Effect of Smoking Status on Changes in Cardiorespiratory Fitness in Cardiac Rehabilitation

Gaalema, DE, Mahoney, K, Yant, B, Savage, P, Rengo, J, Khadanga, S, Ades, P

University of Vermont, Burlington, VT
University of Vermont Medical Center, Burlington, VT

INTRODUCTION

Cardiac rehabilitation is an individualized exercise training and behavioral risk factor modification-based secondary prevention program which is a class 1A recommendation following a major cardiac event, with participation associated with significant reductions in morbidity, mortality and re-hospitalization, as well as improvements in quality of life.[1,2]

Despite its demonstrated benefits, CR is often underutilized; only 13-34% of Medicare eligible patients attend CR.[3] Certain populations, specifically those of lower socioeconomic status (SES) or current smokers, have even lower participation rates.[4-7]

The literature is mixed on whether lower-SES patients experience comparable benefits from CR as higher-SES patients,[8,9] including potentially smaller improvements in cardiorespiratory fitness following CR for lower-SES patients.[10] One potential reason for this finding may be the over-representation of smoking among this population compared to the general population (24.5% vs. 14%).[11]

Those who smoke have lower exercise capacity and lower heart rate reserve based on exercise stress tests than non-smokers;[13-15] and successful quitting may be required to see improvements in cardiovascular fitness.[13] Among cardiac patients, smoking has been shown to be associated with lower measures of baseline fitness[16] and lower fitness gains post-CR than non-smokers.[17,18]

Comparing fitness gains by smoking status can be challenging, those who smoke are also likely to not engage in other health related behaviors that could improve fitness.[19] Lower-SES patients generally have less health-related behavior change following a cardiac event [20,21] including in physical activity. Restricting analyses to lower-SES patients could reduce the heterogeneity of other health-related behaviors, allowing for better examination of smoking status' specific effects on fitness improvement.

PURPOSE

Compare changes in measures of cardiorespiratory fitness between those who smoke and those who do not after completion of a CR program among lower-SES patients. We hypothesized that those who smoke would demonstrate smaller improvements in cardiorespiratory fitness than those who do not.

METHODS

This was a secondary analysis of data from two randomized clinical trials testing interventions to increase CR attendance among lower-SES patients. Peak Metabolic Equivalents of Task (METpeak) was determined via a symptom-limited exercise tolerance test (ETT) at entry and exit from CR. Baseline demographics, self-reported smoking status, and number of CR sessions completed were collected. Smokers were defined as patients reporting smoking at hospitalization. Multiple linear regression was used to examine the impact of smoking status on exit METpeak controlling for age, sex, surgical diagnosis, CR sessions completed, BMI and entry METpeak.

RESULTS

The sample included 129 patients (Characteristics in Table 1). The patients were reflective of a lower-SES population being relatively young with high rates of current smoking.

Table 1. Baseline Characteristics

	Total (N=129)	**Smokers** (N=42)	**Nonsmokers** (N=87)	**P-value**
Age	58.5 ± 8.9	56.6 ± 9.3	59.5 ± 8.6	0.078
Sex (n, % Female)	41 (32)	13 (31)	28 (32)	0.888
Race (n, % White)	93.8	95.2	93.1	0.638
Education[a] (%)				
< HS	16.3	16.7	16.1	0.762
HS/GED	36.4	40.8	34.5	
> HS	47.3	42.9	49.4	
Surgical Diagnosis (n, %)	31 (24)	8 (19)	23 (26)	0.357

[a] HS, High school; GED, General Education Development;

Individuals that were current smokers at time of hospitalization (N=42) completed fewer CR sessions (21.3 vs. 27.8, p=0.01). Overall, mean METpeak improved during CR among smokers and nonsmokers (5.2 to 6.6, p<.0001; Table 2a). However, improvements were half as small in the smoking group (increase of 0.9 vs. 1.8).

