ORIGINAL ARTICLE

Psychosocial Correlates of Nocturnal Blood Pressure Dipping in African Americans: The Jackson Heart Study

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BACKGROUND
African Americans exhibit a lower degree of nocturnal blood pressure (BP) dipping compared with Whites, but the reasons for reduced BP dipping in this group are not fully understood. The aim of this study was to identify psychosocial factors associated with BP dipping in a population-based cohort of African Americans.

METHODS
This cross-sectional study included 668 Jackson Heart Study (JHS) participants with valid 24-hour ambulatory BP data and complete data on psychosocial factors of interest including stress, negative emotions, and psychosocial resources (e.g., perceived support). The association of each psychosocial factor with BP dipping percentage and nondipping status (defined as <10% BP dipping) was assessed using linear and Poisson regression models, respectively, with progressive adjustment for demographic, socioeconomic, biomedical, and behavioral factors.

RESULTS
The prevalence of nondipping was 64%. Higher depressive symptoms, higher hostility, and lower perceived social support were associated with a lower BP dipping percentage in unadjusted models and after adjustment for age, sex, body mass index, and mean 24-hour systolic BP ($P < 0.05$). Only perceived support was associated with BP dipping percentage in fully adjusted models. Also, after full multivariable adjustment, the prevalence ratio for nondipping BP associated with 1 SD (7.1 unit) increase in perceived support was 0.93 (95% CI: 0.88–0.99). No other psychosocial factors were associated with nondipping status.

CONCLUSIONS
Lower perceived support was associated with reduced BP dipping in this study. The role of social support as a potentially modifiable determinant of nocturnal BP dipping warrants further investigation.

Keywords: African Americans; ambulatory blood pressure monitoring; blood pressure dipping; hypertension; Jackson Heart Study; psychosocial factors; social support.

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Racial disparities in hypertension are well documented, with African Americans having a higher prevalence of hypertension, poorer blood pressure (BP) control, and greater hypertension-related morbidity and mortality compared to Whites.[1–3] While the reasons for these disparities are not fully understood, differences in the diurnal pattern of BP have been hypothesized as a possible explanatory factor.[4] Nocturnal BP dipping represents a normal circadian rhythm, and individuals with a decline in nighttime BP of less than 10% of their mean daytime BP are considered nondippers.[4] Reduced BP dipping is associated with adverse cardiovascular outcomes and target organ damage in both individuals with and without hypertension and maintains a stronger association with these outcomes than average 24-hour BP.[5–8] Studies consistently show that African Americans have smaller declines in nocturnal BP compared to Whites and are more likely to be categorized as nondippers.[9–13] Identifying modifiable factors that contribute to inadequate BP dipping in African Americans may help to inform interventions to mitigate this cardiovascular risk factor.

There is a growing body of evidence suggesting that the degree of nocturnal BP dipping is influenced by psychosocial factors. Anger and hostility,[13,14] perceived racism/discrimination,[15–17] job strain,[18] depression,[19] and aspects of social support[10,20–24] have each been associated with BP dipping. However, most of these studies included small

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numbers of African American participants and the generalizability of these findings to the general population is unknown. Further, the various psychosocial factors have largely been investigated individually and consideration of important confounders has generally been limited. In particular, the vast majority of previous studies excluded participants taking antihypertensive medication or did not adjust for its use.

The objective of this study was to determine the psychosocial correlates of nocturnal BP dipping in a cohort of African Americans enrolled in the Jackson Heart Study (JHS). The large population-based sample enrolled in JHS, conduct of ambulatory BP monitoring (ABPM) and extensive psychosocial assessments, provides a unique opportunity to address this objective. We evaluated associations of stress, negative emotions, and psychosocial resources with continuous and dichotomous measures of dipping, independent of potential biomedical, socioeconomic, and behavioral confounders.[25]

