Pediatric Blood Pressure: Ethnic Comparisons in a Primary Care Center

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SUMMARY This study reviews the blood pressure (BP) determinations previously recorded in a primary care center serving a low socioeconomic population and compares the systolic blood pressure (SBP) and diastolic blood pressure (DBP) distributions within the clinic population among the three major ethnic groups represented, and also between this clinic population and a recently reported standard population (Task Force for Blood Pressure Control in Children, NHLBI). The study group consisted of 2810 children 3-17 years of age, of whom 49.2% were of Spanish surname, 23.4% black, and 27.4% white. As a standard clinic procedure, BP readings were obtained from the right arm with the subject seated.

Comparisons of the average SBP by 3-year age groups, by sex, within the clinic population showed that blacks had higher SBPs than children with Spanish surnames or whites in all of the five male subgroups and in four of the five female subgroups. Black males had higher DBPs than Spanish or whites in four of the five subgroups; black females had higher DBPs in three of the five subgroups.

In comparison with the standard population, the overall 95th percentile values for both SBP and DBP were lower. The prevalence of readings above the 95th percentile values reported for the standard population over all age groups was as follows: SBP, 1.53%; DBP, 1.60%; and both SBP and DBP, 0.57%. Proportionately, elevated readings were most common among blacks and least common among whites. However, these differences between ethnic groups could be accounted for statistically, to a great extent, by adjusting for height and weight, since blacks were the tallest and heaviest of the three groups. The results suggest that, even in childhood, blacks presenting at a primary care center have higher BPs than Spanish or whites, but that this difference is largely related to body size. (Hypertension 3: 39-47, 1981)

KEY WORDS • blood pressure • children • ethnic differences • health screening • hypertension

HYPERTENSION is a well-known risk factor in coronary heart disease and stroke and is one of the more common diseases affecting adults of both sexes. Numerous etiological factors have been investigated; within the United States, hypertension is known to be more common in black adults than in white adults.\textsuperscript{1-4} To determine the age of onset of hypertension, many investigators have studied childhood patterns of blood pressure (BP)\textsuperscript{5-20} These studies have shown that BP rises with age in childhood and adolescence. In some of the biracial studies, slight ethnic differences were noted.\textsuperscript{11-13, 16, 17}

However, a major problem with these studies is that they vary in the definition of abnormal BP or hypertension; they also vary in the BP measurement technique. As with adults of Spanish surnames, little information is available regarding BP distributions for children of this ethnic group.

Because of the increasing interest in BP distributions of children, and because of the need to standardize the measurement of BP in children, a task force was established by the National Heart, Lung, and Blood Institute to provide specific guidelines for measurement and evaluation of BP in children.\textsuperscript{21} Using data from three Specialized Centers of Research (SCOR) studies, the Task Force published grids of BP distribution in presumed "normal" children, principally white. The intent of these grids was to allow a practicing clinician to compare a given BP determination with the BP distribution of normal children of the same age and sex. In addition, by recording BP regularly, individual patients' trends might be observed and the "tracking" phenomenon, if it exists, could be documented over periods of time.
The purpose of the present report is to describe pediatric BP distributions from a triethnic (black, Spanish-surname, and white) primary care center and to compare these distributions with those published by the Task Force of the National Heart, Lung, and Blood Institute. Within the clinic population, the relationships between BP and sex, race, age, and body size were also analyzed. The present report deals only with the initial clinic BPs; subsequent readings will be addressed in a future report.

Materials and Methods

All BP determinations were made at the West End Health Center (WEHC) of Houston. The Center is part of a network of eight community health centers of the Harris County Hospital District and serves a low socioeconomic population. In 1970, the West End community consisted of a target population of 53,042 persons living in seven census tracts of Harris County. This triethnic community consists of 26.8% blacks, 20.6% Spanish-surnamed people, and 52.6% whites. There were a total of 14,279 children aged 3–17 years in this area. Of the persons in these census tracts, 24.5% were defined as having incomes below the poverty level. Thus, approximately 3500 children aged 3–17 years who lived in the area would have been eligible for Harris County Hospital District Community Health Program services, based on eligibility requirements at that time. Although clinic utilization need not conform strictly with place of residence, these data reflect reasonably well the actual community served by the WEHC.

