Resting and Ambulatory Blood Pressure Differences in Afro-Caribbeans and Europeans

Nishi Chaturvedi, Paul M. McKeigue, Michael G. Marmot

To investigate why mortality from stroke in people of Afro-Caribbean origin is twice the average for England and Wales, we examined 1166 European and Afro-Caribbean people in London. Age-standardized median systolic blood pressure was 6 mm Hg higher (128 versus 122 mm Hg) in Afro-Caribbean than European men and 17 mm Hg higher (135 versus 118 mm Hg) in Afro-Caribbean than European women. Migrants from West Africa and the Caribbean had similar blood pressures. Body mass index was higher in Afro-Caribbean than European women, accounting for 4 mm Hg of the difference. Diabetes prevalence was 16% in Afro-Caribbeans and 5% in Europeans (P<.001), accounting for 1 mm Hg of the difference in systolic pressure in men and 2 mm Hg in women. In participants not taking antihypertensive medication, mean fall in ambulatory systolic pressure between daytime and nighttime, adjusted for resting blood pressures, was 24 mm Hg in Europeans and 18 mm Hg in Afro-Caribbeans (P=.05), and percent day-night fall in systolic blood pressure adjusted for resting systolic pressure was 17% in Europeans and 12% in Afro-Caribbeans (P<.05). This difference persisted when men and women and normotensive and hypertensive individuals were examined separately. We estimate that the differences in blood pressure between Afro-Caribbeans and Europeans may be enough to account for ethnic differences in stroke mortality in women but not men. The reasons for the high prevalence of hypertension and related morbidity in this and other populations of African descent remain to be established. (Hypertension 1993;22:90-96)

KEY WORDS • blood pressure, ambulatory • ethnic groups • cerebrovascular disorders

Blacks living in the United States, the Caribbean, and the United Kingdom share similar high mortality rates from cerebrovascular disease1,2 and have higher blood pressures than European populations.3 7 However, comparative studies of Afro-Caribbeans with Europeans in the United Kingdom have failed to demonstrate consistent differences in blood pressure required to explain mortality differences.8 11 Caribbean-born migrants to England and Wales have twice the mortality from stroke and four times (in men) to seven times (in women) the mortality from hypertensive disease compared with the national average.2 12 Similar differences in mortality between African Americans and whites have been reported from the United States,1 where death rates from stroke are two times and from hypertensive disease 3.5 times greater than the national average. Using data from the Whitehall cohort study of cardiovascular risk factors and mortality in British civil servants,13 we estimated that a difference of 20 mm Hg in systolic blood pressure between Afro-Caribbean and European men would be required to explain the observed relative risk of 1.8 in stroke mortality. However, findings from UK studies have been inconsistent, and none has found a blood pressure difference of this size.8 11 African Americans and Caribbean blacks originate from the same area of West Africa and presumably share a common genetic ancestry.14 In people of African descent living in the United States3 15 17 and the Caribbean,1 6 18 mean blood pressures have consistently been found to be higher than in European populations. But no study has demonstrated differences large enough to explain the size of the excess stroke mortality, although it has been reported that African Americans have a higher prevalence of target-organ damage than Europeans for a given level of resting blood pressure,3 19 20 and this could be explained by higher average diurnal blood pressures in African Americans.21 Our objectives were to determine the prevalence of hypertension in UK Afro-Caribbeans and to test the hypothesis that diurnal blood pressure patterns may differ in Afro-Caribbeans and Europeans.

Methods

Our study population was based on the lists of six group family practices in the inner London borough of Brent. A sample of 300 subjects in each sex and ethnic group aged 40 to 64 years was calculated to have 90% power to detect a difference of 3.2% in mean systolic and diastolic blood pressures at a 5% level of significance, assuming a coefficient of variation of 12% (means and standard deviations from an earlier UK survey were used22). Exclusion criteria were severe psychiatric disturbance, severe physical disability, infec-
tion hazard, terminal illness, and pregnancy. With the help of practice staff, patients were assigned to one of five groups: European, South Asian, Afro-Caribbean, other, and unknown. The relative proportions of these groups varied by family practice, although the proportion of patients of unknown ethnicity was small. There were fewer Afro-Caribbean than European patients, and to ensure that our subject selection would not be biased toward those who were well known to their family doctor and who may therefore be more regular consulents, we combined the unknown and Afro-Caribbean groups before sampling. A random sample from the combined Afro-Caribbean and unknown group, stratified by 5-year age group and sex, was selected, and an equal sample of Europeans was chosen in the same manner. Ethics committee approval was gained from the Parkside District Health Authority.

