

ORIGINAL REPORT

EFFECT OF AEROBIC VS COMBINED AEROBIC-STRENGTH TRAINING ON 1-YEAR, POST-CARDIAC REHABILITATION OUTCOMES IN WOMEN AFTER A CARDIAC EVENT

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Objective: To compare the effect and sustainability of 6 months combined aerobic/strength training vs aerobic training alone on quality of life in women after coronary artery by-pass graft surgery or myocardial infarction.

Design: Prospective, 2-group, randomized controlled trial.

Participants: Ninety-two women who were 8–10 weeks post-coronary artery by-pass graft surgery or myocardial infarction, able to attend supervised exercise, and fluent in English.

Methods: The aerobic training alone group had supervised exercise twice a week for 6 months. The aerobic/strength training group received aerobic training plus upper and lower body resistance exercises. The amount of active exercise time was matched between groups. The primary outcome, quality of life, was measured by the MOS SF-36; secondary outcomes were self-efficacy, strength and exercise capacity.

Results: After 6 months of supervised exercise training both groups showed statistically significant improvements in physical quality of life ($p = 0.0002$), peak VO_2 (19% in aerobic/strength training vs 22% in aerobic training alone), strength ($p < 0.0001$) and self-efficacy for stair climbing ($p = 0.0024$), lifting ($p < 0.0001$) and walking ($p = 0.0012$). However, by 1-year follow-up there was a statistically significant difference in physical quality of life in favor of the aerobic/strength training group ($p = 0.05$).

Conclusion: Women with coronary artery disease stand to benefit from both aerobic training alone and aerobic/strength training. However, continued improvement in physical quality of life may be achieved through combined strength and aerobic training.

Key words: exercise training, women, coronary artery disease, quality of life, exercise capacity, self-efficacy.

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INTRODUCTION

Cardiovascular disease is the leading cause of mortality in North America, accounting for more than half a million lives

annually (1–2). Coronary artery disease (CAD) accounts for approximately 50% of the cardiovascular disease deaths in women (3). Over the next 2 decades, one-half of North American women will be entering their menopausal years, a time at which the risk of cardiovascular disease increases significantly (1). As a result, women will contribute considerably to a growing demand for cardiac rehabilitation services in the next 20 years.

Cardiac rehabilitation (CR) is a multidisciplinary approach to secondary prevention through risk factor identification and modification in order to aid in the prevention of disease progression and recurrence of cardiac events (4). Exercise training is an important and key component of CR. The benefits of CR, and more specifically, supervised exercise training are well established, with improvements having been shown in functional capacity, risk factor profiles and cardiovascular mortality (5–9). Although women are older than men at the time of their CAD diagnosis and generally have lower levels of physical conditioning, research to date indicates that women have the potential to benefit from CR to the same extent as men (10–13). In fact, it has been suggested that since women may be at a higher risk for cardiovascular morbidity and mortality, they may benefit from CR to a greater extent than men (10–11).

Historically, the primary focus of most CR exercise programs has been aerobic activities. However, over the past decade, strength (or resistance) training has gradually been incorporated into rehabilitation programs, largely based on encouraging results from studies done almost solely in men (12–15). There are limited rigorous data to support and guide this form of training in women.

Ades et al. (16) reported that older women with CAD who participated in a 6-month intensive strength training program improved their physical capacity to perform various activities of daily living (ADL) compared with women who did light yoga and stretching. Although Ades et al. (16) have shown that strength training is better than light yoga and stretching, the extent to which this type of exercise training adds to the established benefits of aerobic training in women is not known. Since female cardiac patients more often tend to be widowed at the time of their cardiac event, quality of life (QoL) and the functional ability to perform everyday activities may be the

most important CR outcomes for women. Strength may be the ingredient that enables functional ability and promotes quality of life in older women following a cardiac event.

Purpose

The purpose of this study was to compare the effect and sustainability of a 6-month combined aerobic and strength training program to aerobic training alone in women who had coronary artery by-pass graft surgery (CABGS) or myocardial infarction (MI). The primary outcome was health-related QoL (HRQoL); secondary outcomes were perceived self-efficacy, strength, and exercise capacity.

METHODS

Participants

Women were recruited between July 2001 and January 2003 from referrals to the Cardiac Health & Rehabilitation Centre (CHRC) at the Hamilton Health Sciences, General Campus, Hamilton, Canada. The CHRC is a multidisciplinary, comprehensive, outpatient CR program, which provides supervised, hospital-based exercise classes, nursing education and support, and dietary counseling.