The pediatric clinic at WEHC serves as a primary care facility. By means of interview and review of birth certificates when available, registration personnel establish ethnic origin, sex, and date of birth for each child. Medical records are maintained at the time of the first visit. Daily log books are kept for all new and return patients in the pediatric clinic. As a standard part of each visit, BP is measured and recorded. This study is based upon a review of patient records for a substantial period of this clinic’s operation up to the time of the study.

Initial BP observations during the period studied were obtained principally by a nurse’s aide who was, in turn, supervised by four nurses. These aides were instructed in proper BP determination technique as recommended in 1975. Periodic observations and retraining by one of us occurred during the course of the 3-year interval. Mercury sphygmomanometers (Baumanometer) placed at the observer’s eye level were used. Selection of bladder sizes for the sphygmomanometer cuff was done per recommendations of Kirkendall et al. and Mitchell et al. The cuff covered two-thirds of the arm above the elbow and at least three-quarters of the circumference of the upper arm. Available cuff sizes were included by name: “infant,” “child,” “adult,” “large adult arm,” and “adult thigh.” The children were seated in the weights-and-measure room, and following a few minutes rest, a single right arm BP determination was made. Observers recorded the first and fourth (muffling) phases of the Korotkoff sounds.

In addition, height (without shoes) and weight (light clothing) were recorded for most clinic visits.

As part of the record review for this study, the following information was abstracted for each patient: chart number, date of birth, sex, ethnic origin, date of first clinic visit, date of first clinic visit with a BP determination (if different from the first clinic visit), SBP, DBP, height, weight. The information above was recorded separately for each subsequent clinic visit.

From July 1, 1975, through June 30, 1978, 5414 children registered as new patients. Of these, 240 children (4.4%) had charts that could not be located. There were 2168 patients (40.0%) excluded from the study in accordance with the following criteria for eligibility: 1) the patient was less than 3 years of age throughout the entire study time; 2) the patient was 18 years or older throughout the entire study time; and 3) the patient had his/her first clinic BP determination before the age of 3 years. Of the remaining 3006 children, 84 (1.5%) had no BP recorded in the medical record. There were 112 children (2.1%) of Oriental or Vietnamese surname who were not included in this study due to insufficient numbers. Thus, the eligible study group with available records and suitable BP readings consisted of 2810 children 3–17 years of age who had their first visit to the WEHC during the specified time period and who had their first clinic BP recorded at a visit occurring at 3 years of age or more.

The study population consisted of 23.4% black, 49.2% Spanish-surnamed, and 27.4% white children. There were 1425 boys and 1385 girls. Classification by age was done by 3-year age groups to construct cells containing sufficiently large numbers. Nearly one-third of the population was in the 3–5 year age group. (Table 1)

The data were keypunched and translated onto a magnetic disc for storage. We calculated means, standard deviations, 50th and 95th percentiles, using the Statistical Package for Social Science and the International Mathematical and Statistical Library.

### Table 1. Composition of Study Population

<table>
<thead>
<tr>
<th>Population</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>2810</td>
</tr>
<tr>
<td>Ethnic group:</td>
<td></td>
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<tr>
<td>Black</td>
<td>657</td>
</tr>
<tr>
<td>Spanish-surnamed</td>
<td>1384</td>
</tr>
<tr>
<td>White</td>
<td>769</td>
</tr>
<tr>
<td>Sex:</td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>1385</td>
</tr>
<tr>
<td>male</td>
<td>1425</td>
</tr>
<tr>
<td>Age group (yr):</td>
<td></td>
</tr>
<tr>
<td>3–5</td>
<td>929</td>
</tr>
<tr>
<td>6–8</td>
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<td>9–11</td>
<td>486</td>
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<tr>
<td>12–14</td>
<td>458</td>
</tr>
<tr>
<td>15–17</td>
<td>250</td>
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</tbody>
</table>
also determined the proportion of subjects in the clinic population who had SBPs or DBPs or both above the 95th percentile of the standard population. A chi-square analysis was done to test for ethnic differences.