Table 2. Fitness Outcomes

	Smokers (n=42)			**Nonsmokers** (n=87)		
	Entry	**Exit**	**p-value**	**Entry**	**Exit**	**p-value**
BMI[b]	29.9 ± 7.5	30.2 ± 7.4	0.595	33.9 ± 7.4	33.6 ± 7.1	**0.057**
Waist Circumference	40.9 ± 7.4	40.6 ± 7.2	0.335	43.9 ± 6.7	43.0 ± 6.7	**0.0002**
Handgrip (lbs)	37.4 ± 12.3	38.1 ± 11.9	0.534	34.8 ± 11.9	37.4 ± 11.7	**<.0001**
MET_{peak}	5.3 ± 2.8	6.2 ± 3.3	**<.0001**	5.1 ± 2.7	6.9 ± 3.3	**<.0001**

[a] Data are mean ± standard deviation unless otherwise noted.

[b] BMI, Body Mass Index

When examined in multiple linear regression (Table 3), smoking predicted smaller METpeak gains (β= -0.904, p=0.016), as did older age (β=-0.054, p=0.009), higher BMI (β=-0.055, p=0.031), higher intake METpeak (β=-.171, p=.018), and fewer CR sessions completed (β=0.043, p<0.0001).

Table 3. Multiple Linear Regression Predicting Change in MET_{peak}[a]

	β	SE(B)	95% Confidence Interval	p-value
Smoking Status	-0.904	0.37	(-1.638, -0.171)	**0.016**
Age	-0.054	0.02	(-0.095, -0.013)	**0.009**
Gender	-0.497	0.35	(-1.191, 0.196)	0.158
Surgical status	-0.679	0.383	(-1.438, 0.080)	0.079
Intake BMI	-0.055	0.025	(-0.105, -0.005)	**0.031**
Intake MET_{peak}	-0.171	0.071	(-0.312, -0.029)	**0.018**
# CR Sessions Completed	0.043	0.012	(0.019, 0.066)	**< .0001**

[a]BMI, Body Mass Index; CR, cardiac rehabilitation

RESULTS

Table 4. Sensitivity Analysis (Fisher's Exact Test)

	Positive METpeak Increase	p-value
Nonsmokers vs.	68.60%	**0.006***
Continued Smokers	37.00%	
Nonsmokers vs.	68.60%	0.163
Quitters	50.00%	
Quitters vs.	50.00%	0.526
Continued Smokers	37.00%	

Comparisons of changes in measures of cardiorespiratory fitness between nonsmokers, continued smokers, and those who quit during CR can be seen in Table 4. The only significant difference in improvement by these three groups was between nonsmokers and continued smokers.

CONCLUSION

Current smokers in this lower-SES population attended fewer sessions of CR. Smoking at the time of hospitalization was also a significant predictor of smaller improvements in METpeak during CR program, even when controlling for number of sessions attended. Smoking negatively impacts improvements in cardiorespiratory fitness during CR and smoking cessation should remain a top priority for patients entering CR. Improving smoking outcomes could also improve cardiovascular fitness in this high-risk population.

ACKNOWLEDGEMENTS

Research reported in this publication was supported by the National Heart, Lung, And Blood Institute of the National Institutes of Health under Award Number R33HL143305 and Centers of Biomedical Research Excellence P20GM103644 award from the National Institute on General Medical Sciences.