Inclusion criteria. Patients were eligible to participate in the study if they were: (i) women, (ii) 8–10 weeks post-CABGS or post-MI, (iii) post-menopausal, as defined by one year without menses, (iv) able to regularly attend a supervised exercise program, and (v) able to complete English language questionnaires.

Exclusion criteria. Patients were excluded if they: (i) demonstrated any of the following responses to baseline exercise testing (a) abnormal hemodynamic response (persistent decrease in systolic blood pressure, > 10 mmHg or increase to > 250 mmHg), (b) > 2 mm ST segment depression, (c) any tachyarrhythmia, or (d) < 40% of predicted maximum metabolic equivalents on progressive cycle ergometry exercise testing; (ii) had a history of hospital admission for heart failure within the past year; (iii) had a forced expiratory volume in 1 sec or forced vital capacity < 50% of predicted or (iv) were unable to participate in exercise training due to non-cardiac limitations to exercise training.

Study design

This was a prospective, 2-group, randomized controlled trial. Eligible and consenting women were randomly assigned to: (i) aerobic exercise training (AT) or (ii) combined aerobic-strength training (AST). Patients in both groups were free to take part in other, non-exercise, services offered by the CHRC as part of their CR program (e.g. nutrition counseling, smoking cessation classes). The use of other services at the CHRC was documented. All study variables were measured at baseline, after 2 months, at the completion of the 6-month exercise training program and one year following discharge from the 6-month program, which was 18 months from baseline.

Outcome measures

The primary outcome was general HRQoL, measured using the Medical Outcomes Study Short Form Health Survey (SF-36). The SF-36 contains 36 items representing 8 subscales covering the domains of physical functioning, role functioning, bodily pain, general health, vitality, social functioning, role-emotional and mental health. Individual subscale scores as well as 2 summary scores, called the physical component summary score (PCS) and mental component summary score (MCS) can be computed.

Secondary outcomes were perceived self-efficacy, strength, and exercise capacity. Self-efficacy refers to an individual's beliefs that he/she is capable of organizing and executing actions needed to

achieve given levels of attainment (17). Higher self-efficacy ratings have predicted improved self-management of risk factors and have been associated with improved outcomes in cardiovascular and other older adult populations (18, 19). Self-efficacy for performing activities relevant to both exercise and activity of daily living (e.g. lifting, walking) was measured using a set of scales developed for clinical use among cardiac patients (20). For each activity, respondents indicated their confidence in their ability to perform the activity using a scale ranging from 0 (not at all confident) to 10 (completely confident).

Strength was determined by measurement of the woman's 1 repetition maximum (1RM). For the purpose of this study, 1RM refers to the maximum weight the patient could comfortably lift once, through a full range of movement. The 1RM was measured during a bilateral movement for the following exercises: leg press, knee extension, elbow flexion, and seated upright bench press. Each participant's 1RM was measured and recorded at baseline, 2 months, 6 months and 1-year follow-up (18 months after randomization). Previous literature shows test-retest reliability of the 1RM to be ± 2 –6% (21). The 1RM protocol for this study was a modification of Kraemer and Fry's methodology (22) and was guided by 2 of the members of this team (RSM and NM), who have published some of the earliest, seminal research on strength training in male cardiac patients.

Peak oxygen uptake was measured by a symptom-limited, graded exercise test (GXT) on an electronically braked cycle ergometer (SensorMedics, Yorba Linda, USA). Initial workload was 100 kpm/min and increased by 100 kpm/minute for every subsequent min. Heart rate, blood pressure, rate of perceived exertion, 12-lead electrocardiogram (ECG), and direct measurement of oxygen uptake (SensorMedics 2900 metabolic cart) were monitored continuously. Exercise tests were terminated if the patient had moderate-to-severe angina, a > 10 mmHg decrease in systolic blood pressure with increasing workload, evidence of significant arrhythmia's (such as > 3 premature ventricular contractions in a row), evidence of poor perfusion, unusual or severe shortness of breath, inability to monitor ECG, or patient's request. Reasons for patient-initiated termination of the test were leg fatigue, dyspnea, dizziness, or angina.

