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Cardiac Rehabilitation Outcomes: Impact of Comorbidities and Age

Jennifer Listerman, MD¹, Vera Bittner, MD, MSPH¹, Bonnie K. Sanderson, PhD, RN², and Todd M. Brown, MD, MSPH¹

¹University of Alabama at Birmingham, Birmingham, Alabama

²Auburn University, Auburn, Alabama

Abstract

PURPOSE—Medical comorbidities (CM) contribute to cardiac rehabilitation (CR) underutilization. Whether individuals with coronary heart disease (CHD) and an increased CM burden achieve similar benefits from CR as those with a low CM burden is unknown.

METHODS—We analyzed 794 patients with CHD completing CR from 1/96 to 4/08. CM burden was assessed using a comorbidity index (CMI) previously validated in a CR population. Distance achieved on a 6 minute walk test, body mass index, and the physical and mental component scores on the Medical Outcomes Short Form 36 were measured at baseline and at CR completion. We performed multivariable linear regression to compare changes in these parameters between individuals with a low CM burden (CMI=0) and those with a moderate (CMI=1–2) or high (CMI >2) CM burden by age group (<56, 56–65, and >65 years of age).

RESULTS—Mean age was 61.6±10.6 years, 29% were women, 31% non-white; 305 individuals had a CMI=0, 305 had a CMI=1–2, and 184 had a CMI >2. All subgroups, regardless of age or CMI, demonstrated improvements with CR on virtually all parameters measured. Among individuals <56 years old, those with a CMI=0 had greater improvements in these parameters after multivariable adjustment than those with a CMI of 1–2 or >2. In contrast, in older age groups, the degree of improvement was similar regardless of CMI.

CONCLUSION—All patient groups, regardless of CM burden, benefited from CR. CM burden, especially among older patients, should not discourage referral to CR.

Key words or phrases

Cardiac rehabilitation outcomes; comorbidities; age

Participation in comprehensive outpatient cardiac rehabilitation (CR) programs results in improvements in exercise capacity, body mass index, lipid profiles, measures of psychosocial well-being and quality of life, and mortality among patients with coronary heart disease (CHD).^{1–4} The mounting scientific evidence on the benefits of CR prompted the American College of Cardiology and the American Heart Association to recommend diagnoses of recent myocardial infarction, unstable angina, stable angina, percutaneous

Corresponding Author: Todd M. Brown, MD, MSPH, University of Alabama at Birmingham, LHRB 313, 701 19th Street South, Birmingham, AL, 35294, 205-934-9630 (phone), 205-975-6237 (fax), tmbrown@uab.edu.

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coronary intervention, or coronary artery bypass graft surgery as Class I indications for participation in a CR program.⁵⁻⁷ Despite these data on the benefits of CR and national guideline recommendations, only a fraction of potentially eligible CHD patients are referred to and participate in CR.^{8,9}

Numerous factors have been shown to influence CR participation and completion. Patient variables such as education level, marital status, gender, age, race, socioeconomic status, baseline level of functioning, and perceived self-efficacy have been demonstrated to influence whether eligible patients enroll and/or complete CR.¹⁰⁻¹² Institutional variables, such as ease of patient access to the program and referring physician belief in the effectiveness of CR have also been associated with CR utilization.¹⁰⁻¹²

The presence of multiple medical comorbidities is another important factor that is associated with a lower odds of referral to and participation in CR.^{8,9} Previous studies have examined the benefit of CR in isolated medical comorbidities such as chronic kidney disease,¹³ diabetes,¹⁴⁻¹⁶ heart failure,¹⁷ or peripheral arterial disease.^{18,19} However, these studies did not examine the impact of multiple coexistent medical comorbidities on benefits from CR. Whether patients with CHD with a high medical comorbidity burden benefit from CR to the same degree as patients without medical comorbidities is unknown. Therefore, the goal of the current study is to examine whether patients with CHD who have multiple medical comorbidities derive the same benefit from participation in CR as patients with CHD who do not have any significant medical comorbidities. We hypothesized that individuals with multiple medical comorbidities would benefit from CR, but the magnitude of benefit would be less than for those with no medical comorbidities.

