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ORIGINAL RESEARCH

Cigarette Smoking and Longitudinal Associations With Blood Pressure: The CARDIA Study

Rachel E. Luehrs, PhD; Dong Zhang, PhD; Gary L. Pierce, PhD; David R. Jacobs, Jr, PhD; Ravi Kalhan, MD; Kara M. Whitaker, PhD

BACKGROUND: The associations of chronic cigarette smoking with blood pressure (BP) remain mixed. It is unclear whether a lack of examination of racial differences contributed to the mixed findings in previous studies. Black smokers metabolize nicotine at a slower rate than White smokers and racial discrimination contributes to nicotine dependence and higher BP among Black smokers.

METHODS AND RESULTS: We studied the association between cigarette smoking and longitudinal (30-year) changes in systolic BP, diastolic BP, and pulse pressure (PP) in 4786 Black and White individuals from the CARDIA (Coronary Artery Risk Development in Young Adults) study using repeated-measures regression models. Neither systolic BP, nor diastolic BP differed between Black consistent smokers compared with Black never smokers, although Black consistent smokers had higher PP than Black never smokers (β=1.01 mm Hg, P=0.028). White consistent smokers had similar systolic BP, but lower diastolic BP (β=−2.27 mm Hg, P<0.001) and higher PP (β=1.59 mm Hg, P<0.001) compared with White never smokers. There were no differences in systolic BP, diastolic BP, or PP between Black or White long-term former smokers compared with never smokers (all P>0.05).

CONCLUSIONS: Although the associations of cigarette smoking with alterations in BP are small, the greater PP observed in consistent smokers may contribute in part to the higher cardiovascular disease risk observed in this group because PP is a strong predictor of cardiovascular disease risk after middle age.

Key Words: cardiovascular disease ■ hypertension ■ pulse pressure

Systolic blood pressure (SBP) increases linearly with age and diastolic blood pressure (DBP) increases until approximately the fifth decade of life and then typically declines, causing a widening of pulse pressure (PP).[1] The development of hypertension (SBP ≥130 and/or DBP ≥80) is strongly associated with an increased risk of developing cardiovascular disease (CVD).[2] In addition to the association between advancing age and increased BP, several modifiable CVD risk factors are also associated with increased BP including obesity, physical inactivity, and an unhealthy diet.[3] Chronic cigarette smoking is a known CVD risk factor, and past reports from the World Health Organization have suggested that cigarette smoking is responsible for ≈10% of all CVD deaths worldwide.[4] However, despite the known association between cigarette smoking and increased CVD risk, the relation between cigarette smoking and BP remains unclear.

Acutely, cigarette smoking invokes a sympathetically mediated pressor response that causes a rise in BP that lasts for ≈15 minutes.[5] However, the chronic effects of cigarette smoking on BP remain mixed.

Correspondence to: Kara M. Whitaker, PhD, Department of Health and Human Physiology, The University of Iowa, E116 Field House, Iowa City, IA 52242. E-mail: kara-whitaker@uiowa.edu

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CLINICAL PERSPECTIVE

What Is New?

- The current study demonstrates that both White and Black consistent smokers demonstrate higher pulse pressure compared with never smokers.
- We also found that White, but not Black, consistent smokers had lower diastolic blood pressure compared with never smokers.
- There were no differences in systolic blood pressure between White or Black consistent smokers and never smokers.

What Are the Clinical Implications?

- Findings from the present study highlight the need for practitioners to monitor pulse pressure closely among consistent smokers even before they reach the sixth decade of life when pulse pressure is typically known to increase.

Nonstandard Abbreviations and Acronyms

CARDIA	Coronary Artery Risk Development in Young Adults

Several cross-sectional, epidemiological studies have demonstrated a paradoxical relation between cigarette smoking and BP in that current smokers have similar or lower SBP and DBP compared with nonsmokers even after adjusting for BMI.[5–8] In contrast, other studies have demonstrated that SBP was higher among current smokers compared with nonsmokers.[9,10]

The discrepancies in these findings may be in part from a lack of examination of racial differences, because the influence of race on the association between cigarette smoking and BP remains unclear. Black smokers metabolize nicotine at a slower rate than White smokers.[11–14] Importantly, a higher presence of serum cotinine, a metabolite of nicotine, is associated with increased activation of the renin-angiotensin-aldosterone system, a pathway commonly associated with hypertension.[11,15] Consistent with this, studies have also demonstrated that nicotine invokes acute increases in BP.[16,17] Therefore, it is possible that chronic renin-angiotensin-aldosterone activation, in part from slower nicotine metabolism, may be associated with higher BP in Black current smokers compared with Black nonsmokers; however, little is known about this relation to date. In addition to potential differences in nicotine metabolism among Black and White smokers, the effects of racial discrimination may also contribute to higher BP among Black smokers. Previous CARDIA (Coronary Artery Risk in Development in Young Adults) studies and others have demonstrated that racial discrimination is associated with higher BP among Black adults.[18–23] Furthermore, everyday discrimination is associated with nicotine dependence among Black people.[24,25] There is a lack of information on the extent to which genetic differences in nicotine metabolism versus psychosocial influences such as discrimination and racism influence BP among cigarette smokers. However, it is possible that both genetic differences in nicotine metabolism as well as the effects of discrimination towards Black people may result in higher BP among Black smokers compared with White smokers.[24] Because of the potential racial differences in the effects of cigarette smoking on BP and the conflicting findings from previous cross-sectional studies, additional research using longitudinal study designs that account for several time-varying confounders are needed to examine the associations of cigarette smoking on changes in BP over time in both Black and White individuals.

In the present study, using data from the CARDIA cohort, we aimed to examine racial differences in longitudinal changes in BP over 30 years (1985–2016) in never smokers and consistent smokers. Based on previous findings, we hypothesized that Black consistent smokers will have higher BP and White consistent smokers will have lower or similar BP over 30 years compared with never smokers of the same race and sex. We also hypothesized that Black and White long-term former smokers would have similar or higher BP compared with Black and White never smokers from the same time frame.

METHODS

Requests to access the data set, analytic methods, and study materials may be sent to the CARDIA Study Coordinating Center. Contact information can be found on the CARDIA website.[26]

Study Participants

CARDIA is a multicenter, longitudinal study of the influence of behavioral, demographic, and physiological factors on the presence and development of CVD risk factors in young adults in the United States. The initial study cohort consisted of 5115 young adult participants, balanced on age, sex, race (Black and White people), and educational status, who had an in-person clinical examination in 1985 to 1986 (baseline) from 1 of 4 field centers: Birmingham, AL; Minneapolis, MN, Chicago, IL, or Oakland, CA. Subsequent in-person examinations were held every 2 to 5 years including year 2 (1987–1988), year 5 (1990–1991), year 7 (1992–1993), year

10 (1995–1996), year 15 (2000–2001), year 20 (2005–2006), year 25 (2010–2011), and year 30 (2015–2016). Retention of the surviving cohort at examination years 2, 5, 7, 10, 15, 20, 25, and 30 was 91%, 85%, 80%, 77%, 74%, 72%, 72%, and 71%, respectively.[27] Details of the CARDIA eligibility criteria have been published previously.[28] The institutional review board at each center approved all study protocols for the primary CARDIA examination, as well as all ancillary studies. Written informed consent was obtained at each examination.

