ORIGINAL INVESTIGATION

Smoking, Menthol Cigarettes, and Peripheral Artery Disease in U.S. Adults

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ABSTRACT

Introduction: Cigarette flavorings, with the exception of menthol, have been banned in the United States under the Family Smoking Prevention and Tobacco Control Act. Given the large number of menthol cigarette smokers in the United States, we investigated whether cigarette type (nonmenthol or menthol) is associated with peripheral artery disease (PAD).

Methods: The authors studied 5,973 adults, 40 years of age and older, who participated in the National Health and Nutrition Examination Survey (NHANES) from 1999 to 2004. Smoking status and cigarette type were derived from self-reported questionnaires. PAD was defined as an ankle-brachial blood pressure index <0.9 in at least 1 leg.

Results: Fifty percent of participants were never-smokers compared to 31%, 14%, and 5% of former, current nonmenthol, and current menthol cigarette smokers, respectively. The weighted prevalence of PAD in the study population was 5%. After multivariable adjustment, the odds ratios for PAD were 1.44 (95% CI: 0.97, 2.15), 3.65 (95% CI: 1.57, 8.50), and 2.51 (95% CI: 1.09, 5.80) comparing former, current nonmenthol cigarette smokers, and current menthol cigarette smokers to never-smokers. The associations between smoking and PAD were similar for smokers of nonmenthol and menthol cigarettes (*p* value for heterogeneity = .59).

Conclusions: In a representative sample of the U.S. population, current use of both menthol and nonmenthol cigarettes was associated with increased prevalence of PAD, with no difference in risk between cigarette types.

INTRODUCTION

Peripheral artery disease (PAD) is associated with significant morbidity and mortality and is a strong marker for future cardiovascular events (Criqui et al., 1992). Several studies have found that cigarette smoking is one of the strongest risk factors for PAD (Navas-Acien et al., 2004; Newman et al., 1993; Selvin & Erlinger, 2004). Despite smoking fewer cigarettes per day (Mustonen, Spencer, Hoskinson, Sachs, & Garvey, 2005), African Americans suffer a disproportionate burden from peripheral artery disease compared to other race groups (Allison et al., 2006; Criqui et al., 1992; Selvin & Erlinger, 2004). One potential explanation for this disparity is the higher prevalence of menthol cigarette use among African American smokers (Caraballo & Asman, 2011; Giovino et al., 2004; Mustonen et al., 2005; U.S. Department of Health and Human Services, 1998). Previous studies of peripheral artery disease, however, have not

differentiated between smoking of menthol and nonmenthol cigarettes.

Under the Family Smoking Prevention and Tobacco Control Act, signed into law in 2009, cigarette flavorings are banned, with the exception of menthol (House of Representatives 1256[111th], 2009). The U.S. Food and Drug Administration (FDA) has the authority to regulate tobacco product constituents, including the use of menthol as an additive, if it is determined to be appropriate for the protection of public health. The objective of this study was to investigate the association between menthol cigarette use and the ankle-brachial blood pressure index (ABI), a highly specific marker of subclinical peripheral artery disease, in adults who participated in the National Health and Nutrition Examination Survey (NHANES) from 1999 through 2004. Recently, we identified that menthol cigarette use was associated with slightly increased blood cadmium levels in U.S. adults compared with nonmenthol smokers (Jones,

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Apelberg, Tellez-Plaza, Samet, & Navas-Acien, 2012). Since cadmium is a risk factor for peripheral artery disease (Navas-Acien et al., 2004; Tellez-Plaza, Navas-Acien, Crainiceanu, Sharrett, & Guallar, 2010), we evaluated whether cadmium could contribute to any differences in risk of peripheral artery disease observed by cigarette type.