METHODS

Overview

The JHS is a population-based study designed to investigate the causes of cardiovascular disease in African Americans. A total of 5,301 noninstitutionalized African American adults ≥21 years of age were enrolled from the Jackson, Mississippi metropolitan area between 2000 and 2004. The JHS was approved by the institutional review boards of the participating institutions: the University of Mississippi Medical Center, Jackson State University, and Tougaloo College. All participants provided written informed consent. Details of the study design, recruitment approach, and measures have been previously published.[26–30]

Study population

Approximately one-fifth of JHS participants completed ABPM (N = 1,148, 21.7%). Compared with participants who did not complete ABPM, this group was older (58.6 vs. 53.8 years, $P < 0.001$) and included a higher percentage of women (68% vs. 62%, $P < 0.001$), a lower percentage of employed individuals (49% vs. 60%, $P < 0.001$), and a higher percentage of individuals taking antihypertensive medication (62% vs. 51%, $P < 0.001$). The present study included 668 participants with complete data on key variables. Of the 480 participants who completed ABPM but were excluded from this study, 102 participants did not have valid ABPM data (described below), 376 participants were missing data on one or more psychosocial factors, and 2 participants were missing body mass index (BMI).

Measurements

Baseline examination data were collected from clinic visits, home interviews with trained interviewers, and self-report questionnaires. ABPM indices, psychosocial measures, and covariates included in this study are described below.

Ambulatory BP monitoring. Measures of 24-hour BP were obtained with a portable, noninvasive oscillometric device (Spacelabs 90207; Medifacts International Ltd, Rockville, MD). Participants were instructed in the proper use, application, and removal of the ABPM device by trained technicians. The device was calibrated using a standardized protocol and programmed to take readings at 20-minute intervals throughout the 24-hour monitoring period. Participants were fitted with an appropriately sized cuff on the nondominant arm and were instructed to proceed through their normal daily activities and keep their arm still and extended at their side during each BP reading. Participants returned the ABPM device approximately 24-hours later. The monitor was connected to a computer and the ABPM readings were downloaded with commercially available software (Medicom, Version 3.41; Medifacts Ltd).

A valid ABPM recording was defined according to the International Database of Ambulatory Blood Pressure in relation to Cardiovascular Outcome (IDACO) criteria as ≥10 valid daytime BP measurements and ≥5 valid nighttime BP measurements.[31] Daytime and nighttime BP readings were defined using time windows of 10 AM–8 PM (daytime) and 12 AM–6 AM (nighttime). Mean 24-hour systolic blood pressure (SBP) was defined as the average of all SBP measurements recorded during the ABPM period. Continuous BP dipping was calculated as the difference between the mean daytime SBP and mean nighttime SBP divided by the mean daytime SBP, expressed as a percentage. Nondippers were defined as those participants with a nocturnal decline in SBP of 10% or less.

Psychosocial factors

Stress exposure—Chronic stress was assessed using the Global Perceived Stress Scale, an 8-item measure developed for the JHS that assesses the degree of chronic stress experienced over the prior 12 months in the following life domains: job, relationships, neighborhood, caregiving, legal, medical, racism and discrimination, and meeting basic needs.[27] Scores range from 0 to 24, with higher scores indicating greater chronic stress. Minor stressful events were assessed using the Weekly Stress Inventory, an 87-item checklist of minor stressors. Participants indicated whether or not each event occurred during the prior week and rated the perceived stressfulness of each event that occurred. These ratings produce 2 subscales indicating the total number of minor stressors (frequency) and the cumulative perceived stressfulness of these events (impact).[27] Scores range from 0 to 87 (frequency) and from 0 to 609 (impact), with higher scores indicating greater weekly stress. Perceived discrimination was assessed using a 21-item instrument developed for the JHS based on several existing measures.[27,32] The JHS measure includes 3 subscales indicating the frequency of everyday discrimination (9 items), lifetime occurrence of unfair treatment (9 items), and burden of lifetime discrimination (3 items). Scores range from 1 to 7 (everyday), from 0 to 9 (lifetime), and from 1 to 4 (burden), with higher scores on each subscale indicating greater perceived discrimination.

