Patients with Diabetes in Cardiac Rehabilitation: Attendance and Exercise Capacity

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ABSTRACT

ARMSTRONG, M. J., B.-J. MARTIN, R. ARENA, T. L. HAUER, L. D. AUSTFORD, J. A. STONE, S. AGGARWAL, and R. J. SIGAL. Patients with Diabetes in Cardiac Rehabilitation: Attendance and Exercise Capacity. *Med. Sci. Sports Exerc.*, Vol. 46, No. 5, pp. 845–850, 2014. **Purpose**: Diabetes increases mortality after myocardial infarction, but participation in cardiac rehabilitation (CR) reduces this risk. Our objectives were to examine whether attendance at CR and changes in cardiorespiratory fitness differed according to diabetic status and sex. **Methods**: Retrospective cohort study of patients referred for CR in Calgary between 1996 and 2010. Cardiorespiratory fitness in metabolic equivalents (METs) was estimated by maximal exercise testing at baseline, at the end of the 12-wk CR program, and 1-yr after CR. **Results**: Among 7036 nondiabetic and 1546 diabetic patients who started, 84.9% of nondiabetic versus 79.5% of diabetic patients completed CR ($P < 0.0001$). The difference between diabetic and nondiabetic patients was greater in women (81.7% vs 72.1%, $P < 0.0001$) than that in men (86.0% vs 82.5%, $P = 0.004$). Patients without diabetes were more likely to return for the 1-yr assessment (53.7% vs 42.7%, $P < 0.0001$), and nondiabetic women were more likely than diabetic women to attend the 1-yr follow-up (44.3% vs 31.7%, $P < 0.0001$). Change in cardiorespiratory fitness from baseline to 12 wk was +1.0 METs in nondiabetic men, +0.9 METS in diabetic men, +0.9 METs in nondiabetic women, and +0.7 METs in diabetic women (within-group change; $P = 0.0009$). Changes in cardiorespiratory fitness at 1 yr compared with baseline were +0.9, +0.6, +0.9, and +0.5 METS, respectively (within-group change, $P = 0.0001$). **Conclusions**: Patients with diabetes, especially females, were less likely than patients without diabetes to complete CR and attend follow-up. Among patients who attended 1-yr follow-up, changes in cardiorespiratory fitness were not as well maintained in diabetic patients as in nondiabetic patients. Identifying barriers and targeting CR adherence interventions to patients with diabetes may help improve outcomes. **Key Words:** DIABETES MELLITUS, CORONARY ARTERY DISEASE, CARDIORESPIRATORY FITNESS, DIABETES COMPLICATIONS, PATIENT COMPLIANCE

Coronary artery disease (CAD) is the most common cause of death in people with diabetes mellitus. Diabetes is independently associated with a twofold increased incidence of a first myocardial infarction (MI) (27) and a twofold increased 5-yr mortality rate after MI, after adjustment for other risk factors (28).

Cardiac rehabilitation (CR) is an essential component of comprehensive care after MI and a key element in secondary prevention. Attendance at CR is strongly associated with a reduction in mortality and morbidity; meta-analyses of randomized trials found that exercise-based CR programs in CAD patients reduced overall mortality by 13%, cardiovascular disease (CVD) mortality by 26%, and hospital admissions by 31% compared with those randomized to no-CR control groups (14). CR has been shown to contribute significantly to the reduction in coronary heart disease mortality, to an extent comparable with reductions obtained from B-blockers, aspirin, or statin therapy (11). CR is indicated with class I evidence for patients after acute coronary syndrome and coronary revascularization and those with stable angina (29,31).

CR programs involve comprehensive multidisciplinary interventions, including diet modification, smoking cessation, lipid control, stress management, and exercise-therapy, with exercise commonly at the core of CR programs. The improvement in cardiorespiratory fitness is particularly important

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given the strong evidence demonstrating that higher cardiorespiratory fitness is consistently associated with lower mortality in both those with coronary heart disease (17,18) and those with diabetes (5,6). In apparently healthy individuals, for each metabolic equivalent (MET) increase in exercise capacity, there is a 13% decrease in all-cause mortality (19). Other investigations have demonstrated the prognostic importance of cardiorespiratory fitness in large CR cohorts (17,18). People with type 2 diabetes comprise a considerable portion of all patients with MI requiring revascularization procedures, and in turn this population represents a large portion of those being referred to CR with reported rates most often around 20% and as high as 44% (10,23). The benefits of exercise training in patients with diabetes are well established (7). Despite this, there are limited data that specifically address CR in people with diabetes. In addition, it has been shown that sex differences exist in CR attendance (9,20), with females demonstrating much lower rates of attendance. It is not clear how these differences are expressed in patients with diabetes.

