Published in final edited form as:
J Cardiopulm Rehabil Prev. 2013 January ; 33(1): 16–25. doi:10.1097/HCR.0b013e3182763192.

Physiological and Exercise Capacity Improvements in Women Completing Cardiac Rehabilitation

Theresa M. Beckie, PhD[1], **Jason. W. Beckstead, PhD**[1], **Kevin Kip, PhD**[1], and **Gerald Fletcher, MD**[2]

[1]College of Nursing, University of South Florida, Tampa, FL

[2]Mayo Clinic College of Medicine, Jacksonville, FL

Abstract

PURPOSE—We sought to examine the improvements in physiological outcomes, including exercise capacity, in women completing a 12-week gender-specific (tailored) compared to a traditional cardiac rehabilitation (CR) program.

METHODS—A 2-group randomized clinical trial compared symptom limited graded exercise test (SL-GXT), lipid, and anthropometric parameters among 99 women completing a traditional 12-week CR program to 137 women completing a tailored CR program.

RESULTS—Compared to baseline, improvement in estimated peak metabolic equivalents (METs) was similar (P=.159) between the tailored (6.0±2.7 to 7.6±2.8) and the traditional CR program (5.6±2.3 to 7.1±2.8). The amount of change in SL-GXT, anthropometric parameters, lipid profiles, and peak treadmill time from baseline to post-CR were also similar between the 2 groups. Given comparable improvements of the 2 CR programs, in the full cohort, factors independently associated with post-CR METs, in rank order, included baseline METs (part correlation=0.44, P<.001), perceived physical functioning (0.24, P<.001), waist circumference (−0.10, P=.006), and age (−0.11, P=.004). Factors independently associated with post-CR treadmill time included baseline treadmill time (part correlation=0.42, P<.001), perceived physical functioning (0.30, p<.001), waist circumference (−0.12, P=.002), and age (−0.10, P=.006).

CONCLUSIONS—Exercise capacity was significantly improved among women completing both CR programs. In the context of CR, modifiable factors positively associated with post-CR exercise capacity included reduced waist circumference and improved physical functioning. Future research on strategies for reducing abdominal obesity and improving perceived physical functioning and exercise capacity among women attending CR is warranted.

Key words or phrases

cardiac rehabilitation; women; exercise capacity; physical functioning

Cardiac rehabilitation/secondary prevention programs (CR/SPPs), internationally endorsed,[1–5] reveal undisputable morbidity and mortality benefits.[6–8] Evidence-based guidelines, including those for women,[9] provide robust recommendations for referral to CR/SPPs for patients with acute myocardial infarction (AMI), chronic stable angina, and after coronary artery bypass graft (CABG) surgery or percutaneous coronary interventions (PCI).[10–14] Contemporary American outpatient CR/SPPs typically comprise 12 weeks of supervised aerobic exercise supplemented with resistance training, and education and

Corresponding Author: Theresa M. Beckie, PhD, FAHA, University of South Florida, 12901 Bruce B. Downs Blvd., Tampa, FL, 33612, Telephone: 813.974.9202, Fax: 813.974.5418, tbeckie@health.usf.edu.

counseling for weight loss, nutrition, smoking cessation and psychosocial issues.[1] These risk reduction interventions are intended to slow coronary heart disease (CHD) progression, improve cardiorespiratory fitness (CRF), and reduce future cardiac events.[2,15] A meta-analysis of randomized controlled trials (RCT) of exercise-based CR/SPPs found that participants were 50% less likely to experience a second AMI, and had a 36% lower risk of cardiac death.[16]

The symptom-limited graded exercise test (SL-GXT) is valuable for identifying individuals at risk for CHD and mortality, evaluating capacity for dynamic exercise, and devising and evaluating exercise prescriptions during CR/SP.[17–20] The merit of exercise capacity for predicting cardiac events and death was highlighted in a meta-analysis of 33 studies comprising nearly 103,000 primarily male participants.[21] Kodama et al[21] determined that each incremental improvement in metabolic equivalents (METs; an index of energy expenditure) corresponded to 13% and 15% reductions in all-cause and cardiovascular (CVS) mortality, respectively. Despite the morbidity and mortality benefits of exercise training, few women comprised most study samples.[22] Women are underrepresented in CR/SP trials relative to their representation in the CHD population,[23] and substantially more research focused on women is essential to guide evidence-based cardiac care.

A greater understanding of the influence of both modifiable and nonmodifiable factors on CRF estimates is vital for prescribing and evaluating exercise prescriptions for women participating in CR/SPPs. We sought to evaluate the physiological and psychosocial outcomes among women completing a gender-specific compared to a traditional CR/SPP. The purpose of this paper was to examine the improvement in physiological outcomes, including CRF, in women completing a gender-specific CR/SPP compared to women completing a traditional CR/SPP. We also report on associations between CRF after CR/SP completion and socio-demographic and clinical characteristics.

METHODS

Using a prospective RCT and after obtaining informed consent, eligible women were randomized to either the gender-specific (hereafter referred to as tailored) CR/SPP or a traditional CR/SPP. Details of the methodological design, recruitment, retention, baseline characteristics, intervention components, and depressive symptom, perceived health, and quality of life (QOL) outcomes have been previously published.[24–29] The Institutional Review Board of the university and participating hospital approved the study protocol.

Participants

Participants were recruited from those referred to an outpatient CR/SPP in Florida from 2004 to 2008. The inclusion criteria were women >21 years 1) diagnosed with a AMI, stable angina, or having undergone CABG surgery or PCI within 12 months and 2) able to read, write, and speak English. The exclusion criteria were 1) health insurance coverage for <36 electrocardiogram (ECG)-monitored exercise sessions, 2) cognitive impairment, and 3) inability to ambulate. We randomly allocated 111 women to traditional CR/SP and 141 to the tailored program of which 99 and 137, respectively, completed the study.

