Resistance Training on Physical Performance in Disabled Older Female Cardiac Patients

PHILIP A. ADES[1], PATRICK D. SAVAGE[1], M. ELAINE CRESS[2], MARTIN BROCHU[3], N. MELINDA LEE[1], and ERIC T. POEHLMAN[4]

[1]Division of Cardiology, University of Vermont College of Medicine, Burlington, VT; [2]Department of Exercise Science and Gerontology, University of Georgia, Athens, GA; and [3]Department of Kinesiology and [4]Department of Nutrition, University of Montreal, Montreal, CANADA

ABSTRACT

ADES, P. A., P. D. SAVAGE, M. E. CRESS, M. BROCHU, N. M. LEE, and E. T. POEHLMAN. Resistance Training on Physical Performance in Disabled Older Female Cardiac Patients. *Med. Sci. Sports Exerc.*, Vol. 35, No. 8, pp. 1265–1270, 2003. **Purpose:** We evaluated the value of resistance training on measures of physical performance in disabled older women with coronary heart disease (CHD). **Methods:** The study intervention consisted of a 6-month program of resistance training in a randomized controlled trial format. Training intensity was at 80% of the single-repetition maximal lift. Control patients performed light yoga and breathing exercises. Study participants included 42 women with CHD, all ≥ 65 yr of age and community dwelling. Subjects were screened by questionnaire to have low self-reported physical function. The primary study measurements related to the performance of 16 household activities of the Continuous Scale Physical Functional Performance test (CSPFP). These ranged from dressing, to kitchen and cleaning activities, to carrying groceries and walking onto a bus with luggage, and a 6-min walk. Activities were measured in time to complete a task, weight carried during a task, or distance walked. Other measures included body composition, measures of aerobic fitness and strength, and questionnaire-based measures of physical function and depression score. **Results:** Study groups were similar at baseline by age, aerobic capacity, strength, body composition, and in performing the CSPFP. After conditioning, 13 of 16 measured activities were performed more rapidly, or with increased weight carried, compared with the control group (all $P < 0.05$). Maximal power for activities that involved weight-bearing over a distance, increased by 40% ($P < 0.05$). **Conclusions:** Disabled older women with CHD who participate in an intense resistance-training program improve physical capacity over a wide range of household physical activities. Benefits extend beyond strength-related activities, as endurance, balance, coordination, and flexibility all improved. Strength training should be considered an important component in the rehabilitation of older women with CHD. **Key Words:** EXERCISE TRAINING, STRENGTH TRAINING, CORONARY ARTERY DISEASE, ELDERLY, DISABILITY

The presence of coronary heart disease (CHD) is a major predictor of physical disability, compounded by the effects of age and physical inactivity (16). Women have significantly higher rates of disability than men of the same age (2,16). Additional factors that predispose to lower physical functioning in older coronary patients include diminished measures of strength, aerobic capacity, and the presence of mental depression (2). In healthy older individuals, resistance training has been shown to improve measures of strength, walking endurance (3,14,19), and flexibility (9). The effects of strength training on the performance of specific measured daily activities in older patients with CHD has not been studied (1,11). We recently reported that resistance training leads to increases in general domain scores for upper-body strength, lower-body strength, endurance, and balance and coordination in older women with CHD (6). In the present study, rather than looking at domain scores, we attempt to gain a more precise insight of the value of resistance training, as it impacts upon the capacity of older women with CHD to perform specific daily activities. Specifically, we analyze the time required for dressing, kitchen and household activities, and for endurance walking, in addition to the capacity to work with resistance loads for pot lifting, grocery carrying, and luggage carrying.

Address for correspondence: Philip A. Ades, M.D., McClure 1, Cardiology, Fletcher-Allen Health Care, Burlington, VT 05401; E-mail: Philip.Ades@vtmednet.org.
Submitted for publication December 2002.
Accepted for publication April 2003.

