthropometric characteristics

	Intervention (<i>n</i> = 13)			Control (<i>n</i> = 12)			<i>P</i> Between Groups
	Pre	Post	%Change	Pre	Post	%Change	
Age, yr	70.5 \pm 4.0			70.7 \pm 5.3			
Body weight, kg	72.1 \pm 12.2	70.6 \pm 11.0	–2.1	78.7 \pm 17.5	77.1 \pm 16.4	–2.0	0.99
Body mass index, kg/m ²	28.5 \pm 3.8	27.8 \pm 2.9	–2.5	31.0 \pm 5.6	30.5 \pm 5.5	–1.6	0.99
Body fat, %	42.2 \pm 7.6	41.7 \pm 6.9	–0.1	43.7 \pm 5.8	43.5 \pm 6.4	–0.5	0.41
Fat mass, kg	29.6 \pm 9.5	28.5 \pm 7.7	–3.7	33.2 \pm 11.2	32.9 \pm 11.4	–0.9	0.80
Lean body mass, kg	39.0 \pm 5.3	38.8 \pm 5.5	+0.5	41.3 \pm 6.3	41.2 \pm 6.1	–0.2	0.64
Appendicular muscle mass, kg	16.4 \pm 2.4	16.5 \pm 2.4	+0.6	17.0 \pm 2.6	17.4 \pm 2.8	3.5	0.18
Bone mineral content, kg	2.3 \pm 0.2	2.3 \pm 0.2	0	2.5 \pm 0.4	2.5 \pm 0.5	0	0.40

Values are means \pm SD; *n*, no. of subjects. Pre, before exercise; Post, after exercise. A nonpaired *t*-test was used for the comparison between groups (baseline, 6-mo, and percent changes after treatment). No differences were observed between groups at baseline. ANOVA for repeated measures were used to determine the effect of treatment.

Table 2. Measures of physical function with the CF-PFP

	Intervention (<i>n</i> = 13)			Control (<i>n</i> = 12)			<i>P</i> Between Groups
	Pre	Post	%Change	Pre	Post	%Change	
CF-PFP total score (Ref. 7)	49.5 ± 11.0	61.2 ± 10.4 [†]	+24	50.5 ± 17.1	52.0 ± 16.5	+3	0.007
Upper body strength score	53.4 ± 16.1	62.8 ± 15.0*	+18	55.5 ± 17.2	58.6 ± 18.0	+6	0.15
Upper body flexibility score	63.8 ± 16.6	70.0 ± 13.1	+10	59.3 ± 21.2	62.2 ± 18.1	+6	0.64
Lower body strength score	43.0 ± 13.6	53.1 ± 11.5 [†]	+23	44.9 ± 17.6	47.7 ± 16.2	+6	0.17
Endurance score	51.0 ± 11.2	64.5 ± 11.5 [†]	+26	51.8 ± 18.5	52.4 ± 18.1	+1	0.005
Balance and coordination score	46.8 ± 9.2	60.4 ± 8.7 [†]	+29	48.6 ± 17.2	47.6 ± 16.0	-2	0.001
6-min Walk, m	382 ± 112	440 ± 99*	+15	401 ± 69	429 ± 104	+7	0.16
Peak $\dot{V}O_2$, ml·kg ⁻¹ ·min ⁻¹	14.9 ± 2.8	16.2 ± 3.6	+9	16.6 ± 2.6	16.6 ± 3.4	0	0.09

Values are means ± SD; *n*, no. of subjects. CF-PFP, Continuous-Scale Physical Functional Performance Test; $\dot{V}O_2$, O₂ consumption. A nonpaired *t*-test was used for the comparison between groups (baseline, 6-mo, and percent changes after treatment). No differences were observed between groups at baseline. ANOVA for repeated measures were used to determine the effect of treatment. Significant difference between groups: **P* < 0.01, [†]*P* < 0.0005.

RESULTS

Baseline Characteristics

Twenty-five subjects out of thirty enrolled completed the protocol. Reasons for dropout included noncompliance to the training program (*n* = 2) and medical problems unrelated to the training program (*n* = 3) (cancer, carpal tunnel, stroke). Both groups were similar at baseline by age and for measures of body composition (Table 1), physical function (Table 2), health status questionnaires (Table 3), strength (Table 4), and cardiac function (ejection fraction, end-diastolic volume, and left ventricular mass; results not shown).