Negative emotions—Anger was assessed with two 8-item subscales of the Spielberger Anger Expression Inventory: anger-in, the tendency to suppress angry feelings, and

anger-out, the tendency to express angry feelings verbally or physically.[27] Scores range from 8 to 32 on each subscale, with higher scores indicating greater anger. Hostility was assessed with a 27-item subset of the Cook-Medley Hostility Scale that includes cynicism, hostile affect, and aggressive responding.[27] Scores range from 0 to 27, with higher scores indicating greater hostility. Depressive symptoms were assessed using the Center for Epidemiologic Studies Depression scale, a 20-item measure of the frequency of depressive symptoms during the previous week.[27] Scores range from 20 to 80, with higher scores indicating greater depressive symptoms. Hopelessness was assessed using a 2-item measure developed for the Kuopio Ischemic Heart Disease Risk Factor Study.[27] Scores range from 2 to 8, with higher scores indicating greater hopelessness.

Psychosocial resources—Perceived social support was assessed with a 16-item version of the Interpersonal Support Evaluation List, a measure of the perceived availability of 4 types of support: tangible, emotional, belonging, and self-esteem.[27] Scores range from 16 to 64, with higher scores indicating greater perceived support. Social network was assessed using an adapted version of the Berkman Social Network Index, which creates a composite score based on marital status, number of friends and relatives, group membership, and frequency of social contact.[27] Scores range from 0 to 5, with higher scores indicating larger social networks. Several dimensions of religion and spirituality were assessed,[27] including attendance at services or other organized religious activities (1 item); frequency of private religious experience (1 item); and religious coping (1 item). Spirituality was assessed with the 6-item Daily Spiritual Experiences Scale. Scores range from 1 to 6 (attendance), from 1 to 8 (prayer), from 1 to 4 (religious coping), and from 6 to 36 (spirituality), with higher scores on each measure indicating greater religiosity. Coping was measured using a 16-item version of the Coping Strategies Inventory, which assesses cognitive and behavioral responses to stressful events and was scored to produce engagement (e.g., problem solving, expressing emotions) and disengagement (e.g., problem avoidance, social withdrawal) subscales.[27] Scores range from 8 to 40 on each subscale, with higher scores indicating greater use of the coping style.

Covariates

Biomedical factors—BMI was calculated from standardized measures of height and weight taken at the baseline clinic visit. Current antihypertensive medication use was defined as use of antihypertensive medication in the 2 weeks prior to the clinic visit based on self-report or pill bottle review. Cardiovascular disease was defined by self-reported history of myocardial infarction, stroke, or coronary revascularization procedures. Diabetes was defined by self-report of a prior diagnosis or fasting glucose ≥126 mg/dl or HbA1c ≥6.5%. Obstructive sleep apnea risk was estimated using a previously validated scoring approach; participants with an obstructive sleep apnea score ≥4.2 were defined as having high obstructive sleep apnea risk.[33]

Socioeconomic factors—Demographic factors include age, sex, marital status (married vs. unmarried), and employment status (employed at least part-time vs. unemployed). A continuous measure of education was created by assigning 12 years for a high school graduate equivalency degree, 13 years for a vocational or trade certificate or for some college but no degree, 14 years for an associate degree, 16 years for a bachelor degree, and 20 years for a graduate or professional degree. A continuous measure of annual family income was created using the median value of each income category and adjusting for household size. Following the approach used by Hickson *et al.*,[34] missing income data were imputed using median sex- and education-specific income values.

Behavioral factors—Physical activity over the past 12 months was assessed using a 30-item measure developed for the JHS that has been validated against accelerometer and pedometer data.[29,35] Current smoking was defined as having smoked at least 400 cigarettes in one's lifetime and self-report of currently smoking. Current alcohol use was defined as any drinking in the past 12 months. Dietary factors including daily intake of sodium (mg) and potassium (mg) were calculated from the 158-item Delta Nutrition Intervention Research Initiative Food Frequency Questionnaire (FFQ), which has been validated for use in adults in the Mississippi area.[30,36] Sleep quality over the prior month was rated on a 5-point scale (poor to excellent) where higher scores indicate better sleep quality.