0195-9131/03/3508-1265
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DOI: 10.1249/01.MSS.0000079044.21828.0E

METHODS

Study Subjects

The study population included 42 women with CHD (diagnosed for >6 months), age 65 yr or greater (72.3 ± 5.6 yr, mean + SD, range 65–88 yr). Patients had definite

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TABLE 1. Physical function responses: performance scores and power.

	Resistance Group (N = 19)			Control Group (N = 14)			P Value between Groups
	Baseline	6 months	P Value	Baseline	6 months	P Value	
CS-PFP total	43.6 ± 13.2	55.7 ± 13.5 (+28%)	0.0001	47.9 ± 19.1	49.0 ± 18.2 (+2%)	NS	0.0001
Upper-body strength	47.7 ± 16.7	58.3 ± 16.6 (+22%)	0.0001	52.9 ± 18.0	55.9 ± 18.2 (+6%)	NS	0.03
Upper-body flexibility	58.5 ± 16.8	68.1 ± 12.8 (+16%)	0.004	58.0 ± 21.5	59.5 ± 20.0 (+3%)	NS	0.07
Lower-body strength	37.7 ± 14.3	48.5 ± 13.5 (+29%)	0.0001	42.1 ± 18.9	44.8 ± 17.5 (+6%)	NS	0.002
Balance—coordination	40.9 ± 12.0	53.9 ± 13.2 (+32%)	0.0001	46.1 ± 19.7	44.6 ± 18.3 (−3%)	NS	0.0001
Endurance	44.5 ± 13.8	58.1 ± 15.1 (+31%)	0.0001	49.0 ± 20.9	49.3 ± 20.3 (+1%)	NS	0.0001
Power pot-carry (W)	38.8 ± 19.4	59.7 ± 29.1 (+54%)	0.0002	46.2 ± 19.4	53.7 ± 22.4 (+16%)	NS	0.01
Power luggage onto bus (W)	6.0 ± 2.8	9.0 ± 3.7 (+50%)	0.0001	6.7 ± 4.3	8.2 ± 4.2 (+22%)	0.003	0.05
Power grocery-carry (W)	63.4 ± 46.2	89.5 ± 32.8 (+41%)	NS	76.8 ± 32.8	83.6 ± 35.8 (+9%)	0.09	NS
Total power	108.2 ± 54.5	158.2 ± 60.4 (+46%)	0.003	129.7 ± 48.3	145.5 ± 53.7 (+12%)	0.07	0.05
MOS SF-36 physical function (self-report)	59 ± 20	65 ± 21 (+10%)	NS	69 ± 15	76 ± 17 (+10%)	NS	NS

CHD; myocardial infarction in 31, coronary revascularization in 27 (13 bypass surgery, 14 percutaneous revascularization), and chronic stable angina in 23. Some patients had more than one cardiac diagnosis. The majority of the women were living alone (60%, 25/42). Inclusion criteria included a physical function score below 85 assessed from the physical function section of the MOS-SF36 health status questionnaire (17,20), approximating the criteria used in the Framingham Disability Study (16). For a score of <85, an individual would have to be at least "limited a little"(vs "limited a lot" or "limited not at all") for ≥3 of the following activities; pushing a vacuum cleaner, climbing several flights of stairs, walking a mile, lifting or carrying groceries, bending or stooping. Exclusion criteria included: 1) hospitalization for an acute coronary syndrome within 6 months; 2) very low threshold angina (≤3 MET workload); 3) exercise-test limiting noncardiac comorbidity (i.e., orthopedic, neuromuscular, peripheral vascular); 4) uncontrolled hypertension (resting blood pressure >160 systolic or 90 diastolic; 5) sternal nonunion after coronary surgery; 6) recent (≤3 months) participation in a cardiac rehabilitation program; 7) inflammatory arthritis; and 8) dementia. All participants signed an informed consent document approved by the Committee on Human Research at the University of Vermont.