METHODS

Study Population

NHANES is conducted by the U.S. National Center for Health Statistics (NCHS; Centers for Disease Control and Prevention [CDC], Atlanta, GA), using a complex multistage sampling design, to obtain a representative sample of the civilian non-institutionalized U.S. population. NHANES study protocols for the 1999–2004 survey years were approved by the National Center for Health Statistics Institutional Review Board, and oral and written informed consent was obtained from all participants. Peripheral artery disease was assessed by ABI in adults 40 years of age or older who participated in NHANES between 1999 and 2004 ($N = 9,970$). The participation rate for NHANES 1994–2004 examinations among participants 40 years of age or older was 68%. We excluded 10 pregnant women, 2,396 participants with missing ABI determinations in both legs, 113 participants whose ABI was >1.4 in at least one leg (related to noncompressible vessels in the legs), 10 participants with missing information on smoking status, 392 with missing serum cotinine measures, and 549 participants with other relevant covariates missing. We further excluded 61 current smokers with missing information on cigarette type and 466 former and current smokers with missing information on years of smoking (data needed to estimate pack-years of smoking), leaving 5,973 participants for this study. Sociodemographic characteristics of study participants were comparable to overall NHANES 1999–2004 participants 40 years of age and older (data not shown).

Peripheral Artery Disease

Following a specific protocol, blood pressure determinations for ABI estimation were obtained in the horizontal position and separately from the determinations used to evaluate hypertension. ABI was computed for each leg as the mean systolic blood pressure in each ankle (posterior tibial artery) divided by the mean systolic blood pressure in the right arm (brachial artery). Systolic blood pressure was measured twice at each site for participants 40–59 years of age and once at each site for participants ≥ 60 years of age by using a Parks Mini-Lab IV Doppler device, model 3100 (Parks Medical Electronics, Inc., Aloha, OR). For participants with conditions interfering with readings in the right arm, the left arm was used to calculate the ABI in both legs. Peripheral artery disease was defined as an ABI value <0.9 in at least one leg.

Cigarette Smoking Status and Menthol Use

Information on participant smoking status and behavior was obtained from a self-reported questionnaire. Participants were classified as never-smokers if they had not smoked at least 100 cigarettes in their lifetime. Former smokers were defined as individuals who had smoked 100 cigarettes in their lifetime but were not currently smoking. For participants who reported current smoking, cigarette type was determined by the brand that

they smoked at the time of the interview and were thereafter categorized as menthol or nonmenthol. Cumulative pack-years of smoking were calculated using the self-reported number of cigarettes smoked per day in the past 5 days for current smokers (or before quitting for former smokers) and the number of years of smoking. Serum cotinine was measured by an isotope-dilution high-performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometric method. The limits of detection for serum cotinine were 0.05 ng/ml for NHANES 1999–2000 and the first phase of NHANES 2001–2002 and 0.015 ng/ml for the second phase of NHANES 2001–2002 and NHANES 2003–2004, resulting in 29.2% of observations below the limit of detection.

Other Variables

Information on sex, age, race/ethnicity, education, and use of medication for treating hypertension, diabetes mellitus, and hypercholesterolemia was collected by self-reported questionnaires. Race/ethnicity was subsequently categorized by NCHS as non-Hispanic White, non-Hispanic Black, Mexican American, other Hispanic, and others. Body mass index (BMI) was calculated by dividing measured weight in kilograms by measured height in meters squared. Blood pressure was measured following the American Heart Association guidelines. Three (and in some cases, four) systolic and diastolic blood pressures were measured on the same day in the sitting position. Hypertension was defined as a mean systolic blood pressure ≥ 140 mmHg, a mean diastolic blood pressure ≥ 90 mmHg, a self-reported physician diagnosis, or use of antihypertensive medication.

Diabetes mellitus was defined as a fasting serum glucose level of ≥ 126 mg/dl, a nonfasting serum glucose level of ≥ 200 mg/dl, a self-reported physician diagnosis, or medication use. Serum total cholesterol was measured enzymatically. High-density lipoprotein (HDL) cholesterol was measured by heparin-manganese precipitation for NHANES 1999–2002 and by direct immunoassay for NHANES 2003–2004. Serum creatinine was measured by a kinetic Jaffé method and was calibrated to account for laboratory differences across survey years (Selvin et al., 2007). Estimated glomerular filtration rate was calculated from calibrated serum creatinine, age, sex, and race/ethnicity by using the Modification of Diet in Renal Disease Study formula (Levey et al., 2006; Selvin et al., 2007).

