Hospitalization routinely lowers blood pressure (BP). This study examined the effects of race and psychologic characteristics on this phenomenon. Data are reported from two separate cohorts of hypertensive and normotensive black and white men and women who were studied following a stay at a clinical research center where sodium intake was held constant. Blacks (N = 88), as compared to whites (N = 77), showed consistently smaller declines in systolic BP (P < .01) following hospitalization (−11.6 mm Hg SBP v −19.5 mm Hg SBP, respectively). A multiple regression model that treated BP as a function of physiologic and psychologic attributes indicated that preadmission BP level, body mass index, stress level, and anger expression were related to the drop in systolic (r² = 65%) and diastolic (r² = 45%) BP brought about by hospitalization (P < .0001). In blacks, high environmental stress ratings were unrelated to the change in BP with hospitalization. In contrast, whites with high environmental stress ratings lowered their BP noticeably with hospitalization. Given that the reduction in BP with hospitalization can be similar to that attained with pharmacologic therapy, these findings may have a bearing on studies examining BP in the hospital. Am J Hypertens 1997;10:1091–1096 © 1997 American Journal of Hypertension, Ltd.

KEY WORDS: Hospitalization, race, blacks, whites, hypertension, blood pressure.

Since first cited in 1932,1 numerous studies demonstrate that black Americans have a higher prevalence of elevated daytime blood pressure (BP) as compared to white Americans.2–4 The advent of ambulatory monitoring extended these observations to show that racial differences in BP persist even during the night.5,6 Investigations into the pathophysiologic basis of this racial gradient in BP suggest underlying genetic, behavioral, and endocrine factors, as well as altered renal function and increased environmental stress.2,4,7–9 Differential effects of sodium intake and acute and chronic stress on blood pressure in blacks have received considerable attention.3,4,6–8,10–12

It is well established that hospitalization is associated with a reduction in BP in both hypertensive and normotensive individuals.13,14 Indeed, hospitalization was one of the only treatments available for hypertension prior to the development of antihypertensive medications. Unfortunately, the “cure” was temporary. BP typically returned to prehospital admission levels within a few days following discharge.13–16 This phenomenon appears to be related to diverse factors associated with hospitalization itself, including changes in sodium intake, habituation to the medical environment, and isolation from the stress and worries of the patient’s regular environment.13,14,16,17 Despite the literature on racial differences in BP, few if
any studies have examined whether ethnicity influences this effect of hospitalization on BP.

We report data gathered from two cohorts of hypertensive and normotensive black and white men and women from two separate studies conducted over a 6-year period. In addition to examining a possible racial influence on the BP-lowering effect of hospitalization, we also sought to identify factors associated with such a phenomenon. Given that psychologic characteristics such as stress, anger, and depression may influence both the racial gradient in BP as well as the effect of hospitalization on BP, we assessed these measures.

**METHODS**

**Subjects** Volunteers were located through community blood pressure screening or word-of-mouth referral. Of approximately 210 individuals screened for study 1, the final study 1 cohort consisted of 38 white and 46 black men and women (age range 19 to 46 years). Of approximately 200 individuals screened for study 2, the final study 2 cohort consisted of 39 white and 42 black men and women (age range 20 to 52 years). Ethnicity was based on self-report. Women were studied during the follicular phase of the menstrual cycle (days 7 to 10 following menses).

**Procedure** The two studies were conducted at the University of California at San Diego, Medical Center Clinical Research Center following either a 3-day (study 1) or a 2-day (study 2) stay, during which an isocaloric diet provided 200 mmol sodium and 100 mmol potassium per day. The studies were part of two larger studies examining the sympathetic nervous system in black and white hypertension. Prior to admission, BP determinations were made on each of two screening occasions approximately 1 week apart (Dinamap 845 XT automated monitor, Critikon, Inc., Tampa, FL). Blood pressures obtained from the Dinamap correlate well (r > 0.95) with mercury sphygmomanometry readings. Subjects were seated for at least 5 min and acclimated to the equipment prior to BP determinations. The mean of three consecutive readings was taken as the “screening” BP. Hypertension was defined as BP > 140 mm Hg systolic or > 90 mm Hg diastolic at screening. Only those whose BP remained stable over the two screening occasions were enrolled into the studies. The protocol was approved by the University of California, San Diego, Institutional Review Board. All subjects gave written informed consent.

On the morning of the final day of hospitalization, BP was again taken while the subject was seated. BP was measured by the same nurse using the same automated monitor and in the same room used during the screening protocol. The mean of three consecutive readings was taken as their hospital BP.