We computed analyses of variance to test for differences among sexes and ethnic groups, adjusting for age. We likewise did analyses of variance among sex and ethnic groups, with age and various expressions of body size (height, weight, and a ponderal index, weight/height²) as covariates. An end-digit preference analysis was also done and revealed 75% of both SBPs and DBPs ended in zero; the remaining 25% of pressures ended in 2, 4, 6, or 8.

Results

The means, standard deviations, median and 95th percentile values for SBP and DBP were determined for each age, sex, and ethnic group. Among boys and girls aged 3–17 years (by 3-year age groups), mean SBP and DBP increased substantially with age. Comparison of the mean SBP by 3-year age groups by sex showed that for girls, black children had higher SBPs than Spanish-surnamed children or white children in four of the five subgroups, and higher DBPs in three of the five subgroups. For boys, blacks had higher SBPs than the other two ethnic groups in all five subgroups and higher DBPs in four of the five subgroups (figs. 1–4). Four of these 20 groups had significant differences. An analysis of variance of all female subjects with regards to SBP by ethnic group, with age as a covariate, revealed a significant difference among ethnic groups (F = 4.539, p = 0.011), and similarly for DBP (F = 4.020, p = 0.018). The ethnic differences showed that blacks had higher pressures than Spanish-surnamed children who in turn had higher pressures than whites. Of particular interest is the subgroup of 9–11 year-old girls. Within this age-sex group, there are marked differences in SBP and DBP, with blacks having higher pressures than Spanish-surnamed or white girls. Across all age subgroups there is a suggestion that black girls attain maximum BP earlier.

Similar analyses for all male subjects for both SBP and DBP revealed significant differences among ethnic groups with the same trend as for females (SBP, F = 4.954, p = 0.007; DBP, F = 3.353, p = 0.035). For both males and females, over the entire population these ethnic differences were only of the magnitude of 3 mm Hg, however. An analysis of variance of the en-
tire population for SBP by sex and race, with age as a covariate, showed males having higher pressures than females ($F = 7.230, p = 0.007$). No significant sex difference was seen for DBP.

Comparison of the entire population's pressures with those of the Task Force of the National Heart, Lung, and Blood Institute (henceforth called the standard population) showed that the median and 95th percentile values for SBP and DBP were lower in the clinic population. Since no standard deviations were published with the means of the Task Force report, a comparison of the means of the two populations could only be done if one assumed that the Task Force means were "true standards," and thus without variation. If one makes this assumption, all age-ethnic groups in the clinic population had significantly lower SBP and DBP than the standard population ($p < 0.01$) by Student's $t$ test comparison.

An analysis was done to determine the number of children from the clinic population who had either SBPs or DBPs or both above or equal to those of the standard population's 95th percentile for SBP or DBP or both. Proportionately, there were more black than Spanish-surname children, and more Spanish-sur-

name than white children with either SBPs or DBPs, or both SBPs and DBPs, above the standard 95th percentile for each sex (table 2). Chi-square analysis showed that these ethnic trends were significant in male groups but not in the female groups. There was no overall sex difference in prevalence of either SBP or DBP. The overall prevalence of elevated pressures was as follows: SBP, 1.53% (43/2810); DBP, 1.60% (45/2810); and both SBP and DBP, 0.57% (16/2810).