Statistical analysis

Characteristics of the study population were calculated overall and by dipping status. Differences in participant characteristics between dippers and nondippers were compared using *t*-tests and chi-square tests, as appropriate. Pearson's correlation coefficients were used to evaluate the associations between psychosocial factors. The association of each psychosocial factor with continuous BP dipping was assessed using nested linear regression models. All psychosocial factors were standardized so that results indicate the difference in BP dipping percentage associated with a 1 SD difference in the psychosocial factor. Model 1 was unadjusted, Model 2 was adjusted for age, sex, BMI, and mean 24-hour SBP, and Model 3 was adjusted for a larger set of potential socioeconomic, biomedical, and behavioral confounders: age, sex, BMI, mean 24-hour SBP, income, years of education, marital status, employment status, antihypertensive medication use, diabetes, cardiovascular disease, high obstructive sleep apnea risk, smoking, alcohol use, physical activity, dietary sodium, dietary potassium, and sleep quality. Because 133 participants in the study sample were missing data on covariates, we performed multiple imputation using full conditional specification. A total of 10 imputed datasets were created and adjusted models were run on the pooled values from all 10 imputations. Next, psychosocial factors that were associated with continuous BP dipping at $P \leq 0.05$ in individual regression models were entered simultaneously in a single model to examine their associations with BP dipping after adjustment for each other. We also examined whether associations between these psychosocial factors and BP dipping varied by age or sex by repeating the analyses with both main effects (e.g., age, perceived support) and multiplicative interaction terms (e.g., age * perceived support). Finally, we conducted Poisson regression to

examine association between the psychosocial factors and nondipping BP with similar adjustment as described above for Models 1, 2, and 3. Analyses were conducted using SPSS Version 22.

RESULTS

Participant characteristics

Participants in the study sample had an average of 61.0 valid ABPM readings (SD = 8.4). The average BP dipping was 6.9% (SD = 7.7%) and almost two-thirds of participants (63.9%) were nondippers. Compared with dippers, nondippers had a higher mean 24-hour SBP and BMI and were more likely than dippers to have diabetes (Table 1). The percentage of participants who were nondippers was similar for those taking and not taking antihypertensive medication. Psychosocial characteristics are presented in Table 2 and correlations between these variables are presented in **Supplementary Table 1**. The level of perceived social support was lower in nondippers compared to dippers. There were no other statistically significant differences in psychosocial characteristics between dippers and nondippers.

Analysis of continuous BP dipping

Greater depressive symptoms, greater hostility, and lower perceived social support were each associated with reduced BP dipping in unadjusted analyses and after adjustment for age, sex, BMI, and mean 24-hour SBP (Table 3). None of the other psychosocial factors examined were associated with dipping. In the full multivariable-adjusted model, only perceived support was associated with BP dipping. The associations between BP dipping and depressive symptoms, hostility and perceived support did not vary by age or sex (*P* values for interactions > 0.11; data not shown).

When depressive symptoms, hostility, and perceived support were adjusted for each other, lower perceived support remained associated with reduced BP dipping. After multivariable adjustment including depressive symptoms and hostility, each SD higher perceived support was associated with 0.83% (SE = 0.33, *P* = 0.01) more dipping. Hostility and depressive symptoms were not associated with BP dipping after adjustment for each other and perceived support (*P* values > 0.27). Despite moderate correlations between these 3 psychosocial factors (*r* from −0.30 to −0.44), diagnostics suggested multicollinearity was not present (all variance inflation factors ≤ 1.65).