Cadmium was measured simultaneously in whole blood on a PerkinElmer Model SIMAA 6000 multielement atomic absorption spectrometer, with Zeeman background correction for NHANES 1999–2002 and on an inductively coupled plasma-mass spectrometer for NHANES 2003–2004. The limit of detection for blood cadmium was 0.3 $\mu\text{g/L}$ for NHANES 1999–2002 and 0.2 $\mu\text{g/L}$ for NHANES 2003–2004, resulting in 16.8% of observations below the limit of detection. For participants below the limit of detection, a level equal to the limit of detection divided by the square root of two was imputed.

Statistical Analysis

We estimated crude and multivariable adjusted odds ratios for the prevalence of peripheral artery disease comparing former smokers, nonmenthol cigarette smokers, and menthol cigarette smokers to never-smokers. Initially, we adjusted statistical models for sex, age (continuous), race/ethnicity (White/Black/Mexican American/Others), and education ($<$ high school/high school/ $>$ high school). Second, we further adjusted for BMI

(continuous), total cholesterol (continuous), HDL cholesterol (continuous), cholesterol-lowering medication use (yes/no), systolic blood pressure (continuous), antihypertensive medication use (yes/no), diabetes mellitus (yes/no), and estimated glomerular filtration rate (continuous). To evaluate potential differences in the association between use of menthol and nonmenthol cigarettes by difference in the duration and intensity of smoking, we further adjusted for pack-years of smoking (continuous) and log-transformed serum cotinine concentrations. To evaluate the possibility that increased cadmium exposure in smokers of menthol cigarettes (Jones et al., 2012) could mediate part of the association between cigarette type and peripheral artery disease, we further adjusted all models for log-transformed blood cadmium concentrations.

Heterogeneity in the odds of peripheral artery disease by cigarette type (menthol/nonmenthol) was assessed using the chi-square heterogeneity test. All statistical analyses were performed using the survey package (Lumley, 2004, 2011; version 3.24) in R software (R Development Core Team, 2010;

version 2.12.1) to account for the complex sampling design and weights in NHANES 1999–2004 and to obtain appropriate estimates and standard errors. All statistical tests were two sided and confidence intervals were set at 95%.

RESULTS

Participant Characteristics

A total of 734 (14.3%) participants smoked nonmenthol cigarettes and 310 (4.9%) participants smoked menthol cigarettes. Further, 4,929 participants were nonsmokers (50.1% never-smokers and 30.7% former smokers). Compared with current nonmenthol cigarette smokers, participants who currently smoked menthol cigarettes were more likely to be women, African American, and have fewer pack-years of smoking and hypertension (Table 1). Serum cotinine and blood cadmium concentrations were also higher in smokers of menthol cigarettes compared to smokers of nonmenthol cigarettes (Table 1).