Exclusions and Inclusions

In this young, healthy cohort at baseline, no participants were excluded from the current analyses on the basis of medical conditions. A total of 236 individuals who did not have 2 BP measurements taken at least 5 years apart were excluded, for an analytic sample of 4786 individuals.

Assessment of Smoking Status

Smoking status was assessed at each of the examinations using the CARDIA Tobacco Use questionnaire, and 4 cigarette-smoking groups were formed using previously defined criteria.[29] Never smokers were considered the reference group and included those who reported not having smoked at any of the examinations where data on smoking status were available, including former smokers at baseline (ie, if an individual never reported current smoking status or former smoking status after baseline). Long-term former smokers were defined as individuals who reported smoking at year 0 or 2 but not at all subsequent examinations (ie, if an individual never reported current smoking after year 2). Consistent smokers were defined as individuals who reported smoking cigarettes at all available examinations (ie, all assessed examinations with current smoking status). The fourth smoking group included individuals with all other patterns of smoking (ie, individuals who reported smoking at 1 or more time points but did not meet the requirements to be classified as a consistent or long-term former smoker).

To better categorize individuals into smoking groups, missing assessments on smoking status were imputed before individuals were grouped into the smoking categories described above. For individuals with the same smoking status before and after missing assessments, the missing smoking status was imputed using the nearest available smoking status. The missing assessments were only imputed for individuals with up to 3 consecutive missing values and up to a total of 4 missing values (50% of all examinations). If they had >4 missing assessments, smoking status was categorized as missing. There were 44 individuals with missing smoking status at year 0. For these individuals, the subsequent assessments on smoking status were manually inspected and categorized into 1 of 4 groups using the criteria described above. Previous studies in this cohort have demonstrated a strong relation between self-reported cigarette smoking and Year 0 serum cotinine measurements.[29]

Assessment of BP

BP measurements were collected on each participant following 5 minutes of quiet rest for all examination years. Three BP measurements were taken from the right arm while participants rested in an upright, seated position. The second and third BP readings were averaged for analyses. For the baseline to year 15 examinations, BP was measured using the Hawksley random zero sphygmomanometer. Because of the risks of mercury toxicity, Hawksley no longer manufactures or services this device. As a result, beginning in year 20 the Omron HEM907CL device was used for all BP measurements, calibrated to the random zero value. The primary BP outcomes include SBP and DBP. PP was also calculated by subtracting SBP-DBP. Treatment effects of antihypertensive medication were accounted for by adding 10 mm Hg to the observed SBP and 5 mm Hg to the observed DBP in treated participants. This technique has been previously described and has been demonstrated to be a more accurate approach to accounting for antihypertensive therapy than by including antihypertensive medication use as a covariate.[30,31]

Covariates

Baseline covariates included study center, sex, and race (Black people/White people). Time-varying covariates included age, education, alcohol consumption, physical activity, BMI, plasma lipids, pack-year smoking history, hypertension medication use (yes/no), history of CVD (yes/no), and history of diabetes mellitus (yes/no). Age was assessed at baseline by self-reported birth date and was then calculated for each subsequent examination year. Education status was based on the self-reported number of years of school completed. Alcohol consumption was determined by self-reported number of alcoholic beverages to calculate the average milliliters of alcohol consumed per day. Physical activity was determined using the CARDIA physical activity history questionnaire that assesses self-reported frequency of participation in 13 categories of sports and exercise over the previous 12 months.[32] BMI was calculated using measured height and weight (kg/m^2). Plasma lipids were measured from a blood sample in the morning following an overnight fast. Pack-year smoking history was determined as the cumulative cigarette pack-years (cigarette packs smoked per day multiplied by the number of years smoking) for baseline through year 30. History of CVD, antihypertensive medication use, and diabetes mellitus were determined by self-report.

Statistical Analysis

One-way ANOVA tests were used to compare participant characteristics across smoking status groups. Mixed-effects linear regression models were used to examine the association between cigarette smoking and longitudinal changes in SBP, DBP, and PP from baseline to year 30 never smokers, long-term former smokers, consistent smokers, and individuals with all other smoking patterns (separate models for each outcome) while stratifying by race. Because previous studies have demonstrated sex differences in the association between cigarette smoking and BP,[9,33] in exploratory analyses we also stratified by sex. The exposure, smoking status, was modeled as a categorical variable (4 groups) and each outcome (SBP, DBP, and PP) was modeled as a continuous variable. Model 1 was adjusted for study center and sex as well as time-varying age. Model 2 additionally adjusted for time-varying BMI, self-reported history of CVD, physical activity, education, and pack-year smoking history. Model 3 additionally adjusted for time-varying alcohol consumption, plasma lipid concentrations, and diabetes mellitus. All models are described algebraically in Table S1. In sensitivity analyses, we adjusted for antihypertensive medication use, rather than adding 10 mm Hg to SBP and 5 mm Hg to DBP.[30,31] As an alternate approach, we also stratified participants by antihypertensive medication use. All mixed-effects linear regression models used a compound symmetry covariance structure. Data were analyzed with SAS software version 9.4 and statistical significance was set at $P<0.05$.

RESULTS

Baseline participant characteristics by smoking status group are presented in Table 1. There were statistically significant differences across groups for sex, race, education, alcohol consumption, high-density lipoprotein, triglycerides, DBP, and PP. As expected, groups also differed by pack-year smoking history. Mean values for SBP, DBP, and PP across examination years by smoking status and race, without adjusting for any covariates, are included in Table S2.

Thirty-Year Longitudinal Association Between Cigarette Smoking and BP by Race

As seen in Table 2, SBP did not differ between Black or White consistent smokers compared with Black or White never smokers (Model 3). White consistent smokers had lower DBP (Model 3; β=–2.27, $P<0.001$) compared with White never smokers; however, DBP did not differ between Black consistent smokers compared with Black never smokers. PP was greater among both Black and White consistent smokers compared with Black and White never smokers (Black: Model 3; β=1.01, $P=0.028$; White: Model 3; β=1.59, $P<0.001$). There were no differences in SBP, DBP, or PP between either Black or White long-term former smokers compared with never smokers. White smokers with other smoking patterns had lower SBP (Model 3; β=–1.42, $P<0.001$) and DBP (Model 3; β=–1.50, $P<0.001$), but no difference in PP compared with White never smokers. In contrast, there were no differences in SBP, DBP, or PP between Black smokers with other smoking patterns compared with Black never smokers.