Interventions

Traditional Cardiac Rehabilitation—The traditional CR/SPP, nationally certified by the American Association of Cardiovascular and Pulmonary Rehabilitation, was delivered by 2 female nurses and 1 exercise physiologist using a case management model. The ECG-monitored and supervised exercise protocol consisted of aerobic exercise and resistance training 3 days per week for 12 weeks. Exercise consisted of a 5-minute warm-up and 35 to

45 minutes of aerobic exercise (treadmill walking, cycling or rowing) with exercise heart rates maintained at 60% to 80% of maximal heart rate calculated from the baseline SL-GXT. Exercise intensity was adjusted to maintain participant Borg scale rating of perceived exertion between "light" and "somewhat hard" (12–14 on a scale of 6–20).[30] Resistance training included 3 sets of wall-pulleys and hand weights and was followed by 5 minutes of cool-down exercises. Women in this group were free to choose any scheduled mixed-gender exercise session between 8 AM and 4 PM. Education classes on CHD risk factor reduction were also provided by the CR/SP personnel on 8 consecutive weeks.

Tailored Cardiac Rehabilitation—The tailored CR/SP exercise protocol was identical to that of the traditional CR/SPP except for the exclusion of men and the restriction of intervention implementation to one time slot when the CR/SP facility was closed. The intervention, guided by the Transtheoretical Model of behavior change[31] and delivered with a motivational interviewing counseling style,[32] was administered by 2 female research nurses and 1 exercise physiologist. A clinical nurse specialist and clinical psychologist also facilitated psychoeducational sessions for 10 consecutive weeks.

Physiological and Psychosocial Measures

Blood pressure (BP) was measured by one automated BP monitor (Datascope, Mahwah, NJ) according to established guidelines.[33] Body mass index (BMI) was calculated as weight kg/height(m^2). Body fat composition was determined using skinfold measurements taken at 3 sites (suprailium, triceps, and thigh).[34] Waist circumference was measured by trained staff between the iliac crest and the lowermost level of ribs. Lipid profiles and serum glucose were measured after a 12-hour fast using the Cholestech LDX System (Haywood, CA).

Standards for SL-GXT were followed,[18,35] with 1 cardiologist supervised all tests using 1 treadmill. CRF was evaluated using the modified Bruce protocol and expressed in METs where a MET typically equals 3.5 mL of oxygen uptake per kilogram per minute. METs were estimated from the final treadmill speed and grade.[36] Baseline SL-GXTs were obtained an average of 3 months after the index cardiac event and within 1 week before beginning CR/SP while exit tests were obtained 1 week after CR/SP completion. Participants continued their medication regimen on the usual schedule and all SL-GXTs were conducted in the morning. Participants were instructed not to grip the handrail and were encouraged to exert maximal effort to volitional fatigue or until the occurrence of abnormal clinical signs or symptoms. A second cardiologist, blind to group assignment, interpreted all SL-GXT results. Termination criteria for exercise testing included fatigue, leg discomfort, dyspnea, abnormal BP responses, or ischemic ECG changes.

Urine cotinine level measured exposure to nicotine. Specimens were screened by immunoassay at a threshold of 25 ng/mL. If positive, it was confirmed by gas chromatography (MedTox Laboratories, St. Paul, MN). The Charlston Comorbidity Index (CMI) measured the burden of 19 comorbid diseases.[37] Scores can range from 0–12 with higher scores representing greater comorbidities.

Anxiety was measured with the 20-item State Anxiety Inventory.[38] Scores range from 20 to 80, with higher scores indicating more anxiety. The 20-item Center for Epidemiological Studies Depression Scale (CES-D) measured depressive symptoms.[39] Scores range from 0 to 60 with scores ≥16 typically the cutoff for an elevated level of depressive symptoms. Quality of life was assessed using the multiple discrepancies theory (MDT) questionnaire[40,41] and the Self-Anchoring Striving Scale (SASS).[42] The MDT evaluates discrepancies between one's current QOL and what one wants, relevant others have, the best one has had in the past, expected to have 3 years ago, expects to have after 5 years, deserves and needs. The 8 items are summed for a total score ranging from 8 to 56. The SASS is a single item depicting a ladder using only numbers as descriptors of the ladder rungs. Participants were asked to indicate where on the ladder (from 0 to 10) they would judge their present life.

The SF-36$_{v2}$ Health Survey assessed perceived health status.[43] The SF-36$_{v2}$ comprises 36 questions measuring health perceptions on 8 subscales. Subscales were totaled and transformed to a 0–100 scale with higher scores representing better perceived health.

Exercise attendance, recorded at each session, was calculated as the number of sessions attended out of 36 prescribed sessions. Education attendance was expressed as a percentage of the number of sessions completed because the tailored CR/SPP comprised 10 and the traditional CR/SPP consisted of 8 education sessions.

Data Analysis

Data were analyzed using IBM®SPSS® version 20 for Windows. Univariate and biavariate distributions were examined using frequencies and crosstabulation procedures to check for outliers and assess normality. Descriptive statistics including means, standard deviations, Pearson correlations and percentages were used to describe the participants and study variables. Categorical variables were compared using the χ^2 test and continuous variables were compared using the *t* test. Urine cotinine levels were log-transformed. Analysis of variance was used to assess between-group differences in changes on physiological and psychosocial variables among the 236 women completing the intervention. To determine predictors of post-CR exercise capacity and treadmill time (n=232) we first examined all bivariate correlations between the exercise test variables and all variables listed in Tables 1 and 2. From this list we selected 10 variables that were correlated with peak METs and treadmill time at r ≥0.2. Forward regression using these 10 predictors (age, waist circumference, physical functioning, social functioning, fasting glucose, CMI, BMI, smoking status, exercise attendance, and left ventricular ejection fraction) was conducted while controlling for baseline levels. All statistical tests were 2-tailed and evaluated for significance using an alpha criterion of .05.

