

# Racial Differences in Diurnal Blood Pressure and Heart Rate Patterns

## Results From the Dietary Approaches to Stop Hypertension (DASH) Trial

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**Background:** Several studies have suggested that blacks, on average, have a blunted decline in nocturnal blood pressure (BP) as compared with nonblacks. It is unknown whether differences in traditional determinants of BP, specifically diet and obesity, account for observed differences in diurnal patterns.

**Methods:** We conducted an analysis of the Dietary Approaches to Stop Hypertension (DASH) trial that enrolled adults with prehypertension or stage 1 hypertension. At the end of a 3-week run-in period, ambulatory BP monitoring data were obtained on 333 participants, all of whom ate the same diet. Mean ambulatory daytime (6 AM–11 PM) and nighttime (11 PM–6 AM) systolic BP, diastolic BP, and heart rate (HR) were measured. Dipping was defined as a nighttime drop of less than 10% from mean daytime values.

**Results:** Office BP was similar in blacks and nonblacks, as were 24-hour and daytime BP and HR. However, blacks demonstrated a statistically significant, blunted nocturnal decline in BP and HR. Blacks were significantly more likely than nonblacks to have systolic nondipping (44.9% vs 26.7%,  $P = .001$ ), diastolic nondipping (20.9% vs 11.6%,  $P = .03$ ), and HR nondipping (40.9% vs 19.9%,  $P < .001$ ). These differences persisted after adjustment for site, sex, age, body mass index, alcohol intake, physical activity, office BP (or HR), education, and income.

**Conclusion:** Blacks with similar office BP, and who consumed the same diet as nonblacks, had a blunted nocturnal decline in systolic BP, diastolic BP, and HR, even after factors that influence BP were controlled for.

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**O**N AVERAGE, BLACKS HAVE higher rates of hypertension and cardiovascular-renal complications than other racial or ethnic populations in the United States.<sup>1</sup> Abnormal diurnal blood pressure (BP) patterns may contribute to the racial disparity in cardiovascular-renal disease. In a meta-analysis of 18 studies of diurnal BP patterns, Profant and Dimsdale<sup>2</sup> reported that blacks were significantly more likely to have a blunted nocturnal decline in BP as compared with nonblacks. Their analysis did not report a diurnal pattern of heart rate (HR). A blunted nocturnal decline, or “nondipping” BP pattern, has been associated with increased left ventricular mass index,<sup>3</sup> congestive heart failure,<sup>4</sup> renal impairment,<sup>5</sup> obstructive sleep apnea,<sup>6</sup> and stroke<sup>7</sup> independent of clinic BP and other established cardiovascular risk factors.

An important limitation of previous studies has been the inability to adequately control for traditional factors that influence BP levels, particularly diet. Previous results from the Dietary Approaches to Stop Hypertension (DASH) trial have shown that both a diet high in

fruits and vegetables and a combination diet high in fruits and vegetables and low-fat dairy products lowered 24-hour ambulatory BP significantly as compared with the control “typical” American diet (fruit and vegetable diet,  $-3.2/-1.9$  mm Hg; combination diet,  $-4.6/-2.6$  mm Hg [ $P < .001$  for systolic BP (SBP) and diastolic BP (DBP) on both diets]). The combination diet lowered ambulatory BP during both day and night.<sup>8</sup>

The objective of the present study was to determine whether racial differences in diurnal BP and HR patterns are present in black and nonblack participants who had similar baseline BP levels and who were consuming the same diet. To address this issue, we used ambulatory BP and HR data from 333 individuals who participated in the run-in period of the DASH trial: a multicenter feeding study conducted in adults with prehypertension or stage 1 hypertension.

## METHODS

Detailed information about the design of the DASH study and its main results have been pro-

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vided elsewhere.<sup>8,9</sup> Four clinical centers, a coordinating center, and the National Heart, Lung, and Blood Institute participated in the study. The protocol was reviewed by an independent protocol review committee and was approved by the National Heart, Lung, and Blood Institute and by the institutional review boards at each center. Each participant gave written informed consent.