Procedures

The joint Research Ethics Board of McMaster University and the Hamilton Health Sciences approved the study. Eligible participants were identified from referral lists to the CHRC followed by medical record review. Patients who provided initial verbal consent by telephone were met at their first CHRC appointment where a complete medical history was obtained and a GXT was scheduled. Written, informed consent was provided at the first visit along with completion of baseline measurements. Baseline data included the primary and secondary outcomes as well as anthropometrics (e.g. height, weight, body mass index, and waist-to-hip ratio); demographic information (e.g. age, sex, highest level of education completed, socioeconomic status and employment status), medical history and risk factor profile (including smoking status, dyslipidemia, hypertension and diabetes). Strength testing (1RM) was not done on the same day as the patient's GXT.

The biostatistician (KT), who had no direct contact with the study participants or the research assistant, prepared the randomization schedule using a blocked format with randomly varying block sizes of 2 and 4. The block sizes were not communicated to the study personnel to prevent prediction of the next allocation. Subject allocation was concealed in sealed opaque envelopes that were opened in sequence by the research assistant after consent and baseline data were obtained. The physicians responsible for the exercise testing were blind to the patients' assignments. Participants began exercise participation within 2 weeks of randomization.

Prior to beginning exercise training, each patient attended an individual, 30-min consultation and teaching session. During this session, the results of the baseline exercise test, together with an individualized exercise prescription, were reviewed.

Initially, patients in both groups attended supervised aerobic exercise classes 2 times per week for 8 weeks. This "run-in" period of aerobic

training was employed in both groups in order to provide a standard entry point to the experimental phase of the study, allowing for the women to become habituated to the exercise environment.

Certified kinesiologists, who had access to the hospital's emergency response team if necessary, supervised all exercise sessions. Total active exercise time was equivalent for both groups. The 2 exercise groups were scheduled at different times. All participants received recommendations to continue aerobic exercise training at home another 2–3 times per week, according to American College of Sports Medicine guidelines that were current at the time (23). Attendance and adherence to supervised exercise was recorded for both groups. Adherence was calculated as a percentage of the total supervised exercise that the participants completed on a weekly basis. Frequency of exercise after discharge from CR was assessed at the 1-year post-discharge follow-up.

Aerobic training

Patients assigned to the AT group were expected to attend supervised exercise sessions 2 times per week for 6 months. Exercise sessions included 10–15 min of warm-up followed by aerobic interval training using stationary cycles, treadmills, arm ergometers and stair climbers. The total exercise time was approximately 40 min. This was followed by a cool-down period of 10–15 min. Exercise intensity was initially prescribed at 40–70% of functional capacity based on GXT results, according to American College of Sports Medicine guidelines (23). Following completion of the 3-month GXT, exercise prescriptions were revised and reviewed with participants to ensure that new training intensities were understood.

Aerobic plus strength training

Patients assigned to the AST group were also expected to attend supervised exercise sessions 2 times per week for 6 months. Following completion of the initial 2-month "run-in" period, strength training was implemented in this group. Thus, in addition to the aerobic exercise training (as above), these participants performed 2 sets of 8–10 repetitions of upper body and 10–12 repetitions of lower body exercises. Initially, lower extremity resistance exercises were performed at an intensity of 50% of 1RM, increasing to a maximum of 70% of 1RM by 4 weeks; upper extremity resistance exercise was initially prescribed at 30% of 1RM, increasing to a maximum of 70% of 1RM by 4 weeks. Seventy percent of 1RM is in the comfortably hard range (5–7 on the Borg 1–10 scale, which is comparable to 13–15 on the 6–20 Borg scale) (24). Each exercise repetition involved a slow controlled movement with approximately 2 sec of concentric lifting and 4 sec of eccentric lowering. Proper breathing techniques were enforced (with expiration during concentric lifting and inspiration during eccentric lowering). Patients were permitted and encouraged to rest for 30 sec to 1 min following each exercise set. Total time spent in strength training was approximately 20–25 min. To ensure the comparability of exposure to exercise between groups the amount of active exercise time was matched; this was achieved by reducing the amount of aerobic exercise time in the combined aerobic-strength group and substituting it with an equivalent amount of resistance training.

Sample size and analysis plans

Sample size estimates were based on SF-36 data from our previously published trial in a similar patient population (25). In that study, the mean change (all subjects) in the PCS was 7.75 (standard deviation (SD) = 9.38); the mean change in the MCS was 3.04 (SD = 11.11). Therefore, a comparison of mean change in 2 groups of 40 patients each, had 80% power to detect a difference of 6 points in the PCS and 7 points in the MCS ($\alpha = 0.05$, 2-sided). This detectable difference represents a treatment effect of 15–20% and is considered clinically significant (26). The sample size of 80 women (40 per group) was also sufficient to detect within-group changes of 23–27%.