The means, standard deviations, medians, and 95th percentile values for height and weight were calculated. An analysis of variance of height by ethnic group with age as a covariate showed that blacks were taller than whites, who were in turn taller than Spanish-surnamed children, for each sex (males, $F = 31.798, p < 0.001$; females, $F = 40.258, p < 0.001$). Over the entire girl population, the average height was 127 cm and the range between highest and lowest ethnic groups was 3.56 cm. Over the entire boy population, the mean height was 127 cm, and the corresponding range was 3.91 cm. Black boys and girls also weighed more; for boys the average weight was 30.45 kg, with the range among ethnic groups 1.30 kg. Spanish-surnamed boys were least heavy. For girls,
the average weight was 30.91 kg with an ethnic group range of 2.70 kg, the latter being the difference between black and white girls.

To see if ethnic trends persisted after adjusting for body size, we did analyses of variance for both SBP and DPP for sex and ethnic effects with age and various expressions of body size, such as height, weight, ponderal index (wt/ht^2), or a combination of any two. The combination of height and ponderal index with age, sex, and race yielded the highest explained variance of any combination of variables. For SBP, this combination accounted for 51.2% of the variance, and for DBP, 41.5%. The BP levels, when related to height and to a ponderal index, suggested a strong influence of height and some small additional influence of the index on both SBP and DBP. Because of this strong influence of height, we did analyses of the effect of ethnicity on SBP and DPP, with only height as a covariate. These were done separately for each sex on all subjects. Again, whites had lower pressures than either blacks or Spanish-surnamed children (females, SBP, F = 4.683, p = 0.009, DBP, F = 4.355, p = 0.013; males, SBP, F = 3.057, p = 0.047, DBP, F = 4.179, p = 0.015). The combination of height and ponderal index as covariates gave similar results.

### Discussion

There is an increasing awareness that the determinants of hypertension may be evident in childhood. Clinicians are urged to measure BP at least once a year in all children 3 years of age and over, as part of a child's continual health care. The availability of a sizable multiethnic pediatric clinic population, with 97.2% (2922/3066) of age-eligible children having had their BP measured and recorded under standard conditions, allowed us to test the applicability of the grids published by the Task Force, and also to study the effect of ethnicity and body size on BP distributions.

The overall prevalence of elevated BP on initial examination was lower than expected. Prevalence rates of "hypertension" surveys done in the past 30 years vary considerably, most likely due to different measurement techniques and definitions of abnormal pressures. Our rates are some of the lowest, if not the lowest, for initial "abnormal" pressures, as based on the published standard curves. This comparatively low prevalence of elevated pressures in the WEHC was present in all groups studied. Numerous analyses of methodology, described below, have failed to suggest a satisfactory explanation.

### Methodology Analyses

Premeasurement activity, body position at time of BP measurement, time of day, observer variability, geographic location, and socioeconomic status (income) have been shown to affect blood pressure. It was not possible to ascertain premeasurement activity on individual patients in this study. However, the time from initial interview at registration to actual BP measurement varied from 30 minutes to 2 hours, and, at least for children 6 years old or over, this time was spent sitting. This would be expected to result in a lower, more basal pressure, e.g., the low pressures of the Bogalusa study are attributed to "basal" conditions.

All children had their BP measured while sitting, as did the children in the Muscatine and Rochester studies. The sitting position elevates DBP and decreases SBP. The supine BP standards are higher than those of our clinic subjects. Londe and Gollub have also studied the effect of arm position. Pressures are higher with the arm hanging than with the arm resting at heart level. Some of our younger children did have their arms hanging during the measurement, thus presumably causing higher pressures. Arm position then would be unlikely to explain the lower pressures.

In the Health Examination Surveys of both adults and children, SBP tended to be slightly higher among those examined in the afternoon than in the morning. The Muscatine children had their pressures measured in the afternoon, the Rochester children in
the morning. Our children had pressures measured at all times from early morning to late afternoon. This, then, would not account for the overall lower pressures, even if such a systematic difference were expected by time of day.