## STUDY POPULATION

Participants aged 22 years or older with an average clinic-based SBP of less than 160 mm Hg and a DBP between 80 and 95 mm Hg (mean of 6 measurements over 3 screening visits) were eligible for the study. Race was defined based on self-identification of investigator-specified options and categorized as black or non-black (primarily non-Hispanic white). Special efforts were made to enroll blacks because of their high rate of BP-related disease. Exclusion criteria included a history of heart disease, renal insufficiency (glomerular filtration rate, <65 mL/min/1.73 m<sup>2</sup>), poorly controlled hyperlipidemia (total cholesterol, >260 mg/dL [to convert to millimoles per liter, multiply by 0.0259]), insulin-requiring or poorly controlled diabetes, special dietary requirements, intake of more than 14 alcoholic drinks per week, or use of medications that might affect BP or nutrient metabolism. Patients taking antihypertensive medications were eligible to enroll in the study if they met the inclusion criteria for BP after supervised withdrawal of medication. We further limited this analysis to DASH participants who had a technically satisfactory 24-hour ambulatory BP monitoring (ABPM) tracing at baseline (n=353) and excluded participants with abnormal self-reported sleep cycles (n=20). For this study, an abnormal sleep cycle was defined as going to sleep between 4:00 AM and 6 PM or waking up before 4 AM or after noon. A total of 333 participants were included in this analysis.

## RUN-IN DIET

During a 3-week run-in period, participants ate a diet typical of what many Americans consume (control diet). The nutritional composition of the control diet at 2100 kcal was as follows: sodium, 3450 mg/d; potassium, 1700 mg/d; calcium, 450 mg/d; total fat, 36% of energy; protein, 15% of energy; and carbohydrate, 49% of energy. Meals were prepared in a metabolic kitchen and served in an outpatient dining facility. Throughout the 14 weeks of feeding, participants agreed to eat only the food provided to them and nothing else. The nutrient composition of the diets was confirmed by chemical analysis. Caloric intake was adjusted to maintain a stable weight.

## MEASUREMENTS

### Ambulatory BP Monitoring

Ambulatory BP monitoring was obtained during the last week of the run-in period, when all participants had been eating the control diet for at least 2 weeks. Ambulatory BP and HR were recorded with a portable, automated noninvasive monitoring device (Space Labs 90207; Spacelabs Inc, Redmond, Washington). Before initiation of the recording period, DASH technicians took 2 random-zero (RZ) sphygmomanometer measurements following standardized BP protocol. An appropriately sized ABPM cuff was placed on the participant's nondominant arm, and 2 readings were manually initiated. Readings were repeated if SBP, DBP, or HR fell outside the predefined acceptable ranges (SBP, 70-240 mm Hg; DBP, 40-150 mm Hg; and HR, 20-150 beats/min). During BP recordings, participants were instructed to keep their arms still and in an extended position.

The monitors were programmed to record BP and pulse rate every 30 minutes throughout the 24-hour period.

After the 24-hour recording period, each monitor was downloaded to a computer using a commercially available software package (Spacelabs 90121, Version 1.1; Space Labs Inc). Per protocol, only ABPM data that contained 14 acceptable readings (predefined acceptable ranges: SBP, 70-240 mm Hg; DBP, 40-150 mm Hg; and HR, 20-150 beats/min) between 6:00 AM and midnight were considered satisfactory (this decision was based on a previous report that indicated that 14 daytime readings provide measurement replication comparable to that seen with 28-52 measurements per monitoring period).<sup>10</sup> For analysis, the ABPM and HR data were cleaned, eg, null values were removed, and data were trimmed and edited so that no more than 24 hours of readings were included.

After the monitoring period, participants completed a questionnaire that collected information on sleeping and waking times. For each participant, mean 24-hour, daytime and nighttime BP and HR, and mean decline in nocturnal levels of BP and HR were calculated. Daytime and nighttime SBP, DBP, and HR were calculated as the mean of the hourly SBP, DBP, and HR values between 8:00 AM and 6:00 PM and between 10:00 PM and 6:00 AM for daytime and nighttime, respectively. These ranges represent the plateau and nadir of the 24-hour diurnal BP patterns and eliminate the retiring and rising periods, during which BP is subject to considerable variation.<sup>4</sup> We calculated nocturnal BP and HR decline by subtracting mean nighttime SBP, DBP, and HR values from mean daytime SBP, DBP, and HR values. Systolic, diastolic, and HR nondippers were defined as those participants with a decrease of less than 10% in nighttime SBP, DBP, and HR values compared with daytime SBP, DBP, and HR values, respectively. In most healthy individuals, there is a nocturnal decline in mean SBP of at least 10% from mean daytime values.<sup>11</sup>