Continuous-Scale Physical Performance Test (CS-PFP)

The CS-PFP is designed to provide measures of physical function in several physical domains (7). It is based upon the measurement of performance during activities of daily life, performed at maximal effort within the bounds of safety and comfort. It utilizes standard conditions and a scripted dialogue. All tasks are quantified by time, distance, or weight carried. Tasks are scored based upon an empirically derived range established from data in older adults with a broad range of abilities (7). The test yields a total score (0–100) averaging five separate physical domain scores (0–100): upper-body strength, lower-body strength, flexibility, balance and coordination, and endurance (8). This report focuses on the effect of resistance training on the 16 specific activities measured in the CS-PFP in older women with CHD compared with a control group (Table 1). For activities that included a measured time and a weight carried, a power measure was calculated in W. These activities included the pot-carry, the luggage-onto-bus carry, and the grocery-carry.

Strength Measures

Single-repetition maximal lift (1 RM). Subjects began weight training with very light resistance to learn proper technique and minimize muscle soreness. At 1 wk, all patients performed a single-repetition maximal lift (1-RM) for the bench press and leg extension on a Universal Gym apparatus (Cedar Rapids, IA). The 1-RM is the maximum load a subject can lift, using correct form, through a full range of motion, for one repetition only. Subsequently, women in the resistance training updated the 1-RM at 2 wk and then on a monthly basis to guide the resistance-training intervention. Both groups were retested at the end of 6 months.

Handgrip. Handgrip strength was measured using a handgrip dynamometer (JAMAR, Jackson, MI) using the dominant hand, averaging three measures.

Self-Reported Physical Function

The MOS SF-36 questionnaire was used to assess self-reported physical function score. This questionnaire has been extensively studied and validated in various populations (17,18,20,21). The MOS-SF36 includes scores in eight domains; however, we present only the data on physical functioning.

Body Composition

Body weight (nearest 0.1 kg) and height (nearest 0.1 cm) were measured and used to calculate the body mass index ($kg \cdot m^{-2}$). Dual Energy X-Ray Absorptiometry (DEXA, model DPX-L; LUNAR Radiation Corp., Madison, WI) was used to measure body composition including fat mass, lean body mass, bone mineral content, and percent body fat (13).

Peak $\dot{V}O_2$

Patients performed a symptom-limited, electrocardiographically monitored, exercise test on treadmill using a modified Balke protocol before and after the exercise program (12). The occurrence of any untoward responses, such

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as low threshold angina or ≥2-mm ST segment depression on the ECG excluded patients from the training protocol. Patients performed this test taking their usual medications. Peak oxygen consumption ($\dot{V}O_{2peak}$) in milliliters per kilogram per minute was the highest 30-s value during the exercise protocol using a SensorMedics V29c metabolic cart (Yorba Linda, CA).

Exercise Training Protocol

Subjects were randomized to either of two exercise training groups. The randomization was stratified by physical function score (SF-36) such that groups were matched at baseline. Patients performed the exercise-training program for 6 months, meeting 3× wk^{-1}. Patients in both study groups were required to attend at least 54 of the 72 sessions (75%) over the 6-month period to be considered in the study analysis. During the first week of the exercise program, after randomization, subjects in both groups were habituated to strength testing (single repetition maximal lifts).

Resistance-training intervention. The exercise-training program was established based upon baseline 1-RM lifts and ratings of perceived exertion (3,5). Patients performed 1-RM testing for two weight exercises; leg extension and bench press at the end of week 1. Weight training began at 50% of 1-RM, and 2 wk later maximal strength was retested and training intensity was increased toward 80% of 1RM, as tolerated. The resistance-training program was performed with Universal weights and dumbbells. The 1-RM was updated monthly and supplemented by perceived exertion scores with patients increasing the resistance when perceived exertion scores drop below a threshold value (14 on the Borg scale of 6–20) (5). The eight exercises focused on leg, arm, and shoulder strength. Exercises included: 1) leg extensions (quadriceps); 2) leg press (gluteals, quadriceps); 3) leg curls (hamstrings); 4) shoulder press (deltoids, triceps); 5) arm curls (biceps); 6) lateral pull-down (latissimus, biceps); 7) bench press (pectoralis); and 8) tricep extension (triceps). Subjects began training with 1 set of 10 repetitions gradually increasing to two sets with a 2-min rest in between each set. Each training session was under the supervision of an exercise physiologist.

