Relationship Between Exercise Workload During Cardiac Rehabilitation and Outcomes in Patients With Coronary Heart Disease

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The purpose of this retrospective, observational study was to describe the relation between exercise workload during cardiac rehabilitation (CR), expressed as metabolic equivalents of task (METs), and prognosis among patients with coronary heart disease. We included patients with coronary heart disease who participated in CR between January 1998 and June 2007. METs were calculated from treadmill workload. Cox regression analysis was used to describe the relationship between METs and time to a composite outcome of all-cause mortality, nonfatal myocardial infarction, or heart failure hospitalization. Among 1,726 patients (36% women; median age 59 years [interquartile range, 52 to 66]), there were 467 events (27%) during a median follow-up of 5.8 years (interquartile range, 2.6 to 8.7). In analyses adjusted for age, sex, Charlson co-morbidity index, hypertension, diabetes, and CR referral diagnosis, METs were independently related to the composite outcome at CR start (Wald chi-square 43, hazard ratio 0.59 [95% confidence interval 0.51 to 0.70]) and CR end (Wald chi-square 47, hazard ratio 0.68 [95% confidence interval 0.61 to 0.76]). Patients exercising below 3.5 METs on exit from CR represent a high-risk group with 1- and 3-year event rates ≥7% and ≥18%, respectively. In conclusion, METs during CR is available at no additional cost and can be used to identify patients at increased risk for an event who may benefit from closer follow-up, extended length of stay in CR, and/or participation in other strategies aimed at maximizing adherence to secondary preventive behaviors and improving exercise capacity. © 2016 Elsevier Inc. All rights reserved. (Am J Cardiol 2016;117:1236−1241)

Maximal exercise capacity is strongly related to prognosis among patients with heart disease.[1−5] Alternately, outpatient cardiac rehabilitation (CR) is a guideline-based secondary prevention therapy for patients with coronary heart disease (CHD).[6] Data on submaximal exercise performance are routinely collected and reported by CR staff based on the exercise training workload. The purpose of this retrospective, observational study was to describe the relationship between exercise training workload during phase 2 (early) CR and risk for a composite outcome of all-cause mortality, nonfatal myocardial infarction (MI), or heart failure (HF) hospitalization among patients with CHD. This information could help identify patients at an increased risk for an event who may benefit from closer follow-up, extended length of stay in CR, and/or participation in other strategies aimed at maximizing adherence to secondary preventive behaviors and improving exercise capacity.

Methods

This was a secondary analysis of a previously published cohort[7] that included patients referred to the Henry Ford Hospital CR program after coronary artery bypass graft surgery without an acute MI, percutaneous coronary intervention with or without an acute MI, acute MI alone, and a diagnosis of coronary artery disease without an acute MI or revascularization procedure. All patients were members of Henry Ford Health System's health maintenance organization (i.e., Health Alliance Plan [HAP]) and completed their insurance-covered phase 2 CR visits between January 1998 and June 2007. During this period, 12 visits of CR was the standard benefit for HAP beneficiaries. Owing to variations in staff practice and patient needs, patients who attended 9 to 15 visits of phase 2 CR were considered for this analysis.

Patients were identified through a query of the Henry Ford Hospital Preventive Cardiology Outcomes database. Because HF is associated with an increased event risk, we excluded those patients with 2 or more outpatient encounters associated with an HF diagnostic code or a primary discharge diagnosis of HF during the 1 to 2 years before starting CR. Patients were also excluded if exercise training workload data were incomplete. No other exclusion criteria were applied. This study was approved by the Institutional Review Board of Henry Ford Health System.

The Henry Ford Hospital phase 2 CR program is offered in Detroit, Michigan, and at 3 suburban locations in the metropolitan Detroit area. Staffed primarily by clinical

exercise physiologists, phase 2 CR is an outpatient program, offered in a group setting, 3 days per week, and each session includes an educational lecture and 30 minutes of aerobic exercise training (plus 5 minutes each of warm-up and cool-down). Multiple exercise modes are available during each visit. Consistent with professional guidelines,[8,9] relative exercise intensity is prescribed at 60% to 80% of measured heart rate reserve based on a maximal exercise test and/or rating of perceived exertion. Using these methods, exercise workloads are selected by patients with guidance from CR staff.