Table 1. Characteristics of Jackson Heart Study participants by BP dipping status

Characteristic	Total sample (*N* = 668)	Dippers (*N* = 241)	Nondippers (*N* = 427)	*P* value
Demographic and socioeconomic factors				
Age, years	58.4 (10.7)	57.4 (11.0)	58.9 (10.5)	0.07
Women, %	68.6	71.4	67.0	0.24
Annual income, $[a]	38,268 (22,676)	39,846 (22,149)	37,375 (22,946)	0.18
Education, years	14.5 (4.0)	14.5 (4.0)	14.5 (4.0)	0.92
Married, %	56.5	58.8	55.2	0.37
Employed, %	49.1	48.5	49.4	0.83
Biomedical factors				
Mean 24-hour SBP, mm Hg	125.8 (13.4)	123.4 (12.8)	127.1 (13.6)	<0.01
Body mass index, kg/m^2	31.2 (6.5)	30.5 (6.2)	31.7 (6.6)	0.03
Antihypertensive medication use, %	61.5	58.2	63.3	0.21
Diabetes, %	27.2	21.9	30.3	0.02
Cardiovascular disease, %	7.9	8.8	7.4	0.54
High obstructive sleep apnea risk, %	37.1	32.3	39.3	0.11
Behavioral factors				
Current smoker, %	9.7	10.0	9.6	.89
Current alcohol use, %	44.1	48.8	41.5	.07
Physical activity	8.3 (2.6)	8.6 (2.6)	8.2 (2.6)	.11
Sleep quality	3.0 (1.1)	3.0 (1.1)	3.0 (1.1)	.62
Dietary sodium, mg	3,880 (2,221)	3,759 (2,336)	3,949 (2,154)	.30
Dietary potassium, mg	2,701 (1,284)	2,608 (1,232)	2,755 (1,312)	.16

Values are mean (SD) or %.
Abbreviations: BP, blood pressure; SBP, systolic blood pressure.
[a]Total annual family income, adjusted for household size.

Table 2. Psychosocial characteristics of Jackson Heart Study participants by BP dipping status

Characteristic	Total sample (*N* = 668)	Dippers (*N* = 241)	Nondippers (*N* = 427)	*P* value
Stress exposure				
Chronic stress	5.1 (4.3)	5.2 (4.4)	5.0 (4.3)	0.47
Weekly stress-frequency	28.9 (20.2)	28.1 (19.0)	29.3 (20.8)	0.45
Weekly stress-impact	74.4 (77.3)	71.4 (76.8)	76.2 (77.7)	0.44
Discrimination-everyday	2.1 (1.0)	2.1 (0.9)	2.1 (1.1)	0.48
Discrimination-lifetime	3.3 (2.2)	3.5 (2.1)	3.2 (2.2)	0.14
Discrimination-burden	2.3 (0.8)	2.3 (0.8)	2.3 (0.8)	0.43
Negative emotions				
Depressive symptoms	30.5 (8.1)	29.8 (7.8)	30.8 (8.2)	0.11
Hopelessness	3.3 (1.6)	3.3 (1.7)	3.4 (1.6)	0.33
Hostility	11.8 (4.7)	11.4 (4.6)	12.0 (4.8)	0.09
Anger-in	13.1 (3.2)	13.3 (3.2)	13.1 (3.2)	0.42
Anger-out	12.3 (2.9)	12.4 (3.1)	12.2 (2.8)	0.41
Psychosocial resources				
Perceived social support	53.5 (7.1)	54.3 (6.7)	52.9 (7.3)	0.02
Social network	4.2 (0.9)	4.2 (0.9)	4.2 (0.8)	0.92
Spirituality	12.6 (4.6)	12.9 (4.8)	12.4 (4.5)	0.15
Religious attendance	1.9 (0.9)	1.9 (1.0)	1.9 (0.9)	0.91
Religious prayer	1.8 (1.3)	1.8 (1.4)	1.8 (1.2)	0.85
Religious coping	1.4 (0.6)	1.4 (0.7)	1.3 (0.6)	0.10
Engagement coping	28.4 (4.3)	28.8 (4.3)	28.2 (4.2)	0.10
Disengagement coping	22.7 (4.4)	22.6 (4.3)	22.8 (4.5)	0.73

Values are mean (SD).
Abbreviation: BP, blood pressure.

Analysis of BP dipping status

Lower perceived support was the only psychosocial factor associated with nondipping BP status (Table 4). In the fully adjusted model, a 1 SD (7.1 unit) higher perceived support was associated with a prevalence ratio of nondipping of 0.93 (95% CI: 0.88–0.99).