Findings for both Black and White smokers were similar in magnitude and statistical significance in sensitivity analyses that include the unadjusted BP measurements and added antihypertension medication use as a time-varying covariate (Table S3). Findings stratified by antihypertension medication use are presented in Table S4. Among individuals who reported using antihypertensive medication at any examination year, there were no differences in SBP, DBP, or PP between Black and White consistent smokers, long-term former smokers, and individuals with other smoking patterns compared with never smokers. In contrast, Black and White consistent smokers who did not report using antihypertensive medication had lower DBP and higher PP compared with never smokers.

Thirty-Year Longitudinal Association Between Cigarette Smoking and BP Stratified by Race and Sex

Exploratory analyses were conducted to examine sex differences in the relation between cigarette smoking and BP. Fully adjusted models only are presented in Table 3. There were no differences in SBP between Black or White male and female consistent smokers compared with never smokers of the same race and sex. White male and female consistent smokers had lower DBP compared with White male and female never smokers (White men: β=–2.23, $P=0.003$; White women: β=–2.44, $P=0.002$). However, DBP did not differ between Black male or female consistent smokers compared with Black male and female never smokers. Black and White female consistent smokers demonstrated greater PP compared with never smokers of the same race and sex (Black women: β=1.38, $P=0.030$; White women: β=1.96, $P=0.002$). Additionally, White male long-term former smokers had lower DBP compared with White male never smokers (β=–2.61, $P=0.010$). White women, White men, and Black men with other smoking patterns demonstrated lower DBP compared with never smokers of the same race and sex (White women:

Table 1. Baseline Participant Characteristics (1985–1986), the CARDIA Study

	Never Smokers (n=2583)	Long-Term Former Smokers (n=190)	Consistent Smokers (n=601)	Other Smoking Patterns (n=1412)	*P* Value
Age, y	24.9±3.7	25.3±3.3	24.9±3.7	24.8±3.6	0.469
Sex (n,% female)	1455 (56)	111 (58)	292 (49)	769 (54)	0.005*
Race (n, % Black)	1227 (48)	86 (45)	391 (65)	720 (51)	<0.001*
BMI, kg/m^2	24.4±5.0	24.5±4.9	24.4±5.4	24.7±5.0	0.395
Baseline smoking history (pack-y) median, IQR	0±0	1.2±4.2	5.0±8.0	1.2±5.0	<0.001*
Years of education	14.4±2.2	13.7±2.2	12.3±1.7	13.4±2.1	<0.001*
Alcohol consumption (mL/d) median, IQR	2.4±9.7	7.5±24.2	9.9±28.6	7.5±19.3	<0.001*
Total MVPA (exercise units) median, IQR	366.5±393.0	352.5±313.0	331.0±353.0	365.0±378.5	0.099
Cardiovascular variables					
SBP, mm Hg	111±11	110±11	111±12	110±11	0.096
DBP, mm Hg	69±9	67±10	68±11	68±10	<0.001*
PP, mm Hg	42±9	43±10	43±9	42±10	<0.001*
HR, bpm	69±11	70±10	70±11	69±11	0.172
High BP (n, % yes)	216 (8)	21 (11)	60 (10)	138 (10)	0.296
Antihypertension medication use (n, % yes)	53 (2)	4 (2)	20 (3)	31 (2)	0.534
Heart problem (n, % yes)	150 (6)	17 (9)	30 (5)	84 (6)	0.537
Total cholesterol, mg/dL	177.3±32.5	179.5±36.9	176.1±36.1	176.9±34.0	0.662
HDL-cholesterol, mg/dL	53.5±12.5	54.2±15.3	51.9±14.5	52.9±13.2	0.030*
LDL-cholesterol, mg/dL	110.1±30.3	109.6±35.2	107.9±34.2	108.8±31.4	0.378
Triglycerides (mg/dL) median, IQR	59.0±36.0	64.0±42.0	67.0±41.0	64.0±41.0	<0.001*
Diabetes mellitus (n, % yes)	17 (0.6)	1 (0.5)	7 (1)	14 (1)	0.474*

All data are mean±SD unless otherwise specified. Note: All blood pressure measurements are adjusted for antihypertension medication use by adding 10 mm Hg to SBP and 5 mm Hg to DBP in individuals who reported taking antihypertension medication. The "other smoking patterns" category includes individuals who reported smoking at 1 or more time points but did not meet the requirements to be classified as a current or former smoker. BMI indicates body mass index; CARDIA, Coronary Artery Risk Development in Young Adults; DBP, diastolic blood pressure; HDL, high-density lipoprotein; HR, heart rate; IQR, interquartile range; LDL, low-density lipoprotein; MVPA, moderate-vigorous physical activity; PP, pulse pressure; and SBP, systolic blood pressure.

*P<0.05.

β=–1.95, *P*<0.001; White men: β=–1.15, *P*=0.013; Black men: β=–1.26, *P*=0.020). White women with other smoking patterns also demonstrated lower SBP compared with White female never smokers (β=–1.67, *P*=0.002).

Findings for both Black and White smokers were similar in magnitude and statistical significance in sensitivity analyses that include the unadjusted BP measurements and added antihypertension medication use as a time-varying covariate (Table S5). Findings stratified by antihypertension medication use are presented in Table S6. Among individuals who reported using antihypertensive medication at any examination year, White female consistent smokers had greater PP compared with White female never smokers. Among individuals who did not report using antihypertensive medication, Black male and White male and female consistent smokers had lower DBP compared with never smokers, and White male and female consistent smokers also had higher PP.

DISCUSSION

The major and novel finding of the present study was that consistent smokers demonstrated greater PP compared with never smokers and the increased PP was most pronounced in Black and White women. Consistent smokers demonstrated slightly lower DBP (≈0.5–2 mm Hg lower) compared with never smokers, although not all associations were statistically significant. The lower DBP may have contributed to the higher PP in consistent smokers compared with never smokers because there were no differences in SBP between these groups. Long-term former smokers and individuals with all other smoking patterns demonstrated lower DBP, and individuals with other smoking patterns also demonstrated lower SBP compared with never smokers. There were no differences in PP between long-term former smokers and individuals with all other smoking patterns compared with never smokers.

