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The Association of Tobacco Use and Gender to Cardiac Rehabilitation Outcomes: A Preliminary Investigation

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Abstract

Introduction—Cardiac rehabilitation (CR) outcomes are measured in terms of cardiovascular disease (CVD) risk factor reductions, and these predict long-term cardiac status. This report examines whether reported tobacco use has differential effects on successful cardiovascular risk factor modification, especially for women who have greater smoking-related CVD consequences than men.

Methods—A retrospective cohort analysis was conducted on 1138 adults (74% male) with diagnosed CVD who participated in 7 weeks of a comprehensive CR program. Eleven CVD risk factors were assessed at CR entry and completion. Tobacco use was assessed by self-report at CR entry. The primary outcomes were attainment of goal levels for each risk factor.

Results—Fewer current and former tobacco users reached the preset goal for Maximal Exercise Capacity. Fewer women than men reached the preset goal for HDL. Women who were current or former tobacco users were less likely to meet the target goals for Triglycerides and more likely to meet target goals for Total Cholesterol and Non-HDL Cholesterol.

Conclusions—This preliminary study suggests the importance of identifying the effect of tobacco use and gender on CR outcomes and the need to evaluate modification of key cardiovascular risk factors for subgroups of cardiac patients.

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DECLARATION OF INTERESTS

The authors have no competing interests to report.

Keywords

Tobacco Use; Gender; Cardiovascular Disease; Cardiovascular Rehabilitation

INTRODUCTION

Smoking is one of the most significant risk factors for the development of cardiovascular disease (CVD) (Kannel et al., 2000; USDHHS, 2001, 2004) and for continued negative health consequences following the development of CVD (Gritz et al., 2007). The risk of CVD is greater for female than male smokers (Bolego et al., 2002; Cote & Chapman, 2009; Tan, Gast, & van der Schouw, 2010; Wenger, 2003) and CVD mortality is higher in women than men (Eastwood & Doering, 2005; Mosca, et al., 2007). A recent meta-analysis showed that, after controlling for other CVD risk factors, female smokers demonstrated a 25% greater risk of coronary heart disease than male smokers (Huxley & Woodward, 2011). While women exhibit greater adverse cardiovascular consequences of tobacco use, successful cessation of tobacco exerts greater cardiovascular benefits for women compared to men (Mercuro et al., 2010).

To assist patients with CVD in achieving successful cardiovascular risk factor modification, cardiac rehabilitation (CR) programs have been developed consisting of nutrition education, behavioral counseling, psychosocial support, and exercise training. The main and gender-specific relationship of tobacco use status to the reduction of CVD risk factors during CR has not yet been empirically investigated. The purpose of this brief report is to examine whether self-reported tobacco use status on entry into a comprehensive CR program is related to improvement in CVD risk factors in female and male cardiac patients.

METHODS

Participants

This is a retrospective cohort analysis, approved by the Riverside Methodist Hospital (Columbus, Ohio) internal review board. Participants provided written informed consent for use of these data extracted from the center's clinical database.

A total of 2,339 adults participated in the CR program between 3/19/2004 and 9/22/2008. This study reports on data from 1,138 adults who completed at least 50% of the CR program (7 weeks), a length of time associated with significant risk factor improvement (Hammill et al., 2010). Adults were excluded from analysis if they completed <7 weeks of CR (n=286) or if medical (n=548) or tobacco use (n=367) data were incomplete. Patients excluded from the analyses had similar clinical characteristics compared with patients included in the analysis, and did not differ by reported tobacco use status. The CR enrollment evaluation and laboratory assessments were performed two to four weeks after hospital discharge for a cardiac event. Enrollment and exit evaluations included a clinical evaluation and history review; weight and waist measurement; a fasting blood sample for lipid profile, glucose, and C-reactive protein; and a review of current medication use. Entry and exit exercise treadmill testing was performed according to a Standard Bruce Protocol.