DISCUSSION

In this population-based study of African Americans, greater hostility and depressive symptoms and lower perceived social support were each associated with reduced BP dipping modeled as a continuous variable. The only statistically significant psychosocial factor correlated with the outcome of nondipping BP (<10% dipping) was perceived support. Each SD higher perceived support was associated with a 1% increase in BP dipping and a 6–7% decrease in the prevalence of nondipping. Though the magnitude of the effects were modest, they remained statistically significant after adjustment for an extensive set of potential demographic, socioeconomic, biomedical, and behavioral confounders.

Findings from the current study are consistent with prior studies demonstrating that lower levels of perceived social support are associated with less nocturnal BP dipping, though there are also conflicting reports.[37] Cooper and colleagues found that lower perceived support was associated with reduced BP dipping among Whites, but with greater dipping among African Americans.[21] This discrepant finding may reflect in part the small number of African Americans (N = 61) and differences in the study sample; participants were young and middle-aged employed, healthy adults who were not taking antihypertensive medications. Interestingly, we did not find significant associations between social network size, a measure of structural or objective support, and BP dipping in this study. Though others have demonstrated this association,[37] our findings parallel recent systematic reviews indicating that functional (i.e., perceived) support is more strongly and consistently associated with BP dipping and coronary heart disease incidence and mortality than structural support.[37,38] While closely related, structural support is not always accompanied by adequate perceived support and may not confer health benefits under those conditions. For example, single individuals have been shown to have lower BP than those in unhappy marriages.[22]

Table 3. Difference in BP dipping % (SE) associated with psychosocial factors

Variable	Difference in BP dipping percentage		
	Model 1	Model 2	Model 3
Stress exposure			
Chronic stress (SD = 4.3)	0.54 (0.30)	0.31 (0.31)	0.51 (0.33)
Weekly stress-frequency (SD = 20.2)	−0.11 (0.30)	−0.22 (0.30)	−0.21 (0.30)
Weekly stress-impact (SD = 77.3)	−0.28 (0.30)	−0.38 (0.30)	−0.28 (0.31)
Discrimination-everyday (SD = 1.0)	−0.02 (0.30)	−0.24 (0.30)	−0.18 (0.30)
Discrimination-lifetime (SD = 2.2)	0.43 (0.30)	0.22 (0.29)	0.23 (0.30)
Discrimination-burden (SD = 0.8)	0.17 (0.30)	0.16 (0.29)	0.28 (0.29)
Negative emotions			
Depressive symptoms (SD = 8.1)	−0.63 (0.30)*	−0.61 (0.29)*	−0.47 (0.33)
Hopelessness (SD = 1.6)	−0.46 (0.30)	−0.33 (0.29)	−0.26 (0.31)
Hostility (SD = 4.7)	−0.66 (0.30)*	−0.58 (0.29)*	−0.52 (0.31)
Anger-in (SD = 3.2)	−0.17 (0.30)	−0.30 (0.29)	−0.16 (0.30)
Anger-out (SD = 2.9)	−0.05 (0.30)	−0.09 (0.29)	−0.05 (.30)
Psychosocial resources			
Perceived support (SD = 7.1)	1.05 (0.29)***	1.01 (0.29)***	0.93 (0.31)**
Social network (SD = 0.9)	−0.13 (0.30)	−0.07 (0.29)	−0.25 (0.31)[a]
Spirituality (SD = 4.6)	0.29 (0.30)	0.15 (0.30)	0.15 (0.30)
Church attendance (SD = 0.9)	−0.31 (0.30)	−0.44 (0.30)	−0.48 (0.31)
Prayer (SD = 1.3)	−0.09 (0.30)	−0.24 (0.30)	−0.31 (0.31)
Religious coping (SD = 0.6)	0.16 (0.30)	0.02 (0.29)	−0.02 (0.30)
Engagement coping (SD = 4.3)	0.46 (0.30)	0.54 (0.29)	0.37 (.30)
Disengagement coping (SD = 4.4)	−0.14 (0.30)	−0.07 (0.29)	0.14 (0.30)