To date, relatively few studies have examined CR and exercise capacity in people with diabetes (2,15,22,23,30,32), and it is unclear whether CR leads to similar improvements in exercise capacity in those with and without diabetes. Furthermore, to our knowledge, no studies have explored differences by sex. The purpose of the present investigation was to examine whether attendance at a CR program and increases in cardiorespiratory fitness differed according to diabetes status and sex in a cohort of sufficient size to address these aims with appropriate statistical power.

METHODS

Study population. We conducted a retrospective cohort study of patients who began CR at the Cardiac Wellness Institute of Calgary (CWIC) between September 1996 and January 2010. CWIC provides a centralized interventional CR program in the city of Calgary, Alberta, Canada. Data used for this analysis were captured in a prospectively collected clinical database that includes records on all patients referred to the CR program. Additional data on patient comorbidities, coronary disease anatomy, and interventions (coronary artery bypass grafting [CABG] or percutaneous coronary intervention [PCI]) were obtained from the Alberta Provincial Project for Outcome Assessment in Coronary Heart (APPROACH) disease database (13), a prospectively collected clinical database with detailed clinical information and outcomes on all patients undergoing cardiac catheterization and/or revascularization in the province of Alberta since 1995. Approval for this study was granted by the University of Calgary Conjoint Health Research Ethics Board.

All patients included in the present analysis had documented coronary artery disease. Patients were considered to have diabetes if, at the time of cardiac catheterization, the patient reported a history of diabetes diagnosed or treated by a physician, or if diabetes was indicated in the patient's hospital chart. As an additional data enhancement in APPROACH, this information is cross-checked through extensive data audits where records are merged with administrative databases to confirm diagnoses based on hospital coding in the Discharge Abstract Database.

The program consisted of a 12-wk supervised exercise program, twice per week, with the participants encouraged to undertake two to three additional exercise sessions weekly on their own. The 1-h program sessions were directly supervised by clinical exercise specialists and registered nurses who ensured patients were exercising safely and at an appropriate level of intensity. After the supervised aerobic training session, a stretching and/or resistance training session with elastic tubing was offered. All patients underwent baseline assessment, including complete physical exam, anthropometric measurements, and maximal exercise treadmill test (see description in the next section). In addition, they were offered classes in nutrition and stress management, along with a referral to a dietician or social worker as needed. Medication changes were made under physician direction, in accordance with the treatment targets set forth by evidence-based clinical practice guidelines (24). All patients underwent repeat assessment at program completion.

Study variables and evaluation procedures. At the intake assessment, clinical characteristics related to cardiovascular risk (e.g., body mass index [BMI], waist circumference, smoking status, laboratory measurements such as lipid panel, hemoglobin A_{1c}, and plasma glucose) were determined and recorded in the CWIC database before CR initiation. Cardiorespiratory fitness was assessed by a symptom-limited maximal exercise stress testing at baseline (i.e. before CR initiation), at the end of the 12-wk program, and at 1-yr postprogram completion. Testing was performed on a treadmill using the Bruce or modified Bruce protocol (3). Each patient was tested with the same treadmill protocol for initial and follow-up exercise testing. The peak estimated MET value was calculated from treadmill speed and grade during the final stage of the exercise protocol using an established equation (21). METs represent a measure of intensity, with one MET defined as the amount of energy consumed while sitting quietly at rest. Maximal aerobic (cardiorespiratory) capacity is reflected in the peak METs achieved on a maximal exercise test. Patients were considered to have started the CR program if they completed the baseline assessment. If patients completed both the baseline and the 12-wk post-CR assessment, they were considered to have completed CR. Reasons for withdrawal (i.e., medical vs nonmedical) from the program were captured and entered into the CWIC database by the program staff.