CR Program

The CR program included education in management of diet, cholesterol, blood pressure (BP), stress, and glucose. Behavioral counseling and support was provided for cessation of tobacco use and weight-loss. Stress management was provided by a social worker with specialized training in stress reduction techniques. Cardiologists, registered nurses, exercise physiologists, registered dietitians, and a cardiac care social worker circulated among patients during exercise training and subsequent sessions to provide ongoing guidance and feedback. Nutrition recommendations were based on the National Cholesterol Education Program Adult Treatment Panel III report Therapeutic Lifestyle Changes Diet (NCEP, 2002).

Statistical Analysis

Eleven CVD risk factors were assessed prior to entry into and at completion of CR with regard to preset goals for CVD risk reduction: 1) Total Cholesterol, 2) Low Density Lipoprotein Cholesterol (LDL), 3) High Density Lipoprotein Cholesterol (HDL), 4) Non-HDL Cholesterol (i.e., Total Cholesterol minus HDL), 5) Triglycerides, 6) Body Mass Index (BMI), 7) Maximal Exercise Capacity expressed in metabolic equivalents, 8) Systolic BP, 9) Diastolic BP, 10) high sensitivity C-Reactive Protein (hsCRP), and 11) Glucose. Each participant was classified at the beginning of the study period as being “At Risk” (yes/no) for each risk factor, and at the end of CR as having met or not met (yes/no) a preset goal for each risk factor. See Table 1 for the threshold levels that defined being “At Risk” and “Met Goal” for each risk factor (Mosca et al., 2011; Smith et al., 2011) and Table 2 for number of participants from the full sample who were classified as “At Risk” for each risk factor, the percentage of men and women from the full sample who were classified as “At Risk” for each risk factor, and the percentages of “At Risk” participants who met treatment goals.

Logistic regression was used to examine the relationship of self-reported tobacco use status and gender to each of the eleven risk factors after completion of CR. A separate logistic regression analysis for each risk factor outcome (goal met vs not) was conducted and each regression included only those participants who were classified as “At Risk” for that risk factor at entry into the study. Categorical variables were dummy-coded and demographics (age, race) and medication agents were entered as control variables in the first step of the analysis when significant (see Table 3). Participants were classified as Current Tobacco Users (current use of any tobacco product), Former Tobacco Users (previously used a tobacco product but have quit), or Never Tobacco Users (have not ever used a tobacco product) based on their self-reported level of tobacco use and history at the beginning of the study. Tobacco use Status (Current Tobacco Users, Former Tobacco Users, Never Tobacco Users) and Gender (Male, Female) were entered as a block in the second step and the Tobacco Use Status x Gender interaction was entered in the third step. The dependent variable was a dichotomous outcome (yes/no) indicating whether or not the “At Risk” participant met the preset goal for risk factor reduction (“Met Goal”) at the end of the study. For each variable that showed a significant Tobacco Use Status x Gender interaction, regression analyses were then conducted for men and women separately to determine the nature of the significant interaction. Due to the small number of self-reported Current Tobacco Users, all analyses were repeated examining Tobacco Use Status as a two-level

variable (Former Tobacco Users, Never Tobacco Users). Statistical analyses were performed using SPSS v.16.0 software for PC (SPSS Inc., Chicago, IL). Statistical tests were two-tailed and differences were considered significant when $p < 0.05$.

RESULTS

Sample Characteristics

Participants in the full sample ($n=1,138$) were primarily male (74%), Caucasian (92%), and married (75%); with an average age of 63 years ($SD=11.0$); and attended the CR program for an average of 11 weeks ($SD=1.9$). Male and female participants did not differ in their length of attendance of CR (Male $M=11.5$ weeks, $SD=1.9$; Female $M=11.4$ weeks, $SD=1.6$; $t=0.42$, $df=589$, $p=0.68$). The primary CVD-related diagnoses were percutaneous transluminal coronary angioplasty (42%), coronary artery bypass grafting (31%), myocardial infarction (14%), and Valve Replacement (7%). Other diagnoses (6%) included coronary artery disease, congestive heart failure, angina, and cardiomyopathy.