Invitations for a health check were sent by recorded delivery. Nonresponders were sent a reminder and then telephoned to confirm that they were still resident; those who did not have a telephone were visited. Of the 3178 subjects mailed, 2088 were resident at that address and 1218 attended for examination. Excluding those who were no longer resident, the response rate was 58%; response rate by ethnicity was difficult to calculate because ethnicity could not be assigned to all patients on family practitioner lists; however, the response rate was similar in the two ethnic groups in those subjects in whom ethnicity could be assigned.

Respondents were invited to attend for a health check and, before the examination, were asked to complete a self-administered questionnaire that included items on past medical history (including diabetes), medication, smoking, alcohol intake, exercise, dietary information, and occupation. After an overnight fast, participants attended a local health center where the questionnaire was checked and completed and informed consent was gained. Ethnicity was assigned by the interviewer based on appearance and parental origin. Social class was assigned according to occupation, using the Office of Population Censuses and Surveys classification of occupation as social class.23 The three higher social classes (I, II, and III nonmanual) were grouped as the nonmanual category, and social classes III manual, IV, and V were grouped as the manual category. Resting blood pressure, height, and weight were measured according to a standard protocol. Blood samples were taken fasting and 2 hours after a 75-g glucose load. Glucose was determined by an enzyme-linked immunosorbent assay (Boehringer, Germany).

At the time of resting blood pressure measurement, all those who were hypertensive and every other normotensive subject were considered for noninvasive ambulatory blood pressure monitoring. Those who did not have full use of both arms or from whom we would be unable to collect the monitor the next day were excluded. The rest were invited to wear the Tokeda TM2420 (Tokyo, Japan) ambulatory blood pressure monitor for the 24-hour period after screening and to return the next day. Those who agreed were fitted with the monitor, and two blood pressure readings were taken at rest. The operation of the monitor was explained to the participant and a contact phone number was similar in the two ethnic groups in those subjects in whom ethnicity could be assigned.

Insulin and body mass index were log transformed before analysis. Continuous variables were analyzed by least-squares regression models with 10-year age group as a categorical variable. Age-adjusted means were calculated as the values predicted in the model when the age variables were held at their mean value. Prevalence rates and medians were directly standardized to
**TABLE 1. Age-Standardized Blood Pressure, Metabolic, and Anthropometric Variables by Sex and Ethnicity**

<table>
<thead>
<tr>
<th>Variable</th>
<th>European (n=272)</th>
<th>Afro-Caribbean (n=247)</th>
<th>European (n=313)</th>
<th>Afro-Caribbean (n=334)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Median BP (mm Hg)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic</td>
<td>122 (120-126)*</td>
<td>128 (125-133)</td>
<td>118 (115-120)†</td>
<td>135 (131-140)</td>
</tr>
<tr>
<td>Diastolic</td>
<td>79 (77-80)*</td>
<td>84 (81-86)</td>
<td>75 (73-76)†</td>
<td>86 (83-88)</td>
</tr>
<tr>
<td>Untreated hypertensive (%)</td>
<td>6.9 (3.9-9.9)</td>
<td>10.6 (6.7-14.5)</td>
<td>3.3 (1.0-5.6)</td>
<td>7.2 (4.0-10.4)</td>
</tr>
<tr>
<td>Treated hypertensive (%)</td>
<td>7.3 (4.3-10.3)†</td>
<td>21.0 (16.0-26.0)</td>
<td>10.0 (6.6-13.4)†</td>
<td>30.2 (25.4-35.0)</td>
</tr>
<tr>
<td>Diabetes prevalence (%)</td>
<td>6.5 (5.0-8.0)†</td>
<td>12.9 (10.4-15.4)</td>
<td>4.0‡ (2.7-5.3)†</td>
<td>17.7 (15.6-19.8)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>26.4 (26.0-26.8)</td>
<td>26.0 (25.6-26.4)</td>
<td>26.0 (25.5-26.8)</td>
<td>29.1 (28.5-29.6)</td>
</tr>
<tr>
<td>Current smokers (%)</td>
<td>37 (31-42)</td>
<td>30 (24-35)</td>
<td>35 (30-40)†</td>
<td>8 (5-11)</td>
</tr>
<tr>
<td>Alcohol (U/wk)</td>
<td>30 (25-35)</td>
<td>19 (14-25)</td>
<td>5 (4-6)</td>
<td>4 (3-5)</td>
</tr>
<tr>
<td>Leisure time exercise (MJ/wk)</td>
<td>5.3 (4.8-5.8)‡</td>
<td>4.9 (4.4-5.4)</td>
<td>4.6 (4.2-5.0)‡</td>
<td>3.9 (3.5-4.3)‡</td>
</tr>
<tr>
<td>Insulin, fasting (mU/L)§</td>
<td>6.6 (6.0-7.0)‡</td>
<td>8.3 (7.5-9.4)</td>
<td>5.8 (5.3-6.2)‡</td>
<td>8.6 (7.9-9.3)‡</td>
</tr>
<tr>
<td>Insulin, 2-hour (mU/L)§</td>
<td>19 (17-21)‡</td>
<td>24 (22-27)</td>
<td>23 (22-25)‡</td>
<td>33 (31-36)</td>
</tr>
</tbody>
</table>