RESULTS

Baseline characteristics were not different across the randomized groups. With a mean age of 63±12 years, most women were white, married, and had a high school or higher education (Table 1). With the exception of angiotensin converting enzyme inhibitors, baseline consumption of CVS medications did not differ between women in two treatment groups and medications remained stable throughout the study. In both groups, 14% were current smokers.

Improvements in Clinical Characteristics by Treatment Group

The tailored group participants attended more exercise sessions (33 ± 8 versus 30 ± 8, $F_{(1, 234)} = 6.575$, P=.01, $\eta^2 = .027$) and a greater percentage of education sessions than the traditional group (88.5 ± 21 versus 60.5 ± 30; $F_{(1, 234)} = 71.168$, P<.001, η^2 =.233). Improvements in lipid profiles or anthropometric indices after completing CR/SP were similar in both groups (Table 2). Compared to the traditional CR/SPP, the tailored group achieved significantly lower depressive symptom and improved QOL scores after completion. They also achieved significantly greater improvements on 5 of the 8 SF-36 Health Survey subscales.

Compared to baseline, improvement in peak METs were similar (P=.159) between the tailored (6.0±2.7 to 7.6±2.8) and traditional CR/SP program (5.6±2.3 to 7.1±2.8). The amount of change in treadmill time from baseline to post-CR was also similar between the 2 groups (Table 3). Given comparable improvements of the 2 CR/SPPs, data were combined for subsequent analyses.

Predictors of Exercise Capacity for the Total Cohort

Two regression models were constructed to predict post-CR/SP METs and treadmill time. Forward regression using 10 independent variables resulted in the final models of 4 predictors of METs and treadmill time that are shown in Table 4 and Table 5, respectively. The factors independently associated with post-CR/SP METs, in rank order, included baseline METs (part [or semi-partial] correlation = 0.44, $P<.001$), perceived physical functioning (0.24, $P<.001$), age (−0.11, $P=.004$), and waist circumference (−0.10, $P=.006$). These variables predicted 68.3% of the variance in post-CR/SP METs (Table 4). Perceived physical functioning was the strongest predictor of METs after controlling for baseline values.

The regression model to predict post-CR/SP treadmill time using the same variables used to predict METs led to similar results (Table 5). Factors independently associated with post-CR/SP treadmill time included baseline treadmill time (part correlation = 0.42, $P<.001$), perceived physical functioning (0.30, $P<.001$), waist circumference (−0.12, $P=.002$), and age (−0.10, $P=.006$). Because of the high correlation between METs and treadmill time (r = .962) in our sample, physical functioning was also the strongest predictor of treadmill time.

DISCUSSION

The aim of the study was to examine the effects of a traditional compared to a tailored CR/SPP on physiological and exercise capacity outcomes among women. To the best of our knowledge, this is the first RCT to compare outcomes of a CR/SPP designed exclusively for women to a traditional CR/SPP. Our primary finding was that lipid profiles, anthropometric indices, and exercise capacity was similarly improved among women completing both programs. Specifically, mean METs improved by 27% (1.6 METs) and treadmill time improved by 24% compared to baseline. A recent meta-analysis of the effects of CR/SPPs on CRF revealed a similar mean improvement of 1.55 METs after completion, with men and patients <55 years achieving greater gains than women, mix-sex groups, or older patients.[15] Kodama et al[21] concluded that the minimum CRF level associated with significantly lower CVS event rates for women was about 6 METs at 50 years of age, and 5 METs at 60 years of age.

The beneficial effects of CR/SP exercise training on peak METs and treadmill time we observed corroborate data reported previously.[44] Arthur et al[45] showed about a 20% improvement in peak VO_2 in 92 women after 6 months of CR/SP exercise. A retrospective analysis of 210 (59% men, mean age 58 years) CR/SP participants completing 70% of prescribed exercise sessions found that exercise capacity increased by 32% from baseline. The improved exercise capacity achieved by our participants is clinically meaningful because aerobic capacity is prognostic of mortality in both apparently healthy and CHD patient populations. The St James Women Take Heart Project showed that women failing to achieve at least 5 METs had a 3-fold increased mortality risk compared with women achieving >8 METs, with each MET improvement associated with a 17% mortality reduction.[46] Others found exercise capacity was predictive of CVS mortality over 20 years of followup,[47,48] and Keteyian et al[49] reported a 15% reduced mortality risk with every 1 $mL \cdot kg^{-1} \cdot min^{-1}$ increase in peak oxygen uptake.

The modifiable factors positively associated with post-CR exercise capacity and treadmill time among our participants included reduced waist circumference and improved perceived physical functioning. The combined effect of central adiposity and low CRF is reportedly particularly detrimental for mortality in CR/SP patients.[20] Lakoski et al[50] argue that achieving high CRF levels is challenging for most obese individuals, given the negative impact of body weight on treadmill times. Savage et al[51] found that women made less improvement in CRF than men in their cohort of 385 (20% women) CR/SP patients and that baseline perceived physical functioning significantly predicted improved CRF, pointing to a readily obtainable score for identifying patients less likely to improve CRF after exercise training.

In the current era of high consumption of statin drugs, improved lipid profiles with CR/SP participation is becoming more difficult to demonstrate.[52,53] Further, the societal epidemic of obesity is mirrored in the profiles of contemporary CR/SP patients.[54,55] Most of our participants were overweight or obese and demonstrated little meaningful weight loss after CR/SP completion, corroborating findings of a meta-analysis of exercise-based CR/SPPs.[16] Despite escalating obesity in CR/SP patients, exercise protocols have remained relatively unchanged, resulting in unimpressive weight loss given the low energy expenditure.[56] Efforts to address modest weight loss in CR/SPPs have led to successes primarily for men. Ades et al[53] found that patients randomized to high energy expenditure exercise training (daily, longer duration, and lower intensity) compared to traditional CR/SP had twice the weight loss after 5 months with CRF improving similarly by group. Innovative strategies for reducing obesity, improving CRF, and fostering healthy lifestyles, require additional exploration among women of diverse ages in CR/SPPs.

