

Heart Rate and Blood Pressure Responses to Tobacco Smoking among African-American Adolescents

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Ethnic differences in both physiological response to and health consequences of tobacco smoking—some of which have been attributed to ethnic preferences for menthol cigarettes—have been described in the literature. We compared acute physiological responses to smoking in African-American and European-American adolescent menthol cigarette smokers seeking smoking cessation treatment. One-hundred-twenty-eight adolescents (32% African-American, 71% female; mean age 15.16 ± 1.32 years, mean Fagerström Test of Nicotine Dependence (FTND) score 6.73 ± 1.53 , cigarettes per day (CPD) 16.9 ± 2.64) participated in an experimental session during which they smoked one menthol cigarette of their usual brand. Blood pressure, heart rate, and exhaled carbon monoxide (CO) concentrations were measured before and after smoking; mean puff volume (mL), puff duration (sec) and maximal puff velocity (mL/sec) during smoking were also determined. Two sample t-tests were performed to assess ethnic differences in smoking topography; analysis of covariance was used to determine whether heart rate and blood pressure after smoking one menthol cigarette varied by ethnicity, after controlling for baseline physiological measures. No significant ethnic differences were observed in either smoking topography or acute cardiovascular response to smoking. These preliminary findings warrant extension to a broader group of non-treatment-seeking adolescent smokers of both ethnicities.

Key words: adolescent ■ tobacco ■ ethnicity ■ heart rate ■ blood pressure ■ health disparities

INTRODUCTION

Compared to other ethnicities in the United States, African Americans incur disproportionate deleterious health consequences of tobacco smoking evidenced by higher rates of mortality due to tobacco-related diseases, such as coronary heart disease, stroke, and possibly respiratory cancers.¹⁻³ While ethnic differences in nicotine and cotinine metabolism,^{4,6} tobacco-use trajectory (i.e. onset and progression of smoking behavior)⁷ and African-American preference for menthol smoking have been reported,⁸ the reasons for this health disparity have not yet been fully elucidated. This excess in mortality is preventable and largely attributable to tobacco addiction,⁹ which typically begins in youth.¹⁰

As such, a better understanding of ethnic differences in smoking behavior among adolescents is critically needed.¹¹⁻¹³ Young smokers, like adults, maintain smoking behavior for pharmacological reasons, such as reinforcement from nicotine.¹⁴ Total puff volume per cigarette determines blood levels of smoke constituents¹⁵ and is linked to health consequences of smoking¹⁶ in adult smokers. Several studies have established a relationship between cigarette smoking and cardiovascular disease.^{17,18} A large-scale population-based study showed that increase in carboxyhemoglobin (COHb) saturation was associated with increased mortality from heart disease, lung cancer, and chronic obstructive lung disease.¹⁹ COHb is directly related to exhaled CO in the absence of obstructive respiratory disease.²⁰

However, relatively little is known about qualitative and quantitative aspects of smoking behavior (topography) and their pathophysiological correlates in teenage smokers. Furthermore, the few studies that have examined such responses have not focused on African-American participants.^{21,22} Compared to adults in other studies, mean puff volume and CO boosts in teenagers who smoke only a few cigarettes per day were similar, but teenagers had higher increases in HR.²¹ As biobehavioral responses that represent both progression along the addictive cycle and potential correlates of the toxic effects of tobacco

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constituents,²¹ such physiologic responses to smoking warrant ethnic comparison during the early phases of smoking, before decades of exposure to toxins.

The aim of this study was thus to record acute changes in cardiovascular parameters as potential precursors of both increased vulnerability to ongoing addiction and consequent future health risk in a biethnic group of dependent adolescent menthol cigarette smokers requesting treatment. It is important to study adolescents who smoke daily, since they comprise a group at higher risk of experiencing the negative health effects because of long-term, dependence-related smoking. Because adult menthol smokers had significantly larger puff volume and cotinine (primary metabolite of nicotine) concentrations than those who smoked regular non-mentholated cigarettes,²³ ethnic differences in physiological responses to smoking can be obscured by ethnic preferences for mentholated cigarettes. These observations, along with the resurgence of menthol smoking among teenagers in our area,²⁴ prompted us to limit the current analysis to menthol smokers only. We hypothesized that smoking would induce higher increases in HR and blood pressure (BP), carbon monoxide (CO) boost, and greater puff topography in African-American adolescent smokers compared to European Americans.