The majority of participants reported that they were Former Tobacco Users (Full Sample 50.0%; Women 38.5%; Men 54.0%) or Never Tobacco Users (Full Sample 45.4%; Women 58.1%; Men 41.0%). Less than 5% of participants reported that they were Current Tobacco Users (Full Sample 4.6%; Women 3.4%; Men 5.0%). Women were more likely than men to report being Never Tobacco Users and less likely to report being Former Tobacco Users ($\chi^2=25.2$, $df=2$, $p<0.001$). Length of CR attendance did not differ by tobacco use status (Current Tobacco Users $M=11.5$, $SD=1.6$; Former Tobacco Users $M=11.4$, $SD=1.9$; Never Tobacco Users $M=11.5$, $SD=1.9$; $F=0.06$, $df=2,1137$; $p=0.94$).

CR risk factor outcomes by self-reported tobacco use status and gender

A significant main effect of Tobacco Use Status was found for predicting Maximal Exercise Capacity outcomes ($p<0.05$). Current and Former Tobacco Users (59.2%) were less likely to reach the goal for Maximal Exercise Capacity at the end of the study than Never Tobacco Users (62.1%). In addition, a main effect of Gender indicated that fewer women (24.4%) than men (37.8%) reached the preset goal for HDL at the end of CR ($p<0.01$).

In examining the relationship of Tobacco Use and Gender, significant Tobacco Use Status x Gender interactions were found for Total Cholesterol ($p<0.01$), Triglycerides ($p<0.05$), and Non-HDL Cholesterol ($p<0.05$) (Table 3). Fewer women who were Current or Former Tobacco Users met the endpoint target levels for Total Cholesterol compared to women who were Never Tobacco Users. Conversely, fewer Never Tobacco Users women met the endpoint goal for Triglycerides or non-HDL Cholesterol levels than women who were Current or Former Tobacco Users. Men did not differ in their ability to reach target levels of these three variables by tobacco use. The results did not substantially change when analyses were repeated including only Former Tobacco Users compared to Never Tobacco Users.

DISCUSSION

This is the first preliminary investigation examining the impact of current and past tobacco use, as reported at CR entry, and gender on successful risk factor modification during a

comprehensive CR program. The analyses demonstrate that fewer current and former tobacco users reached an important goal, Maximal Exercise Capacity. Greater daily smoking is associated with lower exercise capacity in current smokers and adults who quit smoking show greater improvements in exercise capacity than adults who continue to smoke (Asthana et al., 2012). Further, smoking is the most important risk factor in chronic obstructive pulmonary disease (COPD) (Eisner et al., 2010; Løkke et al., 2006) and COPD can impact exercise capacity. Smokers with higher activity levels are less likely to develop COPD than smokers with lower activity levels (Garcia-Aymerich et al., 2007). Changes in pulmonary function during CR in smokers compared to non-smokers have yet to be investigated.

Our findings also indicated that fewer women than men reached the preset goal for HDL, which is important as low HDL rather than high LDL cholesterol levels are more predictive of coronary artery disease in women compared to men (e.g., Roeters van Lennep et al., 2002), and a focus on HDL is especially important for the prevention of CVD in women (Mosca et al., 2011). A recent study found that adults who quit smoking showed improvements in HDL, despite post-cessation weight gain, and these changes were greater for women than men (Gepner et al., 2011). Women who were Current or Former Tobacco Users were less likely to meet the target goals for Triglycerides and more likely to meet target goals for Cholesterol and Non-HDL Cholesterol. Triglycerides are a greater risk factor for CVD for women (Abdel-Maksoud et al., 2012) and more difficult to change with lifestyle modification in women (Wood et al., 1991). Conversely, Non-HDL Cholesterol is more strongly associated with CVD for men than women (Abdel-Madsoud et al., 2012) suggesting the need for increased attention to Non-HDL Cholesterol in men and triglycerides in women who are or were tobacco users. As a note, the majority of the participants in CR were taking lipid lowering agents and these percentages did not differ by gender (male 93.7% versus female 91.1%, $p=0.12$) or tobacco use status (Current Tobacco Users 94.5%, Former Tobacco Users 92.1%, Never Tobacco Users 94.0%, $p=0.44$). Overall, these preliminary findings support the importance of evaluating tobacco use behavior on CVD risk reduction for cardiac patients, and suggest that subgroups of both tobacco users and women, particularly women who used tobacco, may require targeted interventions.