The age of our participants was independently associated with exercise capacity and treadmill time. Others found exercise capacity was strongly related to age[57,58] and particularly low in women entering CR/SP.[59] Earnest et al,[60] examining the CRF response to 6 months of varying exercise training volumes in healthy, overweight postmenopausal women, found an attenuated training response due to age regardless of training volume. Younger, less fit, or women who exercised more during the trial had greater odds of improved fitness with training.[57] An inverse linear relationship between age and exercise capacity was demonstrated in asymptomatic women from the St. James Women Take Heart Project.[61] Others have determined that the decline in maximum aerobic capacity with age is curvilinear with the rate of decline increasingly severe with age.[58] Sandercock et al[15] proposed that providing same-gender exercise groups stratified by age might optimize CRF gains.

That the tailored, compared to the traditional CR/SPP, was superior for improving depressive symptoms, QOL, and perceived health but not exercise capacity or anthropometric indices may reflect the greater differentiation of the psychosocial components and the similarity of the exercise training protocols of the 2 interventions. Future research challenges include disentangling the effective ingredients of CR/SP interventions for specific subgroups and for specific outcomes. Testing alternative exercise protocols, weight loss interventions, and interventions focused on healthy lifestyles for women in CR/SP settings is needed to improve anthropometric indices and exercise capacity.

Limitations of the current study warrant discussion. First, the sample size was relatively small from a single south-eastern American institution and all women had health insurance coverage. Second, in compliance with current exercise training guidelines and Medicare reimbursement, the 36 ECG-monitored exercise sessions in the treatment groups were similar. Third, peak oxygen uptake was estimated from treadmill speed and grade rather than directly measured by ventilator expired gas analysis because of feasibility constraints. While direct measures of oxygen uptake are recommended for more accurate, individualized exercise prescriptions, when unfeasible, estimation of exercise capacity is acceptable[62] and commonly used in clinical practice. Finally, although evidence supports a genetic contribution to exercise training responses,[63–69] we did not evaluate genetic factors. Genetic determinants of aerobic capacity and exercise training responses are prime targets for future research to facilitate designing individualized CR/SP exercise prescriptions.

CONCLUSIONS

Exercise capacity was significantly improved among women completing both CR/SPPs. Modifiable factors positively associated with post-CR/SP exercise capacity included reduced waist circumference and improved perceived physical functioning. The tailored CR/SPP was substantially more effective than traditional CR/SP for improving psychosocial outcomes in women and similarly effective for improving lipid profiles and anthropometric indices. Identifying modifiable characteristics predisposing women to suboptimal improvement in CRF may assist in designing individualized exercise training protocols that optimize physiological outcomes in CR/SP. Exercise training in CR/SP can effectively increase exercise capacity, thereby, improving mobility, independence, and QOL among women. Future research on exercise training strategies for reducing abdominal obesity and improving exercise capacity among women of diverse ages attending CR/CPPs is warranted.

Acknowledgments

Funding: Prioveded by the National Institute of Nursing Research (5R01 NR07678)

References

1. Balady GJ, Williams MA, Ades PA, et al. Core components of cardiac rehabilitation/secondary prevention programs: 2007 update: a scientific statement from the American Heart Association and the American Association of Cardiovascular and Pulmonary Rehabilitation. J Cardiopulm Rehabil Prev. 2007; 27:121–129. [PubMed: 17558191]
2. Balady GJ, Ades PA, Bittner VA, et al. Referral, enrollment, and delivery of cardiac rehabilitation/ secondary prevention programs at clinical centers and beyond: a presidential advisory from the american heart association. Circulation. 2011; 124:2951–2960. [PubMed: 22082676]
3. Smith SC Jr, Benjamin EJ, Bonow RO, et al. AHA/ACCF secondary prevention and risk reduction therapy for patients with coronary and other atherosclerotic vascular disease: 2011 update. Circulation. 2011; 124:2458–2473. [PubMed: 22052934]
4. Corra U, Piepoli MF, Carre F, et al. Secondary prevention through cardiac rehabilitation: physical activity counselling and exercise training: key components of the position paper from the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation. Eur Heart J. 2010; 31:1967–1974. [PubMed: 20643803]
5. Piepoli MF, Corra U, Benzer W, et al. Secondary prevention through cardiac rehabilitation: from knowledge to implementation. A position paper from the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation. Euro J Cardiovasc Prev Rehabil. 2010; 17:1–17.
6. Suaya JA, Stason WB, Ades PA, Normand SL, Shepard DS. Cardiac rehabilitation and survival in older coronary patients. J Am Coll Cardiol. 2009; 54:25–33. [PubMed: 19555836]
7. Goel K, Lennon RJ, Tilbury RT, Squires RW, Thomas RJ. Impact of cardiac rehabilitation on mortality and cardiovascular events after percutaneous coronary intervention in the community. Circulation. 2011; 123:2344–2352. [PubMed: 21576654]
8. Heran BS, Chen JM, Ebrahim S, et al. Exercise-based cardiac rehabilitation for coronary heart disease. Cochrane Database Syst Rev. 2011; (7):CD001800. [PubMed: 21735386]
9. Mosca L, Benjamin EJ, Berra K, et al. Effectiveness-based guidelines for the prevention of cardiovascular disease in women-2011 update: a guideline from the American Heart Association. Circulation. 2011; 123:1243–1262. [PubMed: 21325087]