In the second cohort, prior to the BP determination, a 24-h urine sample was collected for the determination of sodium excretion. In the second study, we also assessed anger, stress, and depression symptoms on hospital admission. The Buss-Durkee Hostility Inventory (BDHI) is a 75-item true-false scale that provides information on general hostility as well as subclasses of hostile behavior. The subscales are combined to form two factors, the “experience of anger” (defined by the resentment and suspiciousness subscales) and the “expression of anger” (defined by the physical assertiveness, verbal expression, and indirect hostility subscales). The stress index from the Cook and Medley Hostility instrument was used to provide an index of stress levels. The Centers for Epidemiologic Studies-Depression Scale (CESD) was used to examine depressive symptoms.

**Data Analysis** The data were analyzed using analysis of variance and regression procedures. For the regression analysis (study 2), multiple linear regression was used to determine possible factors associated with the change in BP following hospitalization. The dependent variable was the change in BP (screening BP minus hospitalization BP); separate regressions were conducted for systolic and diastolic BP. The independent variables included race, gender, age, current cigarette smoking (yes or no), screening BP, 24-h sodium excretion, body mass index, and the psychological variables (the experience and expression of stress).

We also wanted to explicitly test whether the race of the subject affected any possible psychologic effects on the BP observations. To test for this possibility, interaction terms for race and each psychologic term were created. Interaction terms were derived for each of the four psychologic terms (derived as the product of the race coding variable (0 or 1) and the value of the respective psychologic variable). We began by performing an omnibus test of differential impact of the psychological variables for each dependent BP variable. This test compared the quality of the fit of a model that included race and the four psychological variables as independent variables (ie, a “main effects only” model) to a model that also included the four race-by-psychological variable interaction terms. Thus, the test compared a model in which the effect of each psychological variable was the same for both blacks and whites to a model in which the effects may differ for whites and blacks. Only if this test (general linear hypothesis) attained $P < .05$ was the dependent variable considered to show differential effects of psychological variables according to race. Subsequently,
those variables that did not obtain significance at \( P < .05 \) were eliminated from the regression equations and those variables attaining significance at \( P < .05 \) were maintained in the regression equations. However, if an interaction term attained \( P < .05 \), then the associated main-effect term was also maintained. In testing the multiple regression models we examined each functional term was maintained. In testing the race by stress interaction term showed a significant portion of the variance (\( r^2 = .23 \)) versus 10.3 mm Hg (\( SD = 11 \)) respectively; \( F = 3.76, P = .056 \). As before, normotensives showed a smaller decrease in systolic (SBP) and diastolic BP (DBP) as compared to hypertensives (13.3 mm Hg (\( SD = 12 \)) versus 27.1 mm Hg (\( SD = 13 \)), respectively, for SBP [\( F = 23.1 P < .001 \)], and 5.95 mm Hg (\( SD = 7 \)) versus 14.8 mm Hg (\( SD = 11 \)), respectively, for DBP (\( F = 16.4 P < .001 \)).

We also calculated the percentage of blacks and whites who reduced their systolic BP > 10 and > 20 mm Hg with hospitalization. Seventy-five percent of whites and 53% of blacks lowered their BP > 10 mm Hg with hospitalization, whereas approximately 48% of whites and 28% of blacks lowered their BP > 20 mm Hg with hospitalization.

The results of the multiple regression analyses are presented in Table 2. For both the systolic and diastolic BP regression models, the testing of the race by psychologic interactions terms was significant. That is, the effects of environment stress on BP was different between blacks and whites. For this reason, the interaction terms that accounted for these observations were included in the regression model. For the change in systolic BP with hospitalization, a large and significant portion of the variance (\( r^2 = .65 \)) was accounted for by the following variables (listed in decreasing order of the strength of the individual \( t \) statistics): a higher prediabetes systolic BP, higher self-reported stress level, lower anger expression score, and a lower body mass index [multiple \( R = 0.81, F(9,67) = 13.9, P < .0001 \)]. Of the four race by psychologic terms, only the race by stress interaction term showed a significant \( t \) statistic at \( P = .01 \). Simple correlational analysis of

### RESULTS

Whites and blacks were similar in terms of age, weight, body mass index, number of cigarette smokers, screening BP, and 24-h urinary sodium excretion (Table 1). In study 1, of the 46 black subjects, 19 were classified as hypertensive. Of the 38 white subjects, 19 were classified as hypertensive. In study 2, of the 42 black subjects, 10 were classified as hypertensive, whereas 13 of the 39 white subjects were classified as hypertensive. Across both studies, 4 of the hypertensive subjects had previously been on antihypertensive medication but not for at least 3 months prior to study; the remaining hypertensives had never been on antihypertensive medication.