METHODS

Of the 1,316 individuals with CHD who enrolled in an academic medical center CR program between January 1, 1996 and April 30, 2008, we included the 794 individuals (60%) who completed the program. At the time of enrollment into CR, each participant completed an initial assessment by a registered nurse or exercise physiologist. Baseline demographic information, systolic and diastolic blood pressures, fasting lipid profiles, waist circumferences, body mass indices, hemoglobin A1C levels (in those with diabetes), and each participant medication list were documented. Cardiovascular risk factors and noncardiovascular medical comorbidities as documented in the medical record were ascertained and medical comorbidities were summarized in a weighted comorbidity index (CMI) for each participant as previously reported.²⁰ The derivation of the CMI is shown in Table 1. Functional capacity was assessed by 6 minute walk tests at baseline and upon CR completion. The 6 minute walk test was conducted on a walking track in the CR unit based on a previously published protocol.²¹ To assess health related quality of life, physical and mental component scores from the Medical Outcomes Short Form 36 (SF-36)²² were computed at CR entry and completion.

Based on baseline functional capacity, risk factor burden, and medical comorbidities, each participant was given an individualized prescription for exercise and risk factor modification. CR sessions included telemetry-monitored exercise, individual counseling, and group education. A typical treatment course involved 24 to 36 prescribed sessions with sessions occurring 2 to 3 times per week and lasting for approximately 1 hour. Exercise sessions consisted of a combination of aerobic and resistance training. Each participant was reevaluated regularly to monitor progress and to advance the intensity of the exercise prescription as appropriate. This study was approved by the Institutional Review Board of the University associated with our academic medical center where the study was conducted.

Informed consent was obtained from all participants at the time of enrollment for the use of individual data for clinical purposes and aggregate participant data for research purposes.

Statistical Analyses

Initially, we constructed 4 separate linear regression models to investigate the association between CMI group and changes with CR in 6 minute walk test distance, body mass index, and the physical and mental component scores of the SF-36 after adjustment for age, gender, race, and the baseline value of these outcome measures. With these linear regression models, we detected a statistically significant interaction between age and CMI for changes in the physical component score of the SF-36 ($P=.018$), the mental component score of the SF-36, ($P=.009$), and body mass index ($P=.015$), we chose to stratify our analyses by age and CMI. Age was categorized using the following subgroups: age<56, 56–65, and >65 years. Based on the baseline CMI, we classified each individual as having a low (CMI = 0), moderate (CMI = 1–2), or high (CMI >2) medical comorbidity burden for this analysis. Next, using paired T-tests, we compared changes in the distance achieved on a 6 minute walk test, body mass index, and the physical and mental component scores of the SF-36 from baseline to completion stratified by age and CMI. Because this involved conducting multiple t-tests, we adjusted the p-value using the Bonferroni method (alpha/the number of tests) to determine statistical significance. To determine whether the magnitude of the changes in functional capacity, body mass index, and the physical and mental component scores on the SF-36 were uniform across CMI and age subgroups, we performed multivariable linear regression, adjusting for age, gender, race, and the baseline value of the outcome measure.

RESULTS

The mean age of our participants was 61.6 ± 10.6 years. There were 249 individuals under age 56, 235 who were age 56–65, and 310 over age 65. Overall, 29% of our participants were women. There were slightly fewer women in the <56 age category (23%) than in the 56–65 (30%) or >65 (33%) age categories (Pearson Chi Square 6.04, 2 df, $P=.049$). Overall, 31% of participants were non-white, and the proportion of non-white individuals did not vary across the age categories. A total of 305 individuals had a CMI of 0 (CMI Low), 305 had a CMI of 1–2 (CMI Moderate), and 184 had a CMI >2 (CMI High). The frequencies of medical comorbidities for those with a moderate or high CMI are shown in Table 1. Compared to those with a CMI of 0, those with a moderate or high CMI were prescribed more CR sessions and attended more sessions. Individuals with a moderate CMI were prescribed an average of 29.1 ± 7.8 sessions compared to 25.9 ± 8.4 ($P<.001$) for those with a CMI of 0 and attended 28.7 ± 8.0 sessions compared to 25.7 ± 8.2 ($P<.001$) for those with a CMI of 0. Individuals with a high CMI were prescribed an average of 30.7 ± 7.5 sessions compared to 25.9 ± 8.4 ($P<.001$) for those with a CMI of 0 and attended 30.6 ± 7.3 sessions compared to 25.7 ± 8.2 ($P<.001$) for those with a CMI of 0.