Difference in BP dipping percentage associated with 1 SD higher psychosocial factor. SDs for each psychosocial factor are shown in the first column. Each row shows results of regression models for a single psychosocial factor with progressive adjustment for covariates (Models 1–3). Model 1: unadjusted. Model 2: adjusted for: age, sex, body mass index (BMI), and mean 24-hour systolic blood pressure (SBP). Model 3: adjusted for: age, sex, BMI, mean 24-hour SBP, income, years of education, marital status, employment, antihypertensive medication use, diabetes, cardiovascular disease, high obstructive sleep apnea risk, smoking, alcohol use, physical activity, dietary sodium, dietary potassium, and sleep quality.

Abbreviation: BP, blood pressure.

[a]This model is not adjusted for marital status since this variable is used to calculate social network.

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

The cross-sectional design prevents us from drawing conclusions about causality. However, aspects of social relationships and support have been prospectively linked to cardiovascular outcomes, suggesting this is a plausible hypothesis.[39] Both direct and indirect mechanisms have been proposed to explain the protective health effects of social support, including positive influences on important behavioral and physiological processes and buffering the negative effects of stress.[37,40,41] Longitudinal studies are needed to examine the effects of social support on BP dipping over time and the mechanisms underlying this association. Such studies may also help to address the complex interactions between factors that may influence both social relationships and BP in African Americans, including socioeconomic status and various aspects of racial discrimination (e.g., cultural, institutional, individual).[42]

Greater hostility and depressive symptoms were also associated with a lower BP dipping percentage, but these effects were no longer statistically significant in fully adjusted models and were not related to nondipping. Other psychosocial factors that have previously been related to BP dipping, such as anger and perceived discrimination,[14–17] were not related to dipping in any of the models. Longitudinal studies with repeated psychosocial assessments and more comprehensive assessment of different stress domains may reveal relationships between negative emotions, stress, and discrimination and BP dipping. It is also possible that these factors are not strongly related to dipping in African Americans participating in the JHS area due to unique characteristics of the Jackson, MS area (e.g., patterns of racial segregation, which could influence exposure to discrimination and other psychosocial factors).

Table 4. Prevalence ratios for nondipping BP associated with psychosocial factors

Variable	Prevalence ratio (95% CI)		
	Model 1	Model 2	Model 3
Stress exposure			
Chronic stress (SD = 4.3)	0.98 (0.92–1.04)	0.99 (0.93–1.06)	0.99 (0.93–1.06)
Weekly stress-frequency (SD = 20.2)	1.02 (0.97–1.08)	1.03 (0.97–1.08)	1.02 (0.97–1.08)
Weekly stress-impact (SD = 77.3)	1.02 (0.97–1.08)	1.03 (0.97–1.08)	1.02 (0.97–1.08)
Discrimination-everyday (SD = 1.0)	1.02 (0.97–1.08)	1.03 (0.98–1.08)	1.03 (0.98–1.08)
Discrimination-lifetime (SD = 2.2)	0.96 (0.90–1.01)	0.97 (0.91–1.02)	0.96 (0.91–1.02)
Discrimination-burden (SD = 0.8)	0.98 (0.92–1.04)	0.97 (0.92–1.03)	0.97 (0.92–1.03)
Negative emotions			
Depressive symptoms (SD = 8.1)	1.05 (0.99–1.10)	1.05 (0.99–1.10)	1.05 (0.99–1.12)
Hopelessness (SD = 1.6)	1.03 (0.97–1.09)	1.02 (0.96–1.08)	1.02 (0.96–1.08)
Hostility (SD = 4.7)	1.05 (0.99–1.11)	1.04 (0.98–1.10)	1.04 (0.99–1.11)
Anger-in (SD = 3.2)	0.98 (0.92–1.03)	0.98 (0.93–1.04)	0.97 (0.92–1.03)
Anger-out (SD = 2.9)	0.98 (0.92–1.04)	0.98 (0.92–1.04)	0.98 (0.92–1.04)
Psychosocial resources			
Perceived support (SD = 7.1)	0.93 (0.89–0.98)*	0.94 (0.89–0.99)*	0.93 (0.88–0.99)*
Social network (SD = 0.9)	1.00 (0.95–1.06)	1.00 (0.94–1.06)	1.04 (0.96–1.14)[a]
Spirituality (SD = 4.6)	0.96 (0.90–1.02)	0.96 (0.91–1.02)	0.96 (0.91–1.02)
Church attendance (SD = 0.9)	1.00 (0.95–1.06)	1.00 (0.94–1.06)	1.01 (0.95–1.07)
Prayer (SD = 1.3)	0.99 (0.94–1.06)	0.99 (0.94–1.06)	1.00 (0.94–1.06)
Religious coping (SD = 0.6)	0.95 (0.89–1.01)	0.95 (0.89–1.02)	0.95 (0.89–1.02)
Engagement coping (SD = 4.3)	0.95 (0.90–1.01)	0.95 (0.89–1.01)	0.95 (0.90–1.01)
Disengagement coping (SD = 4.4)	1.01 (0.96–1.07)	1.01 (0.95–1.07)	1.00 (0.94–1.06)