Table 2. Thirty-Year Longitudinal Association Between Cigarette Smoking and BP Stratified by Race, Adding 10 mm Hg to SBP and 5 mm Hg to DBP for Individuals on Antihypertensive Medication (1985–2016)

	Consistent Smoker vs Never Smoker		Long-Term Former Smoker vs Never Smoker		Other Smoking Patterns vs Never Smoker	
	β (SE)	*P* Value	β (SE)	*P* Value	β (SE)	*P* Value
Black						
Model 1						
SBP	1.70 (0.59)	0.004*	0.32 (1.11)	0.777	0.42 (0.47)	0.369
DBP	0.00 (0.45)	0.996	−1.00 (0.84)	0.234	−0.37 (0.35)	0.290
PP	1.59 (0.40)	<0.001*	1.52 (0.74)	0.042*	0.87 (0.32)	0.006*
Model 2						
SBP	1.15 (0.65)	0.076	−0.30 (1.08)	0.781	−0.08 (0.48)	0.860
DBP	−0.26 (0.49)	0.603	−1.37 (0.82)	0.093	−0.61 (0.36)	0.090
PP	1.20 (0.45)	0.008*	1.17 (0.74)	0.114	0.55 (0.33)	0.098
Model 3						
SBP	0.58 (0.66)	0.381	−0.44 (1.09)	0.687	−0.30 (0.48)	0.537
DBP	−0.69 (0.50)	0.167	−1.25 (0.82)	0.125	−0.69 (0.36)	0.060
PP	1.01 (0.46)	0.028*	0.92 (0.75)	0.217	0.39 (0.33)	0.250
White						
Model 1						
SBP	1.79 (0.65)	0.006*	0.24 (0.88)	0.780	0.11 (0.40)	0.778
DBP	0.12 (0.52)	0.824	0.00 (0.70)	0.994	−0.14 (0.32)	0.674
PP	1.71 (0.40)	<0.001*	0.42 (0.54)	0.429	0.23 (0.25)	0.362
Model 2						
SBP	0.34 (0.70)	0.624	−0.19 (0.83)	0.822	−0.86 (0.40)	0.033*
DBP	−1.36 (0.56)	0.016*	−0.40 (0.67)	0.551	−1.07 (0.33)	0.001*
PP	1.62 (0.47)	<0.001*	0.31 (0.54)	0.560	0.12 (0.27)	0.645
Model 3						
SBP	−0.66 (0.69)	0.343	−0.82 (0.82)	0.314	−1.42 (0.40)	<0.001*
DBP	−2.27 (0.55)	<0.001*	−0.97 (0.65)	0.133	−1.50 (0.32)	<0.001*
PP	1.59 (0.47)	<0.001*	0.27 (0.54)	0.620	0.05 (0.27)	0.863

The "other smoking patterns" category includes individuals who reported smoking at 1 or more time points but did not meet the requirements to be classified as a current or former smoker. Model 1 adjusts for center, age, and sex. Model 2 additionally adjusts for BMI, history of CVD, MVPA, education, and pack-years. Model 3 additionally adjusts for alcohol, HDL-C, LDL-C, total cholesterol, triglycerides, and diabetes mellitus. BMI indicates body mass index; CVD, cardiovascular disease; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; MVPA, moderate-vigorous physical activity; PP, pulse pressure; and SBP, systolic blood pressure.

*P<0.05.

Although acute cigarette smoking is known to cause a brief rise in BP, the chronic effects of cigarette smoking on BP remain mixed. Several studies have demonstrated that current smokers have similar or lower DBP compared with nonsmokers. In contrast, other studies have demonstrated greater DBP among current smokers compared with nonsmokers.[9,10] Consistent with this, the findings pertaining to SBP among current smokers also remain conflicting. Li et al demonstrated no difference in SBP among current smokers compared with never smokers.[7] In contrast, Imamura et al demonstrated lower SBP among moderate-heavy male smokers, whereas other studies have demonstrated greater SBP among older moderate-heavy male smokers.[8,9] Although it has been suggested that a lower BMI among current smokers may contribute to the lower BP observed in some studies, several studies have demonstrated lower BP among current smokers even after adjusting for BMI. Therefore, it is likely that several additional factors may be responsible for the discrepancies in these findings, including the lack of examination of racial differences and/or the lack of adjustment for potential confounding factors including smoking pack-years, alcohol consumption, lipid concentrations, physical activity levels, antihypertension medication use, and the presence of comorbidities. After examining racial differences and adjusting for numerous covariates known to influence BP, the findings for DBP in the present study are in line with several previous analyses demonstrating that current smokers tend to have lower DBP compared with

Table 3. Thirty-Year Longitudinal Association Between Cigarette Smoking and BP Stratified by Race and Sex Group, Adding 10 mm Hg to SBP and 5 mm Hg to DBP for Individuals on Antihypertensive Medication (1985–2016)

	Consistent Smoker vs Never Smoker		Long-Term Former Smoker vs Never Smoker		Other Smoking Patterns vs Never Smoker	
	β (SE)	*P* Value	β (SE)	*P* Value	β (SE)	*P* Value
Black men						
SBP	−0.13 (0.90)	0.879	0.97 (1.50)	0.517	−0.56 (0.68)	0.405
DBP	−1.19 (0.73)	0.100	−0.57 (1.20)	0.636	−1.26 (0.54)	0.020*
PP	0.57 (0.68)	0.399	1.71 (1.10)	0.122	0.54 (0.50)	0.278
White men						
SBP	−1.11 (0.97)	0.254	−2.18 (1.31)	0.098	−1.29 (0.60)	0.031*
DBP	−2.23 (0.76)	0.003*	−2.61 (1.01)	0.010*	−1.15 (0.46)	0.013*
PP	1.17 (0.70)	0.093	0.64 (0.91)	0.479	−0.12 (0.42)	0.777
Black women						
SBP	0.80 (0.95)	0.400	−1.88 (1.54)	0.222	−0.37 (0.68)	0.592
DBP	−0.68 (0.69)	0.327	−1.96 (1.11)	0.079	−0.38 (0.49)	0.444
PP	1.38 (0.63)	0.030*	0.13 (1.01)	0.897	0.12 (0.45)	0.795
White women						
SBP	−0.38 (0.99)	0.699	−0.21 (1.05)	0.843	−1.67 (0.54)	0.002*
DBP	−2.44 (0.80)	0.002*	−0.23 (0.84)	0.785	−1.95 (0.43)	<0.001*
PP	1.96 (0.64)	0.002*	0.09 (0.65)	0.892	0.18 (0.34)	0.601

The "other smoking patterns" category includes individuals who reported smoking at 1 or more time points but did not meet the requirements to be classified as a consistent or long-term former smoker. Model adjusts for center, age, BMI, history of CVD, MVPA, education, pack-years, alcohol, HDL-C, LDL-C, total cholesterol, triglycerides, and diabetes mellitus. BMI indicates body mass index; CVD, cardiovascular disease; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; MVPA, moderate-vigorous physical activity; PP, pulse pressure; and SBP, systolic blood pressure.

*P<0.05.

never smokers.[7–9] However, we found that the lowest DBP was observed among White male and female consistent smokers compared with never smokers. These findings suggest that the magnitude of the association between cigarette smoking and lower DBP may be stronger in White consistent smokers than Black consistent smokers. Our findings for SBP are in line with those of Li et al and suggest that there are no differences in SBP between consistent smokers and never smokers.