Changes in the distance achieved on a 6 minute walk test, body mass index, and the physical and mental component scores on the SF-36 with CR for each subgroup are shown in Table 2. Even after adjustment for multiple comparisons, most age/CMI subgroups demonstrated statistically significant improvements in 6 minute walk test distance, body mass index, and the physical and mental component scores on the SF-36 (Table 2). Next, we examined whether the magnitude of benefit with CR for each of these outcomes measures was different among individuals with varying degrees of medical comorbidity burden (Table 3). Among individuals <56 years old, those with a low CMI had statistically significant greater improvements in virtually all outcomes measured when compared to those with a moderate or high CMI (Table 3). Among individuals 56–65 years of age, those with a low CMI had statistically significant greater improvements in 6 minute walk distance compared to those with a moderate CMI and 6 minute walk distance and BMI when compared to those with a

high CMI (Table 3). Among individuals >65 years of age, those with low CMI only demonstrated a significantly greater increase in 6 minute walk distance as compared to those with a high CMI, but there were no other statistically significant differences compared to those with a moderate or high CMI in the remainder of the outcomes measured (Table 3).

DISCUSSION

We demonstrated that virtually all individuals with CHD, regardless of their age or **medical** comorbidity burden, can benefit from participation in CR with improvements in 6 minute walk distance, body mass index, and the physical and mental component scores of the SF-36. The degree to which medical comorbidities reduce the magnitude of this improvement, however, seems to vary with age. Among younger CHD patients, the presence of a moderate or high CMI was associated with significantly less improvement in most of the outcome parameters measured compared to patients in this age group with a CMI of 0. However, among those 56–65 and >65 years of age, the magnitude of the benefit with CR was similar, regardless of CMI, for most of the outcomes that we measured, suggesting that the presence of medical comorbidities in these individuals has no significant impact on the benefit of CR among those who are able to complete the program.

Recent analyses of large, national data sets, the Medicare Claims Database⁸ and the Get With The Guidelines Program,⁹ suggest that older age and most medical comorbidities are associated with a lack of referral to and participation in CR. The referring physician perception about the likely benefit of CR is an important predictor of referral to CR.²³ Therefore, if physicians do not believe that older individuals or those with multiple medical comorbidities are likely to benefit from CR, they may be less likely to refer them. Our data would suggest that individuals with medical comorbidities who complete CR do benefit to a similar extent as those without medical comorbidities, particularly in those >65 years of age.

The benefits of CR in older individuals have been explored in previous studies. Participation in a CR program by individuals over the age of 65 years has been associated with increases in aerobic capacity, body strength, quality of life, and overall physical function.^{24–32} Additionally, participation in a CR program among individuals who are over age 75 has been associated with increases in physical function, the achievement of secondary prevention goals, and improvements in the functional status and lipid profiles.^{33–35} Additionally, a number of studies have examined the impact of individual medical comorbidities on CR outcomes. In the recent Heart Failure: A Controlled Trial Investigating Outcomes of Exercise Training (HF-ACTION) clinical trial,^{17,36} individuals with heart failure randomized to CR demonstrated statistically significant improvements in exercise time, peak oxygen uptake, and health status but only nonsignificant improvements in clinical end points compared to those randomized to usual care. Among individuals with diabetes, CR is associated with improvements in exercise capacity, behavioral characteristics, and quality of life.^{14,15} However, the degree of this improvement with CR may be less than in those without diabetes.¹⁶ Similarly, individuals with chronic kidney disease achieve benefits from CR participation as compared with individuals without chronic kidney disease.¹³ Additionally, exercise training is associated with reduced symptoms and improved quality of life among individuals with claudication as a result of peripheral arterial disease.^{18,19}