Statistical analysis. Statistical analysis was performed using Stata (version 11; Stata Corp, College Station, TX). Key baseline differences in categorical data were assessed using χ^2 testing, and differences in continuous baseline data were assessed using a one-way ANOVA according to diabetes classification. Differences in attendance rates were assessed using χ^2 tests, and a mixed model ANOVA was used to assess differences in peak METs achieved according to sex and diabetes status. Multivariate analyses were conducted adjusting for age, sex, presence of chronic obstructive pulmonary disease, peripheral vascular disease, and type of revascularization (i.e., PCI, CABG, or no revascularization). This was performed using linear regression for continuous outcome variables (changes in aerobic fitness between baseline and 12 wk and between baseline and 1 yr post-CR) and logistic regression for binary outcome variables (attendance at 12 wk and attendance at 1 yr after CR). All statistical tests with $P < 0.05$ were considered significant.

RESULTS

A total of 8582 patients were identified as starting the CR program between 1996 and 2010. Baseline demographics and clinical characteristics are shown in Table 1. Of those who began the CR program, 22% were identified as having diabetes. Patients with diabetes were slightly older and had higher mean BMI and waist circumference than patients without diabetes. Patient with diabetes were also more likely to be hypertensive and had higher prevalence of congestive heart failure and renal failure. Mean baseline blood glucose and hemoglobin A_{1c} values were not available on all patients, but available data revealed the expected significantly higher hemoglobin A_{1c} values in patients with diabetes versus those without diabetes. With respect to lipids, mean low-density lipoprotein cholesterol appeared to be slightly higher in those without diabetes, and mean high-density lipoprotein cholesterol was not different between the groups.

Rates of attendance of CR are shown in Table 2. Among 7036 nondiabetic and 1546 diabetic patients who started CR, 84.9% of nondiabetic versus 79.6% of diabetic patients completed the 12-wk CR program ($P < 0.0001$). When assessing males and females separately, although differences were significant in both sexes, the difference between diabetic and nondiabetic patients was greater in women (81.7% vs 72.1%, $P < 0.0001$) than men (86.0% vs 82.5%, $P = 0.004$). In evaluating participation rates for the 1-yr assessment, people without diabetes were more likely to return than people with diabetes (53.7% vs 42.7%, $P < 0.0001$). Men were more likely to attend follow-up than women (54.7% vs 42.0%, $P < 0.0001$); men without diabetes were more likely than men with diabetes to attend the 1-yr follow-up (56.4% vs 46.8%, $P < 0.0001$). Similarly, women without diabetes were more likely than women with diabetes to attend the 1-yr follow-up (44.3% vs 31.7%, $P < 0.0001$). Among those who withdrew from the program, the most common reasons for withdrawal from the program were "discharged for nonmedical reasons" and "medical early withdrawal." People with diabetes were somewhat more likely to drop out due to medical reasons than those without diabetes (29% vs 25% of dropouts). When stratified by sex, dropout due to medical reasons was 22% in nondiabetic men, 27% in diabetic men, 31% in nondiabetic women, and 35% in diabetic women.

Baseline and changes in cardiorespiratory fitness are shown in Table 3. Men without diabetes demonstrated the highest baseline peak MET level, whereas females with diabetes had the lowest. Changes in cardiorespiratory fitness from baseline to 12 wk were +1.0 METs in nondiabetic men, +0.9 METS in diabetic men, +0.9 METs in nondiabetic women, and +0.7 METs in diabetic women ($P = 0.0009$) and increased from baseline of 12%, 12%, 13%, and 11%, respectively. At 1-yr follow-up after program completion,

TABLE 1. Baseline characteristics.

