Factors Related to Blood Pressure in a Biracial Adolescent Female Population

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SUMMARY  Blood pressure levels, anthropometric parameters, and dietary intakes were assessed in 1981 and 1983 in a population of black (n = 236) and white (n = 296) adolescent girls, aged 14 and 16 years in 1983. The 14-year-old black girls exhibited significantly higher mean systolic and diastolic blood pressures than whites in both years. Body weight and Quetelet index were more strongly associated with blood pressure than were height and triceps skinfold thickness. Correcting blood pressures for weight, Quetelet index, 2-year changes in height, and age at menarche decreased in each case (but did not negate) the observed race differences in blood pressure. Dietary calcium and potassium intakes were inversely related to blood pressure, and a race difference in the intake of these nutrients (whites > blacks) was observed. Covariate adjustment for calcium, but not for potassium, decreased the magnitude of race differences in blood pressure. Family type (single-parent vs nuclear) and place of residence (urban vs nonurban) appeared to be the most important confounding variables for race differences in blood pressure, since differences largely were eliminated by controlling for these factors. Conflicting reports in the literature regarding the age range during which race differences in blood pressure become apparent may be partially attributed to the complex interrelationships among these factors and the potential influence of other genetic-environmental interactions that may also play a role in blood pressure regulation. (Hypertension 8: 843-850, 1986)

KEY WORDS  • blood pressure  • weight  • body composition  • social stress  • calcium  • potassium  • epidemiology

ELEVATED blood pressure is a risk factor for various chronic disease processes including atherosclerosis and thus constitutes a major public health problem in most industrialized countries.

There is much evidence relating blood pressure levels in children to levels in later life. An assessment of factors related to elevated blood pressure levels during childhood may suggest preventive measures that could be introduced at a time when intervention may be most effective.

Blacks consistently exhibit higher systolic blood pressure (SBP) and diastolic blood pressure (DBP) than whites during adulthood, but studies assessing blood pressure levels in adolescent populations have yielded conflicting results. The literature contains reports of higher, lower, and similar blood pressure levels in black adolescents compared with whites. The relative contributions of hereditary and environmental factors to race differences in blood pressure have not been clearly defined.

Race differences in body size or composition, or both, within adolescent populations have also been reported. Greater skinfold thicknesses in white girls as compared with black girls have been noted, with differences more pronounced at limb than at trunk sites. The use of densitometry to estimate body fat levels has also suggested that white children have a
higher percentage of body fat compared with age-
matched and sex-matched blacks. In addition, a race
difference exists in rate of physical maturation: black
children tend to be taller and more advanced in skeletal
development. 11, 12

Relationships between anthropometric measures of
body size or composition and blood pressure have been
observed within adolescent populations. 4-6, 13-16 Blood
pressure levels may also be related to sociodemograph-
ic factors 17 and to dietary intake variables such as sodi-
um, potassium, and calcium. 18 although associations
between blood pressure and these nutrient parameters
have not been demonstrated specifically within adoles-
cent groups.

The present investigation reports on blood pressure
changes over a 2-year period in a biracial population of
adolescent girls. Data were collected as part of a south-
ern regional study to assess the nutritional status of
adolescent girls. The potential influence of body size
and composition, sociodemographic factors, and spe-
cific dietary intakes on race differences in blood press-
ure was investigated.

Subjects and Methods

In 1981, 1247 girls (556 black, 691 white) from
eight southern states participated in this study. They
were aged 12, 14, or 16 (± 0.5) years and had no
known metabolic disorders. Recruitment procedures
involved eliciting the support of administrators of
schools located in the geographic areas near the 11
cooperating universities. Black and white girls meet-
ing the age requirements for participation were notified
of the study by fliers, posters, and verbal communica-
tion from teachers. All eligible girls were given the
opportunity to participate. Each state attempted to re-
cruit 80 girls aged 12 years, 80 aged 14 years, and 40
aged 16 years, with each age grouping equally divided
between blacks and whites. Girls were included in the
study regardless of income, but each institution at-
ttempted to include 10 to 15% of subjects for each race
from families with incomes of $2,500 or less and the
same percentage with incomes of more than $4,500 per
capita to ensure a spectrum of incomes.