## Other Measurements

Other baseline measurements included demographic variables, body mass index (BMI), education level, self-reported alcohol intake and physical activity, resting HR, and standard office BP, as assessed by RZ sphygmomanometry (RZ-BP). The BMI was calculated as weight in kilograms divided by height in meters squared. Self-reported physical activity levels were collected by questionnaire as a continuous variable in kilocalories per kilogram per day. The RZ-BP measurements were obtained with the use of a standardized protocol: using an RZ mercury manometer (Hawksley & Son, London, England) and an appropriately sized cuff, trained, certified staff measured BP in participants who had been quietly seated for 5 minutes. The BP on any given day was defined as the average of 2 measurements taken 30 seconds apart. The RZ-BP levels were measured at each of 3 screening visits and on 4 separate days during the last 2 weeks of a 3-week run-in period: the RZ-BP was the average of the BP levels from these 7 visits.

## STATISTICAL METHODS

Data are reported as mean (SD) or number (percentage). Group characteristics were compared using an unpaired 2-tailed *t* test and  $\chi^2$  analysis. All calculations were performed using Stata software (Version 8.2; Stata Corp, College Station, Texas). To determine whether the results were influenced by definitions of BP dipping, we also repeated our analyses with sleeping/waking BP values based on self-reported sleeping/waking times and found no substantial differences in the results. To determine differences in the mean ambulatory values of SBP, DBP, and HR, each of the dependent variables was entered into a sepa-

**Table 1. Baseline Characteristics of the DASH Study Participants by Race<sup>a</sup>**

Characteristic	Blacks (n = 187)	Nonblacks (n = 146)	P Value <sup>b</sup>
Age, mean (SD), y	44.0 (9.3)	46.9 (11.5)	.02
Physical activity, mean (SD), kcal/kg/d	37.2 (6.9)	37.8 (6.3)	.51
Alcohol intake, mean (SD), drinks/wk	0.13 (0.3)	0.30 (0.5)	<.001
BMI, mean (SD)	28.6 (3.8)	27.5 (3.9)	.008
Male	38.0	70.6 <sup>b</sup>	<.001
Full-time employment	80.2	72.6	.57
Education			<.001
High school degree or less	25.7	13.0	
Some college	38.5	24.0	
College degree	23.0	28.1	
Some graduate school	12.8	34.9	
Income, \$			<.001
<30 000	43.3	21.3	
30 000-59 000	41.1	44.0	
≥60 000	15.6	34.7	

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); DASH, Dietary Approaches to Stop Hypertension.

<sup>a</sup>Values are expressed as percentages unless otherwise indicated.

<sup>b</sup>Test of association from  $\chi^2$  test (categorical variables) or *t* test (continuous variables).

rate multivariate linear regression model. We also conducted logistic regression analyses to determine whether there were differences in the prevalence of systolic, diastolic, and HR nondipping by race. We investigated the independent variables (prevalence BP/HR dipping and nocturnal BP/HR decline) in 3 models in a hierarchical fashion: model 1 was a crude analysis and included clinic site, age, and sex as covariates; model 2 included model 1 variables plus mean 24-hour BP or HR and lifestyle variables (BMI, alcohol use, and physical activity); and model 3 included model 2 variables plus socioeconomic variables (education and income). The level of statistical significance for all tests was  $P < .05$ . The results were initially stratified by sex; however, they were consistent across strata, and, when combined, the results of statistical tests for interactions between sex and race were not statistically significant.

## RESULTS

A total of 333 ambulatory BP records were available for the present study, including 187 from black participants and 146 from nonblack participants. Baseline demographic characteristics by race are shown in **Table 1**. Blacks were more likely to be women (62% vs 29.4%,  $P < .001$ ), younger (mean age, 44.0 years vs 46.9 years,  $P = .02$ ), have a greater mean BMI (28.6 vs 27.5,  $P = .008$ ), consume lower amounts of alcoholic beverages per week (0.13 vs 0.30,  $P < .001$ ), have lower levels of education ( $P < .001$  for all categories), and have lower levels of income ( $P < .001$  for all categories).