There were few current smokers in the sample, limiting our ability to evaluate possible differences between current and former smokers. It is known that fewer smokers participate in cardiac rehabilitation (Tzou et al., 2004), suggesting that efforts need to be aimed at increasing the enrollment of smokers for these services. Additionally, current smokers may have misrepresented their tobacco use status. Smokers underreport their tobacco use (Gorber et al., 2009), including adults with acute coronary syndrome (Pell et al., 2008), and underreporting may be greater when there is greater perceived tobacco-related social stigma (Stuber & Galea, 2009). The accuracy of self-reported tobacco status can be improved through biochemical measures of smoking (e.g., expired breath carbon monoxide levels, cotinine levels; Gorber et al., 2009; Patrick et al., 1994) and future studies of cardiac patients should use these measures to determine tobacco use status.

A second limitation of the current study was the assessment of tobacco use status at baseline only. The interaction of changes in risk variables and changes in tobacco use behavior (i.e.,

cessation of use, smoking relapse) could not be examined in the current analyses. It is possible that gender differences in CR outcomes may be a function of gender differences in quitting behavior during CR (i.e., less females quitting than males). However, few subjects reported current tobacco use and future studies should examine larger samples of current smokers and changes in tobacco use status in relation to CR outcomes. Further, the length of time since tobacco use in former smokers was not assessed. Future studies should examine the relationship of the length of abstinence from tobacco with changes in CVD risk factors. Finally, it must be noted that 39% of the patients who entered the CR program could not be included in the analyses due to incomplete medical or smoking data.

CONCLUSIONS

The impact of tobacco use on CVD risk factor modification during CR is an understudied and important area for research attention. Research in this area may identify groups of cardiac patients for whom greater intensity of evaluation and treatment services, including cessation-focused care, are needed to improve outcomes. This may be particularly important for female tobacco users who experience greater negative cardiovascular effects from tobacco use than men.

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Table 1

Classification criteria for being “At Risk” and “Met Goal” for each of the eleven primary outcome variables.

CR Outcome	Criteria to be classified as “At Risk” at study entry	Criteria to be classified as “Met Goal” at study exit
Chol (mg/dL)	200	< 200
LDL (mg/dL)	100	NonDiabetics: < 100 Diabetics: < 70
HDL (mg/dL)	Males: < 40 Females: < 50	Males: 40 Females: 50
Non-HDL	130	< 130
TG (mg/dL)	150	< 150
BMI (kg/m ²)	Males: BMI 25 and Waist > 40 inches Females: BMI 25 and Waist > 35 inches	[(0.004 × weight at study entry) × weeks in CR]
MEC	< 5	> 1 MET level increase
Glu (mg/dL)	100	< 100
SysBP (mm Hg)	140	NonDiabetics: < 140 Diabetics: < 130
DiaBP (mm Hg)	80	NonDiabetics: < 90 Diabetics: < 80
hsCRP (mg/L)	> 3	< 1

Key: BL, baseline; BMI, Body Mass Index; Chol, Total Cholesterol; CR, Cardiac Rehabilitation; DiaBP, Diastolic Blood Pressure; Glu, fasting Glucose; HDL, High Density Lipoprotein Cholesterol; hsCRP, High Sensitivity C-Reactive Protein; LDL, Low Density Lipoprotein Cholesterol; MEC, Maximal Exercise Capacity expressed in metabolic equivalents; Non-HDL, Non-HDL Cholesterol; SysBP, Systolic Blood Pressure; TG, Triglycerides

Note: Levels set in references to American Heart Association guidelines (see Mosca et al., 2011; Smith et al., 2011)

Table 2

Sample sizes of participants who met criteria to be classified as “At Risk” at study entry, average levels of the “At Risk” participants at study entry, percentages of men and women who met criteria to be classified as “At Risk” at study entry, and percentages of “At Risk” participants who were classified as having met the treatment goal criteria (“Met Goal”) at the end of CR for each of the eleven primary outcome variables.