In 1983, attempts were made to recontact those sub-
jects who were aged 12 or 14 years in 1981. Girls aged
16 years in 1981 were not relocated because the prima-
ry objective of the study was to assess nutritional status
during or immediately following the adolescent
growth spurt. Experimental procedures and consent
forms were reviewed and approved at each cooperating
station by the local review boards for research involv-
ing human subjects. In 1983, 665 females participated
in the longitudinal component of the study. The pres-
ent article deals with a sample of 532 girls (236 black, 296
white) for whom complete blood pressure, anthrop-
ometric, and dietary data were obtained in 1981 and
1983. A summary of the distribution of subjects by
age, race, and geographic area is presented above in
Table 1.

Data Collection

Subjects reported to participating institutions' re-
search centers between February and May in 1981 and
in 1983. Blood pressure measurements were taken be-
fore breakfast after an overnight fast. Subjects were
asked to sit quietly for 5 to 10 minutes, after which
single recordings of blood pressure were taken by a
trained professional. Blood pressure was recorded in
the right arm using a standard mercury sphygmoman-
ometer with the subject sitting upright. Although both
the fourth (muffling) and fifth (disappearance) blood
pressure phases were recorded, DBP was reported at
the point of complete disappearance of Korotkoff's
sounds unless the fourth and fifth phases deviated by
more than 10 mm Hg, in which case the fourth phase
was reported. When initial blood pressure levels were
outside the range (i.e., DBP less than 60 or greater
than 90; SBP less than 100 or greater than 120 mm
Hg), blood pressure was remeasured after an interval
of about 15 minutes and these levels were reported.

Changes in blood pressure during the 2-year lon-
titudinal study were computed as the difference be-
tween the 1983 and 1981 levels (e.g., ΔSBP = 1983
SBP - 1981 SBP).

Height, weight, and triceps skinfold (TS) were de-
termined by standard methods 19; subjects were
weighed in light clothing without footwear, and TS
measurements were performed on the right arm. Sub-
jects' weights without clothing were approximated by
subtracting estimated weight of clothing. The Quetelet
index (QUET) was computed as the ratio of body
weight (in kilograms) divided by the square of height
(in meters). Alterations in the anthropometric param-
eters during the 2-year period were computed as the
difference between the 1983 and 1981 levels (e.g.,

Family per capita income (PCI) levels, family type
(nuclear vs single-parent), place of residence (urban vs
nonurban), and parental education levels were as-

### Table 1. Subject Distribution by Age, Race, and Geographic Area

<table>
<thead>
<tr>
<th>Geographic area</th>
<th>Aged 14 yr in 1983</th>
<th>Aged 16 yr in 1983</th>
</tr>
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</tr>
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<td>4</td>
</tr>
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<td>0</td>
</tr>
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<td>27</td>
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<td>32</td>
<td>17</td>
</tr>
<tr>
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<td>5</td>
</tr>
<tr>
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<td>7</td>
</tr>
<tr>
<td>Knoxville, TN</td>
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<td>5</td>
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<td>12</td>
</tr>
<tr>
<td>Blacksburg, VA</td>
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<td>1</td>
</tr>
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<td>Petersburg, VA</td>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td>154</td>
<td>114</td>
</tr>
</tbody>
</table>
sessed from sociodemographic data elicited by questioning the subjects' parents (or legal guardians). Urban was defined on the basis of a population size greater than 100,000. Parental education levels were classified as high, moderate, or low corresponding to post-high school (i.e., some college or technical school) training for each, only one, or neither parent, respectively. For single-parent families, education level was classified as either high or low depending on whether the parent had received post-high school training. The subjects' age at menarche (in months) was obtained by direct questioning of the girls each data collection year. If there was a discrepancy between 1981 and 1983 in the age reported, the 1981 value was accepted as the more valid estimate.