	No Diabetes (*n* = 7036)	Diabetes (*n* = 1546)	*P*
Sex (% male)	73.5	71.7	0.149
Mean age (yr)	58.9	60.1	0.0001
BMI ($kg \cdot m^{-2}$)	27.9	29.8	<0.0001
Waist circumference (cm)	98.7	104.6	<0.0001
Plasma glucose ($mmol \cdot L^{-1}$)	5.48 (*n* = 6436)	7.94 (*n* = 1414)	<0.0001
Hemoglobin A_{1c} (%)	5.8 (*n* = 690)	7.3 (*n* = 976)	0.0001
Hypertension (%)	54.3	72.5	<0.0001
Current smokers (%)	27.4	24.8	0.037
Peripheral artery disease (%)	4.0	6.4	<0.0001
COPD (%)	10.6	13.5	<0.001
Myocardial infarction (%)	52.6	45.4	<0.0001
Revascularization procedures			
PCI (%)	63.7	56.7	<0.0001
CABG (%)	24.3	36.9	<0.0001
None (%)	17.2	14.0	0.003
Congestive heart failure (%)	8.3	12.9	<0.0001
Renal failure (%)	0.9	2.7	<0.0001
LDL cholesterol ($mmol \cdot L^{-1}$)	2.12	1.91	<0.0001
HDL cholesterol ($mmol \cdot L^{-1}$)	1.16	1.18	0.7348

Renal failure present if serum creatinine is >177 $\mu mol \cdot L^{-1}$.
BMI, body mass index; COPD, chronic obstructive pulmonary disease; LDL, low-density lipoprotein; HDL, high-density lipoprotein; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft.

TABLE 2. Attendance rates to a CR program by sex and diabetes status.

	No Diabetes	Diabetes	*P*
Started CR, *n*	7036	1546	
Completed 12-wk CR, *n* (%)	5973 (84.9%)	1230 (79.6%)	<0.0001
Completed 1 yr follow-up, *n* (%)	3773 (53.7%)	660 (42.7%)	<0.0001
Stratified by sex			
Males			
Started CR, *n*	5169	1108	
Completed 12-wk CR, *n* (%)	4447 (86.0%)	914 (82.5%)	0.004
Completed 1 yr follow-up, *n* (%)	2916 (56.4%)	518 (46.8%)	<0.0001
Females			
Started CR, *n*	1867	438	
Completed 12-wk CR, *n* (%)	1526 (81.7%)	316 (72.1%)	<0.0001
Completed 1 yr follow-up, *n* (%)	827 (44.3%)	139 (31.7%)	<0.0001

P values are for comparisons between patients with and without diabetes.
CR, cardiac rehabilitation.

TABLE 3. Changes in exercise capacity stratified by sex and diabetes status.

	Nondiabetic Men	Diabetic Men	Nondiabetic Women	Diabetic Women	*P* (Within Groups)
Baseline METs	8.4	7.4	7.1	6.6	
12-wk METs	9.4	8.3	8.0	7.3	
Change from baseline	+1.0	+0.9	+0.9	+0.7	0.0009
1 yr METs	9.3	8.0	8.0	7.1	
Change from baseline	+0.9	+0.6	+0.9	+0.5	0.0001

TABLE 4. Exercise capacity stratified by patients who did complete and did not complete the 1-yr assessment.

	Baseline	12 wk
	Mean METs (SD)	Mean METs (SD)
Nondiabetic men		
Completed 1 yr	8.3 (1.9)	9.3 (1.9)
Did not complete 1 yr	7.9 (2.0)	8.9 (1.9)
Difference	0.48 (95% CI = 0.59–0.38)	0.43 (95% CI = 0.54–0.31)
Diabetic men		
Completed 1 yr	7.4 (1.9)	8.3 (1.9)
Did not complete 1 yr	6.8 (2.0)	7.7 (2.0)
Difference	0.63 (95% CI = 0.86–0.40)	0.51 (95% CI = 0.77–0.26)
Nondiabetic women		
Completed 1 yr	7.1 (1.8)	8.0 (1.8)
Did not complete 1 yr	6.8 (2.0)	7.8 (1.9)
Difference	0.33 (95% CI = 0.51–0.16)	0.25 (95% CI = 0.43–0.06)
Diabetic women		
Completed 1 yr	6.6 (1.8)	7.3 (1.8)
Did not complete 1 yr	5.7 (2.0)	6.9 (2.0)
Difference	0.92 (95% CI = 1.30–0.53)	0.50 (95% CI = 0.93–0.07)

CI, confidence interval.