Baseline demographic and clinical characteristics were summarized by treatment group to describe the study population and indicate the

degree of balance between groups for important prognostic factors. Analysis was conducted according to principles of intention-to-treat. The primary analysis was conducted using repeated measures analysis of covariance (ANCOVA) on SF-36 scores with treatment as the between-group factor and adjusting for the baseline score. Within group changes between baseline and 6 months or 1-year were tested with a paired *t*-test. For within group changes assessed on the 1-year follow-up data both study groups were combined. Based on a Bonferroni correction for multiple comparisons a *p*-value < 0.004 was required to declare significance.

RESULTS

Between July 2001 and January 2003, 537 women were referred to the CHRC. Of these, 235 were ineligible and 20 failed to attend their intake appointment following referral. A total of 282 women were approached to participate in the study; 190 declined due to difficulties with transportation or distance from the hospital. In total, 92 women (46 aerobic training and 46 combined aerobic-strength training) provided written consent to participate and were subsequently randomized (Fig. 1).

There were no important baseline differences between groups regarding demographics, medical history, peak VO_2 , peak metabolic equivalents level, or strength (Table I). Approximately 71% of the women in both groups attended $\geq 80\%$ of their supervised exercise classes. Compliance with the on-site exercise prescription was also high; participants in both groups completed approximately 97% of their prescribed exercise program. An equal number of women in both groups (approximately 24%), utilized other services of the CHRC. More women in the AST group continued exercising after discharge from CR than those in the AT group (76% vs 68%). There were no

Table I. Baseline characteristics

Characteristic	AT (<i>n</i> = 46) <i>n</i> (%)	AST (<i>n</i> = 46) <i>n</i> (%)
Referral event MI	15 (32.6)	19 (41.3)
Referral event CABG	31 (67.4)	27 (58.7)
Stroke or TIA		
No	43 (93.5)	43 (93.5)
Yes	3 (6.5)	3 (6.5)
PTCA		
No	30 (65.2)	34 (73.9)
Yes	16 (34.8)	12 (26.1)
Diabetes		
No	33 (71.7)	25 (54.3)
Yes	13 (28.3)	21 (45.7)
Smoking history		
No	21 (45.7)	24 (52.2)
Yes	25 (54.3)	22 (47.8)
Hypertension		
No	13 (28.3)	13 (28.3)
Yes	33 (71.7)	33 (71.7)
Hyperlipidemia		
No	5 (10.9)	4 (8.7)
Yes	41 (89.1)	42 (91.3)

AT: aerobic training; AST: combined aerobic-strength training; CABG: coronary artery by-pass graft surgery; MI: myocardial infarction; PTCA: percutaneous transluminal coronary angioplasty; TIA: transient ischemic attack.

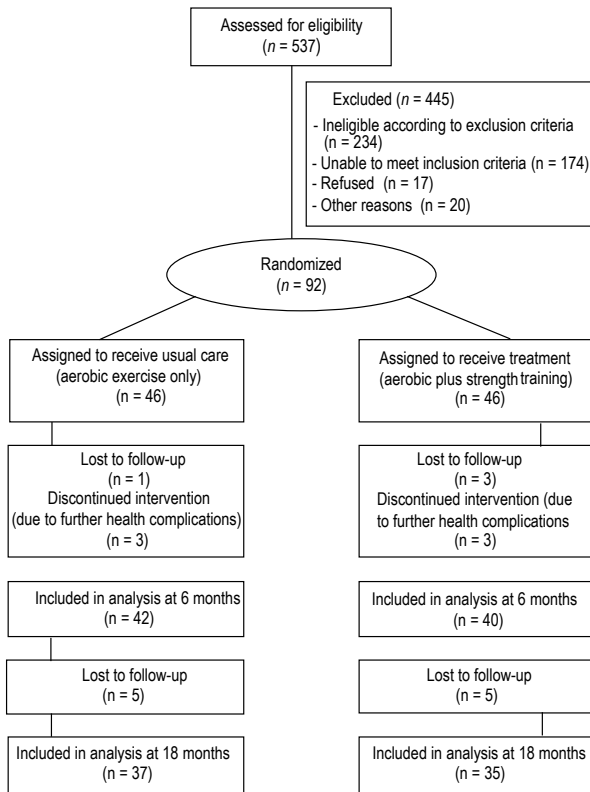


Fig. 1. Flow of participants throughout study.

exercise-related injuries or cardiac events in either group.