10. Hillis LD, Smith PK, Anderson JL, et al. 2011 ACCF/AHA Guideline for Coronary Artery Bypass Graft Surgery. Circulation. 2011; 124:e652–735. [PubMed: 22064599]
11. Anderson JL, Adams CD, Antman EM, et al. 2011 ACCF/AHA Focused Update Incorporated Into the ACC/AHA 2007 Guidelines for the Management of Patients With Unstable Angina/Non-ST-Elevation Myocardial Infarction. Circulation. 2011; 123:e426–579. [PubMed: 21444888]
12. Wright RS, Anderson JL, Adams CD, et al. 2011 ACCF/AHA Focused Update of the Guidelines for the Management of Patients With Unstable Angina/Non-ST-Elevation Myocardial Infarction (Updating the 2007 Guideline). Circulation. 2011; 123:2022–2060. [PubMed: 21444889]
13. Levine GN, Bates ER, Blankenship JC, et al. 2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention. Circulation. 2011; 124:e574–651. [PubMed: 22064601]
14. Thomas RJ, King M, Lui K, Oldridge N, Pina IL, Spertus J. AACVPR/ACCF/AHA 2010 update: performance measures on cardiac rehabilitation for referral to cardiac rehabilitation/secondary prevention services. Circulation. 2010; 122:1342–1350. [PubMed: 20805435]
15. Sandercock G, Hurtado V, Cardoso F. Changes in cardiorespiratory fitness in cardiac rehabilitation patients: A meta-analysis. Int J Cardiol. 2011 doi: 1016/j.ijcard.2011.11.068.
16. Lawler PR, Filion KB, Eisenberg MJ. Efficacy of exercise-based cardiac rehabilitation post-myocardial infarction: a systematic review and meta-analysis of randomized controlled trials. Am Heart J. 2011; 162:571–584. e572. [PubMed: 21982647]
17. Balady GJ, Arena R, Sietsema K, et al. Clinician's Guide to cardiopulmonary exercise testing in adults: a scientific statement from the American Heart Association. Circulation. 2010; 122:191–225. [PubMed: 20585013]
18. Myers J, Arena R, Franklin B, et al. Recommendations for clinical exercise laboratories: a scientific statement from the American Heart Association. Circulation. 2009; 119:3144–3161. [PubMed: 19487589]
19. Arena R, Sietsema KE. Cardiopulmonary exercise testing in the clinical evaluation of patients with heart and lung disease. Circulation. 2011; 123:668–680. [PubMed: 21321183]
20. Goel K, Thomas RJ, Squires RW, et al. Combined effect of cardiorespiratory fitness and adiposity on mortality in patients with coronary artery disease. Am Heart J. 2011; 161:590–597. [PubMed: 21392616]
21. Kodama S, Saito K, Tanaka S, et al. Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in healthy men and women: a meta-analysis. JAMA. 2009; 301:2024–2035. [PubMed: 19454641]
22. Valkeinen H, Aaltonen S, Kujala UM. Effects of exercise training on oxygen uptake in coronary heart disease: a systematic review and meta-analysis. Scand J Med Sci Sports. 2010; 20:545–555. [PubMed: 20492590]
23. Melloni C, Berger JS, Wang TY, et al. Representation of women in randomized clinical trials of cardiovascular disease prevention. Circ Cardiovasc Qual Outcomes. 2010; 3:135–142. [PubMed: 20160159]
24. Beckie TM. A behavior change intervention for women in cardiac rehabilitation. J Cardiovasc Nurs. 2006; 21:146–153. [PubMed: 16601534]
25. Beckie TM, Beckstead JW. Predicting cardiac rehabilitation attendance in a gender-tailored randomized clinical trial. J Cardiopulm Rehabil Prev. 2010; 30:147–156. [PubMed: 20216324]
26. Beckie TM, Beckstead JW. The effects of a cardiac rehabilitation program tailored for women on global quality of life: a randomized clinical trial. J Womens Health. 2010; 19:1977–1985.
27. Beckie TM, Beckstead JW. The effects of a cardiac rehabilitation program tailored for women on their perceptions of health: a randomized clinical trial. J Cardiopulm Rehabil Prev. 2011; 31:25–34. [PubMed: 21037482]
28. Beckie TM, Fletcher GF, Beckstead JW, Schocken DD, Evans ME. Adverse baseline physiological and psychosocial profiles of women enrolled in a cardiac rehabilitation clinical trial. J Cardiopulm Rehabil Prev. 2008; 28:52–60. [PubMed: 18277832]
29. Beckie TM, Beckstead JW, Schocken DD, Evans ME, Fletcher GF. The effects of a tailored cardiac rehabilitation program on depressive symptoms in women: A randomized clinical trial. Int J Nurs Stud. 2011; 48:3–12. [PubMed: 20615504]

30. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982; 14:377–381. [PubMed: 7154893]
31. Prochaska, JO.; Norcross, JC.; DiClemente, CC. Changing for Good. New York: HarperCollins; 1994.
32. Rollnick, S.; Miller, W.; Butler, C. Motivational Interviewing in Health Care: Helping Patients Change Behavior. New York: Guilford Press; 2008.
33. Pickering TG, Hall JE, Appel LJ, et al. Recommendations for blood pressure measurement in humans and experimental animals: part 1: blood pressure measurement in humans: a statement for professionals from the subcommittee of professional and public education of the American Heart Association. Circulation. 2005; 111:697–716. [PubMed: 15699287]
34. Jackson AS, Pollock ML, Ward A. Generalized equations for predicting body density of women. Med Sci Sports Exerc. 1980; 12:175–181. [PubMed: 7402053]
35. Gibbons RJ, Balady GJ, Bricker JT, et al. ACC/AHA 2002 guideline update for exercise testing: summary article. Circulation. 2002; 106:1883–1892. [PubMed: 12356646]
36. American College of Sports Medicine. ACSM's Guidelines for Exercise Testing and Prescription. Philadelphia, PA: Lippincott, Williams & Wilkins; 2010.
37. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987; 40:373–383. [PubMed: 3558716]
38. Spielberger, CD.; Gorsuch, RL.; Lushene, RE. Manual for the state-trait anxiety inventory. Palo Alto: Consulting Psychologists; 1983.
39. Radloff L. The CES-D scale: A self-report depression scale for researching the general population. Application of Psychological Measures. 1977; 1:385–401.
40. Michalos AC. Multiple Discrepancies Theory (MDT). Social Indicators Research. 1985; 16:347–413.
41. Michalos, A. Global report on student well-being: Volume 1: Life satisfaction and happiness. Vol. 1. New York: Springer-Verlag; 1991.
42. Cantril, H. The pattern of human concerns. New Jersey: Rutgers University Press; 1965.
43. Ware, JE.; Kosinski, M.; Dewey, JE. How to score version 2 of the SF-36 health survey. Lincoln, RI: QualityMetric Incorporated; 2000.
44. Arthur HM, Gunn E, Thorpe KE, et al. Effect of aerobic vs combined aerobic-strength training on 1-year, post-cardiac rehabilitation outcomes in women after a cardiac event. J Rehabil Med. 2007; 39:730–735. [PubMed: 17999012]
45. Adams BJ, Carr JG, Ozonoff A, Lauer MS, Balady GJ. Effect of exercise training in supervised cardiac rehabilitation programs on prognostic variables from the exercise tolerance test. Am J Cardiol. 2008; 101:1403–1407. [PubMed: 18471449]
46. Gulati M, Pandey DK, Arnsdorf MF, et al. Exercise capacity and the risk of death in women: the St James Women Take Heart Project. Circulation. 2003; 108:1554–1559. [PubMed: 12975254]
47. Mora S, Redberg RF, Sharrett AR, Blumenthal RS. Enhanced risk assessment in asymptomatic individuals with exercise testing and Framingham risk scores. Circulation. 2005; 112:1566–1572. [PubMed: 16144993]
48. Mora S, Redberg RF, Cui Y, et al. Ability of exercise testing to predict cardiovascular and all-cause death in asymptomatic women: a 20-year follow-up of the lipid research clinics prevalence study. JAMA. 2003; 290:1600–1607. [PubMed: 14506119]
49. Keteyian SJ, Brawner CA, Savage PD, et al. Peak aerobic capacity predicts prognosis in patients with coronary heart disease. Am Heart J. 2008; 156:292–300. [PubMed: 18657659]
50. Lakoski SG, Barlow CE, Farrell SW, Berry JD, Morrow JR Jr, Haskell WL. Impact of body mass index, physical activity, and other clinical factors on cardiorespiratory fitness (from the Cooper Center longitudinal study). Am J Cardiol. 2011; 108:34–39. [PubMed: 21529738]
51. Savage PD, Antkowiak M, Ades PA. Failure to improve cardiopulmonary fitness in cardiac rehabilitation. J Cardiopulm Rehabil Prev. 2009; 29:284–291. [PubMed: 19935140]

52. Janssen V, De Gucht V, Exel HV, Maes S. Beyond resolutions? A randomized controlled trial of a self-regulation lifestyle programme for post-cardiac rehabilitation patients. Eur J Prev Cardiol. 201210.1177/2047487312441728
53. Ades PA, Savage PD, Toth MJ, et al. High-calorie-expenditure exercise. A new approach to cardiac rehabilitation for overweight coronary patients. Circulation. 2009; 119:2671–2678. [PubMed: 19433757]
54. Audelin MC, Savage PD, Ades PA. Changing clinical profile of patients entering cardiac rehabilitation/secondary prevention programs: 1996 to 2006. J Cardiopulm Rehabil Prev. 2008; 28:299–306. [PubMed: 18784538]
55. Savage PD, Banzer JA, Balady GJ, Ades PA. Prevalence of metabolic syndrome in cardiac rehabilitation/secondary prevention programs. Am Heart J. 2005; 149:627–631. [PubMed: 15990744]
56. Savage PD, Brochu M, Scott P, Ades PA. Low caloric expenditure in cardiac rehabilitation. Am Heart J. 2000; 140:527–533. [PubMed: 10966557]
57. Sisson SB, Katzmarzyk PT, Earnest CP, Bouchard C, Blair SN, Church TS. Volume of exercise and fitness nonresponse in sedentary, postmenopausal women. Med Sci Sports Exerc. 2009; 41:539–545. [PubMed: 19204597]
58. Fleg JL, Morrell CH, Bos AG, et al. Accelerated longitudinal decline of aerobic capacity in healthy older adults. Circulation. 2005; 112:674–682. [PubMed: 16043637]
59. Ades PA, Savage PD, Brawner CA, et al. Aerobic capacity in patients entering cardiac rehabilitation. Circulation. 2006; 113:2706–2712. [PubMed: 16754799]
60. Earnest CP, Blair SN, Church TS. Age attenuated response to aerobic conditioning in postmenopausal women. Eur J Appl Physiol. 2010; 110:75–82. [PubMed: 20397024]
61. Gulati M, Black HR, Shaw LJ, et al. The prognostic value of a nomogram for exercise capacity in women. N Engl J Med. 2005; 353:468–475. [PubMed: 16079370]
62. Garber CE, Blissmer B, Deschenes MR, et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc. 2011; 43:1334–1359. [PubMed: 21694556]
63. Rice TK, Sarzynski MA, Sung YJ, et al. Fine mapping of a QTL on chromosome 13 for submaximal exercise capacity training response: the HERITAGE Family Study. Eur J Appl Physiol. 201110.1007/s00241-007-2274-8
64. Rankinen T, Sung YJ, Sarzynski MA, Rice TK, Rao DC, Bouchard C. Heritability of submaximal exercise heart rate response to exercise training is accounted for by nine SNPs. J Appl Physiol. 2012; 112:892–897. [PubMed: 22174390]
65. Bouchard C. Genomic predictors of trainability. Exp Physiol. 2012; 97:347–352. [PubMed: 21967902]
66. Thomaes T, Thomis M, Onkelinx S, et al. A genetic predisposition score for muscular endophenotypes predicts the increase in aerobic power after training: the CAREGENE study. BMC Genet. 2011:12–84.10.1186/1471-2156-12-84 [PubMed: 21255436]
67. Onkelinx S, Cornelissen V, Defoor J, et al. The CAREGENE study: genetic variants of the endothelium and aerobic power in patients with coronary artery disease. Acta Cardiol. 2011; 66:407–414. [PubMed: 21894794]
68. Bouchard C, Daw EW, Rice T, et al. Familial resemblance for VO2max in the sedentary state: the HERITAGE family study. Med Sci Sports Exerc. 1998; 30:252–258. [PubMed: 9502354]
69. Bouchard C, Sarzynski MA, Rice TK, et al. Genomic predictors of the maximal O(2) uptake response to standardized exercise training programs. J Appl Physiol. 2011; 110:1160–1170. [PubMed: 21183627]