Based solely on the findings that DBP tends to be slightly lower in consistent smokers and that cigarette smoking was not associated with higher SBP, it may be assumed that the association between cigarette smoking and CVD risk is not mediated through increased BP. However, one of the most novel findings of the current study was that PP tended to be higher among consistent smokers compared with never smokers, particularly among women. Importantly, Franklin and colleagues (1999) reported that individuals who demonstrate small increases in PP over time, but who have no changes in SBP over the same timeframe, are at greater CVD risk than individuals who demonstrate increases in SBP over time in the absence of changes in PP over the same timeframe.[1] Therefore, the greater PP demonstrated among consistent smokers in the present study, even in the absence of greater SBP, may contribute in part to the increased CVD risk observed among consistent cigarette smokers. In the present study, the increased PP demonstrated in consistent smokers compared with never smokers was small (≈1–2 mm Hg higher); however, because Franklin and colleagues (1999) demonstrated that small increases in PP were associated with greater CVD risk, these findings may have important clinical significance. Furthermore, individuals in the present study were relatively young (baseline median age: 25 years old; 30-year follow-up median age: 51 years old) and the magnitude of the difference in PP between consistent smokers and never smokers could continue to progress over time. Following the sixth decade of life, SBP continues to rise with advancing age; however, DBP decreases, leading to increased PP.[1] Therefore, if consistent smokers are already demonstrating higher PP over their young and early middle-aged years, it is possible that the increase in PP commonly seen after the sixth decade and continuing into older age may be steeper in consistent smokers than in never smokers, especially among female consistent smokers.

It is likely that the consistent trends towards slightly lower DBP observed in consistent smokers may have

contributed to the greater PP demonstrated in this group. The mechanisms underlying the slightly lower DBP demonstrated among consistent smokers in the present study remain unknown; however, it is likely that lower total vascular resistance may contribute. Indeed, current smokers demonstrate lower total vascular resistance compared with never smokers and this is thought to be mediated in part by the vasodilatory effects of cotinine, a metabolite of nicotine, and carbon monoxide.[34] Interestingly, DBP tended to be lower among White consistent smokers compared with Black consistent smokers. Therefore, it is possible that the effects of cotinine and carbon monoxide on total vascular resistance are more pronounced among White consistent smokers or that the effects of racial discrimination blunt the vasodilatory effects of cotinine and carbon monoxide among Black consistent smokers. Future studies that measure cotinine and carbon monoxide concentrations, racial discrimination, total vascular resistance, and BP in the same individuals are needed to better understand these mechanisms.

In addition to the potential effects of cotinine and carbon monoxide, there are likely additional mechanisms contributing to the lower DBP, and ultimately higher PP among consistent smokers, especially among women. Lawless et al demonstrated that the association between perceived stress and nicotine dependence is stronger among women compared with men.[35] However, it is important to note that the majority of women included in the study by Lawless and colleagues were non-Hispanic, White women.[35] This is important because in the present study, the White female consistent smokers demonstrated the lowest DBP compared with never smokers. While future studies examining racial differences in the association between perceived stress and nicotine dependence are needed, it is possible that stress relief from smoking has a more pronounced effect on BP among White female consistent smokers compared with Black female consistent smokers. Although greater PP was most pronounced among both White and Black female consistent smokers, it is possible that different mechanisms may contribute to the greater PP among each group separately. For example, while Black female consistent smokers demonstrated slightly lower DBP, they were the only group that trended to have higher SBP, suggesting that both lower DBP and higher SBP contributed to the greater PP observed in this group. The mechanisms contributing to the lower DBP and higher SBP among Black female consistent smokers cannot be determined in the present study; however, it is possible that greater large elastic central artery stiffness may have contributed. Stiffening of the large elastic central arteries (eg, aorta) decreases the ability of these vessels to distend in response to increased BP during systole and recoil during diastole.[36] This in turn results in increases in SBP, reductions in DBP, and a widening of PP. While the effects of cigarette smoking on large elastic central artery stiffness remain controversial,[37–39] it is possible that cigarette smoking increases large elastic central artery stiffness, and therefore PP, among Black women and that this may be attributed to several potential mechanisms such as greater increases in sympathetic nerve activity following smoking or the effects of discrimination. A recent study by Bromfield et al demonstrated that discrimination is associated with greater aortic stiffness among Black women, but not among Black or White men or White women.[40] While the study by Bromfield and colleagues adjusted for a history of cigarette smoking in their analysis, additional studies in current and never smokers are needed to further explore the interplay between discrimination, nicotine dependence, increased large elastic central artery stiffness, and greater PP among Black women.

In the present study, the increased PP was only observed in the consistent smokers and not long-term former smokers, suggesting that there may be no association between cigarette smoking and increased PP if an individual ceased smoking. Among long-term former smokers, the mechanisms underlying the lower DBP demonstrated among White male long-term former smokers as well as the nonsignificant trends in lower SBP remain unknown. It is important to note that in the present study, long-term former smokers smoked at the first and/or second examinations and then did not report smoking at any of the following examinations. Therefore, long-term former smokers in the present study quit smoking in their early adulthood years and had refrained from smoking for at least 25 years of follow-up period. It is possible that after quitting smoking, the long-term former smokers in the present study also engaged in other positive lifestyle factors that are associated with lower BP. Although numerous factors that are known to influence BP were included as covariates in the present study, additional lifestyle-based covariates, including nutritional factors such as dietary sodium intake, are needed to further examine the relation between long-term smoking cessation and BP.

The results of the present study should be interpreted in the context of several limitations. First, because of the large variety of other smoking patterns included in the "other smoking patterns" category, mechanisms as to why individuals with other smoking patterns have lower DBP, and for White women, higher SBP, are not able to be determined. Future studies examining the association between other smoking patterns and BP, including patterns that have periods of abstinence and then relapse, are needed. Second, former smokers in this study had refrained from smoking for ≈25 years. Future studies should examine differences in BP between Black and White smokers following shorter durations of smoking cessation.

CONCLUSIONS

In conclusion, the novel finding from the present study was that consistent smokers demonstrated higher PP compared with never smokers and the increased PP was most pronounced in female consistent smokers. The slightly higher PP observed in consistent smokers may contribute in part to the greater CVD risk observed in this group. Future studies are needed to determine whether the increase in PP with aging is greater among consistent smokers compared with never smokers and whether higher PP is associated with greater CVD risk in consistent smokers. Future studies are also needed to determine whether lower total vascular resistance contributes to the higher PP demonstrated in current smokers. Finally, consistent with previous studies on former smokers, cigarette smoking does not appear to differ between long-term former smokers and never smokers, suggesting that there is no association between long-term smoking and greater BP in this group.[41,42]

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Affiliations

From the Department of Health and Human Physiology (R.E.L., D.Z., G.L.P., K.M.W.); Department of Epidemiology (K.M.W.); Abboud Cardiovascular Research Center (G.L.P.); Environmental Health Sciences Research Center (G.L.P.); and Fraternal Order of Eagles Diabetes Research Center (G.L.P.), The University of Iowa, Iowa City, IA; Division of Epidemiology and Community Health, The University of Minnesota, MN (D.R.J.); Department of Medicine, Northwestern University, Chicago, IL (R.K.); and Department of Kinesiology, North Central College, Naperville, IL (R.E.L.).