METHOD

Participants

Candidates for this study were a sample of convenience of male and female adolescent smokers who enrolled in a smoking cessation study between September 1999 and May 2003. Participants were recruited through radio, print, and television advertisements broadly directed at Baltimore-area teenage

smokers, with some ethnic-specific channels. Study eligibility required that participants be in general good health and report smoking at least 10 cigarettes per day (CPD) in addition to having a score of at least five on the Fagerström Test of Nicotine Dependence (FTND).²⁵ In this analysis, only teenagers who reported mentholated cigarettes as their usual/preferred brand and who self-identified as African-American or European-American were included.

Procedures

Adolescents and their parents were required to give written informed assent and consent for participation. All participants were compensated for their time and travel costs. The protocol was approved by the NIH/NIDA Intramural Research Program Institutional Review Board.

Smoking History

Prior to randomization to the treatment condition, participant smoking histories, including age of onset, CPD, and number of prior quit attempts were obtained through both self-report questionnaires and a structured screening interview.

Smoking Topography

Smoking measures were obtained for each participant in a specialized smoking laboratory during an initial screening visit. The topography unit (Clinical Research Support System, Plowshare Technologies, Baltimore, MD) was placed in a ventilated smoking chamber, and a nurse was present at all times during the session. Participants were asked to smoke a single cigarette of their own usual brand (mean Federal Trade Commission yields for all brands = approximately 1.2 mg nicotine) through a plastic mouthpiece connected to a converter by a plastic tube. The

Table 1. Demographic and Smoking Characteristics of Study Participants

	Entire Sample	African Americans	European Americans
	(128)	(41)	(87)
Gender (% female)	71.1%	63.4%	74.7%
Age (years)	15.16 ± 1.32	15.2 ± 1.15	15.1 ± 1.41
Age first cigarette (years)	11.4 ± 1.99	12.1 ± 1.75	11.1 ± 2.04
Age daily smoking (years)*	12.6 ± 1.47	13.0 ± 1.35	12.5 ± 1.51
Cigarettes per day	16.9 ± 2.64	16.8 ± 2.56	17.0 ± 2.69
FTND+	6.73 ± 1.53	6.40 ± 1.52	6.86 ± 1.52
Prior quit attempts**	2.82 ± 2.32	2.20 ± 1.45	3.12 ± 2.59
Puff volume (mL)	38.9 ± 12.0	36.6 ± 11.1	39.9 ± 12.3
Puff velocity (mL/sec)	50.4 ± 15.8	47.3 ± 15.2	51.9 ± 16.0
Puff duration (sec)	1.17 ± 0.47	1.21 ± 0.42	1.15 ± 0.49

*Difference between African Americans and European Americans showed a trend toward significance ($t=1.86$, $df=122$, $p=0.065$); **Difference between African Americans and European Americans was statistically significant ($t=-2.56$, $df=122$, $p=0.0117$); + Fagerström Test of Nicotine Dependence

mean puff volume, puff duration, and maximum puff velocity were measured and recorded.²⁶ Topography measures were obtained by averaging the measures from five representative artifact-free puffs (volumes over 12 mL), as previously reported.²⁷

Physiological Measures

HR, systolic blood pressure (SBP), and diastolic blood pressure (DBP) were obtained through the use of an automated cardiovascular monitor (Datascoper, Paramus, NJ). Exhaled CO was measured by a Vitalograph machine (Lenexa, KS). All physiological measures and CO were measured and recorded before and immediately after smoking.

Data Analysis

Baseline characteristics (demographics and smoking history variables) and smoking topography