Table 1

Baseline Characteristics by Randomization Group[a]

Characteristic	Traditional CR (n=99)	Tailored CR (n=137)
Age, mean (SD), y	64±11	63 ±11
Race or ethnicity, n (%)		
Non-Hispanic white	61 (62)	95 (69)
African American	17 (17)	22 (16)
Hispanic	20 (20)	19 (14)
Asian	1 (1)	1 (1)
Education, n (%)		
High school or less	42 (42)	58 (42)
Some college	41 (41)	46 (34)
Baccalaureate degree	9 (9)	24 (17)
Graduate degree	7 (7)	9 (6.5)
Marital Status, n (%)		
Married	54 (54)	73 (53)
Divorced/Separated	22 (22)	33 (24)
Widowed	15 (16)	26 (19)
Single never married	8 (8)	5 (4)
Diagnostic eligibility for cardiac rehabilitation, n (%)		
Percutaneous coronary intervention (PCI)	42 (42.4)	76 (55.5)
Coronary artery bypass graft surgery (CABG)	39 (39.4)	40 (29.2)
Stable angina	14 (14.1)	14 (10.2)
Myocardial infarction (MI)	4 (4.1)	7 (5.1)
Medications, n (%)		
β-Blockers	83 (84)	110 (80)
Statins	89 (90)	121 (88)
Aspirin	87 (88)	115 (84)
Clopidogrel	56 (57)	93 (68)
Angiotensin-converting enzyme inhibitor[b]	30 (30)	60 (44)
Angiotensin receptor blocker	28 (28)	30 (22)
Oral hypoglycemic agents	35 (35)	34 (25)
Nonsteroidal anti-inflammatory agents	23 (23)	35 (25)
Insulin	14 (14)	22 (16)
Pack years smoked, mean ± SD	16±22	18±22
Ejection Fraction, mean ± SD	54.1 ± 11.3	54.1 ± 10.4
Charlson Comorbidity Index, mean ± SD	2 ± 1.7	1.8 ± 1.4
Urine cotinine, ng/mL, mean ± SD	166 ± 389	106 ± 261

Abbreviations: CR, cardiac rehabilitation

[a]Continuous variables are reported as mean ± SD; categorical variables are presented as number and (%).

[b]χ^2 and *t* test for discrete and continuous variables, respectively; $P > .05$ for all except for angiotensin-converting enzyme inhibitor ($P = .042$).

Table 2

Clinical Characteristics of Women Before and after Cardiac rehabilitation (n=236)

			Traditional (n=99)				Tailored (n=137)			
Characteristic	F^a	(η^2)	**Baseline**	**Post-CR**	F^b	(η^2)	**Baseline**	**Post-CR**	F^c	(η^2)
Physiological, mean±SD										
Total cholesterol, mg/dL	.53	.002	167±36	158±36	6.71[d]	.028	163±43	157±38.5	3.75	.016
LDL-cholesterol, mg/dL	.31	.001	91.9±31.9	85.6±29.6	3.72	.018	89.3±31.5	85±29.5	1.91	.009
HDL-cholesterol, mg/dL	.03	.000	44.1±14	44.8±13	.50	.002	46.0±13	47.0±14	1.17	.005
Triglyceride, mg/dL	.15	.001	162±79	151±102	9.21[d]	.038	149±85	141±102	8.93[d]	.037
TC/HDL ratio	1.11	.005	4.2±1.9	3.8±1.5	8.16[d]	.034	3.8±1.5	3.6±1.2	3.02	.013
Fasting glucose, mg/dL	6.34[d]	.026	107±31	113±38	3.17	.013	111±42	106±32	3.22	.014
Body mass index, kg/m^2	<1	.000	31.1±6.7	30.9±6.7	2.10	.009	31.1±7	30.9±7	2.66	.011
Waist circumference, cm	.18	.001	100.0±15	99.0±15	10.37[d]	.042	99.6±16	97.7±16	19.74[d]	.078
Percent body fat	.52	.002	36.8±5.4	36.6±5.8	.61	.003	36.3±6.1	35.9±5.8	4.09[d]	.018
Weight, pounds	.01	.000	180±40.5	178.6±41	3.14	.013	179±44	178±44	3.70	.016
Psychosocial, Mean±SD										
Anxiety	.91	.004	34.4±12	32.9±10.7	1.65	.007	34.9±11.6	32.0±10.8	8.91[d]	.037
Depressive symptoms	7.54[d]	.031	16.7±10.6	14.4±10	5.29[d]	.022	17.8±12	11.8±10.5	48.25[d]	.171
MDT Quality of Life	9.87[d]	.040	35.4±6.6	35.9±7.4	.60	.003	34.8±7.5	37.8±7.9	33.24[d]	.124
SASS	9.49[d]	.039	7.1±1.9	7.2±1.9	.14	.001	7.0±2.1	7.9±1.5	26.99[d]	.103
SF-36 Health Survey, Mean±SD										
Physical Functioning	2.32	.010	49.5±25.1	60.8±26	24.56[d]	.095	48.2±24.6	64.1±25.6	66.93[d]	.222
General Health	7.49[d]	.031	58.6±20.9	59.2±20.5	.12	.001	58.1±18.8	65.1±19.1	21.47[d]	.084
Social Functioning	4.57[d]	.091	68.4±26.1	75.9±25.2	7.93[d]	.033	63.4±26.8	78.3±27.1	43.77[d]	.158
Role Physical	5.85[d]	.024	45.6±25	61.3±27	30.10[d]	.114	41.9±24	66.8±27	103.82[d]	.307
Bodily Pain	2.34	.010	53.7±23.3	57.5±26.7	2.75	.012	51.6±24	59.9±24	18.59[d]	.074
Role Emotional	2.86	.012	65.1±27.3	74.8±24.8	12.77[d]	.052	62.5±29.9	78.2±24.3	46.45[d]	.166
Vitality	9.73[d]	.040	47.7±22.2	53±22.8	6.82[d]	.028	45.9±19.2	59.3±20.7	62.21[d]	.210