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Disclosures

None.

Supplementary Material

Tables S1–S6

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Supplemental Material

Table S1. Algebraic Descriptions of Mixed Effects Linear Regression Models .

Model 1	$BP_{ij} = \beta_0 + \beta_1 smoking\ status_i + \beta_2 year_j + \beta_3 center_i + \beta_4 Sex_i + \beta_5 age_{ij} + \delta_i + \varepsilon_{ij}$
Model 2	$BP_{ij} = \beta_0 + \beta_0 + \beta_1 smoking\ status_i + \beta_2 year_j + \beta_3 center_i + \beta_4 Sex_i + \beta_5 age_{ij} + \beta_6 XBMI_{ij} + \beta_7 self - reported\ history\ of\ cardiovascular\ disease_{ij} + \beta_8 physcial\ activity_{ij} + \beta_9 education_{ij} + \beta_{10} smoking\ packyear_{ij} + \delta_i + \varepsilon_{ij}$
Model 3	$BP_{ij} = \beta_0 + \beta_1 smoking\ status_i + \beta_2 year_j + \beta_3 center_i + \beta_4 Sex_i + \beta_5 age_{ij} + \beta_6 XBMI_{ij} + \beta_7\ self - reported\ history\ of\ cardiovascular\ disease_{ij} + \beta_8 physcial\ activity_{ij} + \beta_9 education_{ij} + \beta_{10} smoking\ packyear_{ij} + \beta_{11} alcohol_{ij} + \beta_{12} plasma\ lipids_{ij} + \delta_i + \varepsilon_{ij}$

All models used a compound symmetry covariance matrix structure. Note. BP; blood pressure, BMI; body mass index.

Table S2. Mean Adjusted Systolic and Diastolic Blood Pressure (1985-2016) across Exam Years by Race and Smoking Status

			Baseline	Year 2	Year 5	Year 7	Year 10	Year 15	Year 20	Year 25	Year 30
Never Smokers	**Black**	SBP	111 ± 11	109 ± 11	110 ± 11	111 ± 71	112 ± 74	116 ± 15	120 ± 16	124 ± 17	129 ± 19
		DBP	70 ± 10	69 ± 10	71 ± 10	71 ± 10	74 ± 10	77 ± 12	76 ± 11	78 ± 11	79 ± 11
		PP	42 ± 10	40 ± 9	39 ± 8	40 ± 9	38 ± 9	39 ± 10	44 ± 9	46 ± 9	51 ± 12
	White	SBP	110 ± 11	107 ± 11	106 ± 11	106 ± 11	107 ± 11	109 ± 13	113 ± 13	115 ± 14	118 ± 16
		DBP	69 ± 9	67 ± 9	68 ± 9	68 ± 9	71 ± 9	73 ± 10	70 ± 11	71 ± 10	72 ± 11
		PP	41 ± 9	39 ± 8	38 ± 8	38 ± 8	37 ± 7	37 ± 9	43 ± 8	44 ± 8	46 ± 9
Long-Term Former Smokers	**Black**	SBP	113 ± 10	109 ± 11	111 ± 10	112 ± 13	113 ± 13	115 ± 15	122 ± 17	125 ± 17	132 ± 19
		DBP	68 ± 12	66 ± 11	70 ± 9	70 ± 9	75 ± 10	75 ± 12	77 ± 11	77 ± 10	80 ± 10
		PP	45 ± 10	43 ± 11	40 ± 8	41 ± 10	38 ± 8	40 ± 10	45 ± 9	48 ± 12	51 ± 13
	White	SBP	108 ± 10	105 ± 11	105 ± 11	105 ± 10	106 ± 10	110 ± 12	112 ± 12	116 ± 14	120 ± 17
		DBP	67 ± 8	65 ± 9	65 ± 9	67 ± 10	69 ± 8	72 ± 10	70 ± 10	73 ± 10	73 ± 12
		PP	41 ± 10	40 ± 10	37 ± 8	38 ± 7	37 ± 8	38 ± 9	42 ± 7	43 ± 7	46 ± 9
Consistent Smokers	**Black**	SBP	112 ± 12	111 ± 13	111 ± 14	113 ± 15	115 ± 16	120 ± 19	120 ± 19	126 ± 16	133 ± 17
		DBP	68 ± 11	69 ± 12	71 ± 13	71 ± 13	75 ± 12	77 ± 14	77 ± 14	79 ± 11	80 ± 11
		PP	44 ± 10	43 ± 10	41 ± 10	42 ± 10	40 ± 10	43 ± 12	46 ± 11	47 ± 10	52 ± 11
	White	SBP	110 ± 12	108 ± 11	107 ± 14	109 ± 12	109 ± 12	113 ± 14	116 ± 15	119 ± 16	123 ± 16
		DBP	67 ± 11	66 ± 11	68 ± 11	69 ± 11	69 ± 11	73 ± 11	73 ± 11	74 ± 10	75 ± 11
		PP	43 ± 9	42 ± 10	39 ± 8	41 ± 9	38 ± 8	39 ± 8	43 ± 9	45 ± 11	48 ± 10

Table S2 (continued). Mean Systolic and Diastolic Blood Pressure Race across Exam Years by Smoking Status and (1985-2016)

Other Smoking Patterns	**Black**	SBP	112 ± 11	110 ± 11	110 ± 12	112 ± 13	114 ± 14	117 ± 16	121 ± 17	125 ± 17	130 ± 19
		DBP	68 ± 10	68 ± 10	70 ± 11	70 ± 12	75 ± 11	77 ± 13	77 ± 12	79 ± 11	80 ± 12
		PP	44 ± 11	42 ± 10	40 ± 10	41 ± 10	39 ± 9	40 ± 11	44 ± 10	46 ± 11	51 ± 12
	White	SBP	108 ± 11	106 ± 10	105 ± 10	106 ± 11	107 ± 11	110 ± 13	113 ± 13	116 ± 15	119 ± 16
		DBP	67 ± 9	66 ± 9	67 ± 10	68 ± 9	70 ± 10	71 ± 10	71 ± 10	72 ± 11	73 ± 11
		PP	41 ± 9	40 ± 9	38 ± 8	39 ± 8	37 ± 7	38 ± 9	42 ± 7	44 ± 8	46 ± 9

All data are mean ± SD unless otherwise specified. Note. All BP measurements are adjusted for anti-HTN medication use by adding 10 mmHg to SBP and 5mmHg to DBP in individuals who reported taking anti-HTN medication. SBP; systolic blood pressure, DBP; diastolic blood pressure, PP; pulse pressure, HR; heart rate, HTN; hypertension.