Trained interviewers with backgrounds in food and nutrition conducted two 24-hour recalls on two separate occasions each data collection year. The first recall typically was conducted at the subjects' homes, while the second occurred at the research center approximately 2 weeks later. Food models or calibrated utensils, or both, were used to aid the girls in estimating the quantities of food they had eaten. Food consumption data were coded and analyzed using the computer bank maintained by the Nutritional Analysis System (Department of Experimental Statistics, Louisiana State University, Baton Rouge, LA, USA). Computed total nutrient intakes included vitamin and mineral intakes derived from supplements. Computed sodium intakes were only estimates of amounts present in food as purchased; no provisions were made for discretionary salt usage.

Statistical Analysis

Analysis of variance models (including the station source of variation) were used to evaluate differences in blood pressure levels based on race and age groupings. The potentially confounding effects of family type, place of residence, and parental education levels on race differences in blood pressure were evaluated by including these independent variables in the analysis of variance models. Analysis of covariance was used to determine the extent to which other potentially confounding variables (PCI, anthropometric and dietary variables, age at menarche) could explain race differences in blood pressure or anthropometric measurements. Pearson product-moment correlation coefficients and regression coefficients obtained from the analysis of covariance were used to assess associations between anthropometric variables or dietary intake variables and blood pressure.

Results

Blood Pressure and Anthropometric Measurements

Means (±SD) for the 1981 and 1983 blood pressure measurements and the blood pressure alterations over the 2-year period are presented by race in Table 2 for girls aged 14 and 16 years. Black girls who were 14 years old in 1983 exhibited significantly higher mean SBP and DBP levels compared with whites in both 1981 and 1983. Only 1983 DBP was significantly higher in blacks within the subpopulation of girls aged 16 years in 1983.

Table 3 shows the means (±SD) for the anthropometric measures (height, weight, TS, QUET) and the alterations in these variables over the 2-year period. A greater number of significant race differences were observed in 14-year-old than in 16-year-old girls. The 14-year-old black girls had significantly higher mean body weights and QUET levels compared with whites in both 1981 and 1983 and a significantly smaller increase in height during this 2-year period. The 16-year-old white girls had a significantly greater height in 1983 and Δheight than did black girls; no other anthropometric variable differed significantly between races within the subpopulation of girls who were aged 16 years.

Subjects' age at menarche was used as a marker of biological age. Only a small minority of whites (7%) and blacks (6%) had not reached menarche by the data collection period in 1983. Age at menarche for whites (150 ± 13 [SD] months) was significantly greater (p < 0.0001) than the corresponding age for blacks (145 ± 13 months).

A covariate adjustment for age at menarche allowed an assessment of whether anthropometric differences between races could be partially attributed to differences in biological age. Correcting for age at menarche

<table>
<thead>
<tr>
<th>Variable</th>
<th>Whites</th>
<th>Blacks</th>
<th>Whites</th>
<th>Blacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981 SBP</td>
<td>101.3 ± 10.4</td>
<td>105.4 ± 13.3</td>
<td>106.9 ± 9.7</td>
<td>107.3 ± 12.1</td>
</tr>
<tr>
<td>1983 SBP</td>
<td>105.8 ± 9.2</td>
<td>107.5 ± 10.9</td>
<td>108.3 ± 10.8</td>
<td>109.1 ± 11.4</td>
</tr>
<tr>
<td>ΔSBP</td>
<td>4.7 ± 10.5</td>
<td>2.2 ± 13.1</td>
<td>1.4 ± 9.7</td>
<td>1.8 ± 13.4</td>
</tr>
<tr>
<td>1981 DBP</td>
<td>63.7 ± 10.4</td>
<td>66.5 ± 10.4</td>
<td>66.3 ± 9.4</td>
<td>69.7 ± 9.6</td>
</tr>
<tr>
<td>1983 DBP</td>
<td>67.2 ± 8.8</td>
<td>70.0 ± 8.6</td>
<td>68.6 ± 9.0</td>
<td>71.6 ± 8.8</td>
</tr>
<tr>
<td>ΔDBP</td>
<td>4.1 ± 10.5</td>
<td>3.5 ± 11.5</td>
<td>2.4 ± 9.3</td>
<td>1.9 ± 11.7</td>
</tr>
</tbody>
</table>