Control group. Control patients met 3× wk^{-1} for 30–40 min at the cardiac rehabilitation facility and participated in a program of stretching, calisthenics, deep-breathing progressive-relaxation exercises, and light yoga.

Statistical Analysis

Values in tables are presented as the mean ± standard deviation. A nonpaired *t*-test was used for the comparison between groups at baseline and after 6 months. ANOVA for repeated measures was used to determine the effect of treatment over the 6-month period within each group. A nonpaired *t*-test approach was used to compare changes between groups for percent changes after the program. Univariate linear regression measured associations between variables of interest. Statistical analyses were carried out using Stat View 4.01 (Stat View 5.0.1: SAS Institute Inc., Cary, NC). A level of significance of $P < 0.05$ was used for hypotheses testing.

RESULTS

Baseline characteristics. Study groups were similar at baseline by age (73.2 ± 6.0 yr vs 72.2 ± 5.7 yr in controls) and for measures of aerobic capacity (15 ± 3 $mL \cdot kg^{-1} \cdot min^{-1}$ vs 16 ± 3 in controls), strength (handgrip 48 ± 13 kg vs 49 ± 16 in controls), body composition (fat-free mass 39 ± 5 kg vs 41 ± 6 in controls, fat mass 30 ± 9 kg vs 33 ± 11 in controls), and self-reported physical function (Table 1). Groups were also similar at baseline for both total and domain scores for the CS-PFP (Table 1). Finally, groups were similar at baseline by specific scores for each CS-PFP activity as well as for the time and weight measures for each specific activity (results not shown). The incidence of angina or ECG ischemia at the baseline exercise test was low (8/42) and did not differ between two groups. Of 42 patients enrolled in this study, 9 dropped out (5 intervention patients) and did not return for testing. Reasons for dropouts included medical problems unrelated to the training program ($N = 7$); and noncompliance to training ($N = 2$). Dropouts did not differ from completers at baseline by aerobic fitness ($\dot{V}O_{2peak}$), CSPFP score, or self-report physical function score. Dropouts had a higher depression score at baseline ($P = 0.003$). No patients dropped out due to injury or soreness from the training program. Pharmacologic regimens for study patients remained highly stable throughout the study.

Response to study interventions. Subjects in the resistance-training group experienced substantial improvement in performing essentially all of the measured physical activities either more rapidly or with a heavier weight load (Table 2). Thirteen of the 16 specific activities that were evaluated were performed more rapidly after resistance training, with the exception of the scarves-pickup and the grocery-carry (although increased weight carried) (Table 1, Fig. 1). For activities that involved a chosen weight to be carried, the weight selected for each of these activities increased (pot-carry, grocery-carry, and suitcase-onto-bus-carry) (all $P < 0.01$). For the 6-min walk, distance increased from 1172 ± 383 ft to 1343 ± 379 ft (+15%, $P < 0.005$) after resistance training. The overall CS-PFP score increased from 44 ± 13 to 56 ± 14 ($P < 0.0001$). Domain scores for upper-body strength, upper-body flexibility, lower-body strength, balance and coordination, and endurance all increased significantly (Table 1). For activities that included both a measured time and a weight carried, power for each of these activities, and total power, were increased in the resistance-training group (Table 1, Fig. 1).