Blacks and nonblacks had similar office SBP and DBP values, but the HR values were slightly lower in blacks than in nonblacks (**Table 2**). Mean daytime SBP, DBP, and HR were higher than nighttime SBP, DBP, and HR, respectively, for both blacks and nonblacks. Although 24-

**Table 2. Blood Pressure (BP) and Heart Rate (HR) Characteristics by Race<sup>a</sup>**

Characteristic	Blacks (n = 187)	Nonblacks (n = 146)	P Value <sup>b</sup>
Hypertensive, % <sup>c</sup>	30.5	27.6	.84
Office BP and HR			
SBP, mm Hg	131.3 (10.2)	131.6 (11.0)	.93
DBP, mm Hg	84.8 (5.0)	84.8 (4.6)	.65
HR, beats/min	73.9 (7.3)	75.3 (8.2)	.009
Ambulatory SBP, mm Hg <sup>d</sup>			
24-h SBP	131.0 (11.8)	131.0 (12.5)	.99
Daytime SBP	135.5 (11.1)	136.6 (11.6)	.26
Nighttime SBP	122.1 (11.1)	120.1 (12.4)	.11
$\Delta$ (day-night) SBP	13.4 (7.0)	16.9 (8.7)	.001
Ambulatory DBP, mm Hg <sup>d</sup>			
24-h DBP	84.4 (6.8)	84.6 (6.1)	.82
Daytime DBP	89.1 (8.1)	89.0 (7.9)	.89
Nighttime DBP	76.4 (8.1)	74.1 (8.0)	.01
$\Delta$ (day-night) DBP	12.3 (6.0)	13.7 (6.9)	.05
Ambulatory HR, beats/min <sup>d</sup>			
24-h HR	77.4 (8.5)	74.4 (8.5)	.002
Daytime HR	81.4 (9.5)	79.6 (9.7)	.09
Nighttime HR	70.8 (9.4)	66.3 (8.4)	<.001
$\Delta$ (day-night) HR	10.7 (7.6)	13.4 (7.9)	.002
Nondipping BP and HR <sup>e</sup>			
Nondipping SBP, mm Hg	44.9	26.7	.001
Nondipping DBP, mm Hg	20.9	11.6	.03
Nondipping SBP or DBP, mm Hg	46.0	27.4	.001
Nondipping HR, beats/min	40.9	19.9	<.001

Abbreviations: DBP, diastolic BP; SBP, systolic BP.

<sup>a</sup>Values are given as mean (SD) unless otherwise indicated.

<sup>b</sup>Test of association from  $\chi^2$  test (categorical variables) or *t* test (continuous variables). *P* values are unadjusted.

<sup>c</sup>Defined by an SBP of 140 mm Hg or higher and/or a DBP of 90 mm Hg or higher.

<sup>d</sup>Daytime, 8:00 AM to 6:00 PM; nighttime, 10:00 PM to 6:00 AM

<sup>e</sup>Defined as a nocturnal drop of less than 10% from mean daytime values.

hour readings of SBP, DBP, and HR were similar between groups, decline in nocturnal SBP and HR was significantly decreased in blacks. For SBP, black participants had an average nocturnal decline of 13.4 mm Hg, while nonblack participants had a mean decline of 16.9 mm Hg ( $P < .001$ ). For DBP, the nocturnal decline was also greater for nonblacks (13.7 mm Hg) than for blacks (12.3 mm Hg) ( $P = .05$ ). Similarly, the mean nocturnal HR decline was 13.4 beats/min for nonblacks and 10.7 beats/min for blacks ( $P = .002$ ). Overall, 46% of blacks and 27.4% of nonblacks had either a nondipping SBP pattern or a nondipping DBP pattern ( $P = .001$ ). Blacks were also more than twice as likely as nonblacks to have a nondipping HR (41% vs 20%,  $P \leq .001$ ). The correlation between percent decline in HR and percent decline in SBP was 0.132 ( $P = .01$ ), and the correlation between percent decline in pulse rate and percent decline in DBP was 0.119 ( $P = .03$ ).

The average BP levels and HR by the hour are presented in **Figures 1** (SBP), **2** (DBP), and **3** (HR). Throughout the daytime hours, the SBP level was slightly higher in nonblacks than in blacks, although the difference was not statistically significant ( $P = .26$ ). However, as the mean SBP gradually declined throughout the evening, the SBP remained higher in blacks. Similar to