Values are means ± SD. SBP = systolic blood pressure; ΔSBP = difference between 1983 and 1981 SBPs; DBP = diastolic blood pressure; ΔDBP = difference between 1983 and 1981 DBPs.

*p < 0.01, t < 0.05, compared with values in whites.
negated the above-stated race differences in weight and QUET but did not alter the observed differences in height and \( \Delta \text{height} \).

**Relationships Between Anthropometric and Blood Pressure Measurements**

Pearson \( r \) values describing simple associations between the levels of anthropometric variables and blood pressure for the total subject population and within the two age groupings are presented in Table 4. Of the four anthropometric variables considered in this study, weight and QUET were more strongly associated with blood pressure levels; variability in these anthropometric indices accounted for between 4.4 and 15.2\% of the variance in 1981 and 1983 blood pressure levels for the total population. Height and TS accounted for only 0.6 to 8.4\% of the total blood pressure variability for girls aged 16 years.

Correlation coefficients were consistently higher within the subpopulation of girls aged 14 years than in those aged 16 years. This is illustrated by the finding that weight and QUET accounted for between 8.4 and 20.2\% of the variability in 1981 and 1983 blood pressure levels for girls aged 14 years but only 0.6 to 8.4\% of the blood pressure variability for girls aged 16 years.

Table 5 indicates the Pearson correlation coefficients computed between the change in height during the 2-year period (\( \Delta \text{height} \)) and blood pressure levels for the total population and for subject subdivisions based on race and on age. Associations of changes in weight, QUET, and TS with blood pressure generally were not statistically significant and are not reported. Correlations between \( \Delta \text{height} \) and blood pressure were negative and more pronounced for 14-year-old girls than for 16-year-old girls and within the white com-

### Table 3. Mean Anthropometric Measurements by Race Within Age

<table>
<thead>
<tr>
<th>Variable</th>
<th>Aged 14 yr in 1983</th>
<th>Aged 16 yr in 1983</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Whites</td>
<td>Blacks</td>
</tr>
<tr>
<td>1981 height (cm)</td>
<td>153.7 ± 7.2</td>
<td>155.1 ± 6.5</td>
</tr>
<tr>
<td>1983 height (cm)</td>
<td>161.6 ± 5.7</td>
<td>160.7 ± 5.3</td>
</tr>
<tr>
<td>( \Delta \text{height} ) (cm)</td>
<td>8.0 ± 4.1</td>
<td>5.6 ± 3.6*</td>
</tr>
<tr>
<td>1981 weight (kg)</td>
<td>44.8 ± 10.3</td>
<td>48.7 ± 12.3*</td>
</tr>
<tr>
<td>1983 weight (kg)</td>
<td>53.3 ± 10.4</td>
<td>56.9 ± 13.2‡</td>
</tr>
<tr>
<td>( \Delta \text{weight} ) (kg)</td>
<td>8.7 ± 4.9</td>
<td>8.4 ± 5.4</td>
</tr>
<tr>
<td>1981 QUET</td>
<td>1.88 ± 0.35</td>
<td>2.01 ± 0.43*</td>
</tr>
<tr>
<td>1983 QUET</td>
<td>2.04 ± 0.35</td>
<td>2.20 ± 0.45‡</td>
</tr>
<tr>
<td>( \Delta \text{QUET} )</td>
<td>0.16 ± 0.18</td>
<td>0.20 ± 0.19</td>
</tr>
<tr>
<td>1981 TS (mm)</td>
<td>15.6 ± 6.1</td>
<td>14.9 ± 6.4</td>
</tr>
<tr>
<td>1983 TS (mm)</td>
<td>15.1 ± 5.5</td>
<td>15.2 ± 6.7</td>
</tr>
<tr>
<td>( \Delta \text{TS} ) (mm)</td>
<td>-0.3 ± 5.0</td>
<td>0.5 ± 4.2</td>
</tr>
</tbody>
</table>