Effect of Treatment

Subjects involved in the resistance-training group significantly improved their total CS-PFP physical performance score (+24%, *P* < 0.0005) and subscale scores for upper body strength (+18%, *P* < 0.01), lower body strength (+23%, *P* < 0.0005), endurance (+26%, *P* < 0.0005), and balance and coordination (+29%, *P* < 0.0005). In addition, women in the resistance-training group significantly improved their endurance as measured by the distance walked during the 6-min walk test (+15%, *P* < 0.01), 1 RM on the bench press (+53%, *P* < 0.0005) (Table 4), and 1 RM for leg extension (+46%, *P* < 0.0005). Leg extension torque at 0° (+12%,

P < 0.0005), 30° (+12%, *P* < 0.0005), and 120° (+17%, *P* < 0.05) also increased significantly. Changes in strength occurred in the absence of changes in lean body mass or appendicular muscle mass (Table 1). Women in the flexibility group showed no improvements for any of the physical function measures, with the exception of a 10% increase in leg extension strength (*P* < 0.01) and an increase in leg extension torque at 0 and 120°. No changes were observed between groups for aerobic capacity (peak $\dot{V}O_2$), depression score, and self-reported physical function score, although depression score decreased within the resistance-training group (-52%, *P* < 0.01). Finally, there was no deterioration in left ventricular ejection fraction, end-diastolic volume, or left-ventricular volumes after the resistance-training program (results not shown).

The resistance-training group showed a greater improvement in the total CS-PFP physical performance score (+24 vs. +3%, *P* = 0.007) and subscale scores for endurance (+26 vs. +1%, *P* = 0.005) and balance and coordination (+29 vs. -2%, *P* = 0.001) than the flexibility control group. Women in the resistance-training group also showed a greater increase in the 1 RM on the bench press (+53 vs. +2%, *P* = 0.0001) and leg extension (+46 vs. +10%, *P* = 0.0001). Neither group demonstrated an improvement in self-reported physi-

Table 3. Health status questionnaires

	Intervention (<i>n</i> = 13)			Control (<i>n</i> = 12)			<i>P</i> Between Groups
	Pre	Post	%Change	Pre	Post	%Change	
MOS SF-36 questionnaire (Ref. 28)							
Physical function	61.9 ± 20.6	65.8 ± 21.6	6	70.4 ± 12.9	77.9 ± 13.7	+11	0.74
Role, physical	53.8 ± 40.6	67.3 ± 35.9*	+25	68.7 ± 40.1	82.2 ± 29.7	+20	0.62
Bodily pain	70.8 ± 17.4	69.1 ± 16.7	-2	72.4 ± 17.3	68.2 ± 29.9	-6	0.47
General health	62.9 ± 21.7	69.2 ± 17.1	+10	74.1 ± 14.9	78.9 ± 12.2	+6	0.36
Vitality	54.2 ± 22.8	65.0 ± 15.0*	+20	61.2 ± 21.4	64.2 ± 23.2	+5	0.12
Social functioning	84.8 ± 17.9	91.9 ± 12.8	+8	82.7 ± 18.3	90.8 ± 13.9 [†]	+10	0.87
Role, emotional	71.8 ± 35.6	82.1 ± 32.2	+14	91.7 ± 28.8	86.1 ± 22.3	-6	0.08
Mental health	74.8 ± 13.6	81.8 ± 12.8*	+9	77.0 ± 20.1	80.7 ± 18.6	+5	0.80
Depression score (Ref. 30)	2.5 ± 2.1	1.2 ± 1.7*	-52	2.1 ± 2.5	1.7 ± 2.1	-20	0.40

Values are means ± SD; *n*, no. of subjects. MOS SF-36, Medical Outcomes Study 36-Item Short Form. A nonpaired *t*-test was used for the comparison between groups (baseline, 6-mo, and percent changes after treatment). No differences were observed between groups at baseline. ANOVA for repeated measures were used to determine the effect of treatment. Significant difference between groups: **P* < 0.05, [†]*P* < 0.01.