Characteristic	F^a	(η^2)	Traditional (n=99) Baseline	Traditional (n=99) Post-CR	F^b	(η^2)	Tailored (n=137) Baseline	Tailored (n=137) Post-CR	F^c	(η^2)
Mental Health	7.05[d]	.029	68.4±21.4	72.3±20.7	4.71[d]	.020	65.3±21.6	75.3±19.1	44.28[d]	.159

Abbreviations: CR, cardiac rehabilitation; HDL, high-density lipoprotein; LDL, low-density lipoprotein; MDT, multiple discrepancies theory; SASS, self-anchoring striving scale; TC, total cholesterol

[a]F test of group by time interaction (degrees of freedom = 1, 234)

[b]F test of simple main effect of time for traditional group (degrees of freedom = 1, 234)

[c]F test of simple main effect of time for tailored group (degrees of freedom = 1, 234)

[d]$P<.05$; Results presented as mean ± SD; η^2, eta squared (standardized effect size measure)

Table 3

Exercise Capacity by Treatment Group Before and after Cardiac rehabilitation (n=232)

Variable			Traditional (n=99)				Tailored (n=137)			
	***F*[a]**	**(η^2)**	**Baseline**	**Post-CR**	***F*[b]**	**(η^2)**	**Baseline**	**Post-CR**	***F*[c]**	**(η^2)**
Resting HR, bpm	.66	.003	72.6±13	69.8±12	6.56[d]	.028	73.6±6	69.6±10	18.87[d]	.076
Resting SBP, mm Hg	.28	.001	124.3±17.6	119.6±16	6.93[d]	.029	121.2±16.4	115.2±15	15.92[d]	.065
Resting DBP, mm Hg	.13	.001	73.8±10.7	71.9±9	2.43	.010	72.6±9.6	70.2±9.5	5.88[d]	.025
Resting RPP	.23	.001	91.0±24	83.7±19.5	12.85[d]	.053	89.1±21	80.5±17	25.58[d]	.100
Peak HR, bpm	2.08	.009	115.9±23.6	117.7±24	.93	.004	121.7±22	120.0±21	1.20	.005
Peak SBP, mm Hg	.23	.001	166.3±22.7	161.4±23	3.87	.017	162.3±21.7	159.0±24	2.63	.011
Peak DBP, mm Hg	.60	.003	83.7±12.2	80.7±12	6.00[d]	.025	80.8±12.4	79.0±12	3.00	.013
Peak RPP	.60	.003	195.5±57	192.5±52	.35	.002	199.0±52	191.0±52	3.69	.016
Peak exercise capacity, METs	<1	.000	5.6±2.3	7.1±2.8	68.82[d]	.230	6.0±2.7	7.6±2.8	98.62[d]	.300
Peak treadmill time, min	2.00	.009	8.0±3.3	10±3.7	60.51[d]	.208	8.3±3.7	10.8±3.3	133.45[d]	.367

Abbreviations: bpm, beats per minute; CR, cardiac rehabilitation; DBP, diastolic blood pressure; HR, heart rate; MET, metabolic equivalent; η^2, eta squared (standardized effect size measure); RPP, rate pressure product ((HR × SBP/100); SBP, systolic blood pressure

[a]F test of group by time interaction (degrees of freedom = 1, 230)

[b]F test of simple main effect of time for traditional group (degrees of freedom = 1, 230)

[c]F test of simple main effect of time for tailored group (degrees of freedom = 1, 230)

[d]$P < .05$; Results presented as mean ± SD.

Table 4

Predictors of Peak Metabolic Equivalents after Cardiac Rehabilitation (n=232)

Predictor	Unstandardized Coefficient (B)	Standard Error	Standardized Coefficient (β)
Step 1			
Intercept	2.319[a]	0.300	
Baseline MET	0.869[a]	0.047	.772
Step 2			
Intercept	5.867[a]	1.345	
Baseline MET	0.631[a]	0.053	.560
Physical functioning	0.031[a]	0.005	.276
Waist circumference	−0.021[a]	0.008	−.115
Age	−0.032[a]	0.011	−.124

R^2 = .596 for Step 1, $F_{(1,230)}$ = 339.648, P<.001; ΔR^2 = .086, $F_{(3, 227)}$ = 20.606, P<.001; Final model R^2 = .683, $F_{(4,227)}$ = 122.081, P<.001.

[a] P<.05.

Abbreviations: MET, metabolic equivalents

Table 5

Predictors of Exercise Treadmill Time after Cardiac Rehabilitation (n=232).

Predictor	Unstandardized Coefficient (B)	Standard Error	Standardized Coefficient (β)
Step 1			
Intercept	4.462[a]	0.383	
Baseline Treadmill Time	0.731[a]	0.043	.746
Step 2			
Intercept	8.536[a]	1.632	
Baseline Treadmill Time	0.507[a]	0.045	.517
Physical Functioning	0.046[a]	0.006	.338
Waist Circumference	−0.029[a]	0.009	−.128
Age	−0.037[a]	0.013	−.116

R^2 = .557 for Step 1, $F_{(1, 230)}$ = 289.417, P<.001; ΔR^2 = .126, $F_{(3, 227)}$ = 30.090, P<.001; Final model R^2 = .683, $F_{(4, 227)}$ = 122.375, P<.001.

[a]P<.05.