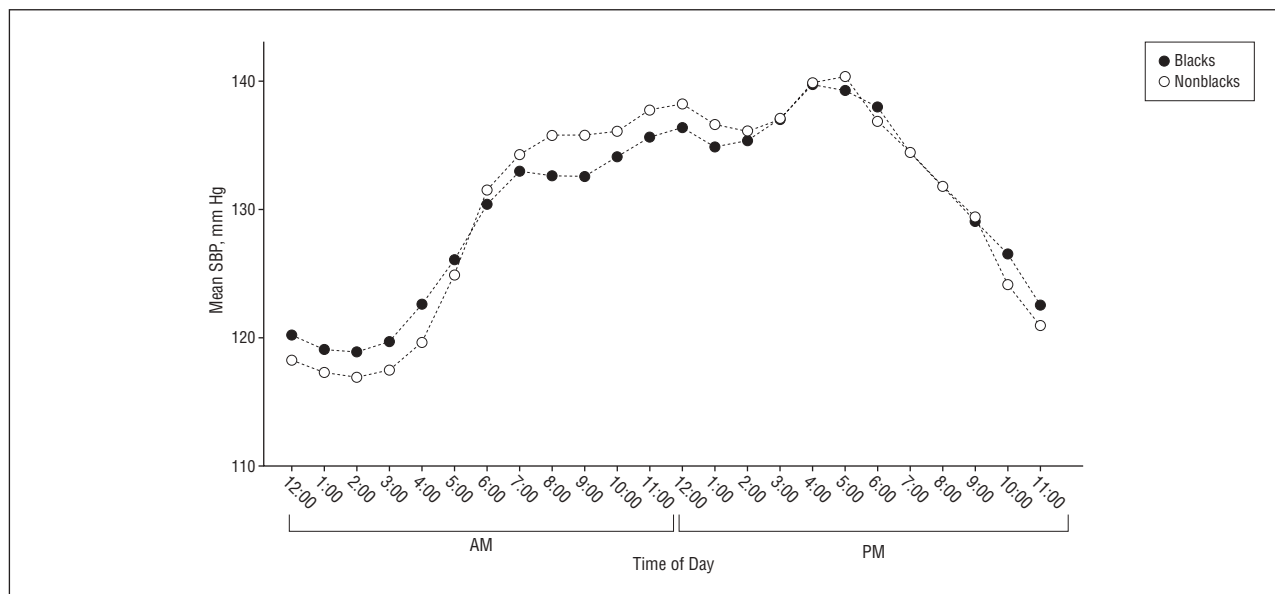


Figure 1. Ambulatory systolic blood pressure (SBP) by race during run-in feeding in the Dietary Approaches to Stop Hypertension trial.

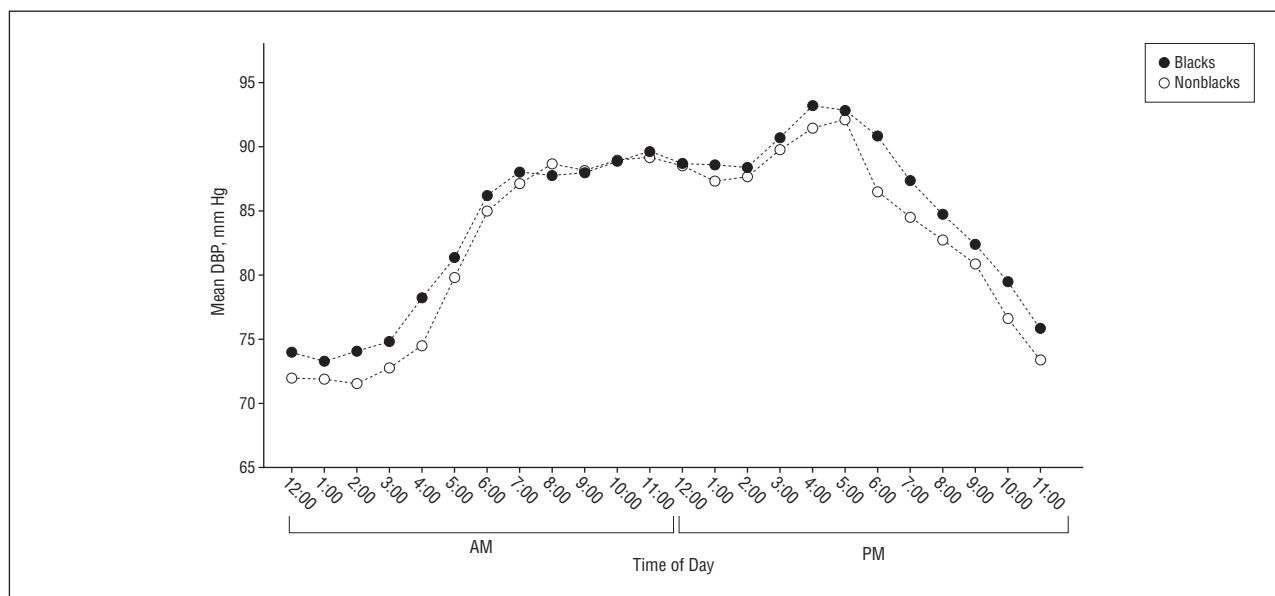


Figure 2. Ambulatory diastolic blood pressure (DBP) by race during run-in feeding in the Dietary Approaches to Stop Hypertension trial.

