24-h Ambulatory Blood Pressure Monitoring in Healthy Young Adult Anglo, Hispanic, and African-American Subjects

H. Peter Chase, Satish K. Garg, Gloria Icaza, Jon A. Carmain, Christine F. Walravens, and Guillermo Marshall

The purpose of this study was to compare office and 24-h ambulatory blood pressure (ABP) values for adolescent and young adult males and females of Anglo, Hispanic, and African-American descent. One hundred and eighteen healthy subjects (62 females, 56 males) participated, with an ethnic distribution of 50 Anglo, 32 Hispanic, and 36 African-American subjects. All subjects came to the clinic for height, weight, sitting blood pressure (BP), and to begin 24-h ABP monitoring using the SpaceLabs model 90207 automatic noninvasive monitor. The monitor recorded readings every 0.5 h from 06:00 to 22:00 and every hour at night from 22:00 to 06:00.

Office systolic and diastolic BP values were higher for all males compared to all females. Mean 24-h, nighttime, and daytime systolic ABP values were also significantly higher for males compared to females. The 24-h mean and daytime systolic ABP values were significantly different by ethnic groups. The African-American subjects always had the highest readings. Mean 24-h diastolic ABP was also significantly different by ethnic groups, with the African-American subjects being higher than the Anglos or the Hispanics. Diastolic ABP (24-h mean, daytime, and nighttime) values (for all subjects combined) increased gradually and varied significantly with age.

This study provides preliminary normative data about ABP in an understudied population (ie, teenagers and young adults of different ethnic backgrounds). It also shows that higher blood pressures are present among males and among subjects of African-American descent in the teenage and young adult population. © 1997 American Journal of Hypertension, Ltd. Am J Hypertens 1997;10:18–23

KEY WORDS: Ambulatory blood pressure, adolescents, young adults, African-Americans, Hispanics, Anglos, race, ethnicity.

Ambulatory blood pressure (ABP) monitoring is now frequently used in the adult population to evaluate office (white coat) hypertension and to determine antihypertensive drug efficacy. It has also been used to allow individual risk analysis for people with diseases such as coronary artery disease, diabetes, and dysautonomia. Twenty-four-hour ABP monitoring has been used less in the adolescent and young adult population in part because of a lack of normal data.
African-American adult populations are known to have a higher incidence of hypertension and a higher incidence of myocardial infarction than for the Anglo population. Several investigators have suggested that the atherosclerotic disease process begins in early life. The use of ABP monitoring at younger ages might help to determine whether elevations in blood pressure (BP) are identifiable by age, gender, or by ethnic group. If differences are detectable, public health strategies can be developed for prevention at an early age in high-risk subjects. The purpose of this study was to evaluate office BP and ABP values for teenage and young adult males and females of Anglo, Hispanic, and African-American descent.

RESEARCH DESIGN AND METHODS

One hundred eighteen subjects between the ages of 16 and 28 years with no first degree relatives with hypertension or diabetes mellitus volunteered to participate in this study. Subjects were recruited from high schools and colleges with the help of students sponsored by the Office of Multicultural Enrichment in Denver, Colorado. The level of socioeconomic status was not evaluated in this study. All subjects signed an informed consent form approved by the Colorado Multiple Institutional Review Board. All subjects had height, weight, and office BP measured before wearing the ABP monitor. Subjects whose body mass index (BMI) was ≥120% of normal for their age and gender were not included in the study. No subject was above the 20% of the desired ideal body weight, with a mean (± SD) body mass index of 22.6 ± 2.7. Office BP was measured using the appropriate sized cuff and a conventional mercury sphygmomanometer after the patient had rested in the sitting position for 5 min as used previously. The oscillometric portable automatic monitor (model 90207, Spacelabs; Redmond, WA) recorded daytime BP readings every 30 min from 0600 to 2200 and nighttime BP readings every hour from 2200 to 0600. This frequency was less than recommended previously because of the subjects acceptability for wearing these monitors based on their age (adolescents and young adults). The 24-h ABP readings were downloaded using a Spacelabs ABP Local Report Generator (model 90229; Spacelabs). The 24-h ABP monitor was calibrated after each usage for each subject. The functioning of the ABP recorder was demonstrated to the subjects and they were asked not to swim or bathe with the monitor. All subjects were given the telephone numbers to contact us in case of any problems. They were asked to keep diaries of their daily activities and times of actual sleep. Because these data were not received in a consistent manner, they were not included in the analyses and this could possibly be a source of error.

The 24-h ABP readings were analyzed for 24-h, daytime, and nighttime systolic and diastolic means. The ABP readings and the office systolic blood pressure (SBP) and diastolic blood pressure (DBP) means for each subject were analyzed along with age, gender, ethnic group, and body mass index.