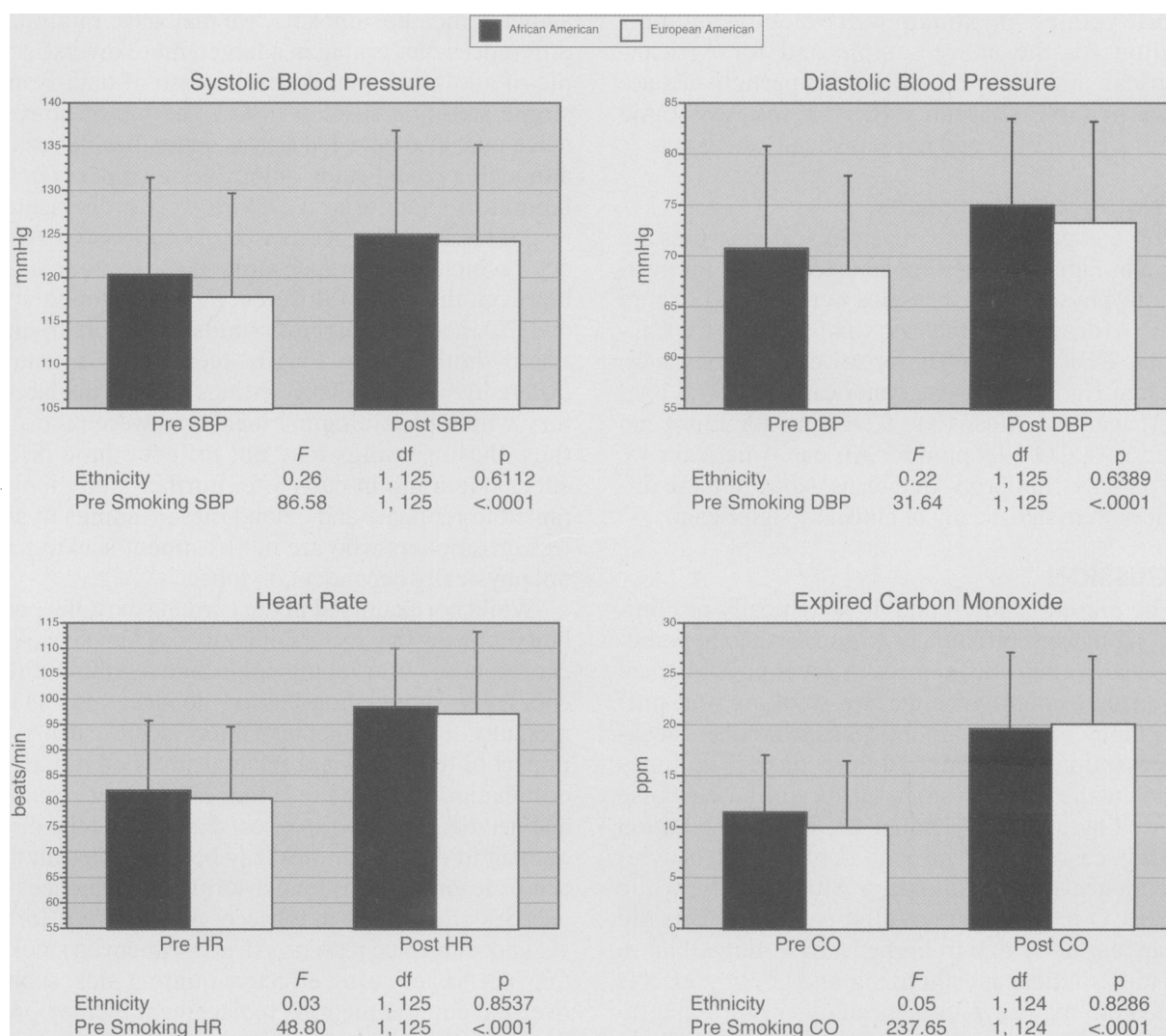
variables were compared using two sample t-tests for continuous variables and Chi-square tests for dichotomous variables. The effect of ethnicity on cardiovascular response to smoking and CO boost was determined using analyses of covariance (ANCOVA). In ANCOVA models, dependent variables were measures assessed after smoking (SBP and DBP, HR, CO). The main effect was ethnicity, and the covariate was the corresponding cardiovascular or CO measure assessed prior to smoking. Associations were considered statistically significant if $p < 0.05$. All analyses were conducted using SAS version 8.1 (SAS Institute, Cary, NC).

RESULTS

Sample Characteristics

One-hundred-fifty-four teenagers participated in

Figure 1. Adolescent Heart Rate, Blood Pressure, and Carbon Monoxide Responses to Cigarette Smoking (Mean + SD)



the smoking cessation trial, four of whom were neither African-American nor European-American. Additionally, 20 participants who did not smoke menthol cigarettes were excluded from this analysis, as well as two participants without available cardiovascular data, leaving a total of 128 participants for the present analysis. Table 1 provides smoking history data for the sample. Of these participants, 41 were African-American (32%; 63% female) and 87 European-American (68%; 75% female). The mean ages of both groups were similar (African-American: 15.2 ± 1.15 years; European-American: 15.1 ± 1.41 years), and participants started daily smoking at a similar age (African Americans: 13.0 ± 1.35 years; European Americans: 12.5 ± 1.51 years). African-American participants reported fewer previous quit attempts than European Americans (2.20 ± 1.45 vs. 3.12 ± 2.59 ; $p=0.017$) as previously found.²⁸ No other ethnic differences in demographic characteristics, smoking histories, or body mass index were statistically significant in this sample ($p<0.05$).