Values are means ± SD. \( \Delta \text{Height} = \text{height difference between 1983 and 1981}; \Delta \text{weight} = \text{weight difference between 1983 and 1981}; \text{QUET} = \text{Quetelet index}; \Delta \text{QUET} = \text{QUET difference between 1983 and 1981}; \text{TS} = \text{triceps skinfold}; \Delta \text{TS} = \text{TS difference between 1983 and 1981}.

* \( p < 0.01, \Delta p < 0.0001, \delta p < 0.05, \n p < 0.001, \text{compared with values in whites.} \)

### Table 4. Pearson Correlation Coefficients Between Anthropometric Variables and Blood Pressure Measurements

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All subjects</td>
<td>Age (yr)</td>
<td>All subjects</td>
<td>Age (yr)</td>
</tr>
<tr>
<td>1981 height</td>
<td>0.23</td>
<td>0.19</td>
<td>0.14</td>
<td>0.25</td>
</tr>
<tr>
<td>1983 height</td>
<td>0.15</td>
<td>0.11</td>
<td>0.12</td>
<td>0.08</td>
</tr>
<tr>
<td>1981 weight</td>
<td>0.39</td>
<td>0.45</td>
<td>0.23</td>
<td>0.27</td>
</tr>
<tr>
<td>1983 weight</td>
<td>0.34</td>
<td>0.43</td>
<td>0.19</td>
<td>0.22</td>
</tr>
<tr>
<td>1981 QUET</td>
<td>0.37</td>
<td>0.45</td>
<td>0.21</td>
<td>0.25</td>
</tr>
<tr>
<td>1983 QUET</td>
<td>0.32</td>
<td>0.43</td>
<td>0.16</td>
<td>0.21</td>
</tr>
<tr>
<td>1981 TS</td>
<td>0.22</td>
<td>0.27</td>
<td>0.15</td>
<td>0.10</td>
</tr>
<tr>
<td>1983 TS</td>
<td>0.22</td>
<td>0.34</td>
<td>0.07</td>
<td>0.20</td>
</tr>
</tbody>
</table>

\( N = 532, 268, \text{and} 264 \) for all subjects, 14-year-olds, and 16-year-olds, respectively. Pearson \( r \) values greater than 0.11 (total population) and 0.15 (subpopulations based on age) are statistically significant \( (p < 0.01) \).

SBP = systolic blood pressure; DBP = diastolic blood pressure; QUET = Quetelet index; TS = triceps skinfold.
TABLE 5. Pearson Correlation Coefficients Between ΔHeight and Blood Pressure

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>All subjects</td>
<td>-0.20*</td>
<td>-0.22*</td>
<td>-0.17*</td>
<td>-0.15†</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Whites</td>
<td>-0.24*</td>
<td>-0.19‡</td>
<td>-0.21†</td>
<td>-0.16‡</td>
</tr>
<tr>
<td>Blacks</td>
<td>-0.11</td>
<td>-0.19‡</td>
<td>-0.10</td>
<td>-0.07</td>
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<tr>
<td>Age (yr)</td>
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<tr>
<td>14</td>
<td>-0.15§</td>
<td>-0.21†</td>
<td>-0.16‡</td>
<td>-0.19‡</td>
</tr>
<tr>
<td>16</td>
<td>-0.05</td>
<td>-0.07</td>
<td>-0.11</td>
<td>-0.01</td>
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</table>

SBP = systolic blood pressure; DBP = diastolic blood pressure. *p < 0.0001, ‡p < 0.01, †p < 0.05, §p < 0.001, significant interactions.

pared with the black subpopulation. None of the Pearson correlation coefficients computed between these variables was statistically significant for girls aged 16 years. Within the black population, Δheight was significantly correlated only with 1981 DBP.