Table S3. 30-year Longitudinal Association between Cigarette Smoking and Blood Pressure Stratified by Race, Adjusting for Anti-Hypertensive Medication Use (1985-2016)

		Consistent Smoker vs. Never Smoker		Long-Term Former Smoker vs. Never Smoker		Other Smoking Patterns vs. Never Smoker	
		β (SE)	**p value**	**β (SE)**	**p value**	**β (SE)**	**p value**
Black							
Model 1	SBP	1.60 (0.57)	**0.005**	0.24 (1.1)	0.822	0.40 (0.45)	0.381
	DBP	-0.02 (0.44)	0.969	-1.03 (0.82)	0.207	-0.38 (0.35)	0.279
	PP	1.29 (0.38)	**<0.001**	1.14 (0.71)	0.111	0.56 (0.30)	0.062
Model 2	SBP	1.06 (0.63)	0.093	-0.35 (1.0)	0.740	-0.11 (0.46)	0.818
	DBP	-0.28 (0.49)	0.572	-1.38 (0.81)	0.086	-0.61 (0.36)	0.086
	PP	1.10 (0.45)	**0.014**	0.99 (0.72)	0.166	0.36 (0.32)	0.267
Model 3	SBP	0.48 (0.64)	0.453	-0.46 (1.06)	0.665	-0.32 (0.47)	0.499
	DBP	-0.66 (0.50)	0.184	-1.27 (0.81)	0.118	-0.69 (0.36)	0.058
	PP	1.11 (0.46)	**0.015**	0.74 (0.72)	0.307	0.29 (0.33)	0.367
White							
Model 1	SBP	1.75 (0.64)	**0.006**	0.24 (0.86)	0.78	0.07 (0.40)	0.862
	DBP	0.09 (0.52)	0.954	-0.04 (0.70)	0.95	-0.16 (0.32)	0.629
	PP	1.30 (0.40)	**0.001**	0.02 (0.53)	0.965	0.14 (0.25)	0.565
Model 2	SBP	0.48 (0.69)	0.48	-0.15 (0.82)	0.853	-0.82 (0.40)	**0.040**
	DBP	-1.35 (0.56)	**0.017**	-0.41 (0.67)	0.537	-1.08 (0.33)	**0.001**
	PP	1.54 (0.47)	**0.001**	0.10 (0.54)	0.854	0.23 (0.27)	0.383
Model 3	SBP	-0.24 (0.69)	0.726	-0.76 (0.81)	0.348	-1.32 (0.40)	**<0.001**
	DBP	-1.91 (0.56)	**<0.001**	-0.90 (0.66)	0.173	-1.44 (0.32)	**<0.001**
	PP	1.48 (0.48)	**0.002**	0.11 (0.54)	0.834	0.22 (0.27)	0.412

Note. BMI; body mass index, MVPA; moderate-vigorous physical activity, CVD; cardiovascular disease, HDL; high-density lipoprotein, LDL; low-density lipoprotein. The ‘other smoking patterns’ category includes individuals who reported smoking at one or more time points but did not meet the requirements to be classified as a consistent or long-term former smoker.

Model 1 adjusts for center, age and sex.

Model 2 additionally adjusts for BMI, history of CVD, MVPA, education, pack-years

Model 3 additionally adjusts for alcohol, HDL-C, LDL-C, total cholesterol, triglycerides and diabetes

Table S4. 30-year Longitudinal Association between Cigarette Smoking and and Anti- Blood Pressure Stratified by Race Hypertensive Medication Use (1985-2016)

		Consistent Smoker vs. Never Smoker		Long-Term Former Smoker vs. Never Smoker		Other Smoking Patterns vs. Never Smoker	
		β (SE)	**p value**	**β (SE)**	**p value**	**β (SE)**	**p value**
Individuals with Anti-Hypertensive Medication Use (n=1525)							
Black							
	SBP	2.00 (1.13)	0.079	0.10 (1.87)	0.958	-0.49 (0.79)	0.540
	DBP	0.63 (0.84)	0.455	-1.07 (1.38)	0.441	-0.35 (0.59)	0.554
	PP	1.33 (0.79)	0.092	1.33 (1.27)	0.296	-0.18 (0.55)	0.737
White							
	SBP	0.63 (1.49)	0.675	-2.77 (1.84)	0.133	-0.84 (0.90)	0.353
	DBP	-0.66 (1.16)	0.567	-1.10 (1.44)	0.444	-0.82 (0.70)	0.242
	PP	1.01 (1.08)	0.354	-2.12 (1.32)	0.107	-0.13 (0.65)	0.839
Individuals with No Anti-Hypertensive Medication Use (n=3261)							
Black							
	SBP	0.34 (0.72)	0.636	0.36 (1.20)	0.765	-0.04 (0.55)	0.941
	DBP	-1.04 (0.56)	0.064	-0.69 (0.90)	0.443	-0.97 (0.42)	**0.021**
	PP	1.39 (0.57)	**0.015**	0.71 (0.91)	0.435	0.95 (0.42)	0.024
White							
	SBP	-0.52 (0.78)	0.508	-1.00 (0.92)	0.274	-1.85 (0.45)	**<0.001**
	DBP	-2.33 (0.62)	**<0.001**	-1.22 (0.71)	0.087	-1.81 (0.35)	**<0.001**
	PP	1.58 (0.56)	**0.005**	0.25 (0.62)	0.681	0.07 (0.31)	0.819

Note. Anti-hypertensive medication use was categorized as self-report of anti-hypertensive medication at any attended exam. All BP values are the unadjusted, observed measurements collected at the attended exams. SBP; systolic blood pressure, DBP; diastolic blood pressure, PP; pulse pressure, BMI; body mass index, MVPA; moderate-vigorous physical activity, CVD; cardiovascular disease,

HDL; high-density lipoprotein, LDL; low-density lipoprotein. The ‘other smoking patterns’ category includes individuals who reported smoking at one or more time points but did not meet the requirements to be classified as a consistent or long-term former smoker.