Main outcomes – health-related quality of life

PCS scores increased over the 6 months of exercise training in both groups ($p = 0.0002$), however the observed increase was not different between groups ($p = 0.52$). As shown in Fig. 2, it appears that the PCS was increasing more rapidly in the

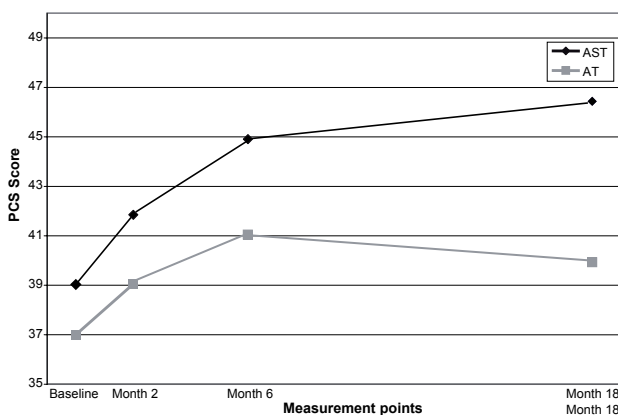


Fig. 2. Change in physical component summary (PCS) score from baseline to 1-year follow-up. AST: combined aerobic-strength training; AT: aerobic exercise training.

combined AST group. One year following completion of the intervention, scores on the PCS continued to diverge; rising in the AST group while falling in the AT group. The 1-year follow-up results indicate a statistically significant difference in scores on the PCS in favor of combined aerobic-strength training ($p = 0.05$). There were no between-group differences in the MCS after 6 months of exercise training or by the 1-year follow-up.

Secondary outcomes

Exercise capacity. After 6 months of exercise training both groups demonstrated similar significant improvements in peak VO_2 (19% increase in the AST group vs 22% increase in the AT group). One year after discharge from CR both groups showed declines in peak VO_2 , though there was no statistically significant difference between them (Table II).

Strength. There were no between-group differences in strength; there were however statistically significant improvements by one year follow-up in both groups in all 4 measures of strength: elbow flexion, bench press, leg press and knee flexion ($p < 0.0001$) (Table II).

Self-efficacy. There were no between-group differences in self-efficacy; however, there were statistically significant improvements by 6 months and 1 year follow-up in both groups regarding self-efficacy for stair climbing ($p = 0.0024$), for lifting ($p < 0.0001$) and for walking ($p = 0.0012$).

DISCUSSION

Scientific statements on exercise standards have indicated that the requirements and recommendations for women may differ from men (27) and “attention is warranted in the evaluation of women and the appropriateness of specific interventions needs definition” (28).

Our findings demonstrate that both supervised aerobic training and combined aerobic-strength training are associated with short-term (6 month) improvements in physical HRQoL in women after CABGS or MI. Both forms of exercise training were also associated with significant improvements in peak VO_2 , strength and self-efficacy during formal, supervised CR. However, combined aerobic-strength training may be associated with longer term sustainability of HRQoL benefits compared to AT based on our finding of a significant between-group effect one year after discharge from supervised CR.

Strength training for female cardiac patients may be an important exercise intervention since most activities performed by persons in later life, especially after a cardiac event, require strength, not endurance. This may be particularly true for women, due to their older age at the time of a cardiac event and the fact that they are typically more debilitated following CABGS or MI. The maintenance of functional independence in every day living requires ability to perform activities such as climbing stairs, carrying groceries, lifting objects, performing housework, getting in and out of chairs and even walking.

Table II. Differences in outcomes between groups from baseline to 1-year post-discharge

Outcome variable	AT		AST		<i>p</i> -value*
	Baseline (<i>n</i> = 46)	18 months (<i>n</i> = 35)	Baseline (<i>n</i> = 46)	18 months (<i>n</i> = 37)	
PCS, mean (SD)	37.00 (8.13)	39.93 (10.93)	39.03 (8.69)	46.44 (8.89)	0.05
MCS, mean (SD)	49.98 (10.88)	52.25 (10.61)	51.60 (12.07)	52.78 (8.46)	ns
Peak V _O ₂ , l/min, mean (SD)	0.93 (0.22)	1.19 (0.28)	0.98 (0.25)	1.12 (0.27)	ns
METS, mean (SD)	3.78 (0.89)	4.74 (1.20)	3.77 (0.85)	4.46 (1.44)	ns
Arm flexion, kg, mean (SD)	7.45 (2.81)	10.50 (3.23)	8.75 (3.20)	12.02 (2.96)	ns
Leg flexion, kg, mean (SD)	15.12 (4.32)	18.45 (5.65)	15.57 (3.80)	18.82 (5.05)	ns
Leg press, kg, mean (SD)	74.57 (20.38)	101.60 (23.93)	76.16 (20.99)	109.34 (39.58)	ns
Bench press, kg, mean (SD)	14.11 (7.33)	22.00 (7.15)	15.21 (6.42)	24.12 (6.99)	ns

**p*-value represents between-group difference from baseline to 1-year follow-up, computed using analysis of covariance (ANCOVA).