REFERENCES

1. Ades PA. Cardiac Rehabilitation and Secondary Prevention of Coronary Heart Disease. NEMJ. 2001;345(12):892-802.
2. Ades PA, Keteyian SJ, Wright JS, Hamm LF, Lui K, Newlin K, Shepard DS, Thomas RJ. Increasing cardiac rehabilitation participation from 20% to 70%: A road map from the million hearts cardiac rehabilitation collaborative. Mayo Clinic Proceedings. 2017;92(2):234-242.
3. Suaya JA, Stason WB, Ades PA, Normand ST, Shepard DS. Cardiac Rehabilitation and Survival in Older Coronary Patients. JACC. 2009;54(1):25-33.
4. Gaalema DE, Savage PD, Rengo JL, Cutler AY, Elliott RJ, Priest JS, Higgins ST, Ades PA. Patient Characteristics Predictive of Cardiac Rehabilitation Adherence. J Cardiopulm Rehabil Prev. 2017b;37(2):103-110.
6. Gaalema DE, Elliott RJ, Savage PD, Rengo JL, Cutler AY, Pericot-Valverde I, Priest JS, Shepard DS, Higgins ST, Ades PA. Financial Incentives to Increase Cardiac Rehabilitation Participation Among Low-Socioeconomic Status Patients: A Randomized Clinical Trial. JACC Heart Fail. 2019;7(7):537-546.
7. Sun EY, Jadotte YT, Halperin W. Disparities in Cardiac Rehabilitation Participation in the United States: A systematic review and meta-analysis. JCRP. 2017;37(1):2-10.
8. Mayer-Berger W, Simic D, Mahmoodzad J, Burtscher R, Kohlmeyer M, Schwitalla B, Redaelli M. Efficacy of a long-term secondary prevention programme following inpatient cardiovascular rehabilitation on risk and health-related quality of life in a low-education cohort: a randomized controlled study. Euro J of Prev Card. 2014;21(2):145-152.
9. Nielsen KM, Meillier LK, Larsen ML. Extended cardiac rehabilitation for socially vulnerable patients improves attendance and outcome. Danish Medical Journal. 2013;60(3):A4591.
10. Mikkelsen N, Dall CH, Frederiksen M, Holdgaard A, Rasmusen H, Prescott E. Depression, Socioeconomic Factors, and Ethnicity as Predictors of Cardiorespiratory Fitness Before and After Cardiac Rehabilitation. J Cardiopulm Rehabil Prev. 2019;39(4):E1-E6.
11. USDHSS 2020
13. Asthana A, Piper ME, McBride PE, Ward A, Fiore MC, Baker TB, Stein JH. Long-term effects of smoking and smoking cessation on exercise stress testing: Three-year outcomes from a randomized controlled trial. The American Heart Journal. 2012;163(1):81-87.
14. De Borba AT, Jost RT, Gass R, Nedel FB, Cardoso DM, Pohl HH, Reckziegel MB, Corbellini VA, Paiva DN. The influence of active and passing smoking on the cardiorespiratory fitness of adults. Multidisciplinary Respiratory Medicine. 2014;9(1), 34.
15. Papathanasiou G, Georgakopoulos G, Spyropoulos P, Perrea D, Evangelou A. Effects of chronic smoking on exercise tolerance and on heart rate-systolic blood pressure product in young healthy adults. European Journal of Cardiovascular Prevention & Rehabilitation. 2007;14(5):646-652.
16. Boss HM, Deijle IA, Van Schaik SM, De Melker EC, Van Den Berg BT, Weinstein HC, Geerlings M, Kappelle LJ, Van den Berg-Vos RM. Cardiorespiratory Fitness after Transient Ischemic Attack and Minor Ischemic Stroke: Baseline Data of the MoveIT Study. Journal of Stroke and Cerebrovascular Diseases. 2017;26(5): 1114-1120.
17. Laddu D, Ozemek C, Lamb B, Hauer T, Aggarwal S, Stone JA, Arena R, Martin BJ. Factors associated with cardiorespiratory fitness at completion of cardiac rehabilitation: identification of specific patient features requiring attention. Canadian Journal of Cardiology. 2018;34(7), 925-932.
18. Reibis R, Salzwedel A, Buhlert H, Wegscheider K, Eichler S, Völler H. Impact of training methods and patient characteristics on exercise capacity in patients in cardiovascular rehabilitation. European Journal of Preventive Cardiology. 2016;23(5), 452–459.
19. Gaalema DE, Bolivar HA, Khadanga S, Priest JS, Higgins ST, Ades PA. Current smoking as a marker of a high-risk behavioral profile after myocardial infarction. Prev Med. 2020;140:106245.
20. Gaalema DE, Elliott RJ, Morford ZH, Higgins ST, Ades PA. Effect of socioeconomic status on propensity to change risk behaviors following myocardial infarction: implications for healthy lifestyle medicine. Prog Cardiovasc Dis. 2017a;60(1):159–168.
21. Sverre E, Otterstad JE, Gjertsen E, Gullestad L, Husebye E, Dammen T, Moum T, Munkhaugen J. Medical and sociodemographic factors predict persistent smoking after coronary events. BMC Cardiovasc Disord. 2017;17(1):241.