Within the resistance-training group, measures of strength, assessed by the 1-RM for leg extension (66 ± 21 to 78 ± 24 kg) and bench press (41 ± 18 to 66 ± 21 kg), and handgrip (48 ± 13 to 53 ± 11), were all markedly increased (all $P < 0.05$). There were no significant changes of body weight, fat mass, fat-free mass or bone mineral

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TABLE 2. Specific physical performance measures.

	Total Population (N = 33)		Resistance Group (N = 19)		Flexibility Group (N = 14)		P Value between Groups	
	Baseline Time (s)	Baseline Weight (kg)	ΔTime (s)	Δ Weight (kg)	Δ Time (s)	Δ Weight (kg)	Δ Time	Δ Weight
PotCarry	5 ± 1	11.8 ± 4.6	−1 ± 1**	+3.0 ± 3.4**	0 ± 1	+1.8 ± 3.1*	0.007	NS
Milk jug pour	8 ± 3	-	−1 ± 1**	-	+0 ± 1	-	0.0008	-
Jacket	16 ± 6	-	−3 ± 4*	-	+1 ± 9	-	NS	-
Shoestrap	7 ± 4	-	−1 ± 2*	-	−1 ± 3	-	NS	-
Scarves pickup	6 ± 3	-	−1 ± 2	-	−1 ± 2	-	NS	-
Height reach (cm)	201 ± 17	-	+1 ± 8	-	+1 ± 9	-	NS	-
Floor sweep	21 ± 10	-	4.1 ± 7.6*	-	−3 ± 8	-	NS	-
Laundry load	31 ± 10	-	−4 ± 6**	-	−2 ± 9	-	NS	-
Dryer load	23 ± 8	-	−2 ± 3**	-	+0 ± 6	-	NS	-
Bedmaking	103 ± 47	-	−30 ± 32**	-	−1 ± 29	-	0.013	-
Vacuum	93 ± 39	-	−27 ± 46*	-	−7 ± 37	-	NS	-
Up from floor	17 ± 10	-	−3 ± 3**	-	−3 ± 6	-	NS	-
Open fire door	4 ± 2	-	−1 ± 1**	-	+0 ± 1	-	0.009	-
Luggage on to bus	26 ± 11	8.2 ± 3.1	−4 ± 4**	+2.2 ± 2.9**	+3 ± 7	+2.9 ± 1.9**	0.0012	NS
Grocerycarry	75 ± 23	9.2 ± 4.0	−2 ± 1.9	+3.0 ± 2.6**	+5 ± 17	+1.3 ± 2.4	NS	0.067
Stair climb	8 ± 2	-	−1 ± 1**	-	+0 ± 2	-	0.019	-
6-min walk (feet)	1215 ± 341	-	+161 ± 192**	-	+63 ± 167	-	.11	-

Δ, change.
No significant differences between groups at baseline for time or weight.
* $P < 0.05$.
** $P < 0.01$.

density. Peak $\dot{V}O_2$ tended to increase after resistance training (15 ± 3 to 16 ± 4 mL·kg^{-1}·min^{-1}, P = 0.06).

Within the control group, the changes were more modest. The overall CS-PFP score was unchanged (48 ± 19 to 49 ± 18, P = 0.53) and none of the five domain scores were increased versus baseline (Table 1). None of the specific physical activities were performed more rapidly after flexibility training although the weight carried for the pot-carry and the suitcase-onto-bus carry each increased ($P < 0.05$) (Table 1). The combined power measure did not increase (Table 1, Fig. 1). Upper-body strength and handgrip strength did not increase in the control group, whereas leg extension strength increased by 11% (vs 45% in the strength group, $P < 0.0001$ between groups). There were no changes in body composition in the control group and peak $\dot{V}O_2$ was unaltered.