Table 1. Participant Characteristics by Smoking Status and Menthol Cigarette Use

Characteristics	Never-smokers	Former smokers	Current smokers	
			Nonmenthol	Menthol
Overall	3,012 (50.1)	1,917 (30.7)	734 (14.3)	310 (4.9)
Sex				
Male	1,156 (38.8)	1,234 (59.9)	462 (58.8)	143 (39.2)
Female	1,856 (61.2)	683 (40.1)	272 (41.2)	167 (60.8)
Age, years	55.8 (0.3)	59.1 (0.3)	52.1 (0.3)	51.6 (0.6)
Education				
<High school	949 (16.4)	609 (18.6)	304 (28.4)	97 (26.2)
High school	652 (23.3)	449 (25.2)	181 (31.7)	109 (36.9)
>High school	1,411 (60.3)	859 (56.2)	249 (39.9)	104 (36.8)
Race/ethnicity				
White	1,562 (76.6)	1,214 (84.1)	437 (80.7)	110 (58.7)
Black	523 (8.9)	236 (5.5)	83 (4.8)	164 (32.3)
Mexican American	689 (5.0)	365 (3.6)	154 (4.4)	18 (1.2)
Others	238 (9.5)	102 (6.8)	60 (10.1)	18 (7.9)
Pack-years of smoking	0 (0)	25.8 (0.9)	36.4 (1.2)	28.9 (1.5)
Years of smoking	0 (0)	21.6 (0.4)	34.0 (0.4)	33.3 (0.7)
Cigarettes smoked per day	0 (0)	21.5 (0.6)	20.9 (0.7)	16.9 (0.8)
Serum cotinine, ng/ml	0.06 (0.06, 0.07)	0.11 (0.09, 0.14)	193.9 (180.7, 208.0)	202.6 (176.6, 232.5)
Blood cadmium, µg/L	0.33 (0.32, 0.35)	0.42 (0.40, 0.43)	1.10 (1.03, 1.17)	1.20 (1.08, 1.33)
Body mass index, kg/m ²	28.4 (0.2)	28.5 (0.2)	26.9 (0.2)	27.5 (0.5)
eGFR, ml/min/1.73 m ²	85.5 (0.9)	83.8 (0.7)	92.6 (1.5)	94.6 (1.9)
Total cholesterol, mg/dl	210.5 (0.9)	210.8 (1.8)	213.4 (2.0)	210.5 (2.9)
HDL cholesterol, mg/dl	54.4 (0.4)	52.8 (0.6)	50.1 (0.8)	52.9 (1.0)
Diabetes mellitus				
Yes	416 (9.9)	330 (12.2)	108 (10.8)	41 (10.7)
No	2,596 (90.1)	1,587 (87.8)	626 (89.2)	269 (89.3)
Hypertension				
Yes	1,671 (47.7)	1,129 (52.3)	321 (37.2)	157 (44.7)
No	1,341 (52.3)	788 (47.7)	413 (62.8)	153 (55.3)
Medication use, % yes				
Antihypertensive	1,008 (27.7)	707 (31.7)	170 (18.9)	81 (22.0)
Cholesterol-lowering	485 (15.0)	461 (22.1)	97 (12.6)	37 (11.5)
PAD				
Yes	149 (3.2)	189 (6.5)	79 (7.0)	25 (5.8)
No	2,863 (96.8)	1,728 (93.5)	655 (93.0)	285 (94.2)

Note. Values represent number (weighted %) for categorical variables or weighted means (SE) for continuous variables, except for serum cotinine and blood cadmium for which geometric means (95% CI) are reported. eGFR = estimated glomerular filtration rate; HDL = high-density lipoprotein; PAD = peripheral artery disease.

Table 2. Participant Characteristics by the Presence or Absence of PAD

Characteristics	No PAD	PAD
Overall	5,531 (95.1)	442 (4.9)
Sex		
Male	2,769 (48.3)	226 (44.8)
Female	2,762 (51.7)	216 (55.2)
Age, years	55.5 (0.2)	67.4 (0.6)
Education		
<High school	1,770 (18.7)	189 (30.9)
High school	1,276 (25.5)	115 (30.7)
>High school	2,485 (55.8)	138 (38.4)
Race/ethnicity		
White	3,071 (78.6)	252 (78.8)
Black	909 (8.1)	97 (13.6)
Mexican American	1,152 (4.3)	74 (3.6)
Others	399 (8.9)	19 (4.0)
Smoking		
Never-smoker	2,863 (51.0)	149 (32.7)
Former smokers	1,728 (30.2)	189 (41.1)
Current smokers		
Nonmenthol cigarettes	655 (14.0)	79 (20.4)
Menthol cigarettes	285 (4.9)	25 (5.8)
Pack-years of smoking	13.78 (0.4)	29.28 (2.0)
Serum cotinine, ng/ml	0.34 (0.28, 0.42)	0.55 (0.36, 0.85)
Blood cadmium, µg/L	0.44 (0.43, 0.46)	0.62 (0.57, 0.68)
Body mass index, kg/m ²	28.2 (0.1)	28.6 (0.3)
eGFR, ml/min/1.73 m ²	87.1 (0.7)	73.8 (1.8)
Total cholesterol, mg/dl	211.1 (0.9)	209.3 (2.7)
HDL cholesterol, mg/dl	53.3 (0.4)	51.1 (0.9)
Diabetes mellitus		
Yes	778 (10.1)	117 (23.8)
No	4,753 (89.9)	325 (76.2)
Hypertension		
Yes	2,934 (46)	344 (75.8)
No	2,597 (54)	98 (24.2)
Medication use, % yes		
Antihypertensive	1,728 (26.2)	238 (51.4)
Cholesterol-lowering	937 (15.9)	143 (32.5)