Our data extend these findings and contribute important new information on the benefits of CR among individuals with multiple medical comorbidities or a high medical comorbidity burden. The benefits of CR among those who completed our program were similar regardless of CMI in those ≥ 56 and especially among those >65 years of age. These findings have important clinical implications. Due to the overall aging of the population and improvements in the prevention and treatment of cardiovascular diseases, CR programs are

seeing an older population with an increasing number of medical comorbidities.³ Physicians should be encouraged to refer these individuals to CR and should not view age or medical comorbidity burden as a barrier for referral to or participation in CR. Additionally, although younger individuals with multiple medical comorbidities did not improve with CR to the same degree as their counterparts without medical comorbidities, virtually all subgroups of these individuals did improve to some degree. Importantly, we did not identify a subgroup that did not benefit to at least some degree from CR.

Our study has a number of limitations. First, these data represent CR participants from a single, academic medical center located in the southeastern United States. These findings may not be representative of other programs in different settings or geographic locations. Second, given that we lack a control group, we cannot exclude that some improvement in the outcome parameters studied could have occurred even without attendance in CR. This limits our ability to draw causal inferences. Third, we only examined those individuals who were able to complete CR. Compared to those with a CMI of 0, a high CMI (OR 1.4, 95% CI 1.1, 1.9) but not a moderate CMI (OR 1.1, 95% CI 0.8, 1.4) was associated with the failure to complete CR. Therefore, we are unable to assess whether the improvements in outcomes with CR that we observed would extend to those individuals with medical comorbidities who currently do not enroll in or fail to complete CR.

Virtually all subgroups of participants with CHD, regardless of age or CMI, demonstrated improvements in functional capacity, body mass index, and health related quality of life with CR. Additionally, there was almost no difference in the magnitude of these improvements in individuals with a high medical comorbidity burden compared to those with no medical comorbidities among those ≥ 56 years of age and especially among those > 65 years of age. These findings suggest that age and medical comorbidity burden should not prevent patients from attending CR or serve as a barrier to physician referral.

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Table 1

Frequency and Arithmetic Weights of the Medical Comorbidities Included in the Comorbidity Index²⁰ by CMI Group^a

	Weights	CMI Mod	CMI High
Peripheral arterial disease	1	7%	31%
Dementia	1	1%	6%
Cerebrovascular disease	1	13%	29%
Chronic obstructive pulmonary disease	1	11%	25%
Connective tissue disease	1	4%	7%
Peptic ulcer disease	1	10%	24%
Diabetes	2	50%	82%
Nonmetastatic cancer	2	15%	38%
End stage renal disease	2	0%	4%
Cirrhosis	3	0%	3%
Metastatic cancer	6	0%	0%

^aThe final comorbidity index is the sum of the total number of points for each comorbidity present.

CMI, comorbidity group

6 Minute Walk Distance, Body Mass Index, PCS, and MCS Before and After Cardiac Rehabilitation by Comorbidity Index and Age Group

Table 2

	CMI Low			CMI Mod			CMI High		
	Before CR	After CR	P value	Before CR	After CR	P value	Before CR	After CR	P value
Individuals <56 y of age (n=249)									
6 MWT, ft	1503±321	1788±281	<.001 ^a	1385±344	1639±419	<.001 ^a	1187±392	1388±435	<.001 ^a
BMI, kg/m²	30.0±5.1	29.2±4.8	<.001 ^a	32.5±6.0	32.1±5.9	.034	33.7±8.0	33.6±7.8	.682
PCS	40.6±10.2	49.7±8.3	<.001 ^a	34.1±9.9	43.0±10.7	<.001 ^a	28.5±9.4	34.4±11.4	.002
MCS	50.1±10.2	54.1±7.0	<.001 ^a	48.0±12.2	50.4±11.1	.010	43.8±11.7	47.7±10.4	.027
Individuals 56–65 y of age (n=235)									
6 MWT, ft	1463±331	1759±301	<.001 ^a	1328±356	1562±399	<.001 ^a	1127±401	1371±434	<.001 ^a
BMI, kg/m²	28.3±4.5	27.7±4.2	<.001 ^a	31.0±6.0	30.3±5.6	<.001 ^a	31.7±6.9	31.4±6.5	.031
PCS	39.3±9.8	48.0±9.7	<.001 ^a	36.1±9.2	42.9±10.4	<.001 ^a	32.6±9.0	36.8±11.3	.003
MCS	50.6±11.0	53.6±7.7	.009	48.4±10.5	53.7±10.0	<.001 ^a	44.7±10.2	50.6±9.5	<.001 ^a
Individuals >65 y of age (n=310)									
6 MWT, ft	1262±343	1494±344	<.001 ^a	1203±335	1386±324	<.001 ^a	1113±416	1312±428	<.001 ^a
BMI, kg/m²	27.2±4.5	26.7±4.4	.001 ^a	28.8±5.9	28.3±5.6	<.001 ^a	28.8±5.5	28.5±5.1	.040
PCS	37.0±9.8	43.9±9.3	<.001 ^a	35.7±9.3	42.3±9.6	<.001 ^a	32.9±8.9	40.1±10.9	<.001 ^a
MCS	51.0±8.9	55.0±7.6	<.001 ^a	49.8±10.1	55.6±7.4	<.001 ^a	48.8±11.6	53.8±8.3	<.001 ^a