BP, blood pressure. Values in parentheses are 95% confidence intervals.

*P<.01, †P<.001, comparing ethnic groups.

**Results**

Age-standardized prevalence of hypertension (treated and untreated) was 35% in Afro-Caribbeans and 14% in Europeans. Afro-Caribbean with hypertension were more likely to be on treatment than their European counterparts (Table 1). Age-standardized median systolic blood pressures were 6 mm Hg higher in Afro-Caribbean men than in European men, and in women this difference was 17 mm Hg. Age-adjusted mean blood pressures, including the resting blood pressure measurement of treated hypertensive subjects, were also compared: for men, systolic pressures were 123 and 128 mm Hg, and for women, pressures were 118 and 131 mm Hg (Europeans and Afro-Caribbeans, respectively). These differences were observed in all age groups except for the 40 to 49 age group in men (Fig 1). Blood pressure was also higher in Afro-Caribbeans at all levels of body mass index (Fig 2), standardizing for body mass index increased the median systolic blood pressure difference to 11 mm Hg in men and reduced it to 13 mm Hg in women. Median systolic blood pressures were not significantly different when those who responded to the first invitation were compared with those who responded to the second.

There was no difference in median blood pressures between Afro-Caribbeans born in the Caribbean and those born in West Africa (Table 2, excludes East African and South African subjects because numbers are too small).

**FIG 1.** Median systolic blood pressure by age and ethnic group.
The prevalence of diabetes was three times as high in Afro-Caribbeans (16%) as in Europeans (5%). Median systolic blood pressures, comparing those who were normoglycemic with those who were glucose intolerant, were 122 and 127 mm Hg for European men, 127 and 135 mm Hg for Afro-Caribbean men, 117 and 118 mm Hg for European women, and 131 and 135 mm Hg for Afro-Caribbean women. Standardizing for glucose intolerance reduced the difference in median systolic blood pressure to 5 mm Hg in men and 15 mm Hg in women. Both fasting and 2-hour serum insulin levels were higher in Afro-Caribbeans than in Europeans \((P<.001)\). However, there was no consistent relation between blood pressure and insulin when the four sex and ethnic groups were examined separately.

In men, median age-standardized systolic blood pressure was 122 mm Hg (95% confidence interval [CI], 119-126 mm Hg) in European nonmanual workers compared with 123 mm Hg (95% CI, 120-127 mm Hg) in manual workers. In Afro-Caribbean nonmanual workers, systolic blood pressure was 126 mm Hg (95% CI, 119-135 mm Hg) and 129 mm Hg (95% CI, 126-135 mm Hg) in Afro-Caribbean manual workers. In both ethnic groups, 66% of participants were owner-occupiers; the ethnic difference in blood pressure remained significant when housing tenure was controlled for \((P=.014)\). Among men who were owner-occupiers, age-standardized median systolic blood pressure was 5 mm Hg higher in Afro-Caribbeans than in Europeans; among men who were tenants, the difference was 10 mm Hg. The prevalence of other risk factors for cerebrovascular disease, such as smoking, heavy drinking, and low levels of exercise, were no higher in Afro-Caribbeans than Europeans (Table 1).

The correlation between mean ambulatory systolic blood pressure and resting blood pressure was 0.43 for the daytime period (9 AM to 11 AM), 0.31 for the evening period (5 PM to 7 PM), and 0.39 for the nighttime period (3 AM to 5 AM). Ambulatory blood pressures for Afro-Caribbeans were generally higher for the whole 24-hour period (Fig 3). For the whole sample, daytime age-adjusted mean systolic blood pressure (Table 3) was no different in Afro-Caribbeans and Europeans, but nighttime mean systolic blood pressure was 107 mm Hg in Europeans and 114 mm Hg in Afro-Caribbeans \((P<.01)\); this difference was reduced and no longer significant when adjusted for resting systolic blood pressure. The difference between daytime and nighttime blood pressure was also not significant (23 mm Hg in Europeans compared with 19 mm Hg in Afro-Caribbeans) but increased and was just significant when adjusted for resting blood pressure \((P=.05)\). The percent fall in systolic blood pressure from daytime to nighttime was 17% in Europeans and 13% in Afro-Caribbeans \((P<.05)\) and remained significant when corrected for resting systolic blood pressure. Similar significant differences were found when normotensive subjects were compared but not when hypertensive subjects were compared. Analyzing men and women separately showed similar findings except that the percent fall in blood pressure was less for Afro-Caribbean women (11%) than for Afro-Caribbean men (15%). Only the ethnic difference in percent fall in blood pressure for normotensive subjects remained significant.
FIG 3. Mean ambulatory systolic blood pressure over 24 hours.