Note. Values represent number (weighted %) for categorical variables or weighted means (*SE*) for continuous variables, except for serum cotinine and blood cadmium, for which geometric means (95% *CI*) are reported. eGFR = estimated glomerular filtration rate; HDL = high-density lipoprotein; PAD = peripheral artery disease.

The weighted prevalence of peripheral artery disease in the study population was 4.9% (Table 2). Compared with participants who did not have peripheral artery disease, participants with peripheral artery disease were more likely to be women, older, less educated, Black, and either former or current smokers. They were also more likely to have a lower estimated glomerular filtration rate (eGFR), diabetes mellitus or hypertension, and higher serum cotinine and blood cadmium concentrations (Table 2).

Peripheral Artery Disease

After adjustment for demographics and risk factors for cardiovascular disease, the odds ratios for peripheral artery disease were 1.98 (95% *CI*: 1.41, 2.79), 5.23 (95% *CI*: 3.40, 8.04), and 3.36

(95% *CI*: 1.86, 6.10) for former, nonmenthol, and menthol smokers, respectively, compared to never-smokers (Table 3, Model 2). Further adjustment for pack-years of smoking and serum cotinine attenuated the odds ratios for peripheral artery disease to 1.44, 3.65, and 2.51 for former, nonmenthol, and menthol smokers, respectively, compared to never-smokers (Table 3, Model 3). We observed no significant difference in the association between smoking and peripheral artery disease for current smokers of nonmenthol and menthol cigarettes (*p* value for heterogeneity = .59). Adjustment for blood cadmium concentrations attenuated the odds ratios for peripheral artery disease by 6%, 25%, and 28% for former, nonmenthol, and menthol smokers, respectively, compared to never-smokers (Table 3, Model 4).

After adjustment for demographics, cardiovascular risk factors, smoking status, pack-years of smoking, and serum cotinine, the odds ratios for peripheral artery disease were 2.35 (95% *CI*: 1.54, 3.59) and 0.74 (95% *CI*: 0.51, 1.07), respectively, for Black participants and for participants of other races compared to those for White participants (Table 4, Model 3). After further adjustment for current menthol cigarette smoking, the odds ratio for peripheral artery disease for Blacks increased to 2.47 (95% *CI*: 1.62, 3.77), with no change for other races compared to White participants (Table 4, Model 4).

DISCUSSION

In a representative sample of U.S. adults who participated in NHANES 1999–2004, we found increased odds of peripheral artery disease for former and current smokers compared to never-smokers, with no difference in risk between current menthol and nonmenthol cigarette smokers. Adjustment for blood cadmium concentrations attenuated the association between current smoking and peripheral artery disease similarly for smokers of menthol and nonmenthol cigarettes, suggesting that it contributes similarly for both types of cigarette smokers. Smoking is known to be a major risk factor for peripheral artery disease (U.S. Department of Health and Human Services, 2004). The present findings demonstrate increased risk for peripheral artery disease among current smokers, regardless of cigarette type, compared to never- and former smokers.

Understanding the health risks of menthol cigarettes compared to nonmenthol cigarettes is critical to informing decision making by the FDA and other public health authorities. Some studies have shown that menthol cigarette use is associated with increased biomarkers of intake of tobacco smoke constituents (Clark, Gautam, & Gerson, 1996; Williams et al., 2007), whereas other studies have found no differences in levels of tobacco biomarkers by cigarette type (Ahijevych, Gillespie, Demirci, & Jagadeesh, 1996; Benowitz, Herrera, & Jacob, III, 2004; Caraballo et al., 2011; Heck, 2009; Muscat et al., 2009; Mustonen et al., 2005; Signorello, Cai, Tarone, McLaughlin, & Blot, 2009; Tobacco Products Scientific Advisory Committee [TPSAC], 2011; Wang et al., 2010). In a study of 161 Black and White smokers, menthol cigarettes were associated with higher cotinine levels and carbon monoxide concentrations after adjusting for race, cigarettes per day, and mean amount of cigarettes smoked (cigarettes smoked per day × average length [in millimeters] of each cigarette smoked; Clark et al., 1996). Higher levels of cotinine and carbon monoxide have been hypothesized to indicate higher absorption of other toxic