In light of the finding that blacks had higher mean levels of weight and QUET and lower mean levels of Δheight and age at menarche, a series of covariate analyses were conducted to determine the extent to which correcting for each of these variables could explain race differences in blood pressure. Table 6 indicates the least-squares (adjusted) blood pressure means before and after covariate adjustments for weight, QUET, Δheight, and age at menarche. The SBP did not differ significantly between races in each year after covariate adjustment for either weight or QUET, whereas race differences in DBP were less pronounced but still statistically significant after these covariate adjustments. Adjustments for Δheight or age at menarche also decreased the level of statistical significance for race differences in 1981 DBP, although significant DBP and 1981 SBP differences persisted. When all four vari-

TABLE 6. Least-Square Blood Pressure Means Before and After Covariate Adjustments for Anthropometric Parameters and Age at Menarche

<table>
<thead>
<tr>
<th>Blood pressure</th>
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<th>1983</th>
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<td>Blacks</td>
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<tr>
<td>Least-square</td>
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<td>105.7*</td>
<td>106.4</td>
<td>108.5†</td>
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<td></td>
</tr>
<tr>
<td>Adjusted for</td>
<td>103.5</td>
<td>105.3</td>
<td>106.8</td>
<td>108.3</td>
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</tr>
<tr>
<td>weight</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted for</td>
<td>103.7</td>
<td>105.5</td>
<td>106.9</td>
<td>108.2</td>
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<tr>
<td>Adjusted for</td>
<td>103.4</td>
<td>105.6†</td>
<td>106.4</td>
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<td>age at menarche</td>
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<tr>
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<tr>
<td>Least-square</td>
<td>64.1</td>
<td>67.3‡</td>
<td>67.8</td>
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<td>64.6</td>
<td>67.0*</td>
<td>67.8</td>
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<td>67.4*</td>
<td>68.1</td>
<td>70.7*</td>
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<td>age at menarche</td>
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See Table 3 for key to abbreviations. *p < 0.01, ‡p < 0.05, †p < 0.0001, §p < 0.001, compared with values in whites.

Sociodemographic Variables

Marked race differences were observed in three of the four sociodemographic variables of interest. Higher mean PCI levels were characteristic of white ($5833) compared with black ($3523) families, and the percentage of nuclear (as differentiated from single-parent) families was higher in the white than in the black subpopulation (85 vs 58%). At least one of the parents of 70% of white compared to 41% of black families had at least some college or technical school training. A similar percentage of blacks (27%) and whites (30%) were classified as residing in urban areas.

Neither PCI nor parental education levels could account for a significant amount of variation in the subjects’ blood pressure levels. In contrast, the addition of family type and place of residence to the analysis of variance model for blood pressure negated race differences in 1983 SBP, 1981 DBP, and 1983 DBP and decreased the level of statistical significance for race differences in 1981 SBP (to p < 0.05). Family type accounted for an appreciable amount of variation in the model for 1981 SBP (p < 0.05) and 1983 SBP (p = 0.08), as higher blood pressure levels were observed in single-parent as compared with nuclear families. Place of residence was a significant independent variable for 1981 DBP (p < 0.0001) and 1983 DBP (p < 0.01); higher DBP levels were observed in subjects living in urban compared with nonurban areas. Significant race-residence interactions (p < 0.05) for 1981 DBP and 1983 DBP indicated that the relative...
magnitude of the urban-nonurban DBP differences was greater in whites than in blacks.