when the two sexes were analyzed separately (17% in Europeans versus 12% in Afro-Caribbeans for both men and women, P<.05).

Discussion

Our response rate of 58% is similar to that of other studies performed on this population in the same part of London when calculated in the same way as our own (we included in our denominator those who were absent for long periods).8,10 This is unlikely to be biased by ethnic group, because the response rate in those subjects in whom ethnicity could be assigned by family practitioners was similar in the two ethnic groups. We also show that blood pressure findings were similar in those who responded to the first and second invitations to the study. To nullify our observed blood pressure differences found in women, the true median resting systolic blood pressure would have to be approximately 35 mm Hg higher in European women than Afro-Caribbean women.

In earlier studies from the United Kingdom, differences in average systolic blood pressures between Afro-Caribbeans and Europeans in men have ranged from being 1 mm Hg lower in Afro-Caribbeans than in Europeans to 9 mm Hg higher, as well as 3 mm Hg lower in Afro-Caribbean women compared with European women to 7 mm Hg higher.8-11,22 Only two studies found a significant ethnic difference in mean systolic blood pressure.9,22 We have demonstrated clear differences in blood pressure between the two ethnic groups and for the first time sex differences in resting blood pressure in Afro-Caribbeans commensurate with mortality data. Ambulatory blood pressure findings were consistent with resting blood pressure data, with levels being generally higher for Afro-Caribbeans when compared with Europeans at all times. This makes it unlikely that ethnic differences in resting blood pressure simply reflect different cardiovascular responses to blood pressure measurement.

Other studies of ethnic differences in ambulatory blood pressure have mainly been performed in the United States28,29 and, despite their relatively small sample size, have demonstrated substantial ethnic differences in diurnal blood pressure patterns, with the percent nighttime fall in blood pressure being on average 14% in whites compared with 8% in African Americans.28 It is surprising that these studies found larger differences in ambulatory blood pressure than our own much larger sample population. The differences between these and our findings could be explained by differences in population selection; we for the first time performed ambulatory monitoring in the two ethnic groups on a community-based sample, whereas other studies have chosen selected clinic populations or volunteers.

However, the only other UK-based study to compare ambulatory blood pressure patterns in Afro-Caribbeans compared with Europeans, using intra-arterial blood pressure monitoring on a small, selected clinical population, found no difference in ambulatory blood pressures in the two ethnic groups.30 Interestingly, when recent (ie, less than a decade ago) migrants from West Africa to the United States were compared with native

TABLE 3. Age-Corrected Mean Systolic Ambulatory Blood Pressure for Different Time Periods by Hypertensive Status and Ethnicity

<table>
<thead>
<tr>
<th>Systolic blood pressure</th>
<th>Normotensive</th>
<th>Hypertensive</th>
<th>Excluding treated hypertensives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>European (n=119)</td>
<td>Afro-Caribbean (n=103)</td>
<td>European (n=33)</td>
</tr>
<tr>
<td>Daytime (mm Hg)</td>
<td>125 (121-129)</td>
<td>127 (122-132)</td>
<td>151 (141-161)</td>
</tr>
<tr>
<td>Adjusted daytime (mm Hg)</td>
<td>126 (122-123)</td>
<td>125 (120-130)</td>
<td>150 (140-160)</td>
</tr>
<tr>
<td>Nighttime (mm Hg)</td>
<td>103* (100-106)</td>
<td>110 (106-114)</td>
<td>123 (116-130)</td>
</tr>
<tr>
<td>Adjusted nighttime (mm Hg)</td>
<td>104† (101-107)</td>
<td>108 (105-112)</td>
<td>122 (115-129)</td>
</tr>
<tr>
<td>Day-night difference (mm Hg)</td>
<td>22 (18-26)</td>
<td>17 (12-22)</td>
<td>27 (17-37)</td>
</tr>
<tr>
<td>Adjusted day-night difference (mm Hg)</td>
<td>22 (18-27)</td>
<td>16 (11-21)</td>
<td>26 (16-36)</td>
</tr>
<tr>
<td>Day-night fall (%)</td>
<td>17† (13-20)</td>
<td>12 (8-15)</td>
<td>17 (10-24)</td>
</tr>
<tr>
<td>Adjusted day-night fall (%)</td>
<td>17† (14-20)</td>
<td>12 (8-15)</td>
<td>17 (10-24)</td>
</tr>
</tbody>
</table>

Values in parentheses are 95% confidence intervals. Adjusted values are adjusted for resting systolic pressure.