In study 1, blacks as compared to whites showed a smaller decrease in systolic BP following hospitalization (screening systolic BP minus systolic BP following hospitalization, 10.2 mm Hg [\( SD = 13 \)] versus 17.5 mm Hg [\( SD = 10 \)], respectively; \( F = 7.40, P = .008 \)). In addition, normotensives as compared to hypertensives showed a smaller decrease in systolic BP following hospitalization (8.6 mm Hg [\( SD = 12 \)] versus 20.2 mm Hg [\( SD = 11 \)], respectively; \( F = 25.6 P < .001 \)) (Figure 1). The change in diastolic BP was not significantly different between blacks and whites (9.4 mm Hg [\( SD = 10 \)] versus 10.6 mm Hg [\( SD = 8 \)], respectively; \( F = 0.32, P = 0.57 \)). As with systolic BP, normotensives as compared to hypertensives showed a smaller decrease in diastolic BP following hospitalization (6.6 mm Hg [\( SD = 10 \)] versus 14.4 mm Hg [\( SD = 10 \)], respectively; \( F = 22.0, P < .001 \)).

In study 2, blacks as compared to whites again showed a smaller decrease in systolic BP following hospitalization (13.2 mm Hg [\( SD = 11 \)] versus 21.1 mm Hg [\( SD = 15 \)], respectively; \( F = 7.07, P = .009 \)) (Figure 1). Given the 5-mm Hg difference (nonsignificant) in screening systolic BP between the blacks and whites in study 2, we repeated this analysis using the screening BP as a covariate and still found the same significant group difference in systolic BP (\( P < .04 \)). Blacks also showed a marginally smaller decrease in diastolic BP following hospitalization (6.16 mm Hg [\( SD = 8 \)] versus 10.3 mm Hg [\( SD = 11 \)], respectively; \( F = 3.76, P = .056 \)). As before, normotensives showed a smaller decrease in systolic (SBP) and diastolic BP (DBP) as compared to hypertensives (13.3 mm Hg [\( SD = 12 \)] versus 27.1 mm Hg [\( SD = 13 \)], respectively, for SBP [\( F = 23.1 P < .001 \)], and 5.95 mm Hg [\( SD = 7 \)] versus 14.8 mm Hg [\( SD = 11 \)], respectively, for DBP [\( F = 16.4 P < .001 \)].

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### TABLE 1. SUBJECT CHARACTERISTICS (MEAN, SD)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Whites</th>
<th>Blacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( N )</td>
<td>38</td>
<td>46</td>
</tr>
<tr>
<td>Age (years)</td>
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<td>33 (6)</td>
</tr>
<tr>
<td>Hypertensives (( N ))</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Screening systolic BP (mm Hg)</td>
<td>136 (15)</td>
<td>133 (15)</td>
</tr>
<tr>
<td>Screening diastolic BP (mm Hg)</td>
<td>86 (10)</td>
<td>84 (14)</td>
</tr>
<tr>
<td>Hospital systolic BP (mm Hg)</td>
<td>118 (11)</td>
<td>122 (12)</td>
</tr>
<tr>
<td>Hospital diastolic BP (mm Hg)</td>
<td>75 (9)</td>
<td>76 (12)</td>
</tr>
<tr>
<td>Study 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( N )</td>
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<td>42</td>
</tr>
<tr>
<td>Age (years)</td>
<td>35 (7)</td>
<td>36 (6)</td>
</tr>
<tr>
<td>Hypertensives (( N ))</td>
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<td>10</td>
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<tr>
<td>Cigarette smokers (( N ))</td>
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<td>31</td>
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<td>Body mass index</td>
<td>25 (4)</td>
<td>26 (4)</td>
</tr>
<tr>
<td>Screening systolic BP (mm Hg)</td>
<td>130 (16)</td>
<td>125 (15)</td>
</tr>
<tr>
<td>Screening diastolic BP (mm Hg)</td>
<td>77 (11)</td>
<td>75 (10)</td>
</tr>
<tr>
<td>Hospital systolic BP (mm Hg)</td>
<td>109 (14)</td>
<td>111 (11)</td>
</tr>
<tr>
<td>Hospital diastolic BP (mm Hg)</td>
<td>66 (10)</td>
<td>68 (8)</td>
</tr>
<tr>
<td>Sodium excretion (mmol)*</td>
<td>181 (58)</td>
<td>180 (61)</td>
</tr>
</tbody>
</table>

* Twenty-four-hour urinary sodium excretion on final day of study.
this term indicated that for blacks higher stress ratings were associated with little or no change in BP ($r = -0.11$) but with an appreciable decline in hospital-associated BP in whites ($r = 0.31$). The regression analysis was then repeated using only the preadmission systolic BP, race, and body mass index as independent variables. In this model $50\%$ ($r^2 = 0.50$) of the variance in the drop in systolic BP was accounted for. Thus the psychologic terms alone accounted for approximately $15\%$ ($r^2$ of 0.65 from the overall regression model minus $r^2$ of 0.50 from the second regression model) of the variance in the decline of systolic BP with hospitalization.