SBP, racial differences in DBP and HR circadian patterns were also most pronounced in the evening.

To determine whether racial differences in nocturnal BP and HR decline could be explained by measured confounding variables, we performed linear regression with adjustment for a number of demographic and lifestyle variables known to influence BP and HR. Overall, the nocturnal declines in SBP, DBP, and HR were significantly greater in nonblacks than in blacks in all 3 multivariate models (**Table 3**). In the maximally adjusted model, the nocturnal SBP decline was 3.54 mm Hg (95% confidence interval [CI], -5.92 to -1.16) less, the DBP decline was 2.24 mm Hg (95% CI, -4.10 to -0.39) less, and the HR decline was 2.64 beats/min (95% CI, -4.71 to -0.57) less in blacks than in nonblacks. Interactions of

race with age, sex, and baseline BP and/or HR were tested, but none of them were statistically significant in any model and consequently were excluded.

Table 3 also shows the multivariable-adjusted odds ratios for prevalent SBP dipping, DBP dipping, and HR dipping in blacks as compared with nonblacks. In the maximally adjusted model (model 3), the prevalence of SBP dipping, DBP dipping, and HR dipping was less likely in blacks than in nonblacks (all statistically significant). When the data were analyzed using self-reported sleeping/waking times rather than the fixed-time definition using average sleeping/waking times, the estimates did not materially change (eg, the odds ratio for SBP dipping in model 3 using the alternative definition was 0.46 [95% CI, 0.26-0.83]).

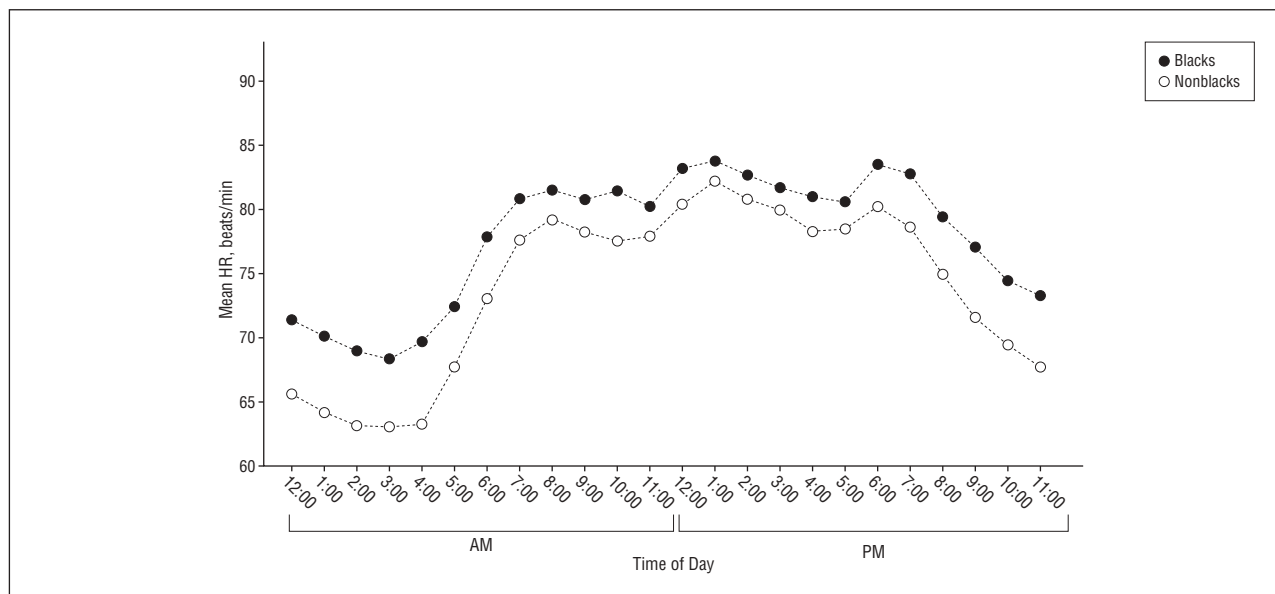


Figure 3. Ambulatory heart rate (HR) by race during run-in feeding in the Dietary Approaches to Stop Hypertension trial.