Dietary Variables

The simultaneous inclusion of selected dietary intake variables in a multiple regression analysis allowed the assessment of the independent contribution of each dietary variable to blood pressure variability after controlling for the other variables (Table 7). The dietary intake variables used in this analysis were averaged over 4 days since two 24-hour recalls were obtained in both years. This resulted in a greater number of significant relationships than were observed when regression coefficients were computed between nutrient intakes and blood pressure levels from the same year. Potassium and calcium intakes were negatively associated and Na/K ratios were positively associated with blood pressure levels, although regression coefficients were not significant in the majority of instances (e.g., a 1-g increase in dietary calcium was associated with a 3.18 mm Hg decrease in 1983 DBP; p < 0.01; coefficients relating calcium intakes to 1981 SBP, 1981 DBP, and 1983 SBP were not statistically significant).

Race differences in the dietary intake variables presented in Table 7 were also observed. Blacks had significantly lower mean calcium (720 vs 930 mg/day; p < 0.0001) and potassium intakes (2.31 vs 2.56 g/day; p < 0.05) compared with whites. No significant race differences were observed either in sodium intakes or in dietary Na/K ratios. Correcting blood pressure levels for dietary calcium (but not for potassium) in an analysis of covariance consistently decreased the magnitude of the observed race differences in blood pressure. With the exception of 1983 SBP (p < 0.05 before adjustment, nonsignificant after adjustment), however, significant race differences were still observed after covariate adjustment for dietary calcium intakes.

The race difference in overall calcium intake was further explored by quantifying mean calcium intakes from selected sources. In both data collection years, whites obtained significantly more calcium from milk products and the food group including cheese and mixed products containing cheese. In contrast, blacks obtained significantly more calcium from vegetables (Table 8).

Discussion

This study was based on data collected by research teams assembled at 11 cooperating universities. The development and distribution of a detailed procedures manual and a prestudy workshop for participating station researchers during which data collection methods were reviewed ensured a high degree of standardization of all data collection procedures. However, some methodological variation between stations was likely. The possibility that methodological differences affected results was minimized by correcting for the station source of variation in the analysis of variance models for blood pressure and anthropometric measurements. We also acknowledge that the generalizability of the results is limited by the recruitment procedures, which yielded a population sample that may not have been totally representative of adolescent girls in the regions studied.

Studies assessing race differences in blood pressure in adolescent populations have yielded divergent results. The present finding of higher blood pressure levels among black than among white adolescent girls in both years is consistent with some reports in the literature but not with others.

Mechanisms responsible for race differences in blood pressure observed during adulthood and reasons for the conflicting reports regarding the age range during which black-white differences become apparent have not been fully delineated. Race differences in blood pressure may be attributed to factors related to socioeconomic status or to genetic-environmental interactions, or to both. Physiological differences between races in internal blood pressure control mechanisms have been proposed. Physiological differences between races in internal blood pressure control mechanisms have been proposed. Physiological differences between races in internal blood pressure control mechanisms have been proposed.

Previously reported race differences in anthropometric measurements within adolescent populations are partially supported by the findings from the present study. Significantly higher weight and QUET levels
observed in 14-year-old black girls compared with whites in 1981 and 1983 could be largely attributed to earlier maturation in blacks, since covariate adjustment for age at menarche negated these race differences. The gain in height between 1981 and 1983 was significantly greater for whites than for blacks within both subject age groupings, and 16-year-old white girls had a significantly greater height in 1983 than did black girls. The race difference in change in height over this 2-year longitudinal study suggested an earlier maturation rate or a less pronounced growth spurt, or both, in blacks compared with whites. Although black children tend to be taller and more advanced in skeletal development, data from the Health Examination Survey indicated that white girls catch up in height by age 14 years and exhibit height levels that are slightly greater than those of blacks by age 17 years.

The significant correlations reported between anthropometric measurements (height, weight, QUET, TS) and blood pressure in this study have been observed within other adolescent populations. The finding that weight and QUET were more highly associated with blood pressure than were height and TS is in agreement with data obtained from the Health Examination Survey; weight had the strongest relationship to blood pressure within this population of adolescents aged 12 to 17 years, although positive associations were also observed for subscapular skinfold thickness and QUET. Other studies also suggested that total body weight may be the single most important anthropometric predictor of blood pressure within adolescent groups.