AT: aerobic training; AST: combined aerobic-strength training; PCS: physical component summary score; MCS: mental component summary score; METs: metabolic equivalents; SD: standard deviation; ns: not significant.

Improvements in strength may facilitate the performance of these activities.

Ades et al. (16) evaluated the effect of intensive resistance training on measures of physical performance in 42 disabled older women with CAD. Their intervention consisted of a 6-month program of resistance training (at 80% of 1RM) compared to a control condition in which women performed light yoga and breathing exercises. The primary outcome was related to the performance of 16 household activities. Their findings showed that older women with CAD who participated in an intense strength training program had improved physical capacity over a wide range of household physical activities. Given the low intensity activity of the women in the control group (light yoga and breathing exercises), the observed differences related to strength training are not surprising.

According to findings from the work of Arent et al. (29) a high-intensity resistance training program is unlikely to result in either positive outcomes related to affect (e.g. anxiety, energy, tension, calmness) or long-term adherence. Arent et al. (29) reported a curvilinear dose-response relationship between intensity of resistance training and affective responses, with moderate intensity training resulting in large and enduring affective benefits. Rejeski (30) suggested that continued engagement in exercise may be influenced by affective responses to initial exercise bouts. Our finding that combined AST led to better long-term physical functional status scores compared to aerobic training alone is consistent with both theory and the empirical evidence noted above.

The mechanism through which both exercise modalities affected 6-month physical HRQoL may be perceived self-efficacy. The concept of self-efficacy is part of social cognitive theory, which purports that people function as anticipative, purposive and self-evaluating regulators of their motivation and actions (31). Most factors associated with motivation are rooted in the core belief that one has the power to produce desired effects; otherwise one has little incentive to act or to persevere in the face of difficulties. The finding that more women in the AST group continued exercising after discharge from supervised cardiac rehabilitation may reflect a relationship between the type of exercise training and perceived self-efficacy.

Netz et al. (32) found that self-efficacy was part of the causal link between physical activity and well-being (specifically fitness related to daily functioning). They suggested that in older adults, whose self-efficacy may be deteriorating along with their functional abilities, physical activity may provide a mastery experience that leads to increased self-efficacy, which in turn leads to improved well-being. Arent et al. (29) suggest that optimal exercise experiences (those that are neither too high nor too low in intensity) may impart a sense of mastery, which then provides for improvements in other behavioral or psychological outcomes. Our findings add to accumulating evidence that exercise is often used to increase participants' self-efficacy (32) and demonstrate the complex, interwoven relationship between exercise, self-efficacy and perceived QoL.

The well-documented early gains that have been observed in CR following CABGS or MI are often attributed to a combination of (i) physiologic recovery, (ii) optimized medical intervention with appropriate secondary prevention therapies and (iii) exercise training. While both groups demonstrated improvements in all outcomes (except mental HRQoL) at the conclusion of the formal CR program, the groups continued on a diverging path in regard to physical QoL during the year after CR discharge. Improved long term functional status may have implications beyond quality of life and its effect on morbidity, health service utilization and mood (e.g. anxiety and depression) should be investigated further.

There are possible explanations for why, despite a trend in the data, we did not detect a between-group difference after 6 months of exercise training. First, we employed a 2-month "run-in" period where all women participated in AT only, based on the rationale described earlier. This decision may have diminished the chance of finding 6-month between-group differences due to the rapid improvements that occurred among all women in the first 2 months of CR. Second, our decision to employ a moderate intensity strength training regimen may have reduced the short-term impact of the exercise program in favor of a long-term benefit. Although we did not observe statistically significant between-group differences after 6 months, the work done by Arent et al. (29) suggests that our protocol for strength training was ideal in regard to promotion of exercise adherence. This is borne out by the differences observed at the 1-year follow up.

In conclusion, women in CR programs stand to benefit from both aerobic and combined AST protocols. Both physical and psychological gains are apparent with either form of exercise. It is possible that sustained or continued improvements may be achieved best through combined strength and aerobic training in women with CAD.

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