CR Outcome	“At Risk” Participants at CR entry			At Risk Participants who “Met Goal”		
	Full Sample for Risk Factor			Men		
	n	M (SD) ^a	%	n	M (SD) ^a	%
Chol (mg/dL)	n=149	231 (34.8)	10.3***	21.3***		64
LDL (mg/dL)	n=303	124.6 (25.5)	26.0	28.5		43
HDL (mg/dL)	n=443	36.2 (5.84)	38.1	41.2		34
Non-HDL	n=316	159 (32.9)	26.2*	32.3*		59
TG (mg/dL)	n=204	199 (117)	17.7	18.6		30
BMI (kg/m²)	n=587	33.3 (5.1)	49.2**	58.4**		16
MEC	n=390	3.6 (1.0)	26.7***	56.4***		61
Glu (mg/dL)	n=605	126 (33.7)	55.4	58.3		24
SysBP (mm Hg)	n=195	154 (9.5)	19.4	15.9		64
DiaBP (mm Hg)	n=56	88.0 (6.0)	6.2*	2.6*		63
hsCRP (mg/L)	n=755	10.5 (18.6)	80.7	84.5		14

Key: BL, baseline; BMI, Body Mass Index; Chol, Total Cholesterol; CR, Cardiac Rehabilitation; DiaBP, Diastolic Blood Pressure; Glu, fasting Glucose; HDL, High Density Lipoprotein Cholesterol; hsCRP, High Sensitivity C-Reactive Protein; LDL, Low Density Lipoprotein Cholesterol; MEC, Maximal Exercise Capacity expressed in metabolic equivalents; Non-HDL, Non-HDL Cholesterol; SysBP, Systolic Blood Pressure; TG, Triglycerides

^a Average levels for each risk factor at CR entry for “at risk” participants

* p<0.05,

**

p<0.01,

*** p<0.001, male versus female

Table 3

The impact of tobacco use, gender, and tobacco use by gender interactions on CR outcomes.

CR Outcome	OR	95% CI	p-value
Cholesterol^a			
Tobacco Use ^f	0.67	0.21, 2.09	0.49
Gender ^g	0.29	0.08, 1.03	0.06
Gender x Tobacco Use	17.24	2.47, 120.20	0.004
HDL^b			
Tobacco Use ^f	0.92	0.58, 1.47	0.74
Gender ^g	0.51	0.32, 0.84	0.008
Gender x Tobacco Use	0.62	0.23, 1.71	0.36
Non-HDL Cholesterol^c			
Tobacco Use ^f	0.96	0.53, 1.76	0.90
Gender ^g	0.50	0.23, 1.08	0.08
Gender x Tobacco Use	3.25	1.05, 10.04	0.04
Triglycerides^d			
Tobacco Use ^f	1.52	0.68, 3.38	0.31
Gender ^g	2.48	0.90, 6.87	0.08
Gender x Tobacco Use	0.22	0.05, 0.99	0.05
Maximal Exercise Capacity^e			
Tobacco Use ^f	5.42	1.14, 25.64	0.03
Gender ^g	1.77	0.96, 3.30	0.07
Gender x Tobacco Use	0.47	0.20, 1.12	0.08

Note: There were no significant results for the risk factors not presented in this table (Body Mass Index, Diastolic Blood Pressure, Glucose, High Sensitivity C-Reactive Protein; Low Density Lipoproteins, Systolic Blood Pressure).

Key: CI, Confidence Interval; CR, Cardiac Rehabilitation; HDL, High Density Lipoprotein Cholesterol; OR, Odds Ratio

^aControlling for Age, Antiarrhythmic agents, Benzodiazepine agents, Antidepressant agents, Lipid Lowering agents

^bControlling for Diabetic agents

^cControlling for Age, Benzodiazepine agents, Bet Blocker agents, Lipid Lowering agents

^dControlling for Antidepressant agents

^eNo significant differences on demographics or medication, no covariates

^fReference group=Current or Former Tobacco User

^gReference group=Men