Table 4. Measures of strength

	Intervention (n = 13)			Control (n = 12)			P Between Groups
	Pre	Post	%Change	Pre	Post	%Change	
1 RM							
Bench press, kg	22.0 ± 6.4	33.6 ± 7.3‡	+53	19.7 ± 2.7	20.2 ± 3.1	2	0.0001
Leg extension, kg	14.7 ± 4.3	21.4 ± 4.4‡	+46	17.6 ± 5.8	19.4 ± 6.8†	+10	0.0001
Isokinetic dynamometer							
Torque at 0°, N	80.1 ± 16.1	90.1 ± 17.3‡	+12	78.4 ± 23.9	88.1 ± 17.1*	+12	0.53
Torque at 30°, N	57.8 ± 14.4	65.0 ± 14.7‡	+12	58.3 ± 19.3	62.8 ± 18.3	+8	0.46
Torque at 120°, N	38.4 ± 12.7	45.0 ± 14.0*	+17	39.7 ± 17.0	43.8 ± 16.8*	+10	0.32
Handgrip, kg	24.4 ± 4.6	25.6 ± 4.5	+5	23.8 ± 3.8	23.8 ± 9.0	+0	0.02

Values are means ± SD; n, no. of subjects. 1 RM, single-repetition maximum lift. A nonpaired *t*-test was used for the comparison between groups (baseline, 6-mo, and percent changes after treatment). No differences were observed between groups at baseline. ANOVA for repeated measures were used to determine the effect of treatment. Significant difference between groups: **P* < 0.05, †*P* < 0.01, ‡*P* < 0.0005.

cal function score, nor were there between-group differences for other self-reported quality of life domains (Table 3).

At baseline, the total CS-PFP physical performance score was highly correlated with handgrip strength ($r = 0.67$, $P < 0.0003$) and peak $\dot{V}O_2$ ($r = 0.59$, $P < 0.001$). The self-reported physical function score by questionnaire (SF-36) was borderline associated with peak $\dot{V}O_2$ ($r = 0.45$, $P = 0.07$). No association was observed between the total CS-PFP physical performance score and the SF-36 questionnaire, suggesting that they assess different concepts ($r = 0.24$, $P = 0.25$).

After conditioning, changes in total CS-PFP physical performance score were correlated with changes in maximal strength for the bench press ($r = 0.71$, $P = 0.001$) (Fig. 1) and for leg extension ($r = 0.53$, $P = 0.01$). In contrast to measured physical function (CS-PFP), changes in self-reported physical function measured by the SF-36 questionnaire were not associated with changes in strength (1 RM, handgrip, and torque measures) or peak $\dot{V}O_2$ (results not shown).

Safety of the Exercise Training Program

Six patients, two of whom were randomized to the control group, described anginal symptoms during the

baseline exercise tolerance test. None of the four subjects in the weight-training group experienced angina during any of their training sessions. This is consistent with the observations of Featherstone et al. (9) that heart rate and blood pressure product during resistance training at 80% of 1 RM is lower than peak measures during exercise treadmill testing.

Two individuals experienced occasional, significant exacerbation of arthritic conditions during the exercise training program. The subjects were instructed to avoid those exercises involving the affected joint. One individual experienced significant dizziness in a supine position, and this was ameliorated with a change in exercise body positioning.

DISCUSSION

Physical disability is highly prevalent in coronary patients, particularly in women over the age of 65 yr (18). The increased disability rates in older CHD patients is explained by a combination of cardiovascular factors (angina, claudication, arrhythmia, heart failure) and noncardiovascular factors (decrease in skeletal muscle mass and strength, arthritis, psychological factors, and other comorbidities). In that measures of strength correlate with measures of self-reported physical function in older CHD patients (3), we analyzed the effect of a focused strength-training program in disabled older women with CHD but no recent coronary event (>6 mo) and compared results with a control group. Thus we isolated the effects of strength training for women with chronic CHD. We found that strength, balance and coordination, endurance, and overall physical function, assessed with the CS-PFP, are all improved after resistance training. Thus disabled older women with clinical CHD can indeed attain a training intensity sufficient to significantly improve strength and strength-related physical function.