The findings that whites exhibited a significantly greater Δheight and a later mean age at menarche than blacks are consistent with the possibility of an earlier attainment of physical maturation in blacks. Since physiological maturity (as assessed by skeletal age) is highly correlated with weight and height in adolescent populations, associations between anthropometric variables and blood pressure during adolescence are likely to be partially mediated by the relationship between physiological maturity and blood pressure. Associations of blood pressure with body weight or body composition and with physiological maturity are potentially confounding factors for the assessment of blood pressure differences between races. In the present study, covariate adjustments for either weight, QUET, Δheight, or age at menarche decreased the level of statistical significance in the observed race differences in SBP and DBP. The primary importance of body weight as a correlate of blood pressure was reemphasized by the finding that of these four variables, only weight consistently accounted for a significant proportion of the blood pressure variability after statistically controlling for the remaining three variables.

Although blood pressure levels in adults are inversely related to various measures of socioeconomic status including educational levels, studies in children and adolescents generally have not observed these independent relationships. Neither PCI nor parents' education level was associated with blood pressure in the present study. Conversely, two sociodemographic variables (place of residence and family type) were predictive of blood pressure levels, and inclusion of these variables in the analysis of variance models largely negated the observed race differences in blood pressure. These findings support the hypothesis that environmentally induced stress may be causally related to elevated blood pressure in blacks. Higher blood pressures among blacks attending inner-city schools compared with those attending suburban or private schools emphasize the importance of environmental determinants of hypertension.

Other studies have attempted to clarify relationships between dietary intakes of specific electrolytes and blood pressure. The present findings that blood pressure levels were negatively associated with both potassium and calcium intakes and positively associated with Na/K ratios have been reported previously within other population groups. Dietary intake differences between races may be a partial explanation for the relatively high blood pressure and incidence of hypertension among American blacks. Lower mean calcium and potassium intakes were observed in black girls compared with white girls in the present study. Lower potassium intakes in blacks have been reported in other studies, although data from the National Health and Nutrition Examination Survey suggested that increased dietary Na/K ratios in blacks could not independently explain the race differences in the prevalence of hypertension.

Marked race differences in calcium intakes were observed in the present study, and correcting blood pressure levels for dietary calcium consistently decreased the magnitude of the observed race differences in blood pressure. McCarron et al. reported that low calcium intake was the dietary parameter most consistently associated with high blood pressure, although the use of the same data base (National Health and Nutrition Examination Survey I) by Gruchow et al. indicated that calcium was inversely related to blood pressure for nonwhite men only. Lower calcium intakes among the black girls in the present study could be attributed primarily to their lower consumption of milk and cheese products. Inverse relationships between milk consumption and blood pressure from large-scale cross-sectional studies lend additional support to the supposition that the presently observed race differences in blood pressure may be partially attributed to black-white differences in dairy product or total calcium intakes.

In conclusion, the present study suggests that black-white differences in anthropometric measures of body size and rate of physiological maturity, and in certain dietary intake parameters, may interact with sociodemographic factors to provide a partial explanation for race differences in blood pressure during adolescence. Conflicting reports regarding the age range during which race differences in blood pressure become apparent may be attributed to the complex interrelationships among these factors and the potentially con-
founding influence of other genetic-environmental interactions that may also play a role in blood pressure regulation.

Furthermore, these data emphasize the primary importance of body weight as a nutrition-related determinant of blood pressure. Other environmental factors associated with blood pressure appear to include certain sociodemographic factors, although these are likely to be more resistant to modification than are factors involved in energy balance and body weight regulation. If race differences in blood pressure during adulthood can be largely attributed to multiple environmental factors, then the maintenance of ideal body weight appears to be the single most important preventive measure against the development of hypertension.

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Hypertension. 1986;8:843-850
doi: 10.1161/01.HYP.8.10.843

Hypertension is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0194-911X. Online ISSN: 1524-4563

The online version of this article, along with updated information and services, is located on the World Wide Web at:
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