Between-group analysis shows that the resistance-training group increased leg and arm strength compared with the control group ($P < 0.001$). The total CS-PFP score and the domain scores for upper-body strength, lower-body strength, balance and coordination, and endurance all increased to a greater degree in the resistance-training group than in the flexibility-control group (Table 1). The resistance group also tended to show a greater improvement in upper-body flexibility than did the flexibility-control group (P = 0.07). Speed in completing tasks was increased in the resistance group compared with controls for the milk-pour, bed-making, suitcase-onto-bus, grocery-carry, stair climbing, and for the fire-door-open (Table 2). Weight during the grocery-carry tended to increase to a greater degree in the resistance-training group than in the flexibility (P = 0.06). The total power measure, combining the three weight variable measures, increased to a substantially greater degree in the strength-training group (+ 46% vs + 12%, $P <$ 0.05, Table 1, Fig. 1).

Relationships between functional measures. At baseline (N = 42), there was a significant correlation between the total CSPFP score and the combined leg and arm strength measure (R = 0.48, P = 0.0006). The CSPFP also correlated with baseline $\dot{V}O_{2peak}$ (R = 0.50, P = 0.0043). Although there was a significant correlation at baseline between the total CSPFP score and the physical function score from the SF-36 self-report questionnaire (R = 0.48, P = 0.0006), the CSPFP was responsive to the strength-training intervention (P = 0.0001), whereas the SF-36 physical function score did not change after training (P = NS). Thus, the SF-36 self reported physical function questionnaire was insensitive to an increase in strength in the study population. There was little correlation between the SF-36 description of an activity and the CS-PFP reproduction of that activity such as vacuuming time, bending, and stooping or carrying groceries. The distance walked during the CS-PFP 6-min walk did correlate with the SF-36 questions on "walk a mile" (R = 0.62, P = 0.0001), "walk several blocks" (R = 0.54 P = 0.0001), and "walk 1 block" (R = 0.38 P = 0.009).

DISCUSSION

Our results document that strength training improves the performance of a wide range of specific measured physical activities in a simulated home-setting laboratory, in disabled women with CHD. Activities such as stair-climbing, bed-making, carrying luggage onto a bus, and carrying groceries were all performed more rapidly after strength training compared with control patients. Maximal power during testing of household activities, in these older women with CHD, was increased by 46% versus 12% in controls ($P < 0.05$ between groups).

It was notable that the beneficial effects of resistance training extended beyond activities that involved just lifting. Also improved were endurance activities such as the 6-min walk and the stair climb, and activities that involved flexibility and coordination such as pouring milk, putting on a

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jacket, floor sweeping, vacuuming, laundry loading/unloading, and bed-making. Beneficial effects of strength training on endurance-related activities have previously been demonstrated in healthy elders (3,19). Beneficial effects of resistance training on nonendurance activities such as those involving flexibility and coordination has not previously been shown in an older population burdened by the presence of significant chronic disease as in our cohort of older women with CHD. It should be noted that our control group was not inactive, but rather, participated in a program of light yoga and flexibility training. Although they did not increase their strength to the degree documented in the resistance-training group, participation was associated with a slight increase in leg strength. The measured increases in physical functioning were far greater in the resistance-training group.

The improvements that we documented on the ability of older women to perform household activities relate to the potential of older women with CHD to function independently in the home setting. The majority of these women live alone and thus are required to perform home activities on a daily basis. Furthermore, even when living with a spouse, women return to the performance of household activities sooner than do men after a coronary event (4,15). Thus, it appears that resistance training should be considered as a component of the rehabilitation of older women with CHD

This intensive strength-training protocol was performed with almost a total lack of exercise-related angina or other cardiac events. Lower rates of angina during resistance exercise compared with treadmill exercise (10) may be due to enhanced coronary artery filling during the lifting phase of resistance exercise.