Geographic location may account for BP differences. Data from the National Health and Nutrition Examination Survey (HANES) 1971-1974, on whites 6-74 years of age, showed the mean age-adjusted SBP of those in the South was higher than those in the Midwest, Northeast, and West respectively. No regional differences in DBP pressure were seen. However, comparison of our results with those from BP surveys done under standardized protocols shows that our values are similar to those of essentially well children in Bogalusa, Louisiana, and Dallas, Texas. The distributions of the Task Force population are based on data from principally all-white school children from two Northern cities, Muscatine, Iowa, and Rochester, Minnesota. (The Task Force population does include a small number of preschool children, black and white, from Miami, Florida.) By definition, our study population is from a low socio-economic group. Data from HANES showed that mean SBP levels of the U.S. population were inversely related to the size of the family income. Syme et al. in a review of BP determinants of members in the Kaiser Foundation Health Plan found that, regardless of race, those in the lowest social classes had the highest BP. This, then, could not account for our pressures being lower than those of the standard population in that the latter probably represent a more heterogeneous group with regard to family income.

Observer variability and bias could be a major factor in these lower pressures, in that these measurements were performed principally by one observer who might have been biased in her readings to avoid labeling any child as hypertensive. Our values are lower than those of Londe. However, the values of our 95th percentile group are similar to those averaged by Mitchell et al. No attempt was made to test the principal observer's hearing, although she did not have a history of abnormal hearing. Inaccurate recording of the fourth Korotkoff sound (muffling) could occur with a hearing deficit. Further, even though digit preference was discussed with the observer, the frequent occurrence of the "0" digit in these data indicates that the recorded BP values could be less accurate than those of the Task Force distribution, although no statement is explicitly made in the Task Force report regarding end-digit preference.

Ethnic Comparisons

As noted by Lieberman, information is generally very limited on childhood BP levels in Spanish-surnamed Americans. Although there have been several published epidemiologic studies on black children and adolescents, the findings as well as the protocols differ from study to study. In the studies of the Bogalusa children and those of the Health Examination Survey Cycle II, there is a suggestion that, in prepubertal black children, BP levels may be higher than in their white peers. Kilcoyne et al. surveyed a triethnic (black, Latin-American, white) Harlem high school student population and found the frequency distributions for all three ethnic groups comparable for both SBP and DBP. No significant difference in prevalence among races was noted. Black males did have a higher prevalence rate of persistent diastolic hypertension, although the differences were not statistically significant. Another study involving black and white urban high school seniors reported only SBP. Abnormals were defined as having a SBP greater than 140 mm Hg; 1% of black females and 2% of black males were considered hypertensive. No white males or females had a SBP greater than 140 mm Hg. High SBPs were found in black males at all weight levels. Adjusting for differences due to weight, blacks still had higher BP than whites. The older children in Bogalusa likewise had higher BPs than white children. The DBPs of black youths were generally higher than those of white youths in the HES, Cycle III. However, SBPs of white youths were generally higher than those of blacks. Data from Evans County, Georgia, on young adults aged 15-29 years showed a greater number of blacks, both male and female, having abnormal pressures than whites.

On the other hand, five studies have shown either no major difference in black-white pressures or that whites have higher pressures. The Dallas triethnic study showed Spanish-surnamed youths had no major differences in pressures when compared with blacks and whites. The 1971-1974 HANES did enumerate some Spanish-Mexican Americans whose mean SBP and DBP were generally less than those of the black population; however, because of the small size of the groups and the correspondingly large sampling variability, only the differences for ages 65-74 years were large enough to be significant.

Our results lend credence to the concept that the elevated pressures characteristic of black adults appear earlier in life. Though Spanish-surnamed children generally had lower pressures than those of blacks and higher than those of white children, no significant trend was noted.