**Table 3. Mean Difference in Day-Night Blood Pressure (BP) and Heart Rate (HR) Change and Odds of Dipping in 333 Study Participants**

	Mean Difference Between Blacks and Nonblacks in Day-Night BP and HR Change <sup>a</sup>		Odds of Dipping in Blacks vs Nonblacks	
	Mean (95% CI)	P Value	OR (95% CI)	P Value
SBP, mm Hg				
Model 1 <sup>b</sup>	-4.15 (-6.31 to -1.98)	<.001	0.46 (0.36 to 0.78)	.005
Model 2 <sup>c</sup>	-4.04 (-6.31 to -1.71)	.001	0.48 (0.27 to 0.84)	.01
Model 3 <sup>d</sup>	-3.54 (-5.92 to -1.16)	.004	0.46 (0.25 to 0.84)	.01
DBP, mm Hg				
Model 1 <sup>b</sup>	-2.55 (-4.25 to -0.85)	.003	0.39 (0.19 to 0.80)	.01
Model 2 <sup>c</sup>	-2.43 (-4.19 to -0.68)	.007	0.43 (0.21 to 0.90)	.02
Model 3 <sup>d</sup>	-2.24 (-4.10 to -0.39)	.02	0.33 (0.15 to 0.74)	.007
HR, beats/min				
Model 1 <sup>b</sup>	-2.40 (-4.33 to -0.47)	.02	0.37 (0.21 to 0.66)	.001
Model 2 <sup>c</sup>	-2.91 (-4.89 to -0.94)	.004	0.34 (0.18 to 0.64)	.001
Model 3 <sup>d</sup>	-2.64 (-4.71 to -0.57)	.01	0.39 (0.20 to 0.76)	.03

Abbreviations: CI, confidence interval; DBP, diastolic BP; OR, odds ratio; SBP, systolic BP.

<sup>a</sup>Mean difference calculated as day-night change in blacks minus day-night change in nonblacks adjusted for baseline.

<sup>b</sup>Adjusted for site, sex, and age.

<sup>c</sup>Adjusted for study site, sex, age, body mass index, alcohol, activity, and 24-h BP and/or HR.

<sup>d</sup>Adjusted for study site, sex, age, body mass index, alcohol, activity, 24-h BP and/or HR, education, and income.

## COMMENT

In a diverse population of individuals with prehypertension and hypertension who were fed a common diet that is typical of what many Americans eat, blacks had a higher nighttime BP level than nonblacks despite similar levels of daytime BP, 24-hour BP, and baseline office BP. These differences persisted after the effects of lifestyle factors that influence BP were controlled for. In parallel analyses, blacks had a higher HR at nighttime than nonblacks.

A number of previous studies have demonstrated that blacks have higher 24-hour BP readings, blunted noc-

turnal BP decline, and higher BP variability (defined as the SD of BP over a 24-hour period) than nonblacks. Mayet et al<sup>12</sup> reported a smaller nocturnal dip in mean BP in black vs nonblack hypertensive subjects, even though there were no differences noted in 24-hour mean BP. Profant and Dimsdale<sup>2</sup> conducted a meta-analysis of 18 studies, involving 2852 participants, and concluded that black/nonblack differences in BP patterns were significantly greater at night than during the day; however, racial differences in nocturnal BP decline were only significant in American blacks. The findings of a blunted nocturnal decline were consistent across all but 1 study, even though the studies were heterogeneous with respect to geo-

graphic location, population demographics, ABPM device, and definition of daytime/nighttime.

Higher nighttime BP levels and HR in blacks than in nonblacks may partially explain the greater risk of cardiovascular disease in blacks. In prospective observational studies, higher nighttime BP, a nondipping BP pattern, and low HR variability have been shown to be strong predictors of future cardiovascular morbidity and mortality, even after adjustment for conventional office BP.<sup>13</sup> Kikuya et al<sup>14</sup> demonstrated that a nondipping BP pattern was associated with an increased cardiovascular risk and that nighttime BP more accurately predicted cardiovascular events than daytime BP. Similarly, Ohkubo et al<sup>15</sup> reported that nondippers had a significantly increased risk of cardiovascular mortality over a 5-year follow-up period as compared with dippers with a nocturnal BP decline of greater than 10%.