Statistical Methods The SAS/STAT program package was used for the majority of data processing. Statistical analyses included Pearson’s correlation coefficient, Student’s t test, ANOVA, and linear regression models. Eight dependent variables were analyzed: office SBP and DBP, mean of 24-h systolic and diastolic ABP, mean of nighttime systolic and diastolic ABP, and mean of daytime systolic and diastolic ABP. For each of these dependent variables we fitted a linear regression model including gender, ethnic groups, age, and BMI as independent variables. If one or more of the independent variables was not significant at the P < .05 level, the variable was deleted from the model. Linear contrasts were used to compare means across ethnic groups in the linear regression model. When a specific statistical test other than linear regression was used, the test was specified after the P value.

RESULTS

There were 118 subjects in this study, including 56 males and 62 females (Table 1). There were 50 Anglo, 32 Hispanic, and 36 African-American subjects. The mean (± SD) age in years of the entire group was 21.5 ± 3.78, and of the three ethnic groups was 22.4 ± 3.71

<table>
<thead>
<tr>
<th>Ethnic Group</th>
<th>Number</th>
<th>Mean Age*</th>
<th>Number</th>
<th>Mean Age*</th>
<th>Number</th>
<th>Mean Age*</th>
</tr>
</thead>
<tbody>
<tr>
<td>African-American</td>
<td>32</td>
<td>20.6 ± 0.67</td>
<td>20</td>
<td>20.7 ± 1.03</td>
<td>16</td>
<td>20.6 ± 0.84</td>
</tr>
<tr>
<td>Anglo</td>
<td>50</td>
<td>22.4 ± 0.52</td>
<td>22</td>
<td>22.9 ± 0.80</td>
<td>28</td>
<td>22.0 ± 0.70</td>
</tr>
<tr>
<td>Hispanic</td>
<td>36</td>
<td>20.9 ± 0.59</td>
<td>14</td>
<td>20.6 ± 0.91</td>
<td>18</td>
<td>21.1 ± 0.79</td>
</tr>
<tr>
<td>All</td>
<td>118</td>
<td>21.5 ± 0.35</td>
<td>56</td>
<td>21.5 ± 0.55</td>
<td>62</td>
<td>21.4 ± 0.45</td>
</tr>
</tbody>
</table>

* The mean ± SEM ages for the three ethnic groups for all subjects or for males or females were not statistically different (P > .05; ANOVA).
for Anglos, 20.9 ± 4.04 for Hispanics, and 20.6 ± 3.33 for African-Americans (P > .05; ANOVA). The gender distribution and mean age for each ethnic group are shown in Table 1. When BMI was considered as a continuous variable, there were no significant differences by office BP values or by any 24-h ABP values.

Only the readings that did not include an event/error code were included in the analyses. The mean number of total error codes were 8.1, 4.1, and 4.9 for Anglo, African-American, and Hispanic males, respectively (P > .05). However, the ABP monitor automatically redetermined the BP value when these error codes occurred.

The mean (± SD) office SBP and DBP values for each ethnic group and for all males and females in each ethnic group are shown in Table 2. The office SBP and DBP values were significantly higher for all males compared to all females (P < .001; Student’s t test). The office SBP and DBP were not significantly different (P > .05; ANOVA) in the three ethnic groups (Table 2). A comparison of our office BP values with those published previously for subjects between the ages of 16 and 18 years were similar (P > .001; Table 3). The mean (± SD) 24-h systolic and diastolic ABP values for the entire group were 117 ± 7 and 70 ± 6 mm Hg, respectively. Both 24-h mean systolic ABP (P < .01) and diastolic ABP (P < .001) were significantly different for all subjects by ethnic group. When the hypothesis was tested that mean 24-h diastolic ABP was higher for African-Americans than for Anglos, or for African-Americans than for Hispanics, both were significant at P < .02. Mean 24-h diastolic ABP values for all subjects combined varied significantly with age (P < .001).

The mean (± SD) nighttime diastolic and systolic ABP values are given for all subjects and for males and females in each ethnic group (Table 4). The mean nighttime systolic ABP values were significantly higher for all males compared with all females for the three ethnic groups combined (P < .001; Student’s t test). The mean nighttime systolic ABP was not statistically different in the three ethnic groups (P > .05). The mean nighttime diastolic ABP was significantly higher for all males compared with all females for all subjects combined (P < .001). The mean nighttime diastolic ABP was not statistically significant for the three ethnic groups (P > .05). The mean nighttime diastolic ABP was significantly different by age group in the three ethnic groups and for all subjects combined (P < .001).

The mean (± SD) daytime diastolic and systolic ABP values are given for all subjects and for males

### TABLE 2. MEAN (±SD) OFFICE SYSTOLIC AND DIASTOLIC BLOOD PRESSURE VALUES BY GENDER AND ETHNIC GROUPS

<table>
<thead>
<tr>
<th>Ethnic Group</th>
<th>Systolic Blood Pressure</th>
<th>Diastolic Blood Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>Males</td>
</tr>
<tr>
<td>Number</td>
<td>117</td>
<td>56</td>
</tr>
<tr>
<td>African-American</td>
<td>118 ± 9</td>
<td>121 ± 7</td>
</tr>
<tr>
<td>Anglo</td>
<td>115 ± 9</td>
<td>119 ± 7</td>
</tr>
<tr>
<td>Hispanic</td>
<td>113 ± 10</td>
<td>115 ± 9</td>
</tr>
<tr>
<td>All</td>
<td>115 ± 9</td>
<td>119 ± 8*</td>
</tr>
</tbody>
</table>

* Office systolic BP and diastolic BP values were significantly higher for all males compared to all females (P < .001; Student’s t test).