Model adjusts for center, age, sex, BMI, history of CVD, MVPA, education, pack-years, alcohol, HDL, LDL, total cholesterol, triglycerides and diabetes

Table S5. 30-year Longitudinal Association between Cigarette Smoking and Blood and Sex Pressure Stratified by Race Group, Adjusting for Anti-Hypertensive Medication Use (1985-2016)

		Consistent Smoker vs. Never Smoker		Long-Term Former Smoker vs. Never Smoker		Other Smoking Patterns vs. Never Smoker	
		β (SE)	**p value**	**β (SE)**	**p value**	**β (SE)**	**p value**
Black Males							
	SBP	-0.14 (0.89)	0.879	1.05 (1.48)	0.476	-0.60 (0.67)	0.376
	DBP	-1.04 (0.73)	0.155	-0.52 (1.21)	0.668	-1.24 (0.55)	**0.023**
	PP	1.03 (0.69)	0.136	1.42 (1.11)	0.200	0.78 (0.50)	0.121
White Males							
	SBP	-0.59 (0.96)	0.541	-2.04 (1.31)	0.119	-1.13 (0.59)	0.058
	DBP	-1.75 (0.77)	**0.024**	-2.45 (1.04)	**0.019**	-1.00 (0.48)	**0.035**
	PP	0.81 (0.70)	0.249	0.33 (0.90)	0.718	-0.15 (0.42)	0.729
Black Females							
	SBP	0.69 (0.92)	0.455	-1.96 (1.49)	0.189	-0.38 (0.66)	0.569
	DBP	-0.68 (0.69)	0.327	-2.00 (1.11)	0.070	-0.38 (0.49)	0.444
	PP	1.25 (0.62)	**0.043**	0.10 (0.95)	0.915	-0.22 (0.43)	0.606
White Females							
	SBP	0.04 (0.98)	0.971	-0.16 (1.03)	0.875	-1.58 (0.53)	**0.003**
	DBP	-2.11 (0.81)	**0.009**	-0.19 (0.86)	0.828	-1.91 (0.44)	**<0.001**
	PP	2.15 (0.66)	**0.001**	0.03 (0.67)	0.962	0.51 (0.35)	0.149

BMI; body mass index, MVPA; moderate-vigorous physical activity, CVD; cardiovascular disease, HDL; high-density lipoprotein, LDL; low-density lipoprotein. The 'other smoking patterns' category includes individuals who reported smoking at one or more time points but did not meet the requirements to be classified as a consistent or long-term former smoker.

Model adjusts for center, age, BMI, history of CVD, MVPA, education, pack-years, alcohol, HDL LDL, total cholesterol, triglycerides and diabetes

Table S6. 30-year Longitudinal Association between Cigarette Smoking and and Sex Blood Pressure Stratified by Race Group and Anti-Hypertensive Medication Use (1985-2016)

		Consistent Smoker vs. Never Smoker		Long-Term Former Smoker vs. Never Smoker		Other Smoking Patterns vs. Never Smoker	
		β (SE)	**p value**	**β (SE)**	**p value**	**β (SE)**	**p value**
Individuals with Anti-Hypertensive Medication Use (n=1525)							
Black Female							
	SBP	2.30 (1.54)	0.136	-1.29 (2.42)	0.596	-0.10 (1.03)	0.921
	DBP	0.62 (1.11)	0.581	-1.99 (1.75)	0.255	-0.18 (0.75)	0.807
	PP	1.68 (1.03)	0.104	1.40 (1.59)	0.375	-0.17 (0.69)	0.802
Black Male							
	SBP	1.11 (1.58)	0.484	1.94 (2.72)	0.477	-1.28 (1.15)	0.265
	DBP	0.29 (1.29)	0.820	0.26 (2.22)	0.907	-0.76 (0.94)	0.418
	PP	0.66 (1.18)	0.577	1.02 (1.99)	0.610	-0.38 (0.85)	0.653
White Female							
	SBP	3.03 (2.14)	0.157	-1.91 (2.04)	0.349	-0.52 (1.24)	0.674
	DBP	0.13 (1.71)	0.942	-0.63 (1.65)	0.703	-1.80 (1.00)	0.072
	PP	3.62 (1.63)	**0.027**	-1.60 (1.54)	0.300	1.27 (0.94)	0.179
White Male							
	SBP	-1.07 (1.89)	0.573	-0.36 (3.21)	0.911	-0.64 (1.19)	0.591
	DBP	-1.23 (1.52)	0.417	-1.17 (2.60)	0.653	0.37 (0.97)	0.704
	PP	-0.67 (1.39)	0.628	0.86 (2.32)	0.713	-1.21 (0.87)	0.163

Table S6 (continued). 30-year Longitudinal Association between Cigarette Smoking and Blood Pressure Stratified by Race and Sex Group and Anti-Hypertensive Medication Use (1985-2016)

Individuals with No Anti-Hypertensive Medication Use (n=3261)							
Black Female							
	SBP	0.28 (0.97)	0.768	-1.59 (1.57)	0.311	-1.01 (0.73)	0.164
	DBP	-1.19 (0.74)	0.111	-1.57 (1.18)	0.185	-0.96 (0.55)	0.081
	PP	1.40 (0.75)	0.061	-0.49 (1.16)	0.673	-0.05 (0.55)	0.934
Black Male							
	SBP	-0.84 (0.97)	0.389	1.28 (1.58)	0.420	-0.22 (0.74)	0.763
	DBP	-1.70 (0.80)	**0.034**	-0.45 (1.29)	0.730	-1.59 (0.61)	**0.009**
	PP	1.27 (0.84)	0.133	1.73 (1.33)	0.193	1.53 (0.63)	**0.015**
White Female							
	SBP	-0.15 (0.99)	0.878	0.35 (1.06)	0.742	-1.35 (0.53)	**0.011**
	DBP	-2.26 (0.84)	**0.007**	-0.27 (0.90)	0.766	-1.62 (0.45)	**<0.001**
	PP	1.90 (0.72)	**0.008**	0.73 (0.74)	0.326	0.45 (0.38)	0.229
White Male							
	SBP	-0.58 (1.03)	0.546	-1.67 (1.31)	0.204	-1.35 (0.63)	**0.032**
	DBP	-2.26 (0.84)	**0.007**	-2.13 (1.05)	**0.043**	-1.45 (0.51)	**0.004**
	PP	1.66 (0.81)	**0.040**	0.29 (0.97)	0.762	0.17 (0.48)	0.726

Note. Anti-hypertensive medication use was categorized as self-report of anti-hypertensive medication at any attended exam. All BP values are the unadjusted, observed measurements collected at the attended exams. SBP; systolic blood pressure, DBP; diastolic blood pressure, PP; pulse pressure, BMI; body mass index, MVPA; moderate-vigorous physical activity, CVD; cardiovascular disease, HDL; high-density lipoprotein, LDL; low-density lipoprotein. The 'other smoking patterns' category includes individuals who reported smoking at one or more time points but did not meet the requirements to be classified as a consistent or long-term former smoker.

Model adjusts for center, age, BMI, history of CVD, MVPA, education, pack-years, alcohol, HDL, LDL, total cholesterol, triglycerides and diabetes.