changes in cardiorespiratory fitness were +0.9 in nondiabetic men, +0.6 in diabetic men, +0.9 in nondiabetic women, and +0.5 METs in diabetic women (P = 0.0001), corresponding to increases from baseline of 11%, 8%, 13%, and 7% in exercise capacity, respectively. Both men and women with diabetes were less likely than those without diabetes to maintain the changes in cardiorespiratory fitness at the 1-yr follow-up. Table 4 outlines mean METs at baseline and 12 wk stratified by patients who completed and by those who did not complete the 1-yr follow-up assessment. Patients who did not complete the 1-yr follow-up assessment had lower baseline cardiorespiratory fitness, with diabetic women demonstrating the largest difference. In multivariate analyses, we found that the associations between diabetes and change in cardiorespiratory fitness and attendance at 12 wk and 1 yr after CR program were not materially altered by adjustment for age, sex, chronic obstructive pulmonary disease, PAD, or type of revascularization (i.e., PCI, CABG, or no revascularization).

DISCUSSION

Within a large CR cohort, we found that patients with diabetes, and in particular females, were less likely to complete the 12-wk CR program and also less likely than those without diabetes to attend a 1-yr follow-up assessment. In addition, for patients who attended follow-up assessments, people with diabetes were less likely to maintain improvements at 1 yr. Given that the incidence and prevalence of diabetes are increasing (33), this is an important finding considering the importance of cardiorespiratory fitness in protecting against secondary events and death.

The attendance rate of 85% in patients without diabetes and of 80% in those with diabetes in the 12-wk CR program is high within the range reported for other CR programs (1). These rates are dissimilar to a study by Banzer et al. (2) with 952 subjects of whom 250 had diabetes. They reported an adherence of only 38% in patients with diabetes to a 10-wk CR program. However, in our study, it is concerning that people with diabetes had lower rates of attendance at both follow-up times. It is particularly concerning that women with diabetes had completion rates at 12 wk of just 72% and only 32% at the 1-yr follow-up, significantly less than the other groups. During the 12-wk program, patients with diabetes, in particular women were more likely to report dropout due to "medical early withdrawal." Details on specific medical reasons are not readily available in the database. However, people with diabetes had greater prevalence of comorbidities at entry into the program and might have withdrawn more often because of coexisting medical conditions as well as depression and/or motivational issues. Moreover, women are faced with several unique barriers to program participation that may account for their higher dropout rates. Research investigating barriers to attendance in smaller cohorts found that fulfilling the role of a caregiver, feeling uncomfortable in a program dominated by men, and lack of prior physical activity experience influenced attendance by women (8). Other potential barriers to participation in CR include poverty and lower levels of education, both of which are more common in people with type 2 diabetes than in those without diabetes (26). Nonetheless, identifying specific barriers and targeting CR adherence interventions to people with diabetes, and specifically women with diabetes, may help to improve attendance rates.

The effect of CR on cardiorespiratory fitness in patients with diabetes has been studied by others with varied results (2,15,22,23,32). Several studies found fitness improvements to be similar in patients with and without diabetes. In 291 patients, including 70 with diabetes, Milani and Lavie (22) demonstrated significant improvements in fitness after a 3-month program in both patients with diabetes (38% improvement) and those without (34% improvement). Correspondingly, Banzer et al. (2) found that diabetic patients (n = 250) improved exercise capacity by 26% versus 27% in those without diabetes (n = 702). In a larger sample, Hindman et al. (15) reported that exercise capacity improved by 26.3% in patients with diabetes (n = 292) and by 25.5%

in nondiabetic patients (n = 1213), and more recently Mourot et al. (23) reported increases in exercise capacity in 413 patients with and 614 without diabetes of 27.6% and 30.5%, respectively. In our study, at the end of the 12-wk program, we found improvements of 11% in those with diabetes and 12% in those without diabetes. It is unclear why we found a smaller percentage increase in exercise capacity in all patients; however, patients in the present study had higher baseline MET levels compared with other studies, which may account for the difference. It is uncertain why patients in this study had higher baseline MET levels; it could be that patients had more time before enrolling into this outpatient program and hence had more time to train on their own. We have previously reported that median time from referral to enrollment within this program was 84 d (20); in some CR programs, this time is much less. Another reason could be that the exercise protocol used was the BRUCE protocol, which has been reported to overestimate METs (12); however, this exercise stress testing protocol is used in many CR programs. In contrast to this and the above-mentioned studies, Verges et al. (32) reported significantly lower increases in cardiorespiratory fitness in 59 patients with diabetes (13%) compared with 36 patients without diabetes (30%). Variations in program length and exercise dosage may also be reasons for the discrepancies.