*P<.01, †P<.05.
African Americans and US whites, both US whites and the recent African migrants had a persistent nocturnal decline in systolic blood pressure, which was not seen in native African Americans. Studies of Barbadian blacks have also shown that the usual decline in nocturnal blood pressure is preserved. The Afro-Caribbean population studied here were all first-generation migrants from the Caribbean and West Africa, and it is possible that as recent migrants, this population, unlike their US counterparts, have not fully lost the usual decline in nocturnal blood pressure.

The reasons for the loss in nocturnal decline in African Americans are not known, but it is postulated that environmental factors may play a part and that this may be mediated by changes in the sympathoadrenal system with blunting of the usual diurnal variation in the amplitude of sympathoadrenal activity.

Ambulatory blood pressures have been reported to correlate better with indexes of end-organ damage than resting blood pressure. Our demonstration of a smaller decline in nocturnal blood pressure may help to explain why Afro-Caribbeans experience a greater amount of end-organ damage than Europeans for a given level of resting blood pressure.

Based on the slope of the relation between stroke mortality and blood pressure observed in the Whitehall study, a twofold relative risk of stroke mortality would require a difference in systolic pressure of 20 mm Hg, rather than the difference of 6 mm Hg that we observed. However, blood pressure in the Whitehall study was measured on only one occasion, and it has been estimated that reliance on a single blood pressure measurement underestimates the true slope of the relation between stroke and blood pressure by a factor of approximately 1.6. On this basis, a difference of 13 mm Hg rather than 20 mm Hg in systolic pressure would be sufficient to account for the mortality difference in men.

If the relation between systolic pressure and relative stroke mortality is the same in women as in men, our measured difference of 17 mm Hg could explain a relative risk of 2.1. Resting blood pressure differences therefore could fully explain stroke mortality findings in women but only a 50% increase in men. One study has suggested that the slope of the relation between resting blood pressure and stroke mortality is steeper in US blacks than in Europeans, and one possible explanation could be that resting blood pressure does not take diurnal variation into account. On this basis, the paradox of a high hypertension-related mortality without significant differences in blood pressure may be partially resolved, in women at least, although the reasons for these differences are less clear. We have shown that adjusting for body mass index only partially explains the ethnic difference in blood pressure in women. Although the prevalence of diabetes was greater in Afro-Caribbeans, and in each ethnic group median blood pressures were higher in glucose-intolerant than in normoglycemic subjects, adjusting for glucose intolerance did not account for blood pressure differences. Average fasting and 2-hour insulin levels are significantly higher in Afro-Caribbean adults compared with Europeans, but there was no consistent relation between blood pressure and insulin in any of the four ethnic and sex groups.

Some US studies have suggested that socioeconomic factors can explain much of the difference in blood pressure between blacks and whites. There is a class gradient in blood pressure in UK Europeans, but standardizing for housing tenure or social class did not account for blood pressure differences.

Differences in blood pressure may be related to variations in salt handling, and studies have shown that US blacks have a delayed renal excretory response to salt loading. The reasons for this are unclear, although one suggestion is that the vulnerability of Afro-Caribbeans to hypertension results from a genetically determined tendency to conserve salt, perhaps as an adaptation to survival in sub-Saharan Africa. Others have taken this further to suggest that the high prevalence of hypertension among people of African descent in the United States results from the selective survival of those with this sodium-conserving ability during the period of slavery. Our findings do not support this latter hypothesis; median blood pressures were as high in West African–born migrants as they were in Caribbean–born migrants.

In conclusion, our findings indicate that the differences in resting blood pressures between Afro-Caribbeans and Europeans in the United Kingdom are larger than previously demonstrated. In women but not in men these differences may be large enough to explain the excess stroke mortality in Afro-Caribbeans compared with Europeans. It is possible that a smaller nocturnal decline in ambulatory blood pressure in Afro-Caribbeans makes some additional contribution to the ethnic difference in risk of hypertensive end-organ damage. The reasons for these ethnic differences in blood pressure and the effectiveness of measures to prevent hypertension in people of African descent remain to be established.

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