For diastolic BP, $45\%$ of the variance in the change in diastolic BP was predicted. The significant predictor variables included (listed in order of the strength of the individual $t$ statistics): a higher screening diastolic BP, higher self-reported stress level, and lower anger expression [multiple $R = 0.67$, $F(8,68) = 7.17$, $P < .0001$]. As with systolic BP, a significant race-by-stress interaction term ($P = .01$) showed that higher stress ratings were associated with little change in BP in blacks ($r = -0.20$) but with a hospital-associated decline in BP in whites ($r = 0.28$). The regression analysis was then repeated using the preadmission diastolic BP and race as independent variables. In this model $35\%$ ($r^2 = 0.35$) of the variance in the drop in diastolic BP was accounted for. Thus the psychologic terms alone accounted for approximately $10\%$ ($r^2$ of 0.45 minus $r^2$ of 0.35) of the variance in the decline of diastolic BP with hospitalization.

**DISCUSSION**

We have observed the same phenomenon of a racial influence on the effect of hospitalization on BP in two separate cohorts of subjects. In addition, anger, stress levels (only in whites), and weight were found to affect the drop in BP with hospitalization. Other demographic characteristics such as age, gender, and cigarette smoking were unrelated to this phenomenon.

As previously shown, the findings also indicated that the patient's preadmission BP was the single strongest determinant of hospital BP (i.e., the greatest drop in BP following hospitalization occurred in those with the highest preadmission BP, those subjects with hypertension). Prior to the development of antihypertensive medications, hospitalization was one of the few treatments available for hypertension. The literature on white coat hypertension suggests that a subset of approximately $20\%$ of hypertensive individuals show a pronounced white coat effect, i.e., may be more likely to show a reduction in BP outside the doctor's office. In these two studies, the number of black and white hypertensive subjects was fairly balanced (29 and 32, respectively). We are unaware of any literature reporting whether there exists a racial gradient in the white coat effect, but the findings from this study support such a conjecture.

We attempted to control for possible confounding factors such as antihypertensive medication and sodium intake, which could have influenced our observations. Those hypertensives previously on antihypertensive medication ($N = 2$) were tapered off medication for at least 3 weeks prior to study. Regarding sodium intake, prior studies show that sodium can affect both the decline in BP with hospitalization as
of the experimenter on the subject’s BP but do find effects on the subject’s heart rate.26,27

As with prior studies, we found that both stress and anger were related to BP.20,29–31 We examined two distinct aspects of anger—the experience of anger and the expression of anger. The experience of anger was found to be unrelated to BP, whereas the expression of anger was inversely related to the drop in BP, ie, people with high anger expression dropped their BP very little with hospitalization. It may be interesting to note that Suarez and Williams20 reported similar findings concerning the expression of anger as related to greater BP responses and poorer BP recovery from acute stress in a controlled laboratory environment. Given the subcomponents comprising the anger expression scale, our findings suggest that individuals who are more assertive and hostile have less change in BP with hospitalization. Perhaps individuals with this personality style are unable to “escape” its influence on BP, including while being in the BP-lowering environment of the hospital.

Although physiologic factors have been examined as potential mechanisms underlying the decline in BP with hospitalization,13–16 ethnicity has not. There is a substantial literature on the incidence of elevated BP in blacks as compared to whites,2–6 with a parallel literature showing blacks to be less responsive to certain pharmacologic antihypertensive therapies.32,33 The data from this study suggest that blacks’ BP responds differently to hospitalization as well. Among the white subjects, 65% dropped their systolic BP below the median, whereas only 35% of the black subjects did. The lack of a relationship between stress and BP in blacks suggests that blacks with high levels of stress do not find repose while they are in the hospital. BP in blacks with high stress, however, can be suppressed anger whereas suppressed anger showed no relationship to hypertension development in white subjects.35

A number of other studies report differential relationships in blacks and whites between anger and stress and BP.35,36 It has been prospectively demonstrated, for example, that normotensive blacks who subsequently develop hypertension showed higher initial levels of suppressed anger whereas suppressed anger showed no relationship to hypertension development in white subjects.35

In summary, in addition to initial BP level, these data suggest that race, anger, and stress may affect BP during hospitalization. Given that the reduction in BP with hospitalization can be similar to that attained with pharmacologic therapy,13 these findings may have a bearing on studies examining antihypertensive therapy in the hospital setting.

**REFERENCES**