Values in table represent the prevalence ratio (95% CI) associated with 1 SD higher psychosocial factor. SDs for each psychosocial factor are shown in the first column. Each row shows results of regression models for a single psychosocial factor with progressive adjustment for covariates (Models 1–3). Model 1: unadjusted. Model 2: adjusted for: age, sex, body mass index (BMI), and mean 24-hour systolic blood pressure (SBP). Model 3: adjusted for: age, sex, BMI, mean 24-hour SBP, income, years of education, marital status, employment, antihypertensive medication use, diabetes, cardiovascular disease, high obstructive sleep apnea risk, smoking, alcohol use, physical activity, dietary sodium, dietary potassium, and sleep quality.

Abbreviations: BP, blood pressure; CI, confidence interval.

[a]This model is not adjusted for marital status since this variable is used to calculate social network.

*$P < 0.05$.

The large, population-based sample of African Americans with ABPM data, examination of multiple psychosocial risk factors and resources, and assessment of relevant biomedical, socioeconomic, and behavioral confounders are important strengths of this study. There are also several limitations worth noting. First, given the large number of psychosocial factors examined, it is possible that the observed association between perceived support and BP dipping is a chance finding. We chose not to correct for multiple testing to avoid missing potentially important relationships; thus, these results should be considered hypothesis generating and need to be confirmed in future studies. Second, there is some evidence of self-selection with regard to participation in the 24-hour ABPM protocol. JHS participants who did not complete the ABPM substudy were younger, more likely to be male, more likely to be employed, and less likely to be taking antihypertensive medication. Although small in magnitude, it is unclear how these differences may have biased the results. A third limitation is the single 24-hour ABPM recording given the relatively modest reproducibility of nocturnal BP dipping.[43] Perceived support was related to both continuous and dichotomous measures of dipping after adjusting for potential confounders, increasing our confidence in these results. However, the low reliability of dichotomized dipping status in particular may help to explain the weaker associations we observed between perceived support, hostility and depressive symptoms, and nondipping. Other limitations include lack of adjustment for antidepressant medication use and the exclusion of several relevant psychosocial constructs (job strain, optimism, John Henryism, major stressful life events, neighborhood characteristics) that were assessed only at follow-up visits. Finally, the exclusively African American sample prevents comparisons with Whites and can not address whether

differences in social support may account for race differences in BP dipping.

In summary, the present study demonstrates that higher levels of perceived social support are associated with a lower prevalence of nondipping BP. Given the high prevalence of nondipping BP among African Americans and the increased cardiovascular risk it confers, the role of social support as a potentially modifiable risk factor warrants further investigation. In particular, different types and sources of support and longitudinal effects on BP dipping and hypertension-related outcomes are important areas for future research.

SUPPLEMENTARY MATERIAL

Supplementary materials are available at *American Journal of Hypertension* (http://ajh.oxfordjournals.org).

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DISCLOSURE

The authors have no other potential conflicts of interest to declare.

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