^a Statistically significant after Bonferroni correction for multiple comparisons. A total of 36 comparisons were performed. As such, a *P* value <.0014 (0.05/36) was considered statistically significant.

Abbreviations: 6 MWT, 6 minute walk test; BMI, body mass index; CMI, comorbidity index; CR, cardiac rehabilitation; MCS, mental component score of the Medical Outcomes Study; Mod, moderate; PCS, physical component score of the Medical Outcomes Study.

Table 3

Comparison of Changes in 6 Minute Walk Distance, Body Mass Index, PCS, and MCS with Cardiac Rehabilitation by Comorbidity Index and Age Group after Multivariable Adjustment^{a,b}

	6 MWT (feet) Change (95% CI)	BMI (kg/m ²) Change (95% CI)	PCS Change (95% CI)	MCS Change (95% CI)
Individuals <56 y of age (n=249)				
CMI Low	Referent	Referent	Referent	Referent
CMI Moderate	-64 (-137, 8.6)	0.6 (0.2, 0.9)	-3.5 (-5.9, -1.1)	-2.5 (-4.5, -0.5)
CMI High	-203 (-297, -109)	0.8 (0.4, 1.3)	-9.3 (-12.6, -6.0)	-4.0 (-6.8, -1.2)
Individuals 56–65 y of age (n=235)				
CMI Low	Referent	Referent	Referent	Referent
CMI Moderate	-87 (-161, -12)	0.2 (-0.1, 0.5)	-1.36 (-4.2, 1.4)	1.0 (-1.5, 3.4)
CMI High	-119 (-204, -35)	0.6 (0.2, 0.9)	-2.8 (-6.1, 0.6)	-1.2 (-4.0, 1.6)
Individuals >65 y of age (n=310)				
CMI Low	Referent	Referent	Referent	Referent
CMI Moderate	-54 (-109, 0.6)	0.2 (-0.1, 0.5)	-0.8 (-3.0, 1.5)	0.7 (-1.3, 2.8)
CMI High	-71 (-133, -10)	0.3 (-0.1, 0.8)	-1.7 (-4.3, 1.0)	-0.7 (-3, 1.5)

^a Models are adjusted for age, gender, race, and the baseline value of the parameter. Statistically significant findings are bolded and italicized.

^b The parameter estimates above reflect the magnitude of change in the outcome variables with Cardiac Rehabilitation in those with a moderate or high CMI relative to those with a low CMI. As an example, for individuals who are less than 56 years of age, the parameter estimate for change in body mass index is 0.6 for individuals with a CMI that is moderate vs. low. This does not mean that body mass index increased. Rather, this means that the change in body mass index was 0.6 points higher (or in this case 0.6 points less negative) in the moderate group than the low group, after multivariable adjustment.

Abbreviations: 6 MWT, 6 minute walk test; BMI, body mass index; CMI, comorbidity index; MCS, mental component score of the Medical Outcomes Study; PCS, physical component score of the Medical Outcomes Study.