To date, we are unaware of other studies that addressed sex differences in patients with and without diabetes within the same large cohort. We found that diabetic women had the lowest MET level at baseline and that nondiabetic men had the highest MET level at baseline. All groups had similar mean percentage increases in exercise capacity over the course of the program. However, females with diabetes were less likely to maintain the changes in cardiorespiratory fitness at 1-yr follow-up. We speculate that this might be due to increased barriers to participation in exercise in diabetic women.

One interpretation of these results is that cardiorespiratory fitness increased substantially from baseline to 12 wk, and these gains were somewhat maintained a year later in those who attended the 1-yr follow-up assessment. However, other scenarios may be possible. For example, as we see in Table 4, it could be that baseline peak METs were lower than 12-wk peak METs because the subjects who were less fit at baseline were more likely to drop out. Likewise, it is possible that those with higher cardiorespiratory fitness at 12 wk were more likely to attend the 1-yr assessment than those with lower cardiorespiratory fitness. Clearly, selection bias may be a factor confounding clinically meaningful interpretation of the peak MET values obtained at the 1-yr follow-up.

The increase in peak METs found in all groups with CR is important in the context of the American College of Sports Medicine's "Exercise is Medicine" initiative (25) and the American Heart Association's recent policy advocating for cardiorespiratory fitness as a key health metric (16). The increase in peak METs may be especially valuable in those with diabetes. In a cohort of 2196 men with diabetes not enrolled in CR, Church et al. (5) reported that for each 1-MET increase, they found 26% lower risk of death in a model including BMI and other clinical variables. Although not specifically evaluated in this study, improvement in peak MET level is likely to also yield benefits in activities of daily living and quality of life.

A limitation of this study is the lack of a control group, which limits our ability to draw causal inferences. Data collected for this study were collected primarily for clinical purposes and subject to imperfect or incomplete data entry. Another limitation is the definition of diabetes within these data does not distinguish between type 1 and type 2 diabetes, which may be problematic as people with these two conditions may have different barriers to attendance to an exercise program. In general, approximately 90%–95% of reported diabetes is type 2 diabetes (4), so we can presume that the majority of our diabetic participants had type 2 diabetes. Inability to distinguish between type 1 and type 2 diabetes is a limitation of many administrative and clinical databases. In the APPROACH database, patients were identified as having diabetes at the time of cardiac catheterization if the patient reported a history of diabetes diagnosed or treated by a physician, or if diabetes was indicated in the patient hospital chart. The database does not distinguish between type 1 and type 2 diabetes. The fact that the METs reported in this study were not directly measured but estimated from treadmill speed and grade during the final stage of the Bruce exercise protocol could be viewed as another limitation. However, this is a common method to assess cardiorespiratory fitness in CR programs and all subjects underwent the same protocol before and after the CR program. In addition, we only examined cardiorespiratory fitness changes in those who were able to complete CR. Therefore, we are unable to assess whether improvements in cardiorespiratory fitness would extend to those who did not enroll or failed to complete CR. Details on specific medical reasons for withdrawal were not available in the database, so unfortunately we cannot fully understand why people with diabetes are more likely to withdraw than those without. This is an area for further research.

In this analysis of one of the largest CR cohorts ever studied, patients with diabetes, especially females, were less likely to complete CR and attend follow-up at the 1-yr assessment. For patients who attended follow-up, changes in cardiorespiratory fitness were similar in males and females. However, patients with diabetes were less likely to maintain the improvements they had achieved during the 12-wk CR program. With the rising epidemic of diabetes, the prevalence of patients with diabetes in CR will most likely increase, and identifying barriers, targeting adherence interventions, and directing resources to diabetic patients may help improve outcomes in people with both CAD and diabetes. Considering the impressive clinical benefits that may result from completing CR, improving attendance rates in this population has the potential to yield an excellent return on investment.

CLINICAL SCIENCES

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