Covariate data were obtained from the outcomes database and the Henry Ford Health System's administrative database (linked by medical record number), the latter of which includes HAP insurance claims data. Charlson co-morbidity index was calculated based on the methods of D'Hoore et al.[10] Data for the Charlson index and cardio-vascular risk factors were identified based on the International Classification of Diseases, Ninth Revision, Clinical Modification codes from encounters during the 1 to 2 years before starting CR. Medications were identified from pharmacy claims during the same period. Exercise workload during CR was described in metabolic equivalents of task (MET; where 1 MET represents 3.5 ml O_2/kg/min). METs were calculated based on the speed and grade recorded from the treadmill during typical CR visits using equation 1.[11]

$$\text{Equation 1}: \text{METs} = [3.5 + (0.1 \times S) + (1.8 \times S \times G)] \div 3.5$$

S = walking speed in m/min; G = grade/incline of the treadmill expressed as a decimal (e.g., 2% is 0.02).

Exercise training METs at the start of CR was the average of visits 2 and 3, whereas METs on exit from CR was the average of the last 2 visits. METs were calculated using an online calculator (*www.fedel.com/mets/*) and captured prospectively in the outcomes database. Mortality data were obtained from the US Centers for Disease Control and Prevention's National Death Index using social security number, name, and date of birth, which were available on 100% of the cohort. Data on nonfatal MI and HF hospitalization were obtained from the Henry Ford Health System's administrative database based on the International Classification of Diseases, Ninth Revision, Clinical Modification codes for a primary inpatient diagnosis as endorsed by the National Quality Forum.[12] Mortality and hospitalization data were available through the end of 2011.

The primary outcome was time to first event based on a composite of all-cause mortality, nonfatal MI, or HF hospitalization. The secondary outcome was all-cause mortality. The index date was the last date in CR. Follow-up time was calculated separately for the primary and secondary outcomes as days between the last CR visit and the event date (when present) or December 31, 2011. For the primary composite outcome, patients without an event who changed their health insurance coverage from HAP were censored at the last date of their coverage.

Cox proportional hazards regression was performed to describe the association between METs during CR and time to event with adjustment for age, sex, Charlson co-morbidity index, hypertension, diabetes mellitus, and CR referral

Table 1
Characteristics of the study cohort (n = 1,726)

Characteristic	Statistic
Age (years)	59 (52 to 66)
Women	620 (36%)
Race	
White	1044 (61%)
Black	581 (34%)
Other	101 (6%)
Body mass index (kg•m^{-2})*	30 (26 to 34)
Hypertension	1320 (77%)
Diabetes mellitus (type 1 or 2)	537 (31%)
Dyslipidemia	1247 (72%)
Charlson Comorbidity Index	2 (1 to 3)
Referral Diagnosis	
Coronary artery bypass graft surgery without myocardial infarction	328 (19%)
Percutaneous coronary intervention without myocardial infarction	326 (19%)
Percutaneous coronary intervention with myocardial infarction	455 (26%)
Myocardial infarction only	179 (10%)
Medical therapy only	438 (25%)
Medications[†]	
Beta-adrenergic blockade	1017 (74%)
Angiotensin converting enzyme inhibitor or receptor blocker	796 (58%)
Lipid lowering	907 (66%)

Data are median (interquartile range) or n (%).
* Body mass index data available on n = 1,059.
[†] Medication data available on n = 1,379.

diagnosis. In a subgroup of patients with medication data, analyses were further adjusted for β-adrenergic blockade, angiotensin-converting enzyme inhibitor or angiotensin receptor blockade, and lipid therapy. Interaction effect analyses were performed for sex, race (black vs white), referral diagnosis, and age (<65 vs ≥65 years). Kaplan-Meier survival curves were developed to show unadjusted cumulative event rates over time by categories of METs (i.e., <2.5, 2.5 to 3.4, 3.5 to 4.4, 4.5 to 5.4, ≥5.5). Alpha level was 5%. IBM SPSS version 22 (IBM, Somers, NY) with the advanced statistics and survival modules was used for all analyses.

Results

We identified 1,949 patients who met the inclusion criteria and were not known to have a history of HF during the 1- to 2-year period before CR. Among these patients, 223 were excluded because of incomplete exercise training data. Characteristics of the final cohort (n = 1,726) are listed in Table 1. Patients completed a median of 12 visits (interquartile range [IQR] 12 to 12 visits) of CR during a median of 4.3 weeks (IQR 4.0 to 5.3 weeks). Exercise training workload at the start and end of CR was 2.7 METs (IQR 2.2 to 3.2 METs) and 3.6 METs (IQR 2.9 to 4.4 METs), respectively.

During a median follow-up of 5.8 years (IQR 2.6 to 8.7 years) after completion of CR, 467 patients (27%) experienced the primary composite outcome of all-cause mortality