Table 3. Odds Ratios (95% CI) of Periphery Artery Disease (PAD) by Smoking Status

	No PAD, <i>N</i>	PAD, <i>N</i>	Model 1	Model 2	Model 3	Model 4
Never	2,863	149	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Former	1,728	189	2.01 (1.43, 2.82)	1.98 (1.41, 2.79)	1.44 (0.97, 2.14)	1.35 (0.91, 1.99)
Current						
Nonmenthol	655	79	4.64 (3.06, 7.05)	5.23 (3.40, 8.04)	3.65 (1.57, 8.49)	2.72 (1.19, 6.20)
Menthol	285	25	3.04 (1.70, 5.45)	3.36 (1.86, 6.10)	2.51 (1.09, 5.79)	1.81 (0.75, 4.38)

Note. Model 1 adjusted for sex, age, race/ethnicity, and education. Model 2 further adjusted for body mass index, total cholesterol, high-density lipoprotein cholesterol, cholesterol-lowering medication use, systolic blood pressure, antihypertensive medication use, diabetes mellitus, and estimated glomerular filtration rate. Model 3 further adjusted for pack-years of smoking and serum cotinine. Model 4 further adjusted for blood cadmium.

Table 4. Odds Ratios (95% CI) of Periphery Artery Disease (PAD) by Race/Ethnicity

	No PAD, <i>N</i>	PAD, <i>N</i>	Model 1	Model 2	Model 3	Model 4	Model 5
White	3,071	252	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Black	909	97	2.09 (1.48, 2.96)	2.08 (1.35, 3.19)	2.35 (1.54, 3.59)	2.47 (1.62, 3.77)	2.52 (1.65, 3.84)
Others	1,551	93	0.67 (0.48, 0.93)	0.63 (0.44, 0.91)	0.74 (0.51, 1.07)	0.74 (0.51, 1.07)	0.71 (0.49, 1.02)

Note. Model 1 adjusted for sex, age, and education. Model 2 further adjusted for body mass index, total cholesterol, high-density lipoprotein cholesterol, cholesterol-lowering medication use, systolic blood pressure, antihypertensive medication use, diabetes mellitus, and estimated glomerular filtration rate. Model 3 further adjusted for smoking status (never/former/current), pack-years of smoking, and serum cotinine. Model 4 further adjusted for menthol use (nonsmoker/current nonmenthol/current menthol). Model 5 further adjusted for blood cadmium.

components in tobacco smoke (Clark et al., 1996). The cooling and anti-irritant effects of menthol could result in greater depth of inhalation and facilitate the absorption of tobacco toxicants, although this possibility has not been shown in human studies (Benowitz et al., 2004; Jarvik, Tashkin, Caskey, McCarthy, & Rosenblatt, 1994; Perez-Stable, Herrera, Jacob, III, & Benowitz, 1998).

In this study, menthol cigarette smokers were observed to have higher serum cotinine and blood cadmium concentrations compared to smokers of nonmenthol cigarettes. These findings however, need to be considered cautiously as these analyses were conducted in a descriptive manner without adjustment for smoking patterns (including pack-years) or sociodemographic characteristics. In addition to lower pack-years of smoking (due to both lower number of years and lower number of cigarettes smoked per day), differences in tobacco-related biomarkers between menthol and nonmenthol cigarette smokers could be due to the characteristics of menthol cigarette smokers as Blacks have been found to have higher concentrations of serum cotinine (Ahijevych & Parsley, 1999; Clark et al., 1996) and women have been found to have higher concentrations of blood cadmium (Nishijo, Satarug, Honda, Tsuritani, & Aoshima, 2004; Vahter, Akesson, Liden, Ceccatelli, & Berglund, 2007). In another study in the same NHANES population, menthol cigarette use was associated with higher concentrations of blood cadmium but not serum cotinine after adjustment for pack-years, race/ethnicity, sex, and other sociodemographic variables (Jones et al., 2012).