Smoking Topography

Puff volume, maximum puff velocity, and puff duration for the entire sample and for African-American and European-American participants are shown in Table 1. Mean values for the two ethnic groups were similar and not statistically different.

Physiological Responses

Pre- and postsmoking physiological measures are shown in Figure 1. Baseline-adjusted means for post-smoking physiological measures were: SBP 123.8 mm Hg for African Americans vs. 124.6 mm Hg for Caucasians; DBP 74.3 mm Hg for African Americans vs. 73.5 mm Hg for European Americans; HR 97.8 bpm for African Americans vs. 97.4 bpm for European Americans; CO 19.9 ppm for African Americans vs. 20.0 ppm for European Americans. None of these differences were statistically or clinically significant.

DISCUSSION

The present study found no statistically or clinically significant differences to support the hypotheses of early ethnic differences in acute physiological responses to menthol cigarette smoking and puff topography measures among teenage smokers seeking cessation treatment. Adolescent puff volumes found in the current study were similar to those reported by others.^{21,22} Higher CO in our population seeking cessation treatment may reflect heavier dependence-related smoking. Alternatively, while higher CO in this group of all menthol smokers did not appear to be due to higher puff volume than in previous studies, anesthetizing and cooling effects of menthol may have influenced other puff topography variables (e.g., depth of inhalation) to allow

greater smoke exposure.^{23,24,29}

Ethnic differences in smoking topography and physiological response to smoking can be obscured by ethnic differences in preference for menthol cigarettes. This study of all menthol smokers clarified these relationships by controlling for menthol preference. The overwhelmingly high prevalence of menthol smoking in both ethnic groups of adolescents is consistent with other data that report targeted marketing of mentholated cigarettes.³⁰ Given the resurgence of menthol smoking among both African-American and European-American teenagers and the higher-than-average mean nicotine content of menthol cigarettes in the current study,³¹ we suggest that future research extend these findings by evaluating ethnic differences in smoking topography and physiological responses to smoking in a 2-x-2 factorial experimental design that includes adolescents who smoke both menthol and nonmenthol cigarettes on a regular basis.

However, these findings are preliminary and suffer limitations of generalizability. By studying a self-selected, treatment-seeking sample of highly addicted menthol smokers, we may have minimized differences observable in a larger, more diverse sample of adolescent smokers. The use of data from a single smoking session in this sample of convenience may also have led to less generalizable results, although a recent study among adult smokers in our laboratory supports its validity.³² Cardiovascular responses are influenced by degree of nicotine delivery,³³ which was not measured in the current study; however, the lack of differences in puff topography and CO measures suggests similar exposure to nicotine by both groups. Finally, teenagers may smoke differently in naturalistic settings outside the laboratory where physiological measures were recorded, thus, these findings may not reflect ethnic differences operating in daily life. Further study is warranted to replicate and extend these findings to adolescent smokers who are not treatment-seeking and not physically dependent on tobacco.

While not examined in the current study, the possibility remains that factors other than acute physiological responses to smoking contribute to ethnic differences in population-based, tobacco-attributable mortality. Indirect rather than direct factors, such as the impact of the social and societal stress of ethnic discrimination^{34,35} and its resulting effects (e.g., immune and neuroendocrine responses) that mediate the development of disease entities may be more relevant than acute responses to longer-term consequences of decades of exposure to tobacco. Alternatively, for as-yet undocumented reasons, African-American smokers may not be accessing effective quitting aids, such as over-the-counter nicotine replacement therapy products (i.e., nicotine patch and gum) at the same rate,^{28,36}

resulting in less successful quit attempts and longer exposure to tobacco. As such, longitudinal, population-based, and laboratory studies in a broader sample of young smokers are needed to better understand the mechanisms underlying ethnic differences in tobacco-related health outcomes.

ACKNOWLEDGEMENTS

We are grateful to the dedicated staff of the Teen Tobacco Addiction Treatment Research Clinic in Baltimore, MD. This research was supported by NIDA Intramural funds.

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