Disability is a complex concept that includes psychological status, judgment, mood state, apprehension of physical activity, as well as fitness level and strength (4). Several methods have been developed to assess the level of disability (4), although it is most commonly assessed by self-report combined with performance on an exercise tolerance test. These methods have been

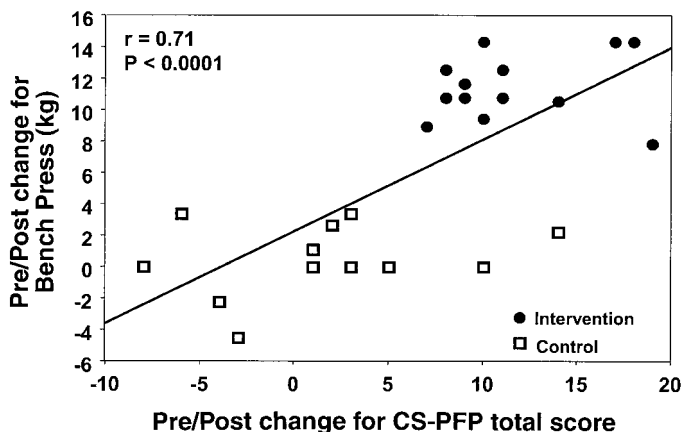


Fig. 1. Association between percent changes in total Continuous-Scale Physical Functional Performance test (CS-PFP) physical performance score and percent changes in maximal strength on the bench press. Pre, before exercise; Post, after exercise.

shown to be simple to administer and are clinically useful and reliable (4, 14). However, it has also been shown that self-reported assessment instruments to quantify disability levels are often insensitive to subtle but potentially important clinical changes and only measure the patient's subjective assessment of function rather than actual performance (4). Others have demonstrated that self-reported physical function correlates poorly with exercise tolerance tests (15). It is interesting to note that most studies of disability in CHD patients have used self-reported assessment instruments (questionnaires) to measure physical function (2, 16, 18).

We attempted to overcome the limitations of self-reported measures by quantifying disability, before and after strength training, with direct measures of physical performance using standardized criteria developed for older individuals (CS-PFP) (7, 8). Indeed, the CS-PFP was far more sensitive than self-reporting in documenting improvements in strength-related physical performance. Our laboratory has previously demonstrated that, in the early recovery period (3–6 mo) after an acute coronary event, the self-reported physical function score improves after a combination of aerobic training and resistance training, in the cardiac rehabilitation setting, for younger and older patients (2). However, it is well known that exercise capacity increases spontaneously for many weeks after an acute coronary event, even in the absence of an exercise program (23).

The resistive training program utilized in the present study was performed at an intensity that did not cause prominent side effects (angina or muscle soreness) that might have a negative impact on progress with training as well as daily activities. There were no training-induced injuries that required a participant to miss an exercise session. A lack of serious, adverse events is consistent with our laboratory's previous experience with an elderly coronary population (10). If patients complained of general fatigue, training sessions were altered accordingly by reducing the resistance or number of repetitions performed.

The present study highlights several findings. First, our results clearly demonstrate that older, disabled women with CHD can perform resistance training at an intensity that results in increased strength and that this results in improved measured performance of daily physical activities. Second, our results imply that improvements observed for the CS-PFP after resistance training do not spontaneously translate into an improved, subjective perception of self-reported physical function on the part of the patient. Our results also demonstrate that the beneficial effects of resistance training on strength occurred without any increase in muscle mass or deterioration of cardiac function. Finally, our data indicate that older female CHD patients greatly underestimate their capacity to perform daily physical activities.

Neill et al. (15) described the fact that middle-aged CHD patients commonly limit physical activity due to both personal apprehension and advice of family and

physicians regarding safety of physical activities for their heart rather than for cardiac-related symptoms. Furthermore, in the absence of formal activity counseling, CHD patients may not have activity-inducing stimuli to actively take on the challenge of higher level physical activities. Older coronary patients, such as those involved in the present study, have presumably adapted to their sedentary lifestyle. The long-term effect of a sedentary lifestyle and the deconditioning associated with CHD may cause a malperception of their true physical capacity. Consequently, these factors could be associated with a vicious cycle of sedentary lifestyle and higher levels of disability.

In a non-CHD population of older individuals with disabilities, regular participation in a home-based resistance exercise program is associated with increases in muscle strength as well as decreases in disability levels (13). Our results extend these findings to the large population of older women with CHD who have generally been excluded from studies of "healthy" elders (1, 13). Thus resistance exercise training, in combination with activity counseling, should maximize the beneficial effects of the strength-enhancing intervention during daily activities and prevent further deteriorations in physical capacity in older female patients with CHD. The CS-PFP appears to be a very useful tool to measure functional capacity accurately in older female coronary patients.

In conclusion, the present study demonstrates that disabled older women with CHD who participate in a 6-mo program of strength training are able to train at an intensity sufficient to result in improvements in measured physical functional performance, despite no change in lean body mass or in self-reported physical function.

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