Body Size

Since BP does rise with age in childhood, what are the determinants of this change? Is it the age alone or is it due to changes in weight or height? In adults, the association of obesity with elevated BP has frequently been noted. Lauer et al. found an increased prevalence of higher levels of BP in children with higher relative weights (percentage above or below the median weight for all subjects with the same height, age, and sex). Voors et al. found that height with a combined weight and height index (wt/ht4) accounted for most of the explained variation in SBP. Their choice of this particular index was based on the constancy of it during body expansion; in contrast, wt/ht (Quetlet index) increases proportionately with height and wt/ht increases proportionately to ht2. This is on
the assumption that the expanding body structure maintains relative proportions of body composition. After controlling for these variables, Voors et al. found no association between age and BP in children 5 to 14 years of age.

We also found that this combination of height and the wt/ht² index, along with age, race, and sex, accounted for the highest amount of explained variation in pressures and that most of the variation was due to height. If tall and heavy children have higher BP than smaller children at similar ages, it is not surprising that the blacks, the tallest and heaviest of our ethnic groups, had higher pressures. Furthermore, Harlan and coworkers²⁴ reported that black girls are significantly more advanced in secondary sex characteristics than white girls of the same chronologic age. The marked differences for both SBP and DBP in the 9–11 year-old female group may reflect earlier sexual maturation in the black girls. Others have shown that, in children of the same age, BP is not higher in those of more advanced sexual development.²⁵

After adjusting for body size, however, there remains a small (1.5 to 2.00 mm Hg) but significant ethnic difference in the entire population, that is, whites have lower BP than either blacks or Spanish-surnamed children.

Conclusions

Comparison of BP among groups is difficult, particularly if there is a question of different measurement technique. Since observer bias and more basal conditions may have influenced the WEHC data, comparison of the WEHC population with the standard population is perhaps artificial. However, if the lower BPs of our study group represent a true geographic difference, local standards should be established. Although statistically significant ethnic trends were present before and after adjusting for body size, the clinical significance of these differences is unknown. However, our data suggest that BP measurement in children be accompanied by measurement of height and weight, and that these data, in addition to age, be considered in evaluating children's BP levels.

References


In childhood, blood pressure (BP) levels are significantly lower than in adults. Thus, children rarely have the BP levels that in adults are predictive of future complications. No childhood population has been followed longitudinally to see the relationship of early childhood BP levels to the development of coronary heart disease, renal disease, or stroke in adult life. There is also little information that relates to the efficacy of lowering the BP of children some under more anxious conditions, some in mixed positions at present must be extrapolated from information that is less direct.

The importance of recognizing and treating hypertension in adults resulted in a consideration of the significance of BP measurement in children by a Task Force on Blood Pressure Control in Children, appointed by the National Heart, Lung, and Blood Institute. The Task Force was charged with providing guidelines for practicing physicians and health care providers involved in school health and other community programs for children.

Normal BP values in children in relation to age, maturation indices, race, and sex have been published by numerous authors. Each has established a BP reference in a different manner: some with subjects seated, some recumbent, some under basal conditions, some under more anxious conditions, some in mixed racial groups, some in blacks, some in whites, some utilizing mercury sphygmomanometers, and some by using automated devices. It is therefore difficult to assess whether children's BP varies in different geographic areas and to establish the reference BP levels for physicians investigating whether an individual child's BP is high. There is general agreement that height and weight, in addition to age, should be included in evaluating a child's BP level.

In this issue of Hypertension, Gutgesell et al. present BP data derived from groups of children and emphasize the difficulty of comparisons with other

Commentary

Where Are Children's Blood Pressures Headed?

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AND
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Presented as a commentary by the peer reviewers of the preceding article: Gutgesell M, Terrell G, Labarthe D: Pediatric Blood Pressure: Ethnic Comparisons in a Primary Care Center.

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Pediatric blood pressure: ethnic comparisons in a primary care center.
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_Hypertension_. 1981;3:39-47
doi: 10.1161/01.HYP.3.1.39

_Hypertension_ is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1981 American Heart Association, Inc. All rights reserved.
Print ISSN: 0194-911X. Online ISSN: 1524-4563

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