To date, studies have not evaluated the association of menthol cigarette use with peripheral artery disease. Our findings are consistent with two previous epidemiological studies that found no difference in risk comparing menthol and nonmenthol cigarette smokers for other cardiovascular outcomes (Murray, Connett, Skeans, & Tashkin, 2007; Pletcher et al., 2006).

In 1,535 smokers who participated in the Coronary Arterial Risk Development in Young Adults (CARDIA) study, cumulative exposure to menthol and nonmenthol cigarettes between 1985 and 2000 was not associated with prevalent coronary arterial calcification measured in 2000 (odds ratios: 1.16 and 1.23 for menthol and nonmenthol cigarettes per 10-pack-year increase, respectively, $p = .67$ for Wald test), although comparisons to nonsmokers were not reported (Pletcher et al., 2006). In 5,887 smokers with mild lung impairment, the Lung Health Study found no difference in coronary heart disease mortality (hazard ratio, HR: 1.31, 95% CI: 0.77, 2.22), cardiovascular disease mortality (HR: 1.03, 95% CI: 0.70, 1.52), or all-cause mortality (HR: 1.00, 95% CI: 0.83, 1.20) in 14 years comparing baseline self-reported menthol cigarette use to nonmenthol cigarette use (Murray et al., 2007). This study, however, was not a community-based sample and only about 4% of the cohort comprised Blacks. Several studies have also evaluated menthol cigarette use and lung cancer risk. Most of these studies found no difference in lung cancer risk by cigarette type (Brooks, Palmer, Strom, & Rosenberg, 2003; Carpenter, Jarvik, Morgenstern, McCarthy, & London, 1999; Kabat & Hebert, 1991; Murray et al., 2007; TPSAC, 2011), although two studies showed significantly lower risk for menthol smokers (Blot et al., 2011; Rostron, 2012) and one cohort study showed significantly higher risk among male menthol smokers (Sidney, Tekawa, Friedman, Sadler, & Tashkin, 1995).

Although the prevalence of hypertension was higher in menthol cigarette smokers compared to nonmenthol cigarette smokers, these bivariate associations need to be interpreted cautiously as they could be confounded by sociodemographic characteristics, including the higher proportion of Blacks who smoke menthol cigarettes. A careful evaluation of the association between menthol cigarettes and hypertension, including systolic and diastolic blood pressure levels, is needed.

Strengths and Limitations

This study, characterized by rigorous quality control measures, was conducted in a representative sample of the U.S. population. The assessment of peripheral artery disease in all participants, which is subclinical in some subjects, is an additional strength of this study. However, the study is limited by its cross-sectional design. It is thus possible that participants with peripheral artery disease could have quit smoking or changed their smoking behavior following diagnosis, which would result in an underestimation of the association between smoking and peripheral artery disease. This would not be expected to be differential by cigarette type and should not bias findings regarding a difference in risk between current menthol and nonmenthol cigarette smokers. No information was available regarding whether cigarette type had changed over time among current smokers. The use of menthol cigarettes, however, has been shown to be relatively constant over time and individuals are unlikely to switch between cigarette types (Murray et al., 2007; Pletcher et al., 2006; Roper Organization, 1979). Finally, information on cigarette type (menthol vs. nonmenthol) was not available for former smokers; therefore, we were unable to assess the influence of cigarette type among former smokers.

CONCLUSIONS

In a representative sample of U.S. adults, current use of menthol and nonmenthol cigarettes were associated with similarly increased prevalence of peripheral artery disease. Given the importance of menthol cigarette use and the few available studies investigating cigarette type and cardiovascular disease outcomes, additional studies, especially prospective studies, are needed to evaluate the relationship between menthol and nonmenthol cigarette use and risk of peripheral artery disease and to confirm the lack of a difference by cigarette type.

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DECLARATION OF INTERESTS

None declared.

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