The mechanisms underlying an abnormal nighttime BP dipping pattern are not fully understood. Several demographic, physiological, and psychosocial factors, including age,<sup>16</sup> sodium sensitivity,<sup>17</sup> postmenopausal status,<sup>18</sup> sleep apnea,<sup>6</sup> and poor sleep quality,<sup>19</sup> appear to have an association with a nondipping BP pattern. Also, as reviewed by Routledge and McFetridge-Durdle,<sup>16</sup> several studies have reported psychosocial factors such as increased anger, hostility, depression, and stress, as well as decreased social support and self-esteem, among individuals with essential hypertension and a nondipping BP profile. Physiological factors that exhibit circadian patterns, including hormones, growth factors, immunomodulators, activity of the renin-angiotensin system, baroreflex sensitivity, endothelial function, and increased nocturnal sympathetic activity, may account for these associations.<sup>20</sup>

A unique finding of our study, which, to our knowledge, was not previously addressed in other articles that examined racial differences in diurnal BP, are our HR results. The fact that we observed an impaired diurnal variation in both BP and HR values in this cohort suggests the possibility that the autonomic nervous system may play an important role in explaining our findings. Nondipping BP is related to altered sympathovagal balance as measured by other HR-derived measures of autonomic balance, such as HR variability and HR recovery after exercise.<sup>21</sup> Consequently, circadian changes in HR tend to mirror changes in BP.<sup>5</sup> Like nondipping BP, nondipping HR has been associated with states of chronic psychological stress,<sup>22</sup> experimental hyperinsulinemia,<sup>23</sup> and target organ disease.<sup>24</sup> These observations suggest that both nondipping BP and HR may result in part from a failure of the sympathetic nervous system to rest at night.<sup>25</sup> This change may have important clinical consequences: altered autonomic tone has been associated with sudden cardiac death and heart failure<sup>26</sup> and has been shown to be related to components of the metabolic syndrome, including visceral fat deposition, insulin resistance, glucose intolerance, increased inflammation, dyslipidemia, and hypertension.<sup>27</sup>

Racial (black-white) differences in autonomic regulation have been documented in adults<sup>28,29</sup> and children,<sup>30</sup> and an unhealthy autonomic balance has also been linked to low socioeconomic status.<sup>31</sup> Our observation

that nondipping BP and HR are more common in blacks than in nonblacks is consistent with the notion that unhealthy sympathovagal balance may be more prevalent among blacks than nonblacks. Interestingly, Uzu et al<sup>32</sup> have reported that sodium restriction can restore nocturnal BP decline, particularly in patients with enhanced sodium sensitivity. Although we were not able to assess whether sodium restriction had a differential effect on nocturnal BP in blacks vs nonblacks in this study, we believe that this would be an important area for future research.

The strengths of this study include the large, multicenter feeding trial design. All study participants consumed a common diet for 3 weeks, and participants were instructed not to alter their physical activity habits, thereby reducing the influence of lifestyle factors on BP and HR variability. Nevertheless, several limitations should be considered in interpreting the results of our study. The population consisted of volunteers for a clinical trial. Furthermore, the DASH trial used strict trial eligibility requirements for BP, particularly DBP, narrowing the range of BP values to be analyzed. This restricted range of DBP may explain the greater black-nonblack differences observed for SBP decline as compared with DBP decline.

Furthermore, there is considerable heterogeneity in the literature regarding the optimal definition of daytime vs nighttime BP. We attempted to address this issue in our study by conducting additional analyses using self-reported sleeping/waking times determined by patient diaries, rather than using fixed daytime/nighttime clock times, and the main results did not differ. Also, we were not able to address sleep quality, which has previously been shown to influence diurnal BP patterns. Another possible limitation is multiple statistical testing, given the large number of analyses. However, all analyses were specified a priori, and the findings were consistent across all models. Finally, we did not examine racial differences in morning BP surge. Although it has been documented that morning BP surge is an independent risk factor for both silent cerebral infarcts (assessed by magnetic resonance imaging) and clinical stroke events,<sup>33</sup> most of the existing research demonstrating that morning BP surge is associated with cardiovascular morbidity has focused largely on elderly hypertensive patients. Because our sample was much younger, we believe that highlighting racial differences in BP dipping may be of greater importance than highlighting differences in morning BP surge.

In conclusion, the findings from this study suggest that blacks and nonblacks have significantly different diurnal BP and HR patterns. These racial differences in diurnal BP patterns are not explained by racial differences in dietary patterns.

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