We have previously shown that measures of strength and appendicular muscle mass correlate with self-reported physical function score in older individuals with CHD (2). In the present investigation, strength training was associated with an improvement in measured performance of a wide array of practical daily activities but not in muscle mass or in self-reported physical function score. Although at baseline there was a correlation between measured physical function and questionnaire-based self-reported physical function, this did not persist after training. Thus, although actual measured performance of daily activities, in the laboratory setting, increased with strength training, the self-report score of home physical activity did not increase. This may be due to the relatively coarse gradations for performance of an activity on the SF-36 questionnaire ("limited a little," "limited a lot," "not limited at all"), which limits the ability of the subject to describe subtle, though clinically relevant, changes. Alternatively, it may be that while the disabled older women in this study increase their measured capacity, that is, their potential, to perform daily activities, they may choose in their actual daily lives, to continue on with their established routines and not take on new activities despite their improved capacity to perform. Counseling patients to utilize their increased strength to perform a greater range of physical activities in the home setting may be necessary in patients already concerned about the safety of specific activities due to the presence of CHD.

In conclusion, the results of this study of older women with CHD demonstrate that participation in an intense resistance-training program improves the performance of a wide range of specific household related activities. Resistance-training benefits extended beyond activities that were strength related and extended to activities characterized by balance, coordination, flexibility, and endurance. The resistance-training program was well tolerated and performed without significant adverse effects. Rehabilitation programs for older women with CHD should consider the use of resistance training as a means to improve strength, endurance, balance, and coordination. Additional research is needed, however, to translate strength gains into improved real-life functioning.

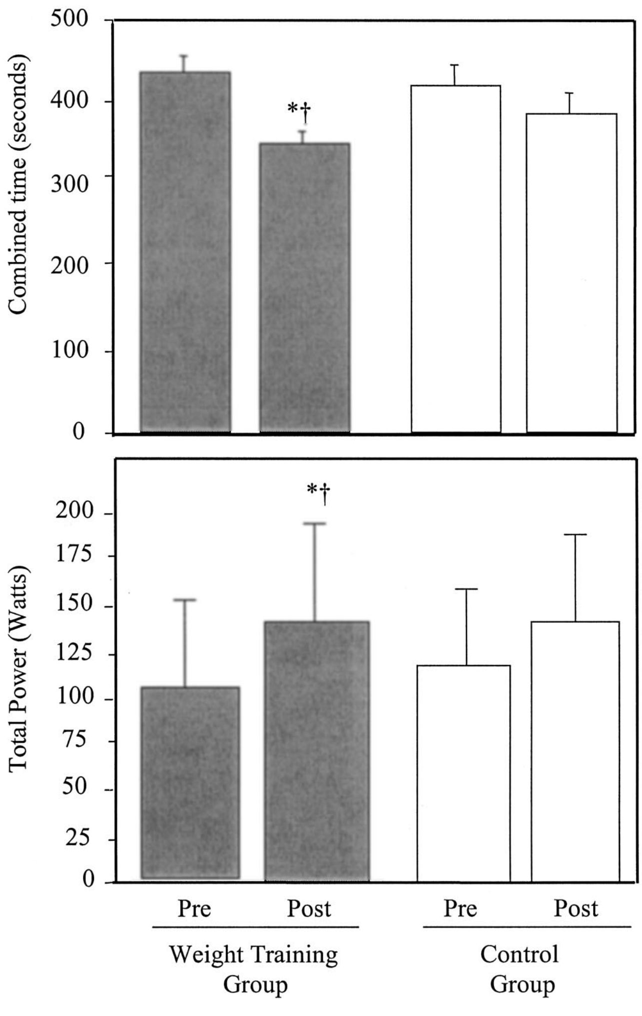

FIGURE 1—Top: Combined time to complete the 13 CSPFP timed activities. Bottom: Combined power (W) for the three CSPFP activities that involve carrying a variable weight over a timed course (pot-carry, luggage on to bus, grocery-carry. * $P < 0.05$ vs baseline; † $P < 0.05$ prepost change vs other group.

This study was funded by grant support from the National Institute on Aging (RO1 AG-15115, Dr. Ades) and by the University of Vermont General Clinical Research Center (RR-109). Dr. Brochu was supported by a Medical Research Council of Canada Postdoctoral Fellowship.

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