### TABLE 3. MEAN (±SD) OF 24-H SYSTOLIC AND DIASTOLIC AMBULATORY BLOOD PRESSURE VALUES BY GENDER AND ETHNIC GROUP

<table>
<thead>
<tr>
<th>Ethnic Group</th>
<th>Systolic Ambulatory Blood Pressure</th>
<th>Diastolic Ambulatory Blood Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All*</td>
<td>Males</td>
</tr>
<tr>
<td>Number</td>
<td>118</td>
<td>56</td>
</tr>
<tr>
<td>African-American</td>
<td>120 ± 8</td>
<td>123 ± 6†</td>
</tr>
<tr>
<td>Anglo</td>
<td>117 ± 7</td>
<td>121 ± 6†</td>
</tr>
<tr>
<td>Hispanic</td>
<td>114 ± 7</td>
<td>117 ± 5†</td>
</tr>
<tr>
<td>All</td>
<td>117 ± 7</td>
<td>121 ± 6†</td>
</tr>
</tbody>
</table>

* Systolic ABP was significantly different for all subjects for the three ethnic groups (P < .01).
† Diastolic ABP was significantly different for all subjects by the three ethnic groups (P < .001). When the hypothesis was tested that for diastolic ABP, African-Americans were higher than Anglos, and African-Americans were higher than Hispanics, significance was attained at P < .02 for both. Age was also a significant independent variable for diastolic ABP (P < .001).
‡ Systolic ABP was significantly higher in males compared with females for each ethnic group and for all subjects combined (P < .001).
and females in each ethnic group (Table 5). Systolic daytime ABP values were significantly higher for all males compared with all females for each ethnic group and for all subjects combined (P < .001). Daytime systolic ABP was significantly different for all subjects for the three ethnic groups (P < .01). Daytime diastolic ABP for all subjects combined varied significantly with age (P < .001).

The office systolic BP and diastolic BP values correlated with mean daytime systolic and diastolic ABP values at r = 0.41 and r = 0.49, respectively (Pearson correlation coefficient; P > .001).

**DISCUSSION**

This study evaluates office and 24-h ABP in adolescents and young adults from three ethnic groups. Significant ethnic differences were found for 24-h mean and daytime systolic ABP values and for 24-h mean diastolic ABP values. The African-American subjects always had the highest values for each of these measurements. Harshfield et al. studied ABP in adolescents of African-American and Anglo descent. They found significantly higher values for boys compared with girls throughout the day and for African-Americans compared with Anglos at night (systolic and diastolic). These findings could be important in relation to the occurrence of hypertension within African-Americans in later life. Many studies have described a higher incidence of hypertension in adult African-Americans compared to adult Anglos. From the results of our study, and the previous study by Harshfield et al, it may be necessary to develop preventive measures starting in the teenage (early) years to effectively decrease the occurrence of adult hypertension in African-Americans.

Gender clearly influences BP. Office systolic and diastolic BP values were significantly higher for all males compared with all females. The mean systolic ABP was also higher in males for mean 24-h values and for both night and day values. The mean diastolic ABP was higher at nighttime for males compared with females. Staessen et al. reviewed the results of eight studies of adult ABP and found the mean 24-h systolic ABP was, on average, 6 mm Hg higher in men compared with women, and the mean 24-h diastolic ABP was 4 mm Hg higher in the men.

A major difference between the present study of ABP and the previous studies of Harshfield et al. and of Nishibata et al. is the exclusion of subjects in the present study with a BMI > 120% of normal. This was not done in either of the two previous studies, and BMI clearly had an effect in the report by Nishibata et al.
bata et al. African-American girls, in particular, are more apt to have a higher BMI than Anglo girls. Exclusion of this group with increased BMIs may have resulted in some of the differences in this study compared with previous studies.

In this study, we analyzed ABP recordings every 0.5 h during the day and every 1 h at night for 24 h. It has been recommended that recordings be more often and for longer time periods. The main reason for using this frequency in the present study was for acceptability by the adolescents and young adults. Harshfield et al19 also did recordings every hour during the night in their adolescents and young adults, whereas Nishibata et al25 used intervals of 30 min throughout the 24 h. The smaller numbers of readings in our study may have resulted in smaller differences in BP values observed between groups.

Relatively low r values were found in comparing the office BP values and the mean daytime 24-h ABP values. The differences in office and ABP values could be partly attributable to the increased number of ABP readings, and partly attributable to the effect of daily activities. The number of subjects studied in this report was relatively small, but we found only one other report of ABP monitoring in 100 or more adolescent/young adult subjects.20 As more normal data accumulate, hopefully it will be possible to establish normal values for ABP by age, ethnic group, and gender as has been done with office BPs.

It is likely that the use of ABP monitoring will gradually increase in adolescents and young adults. This may be for evaluation of "white coat" hypertension (as was done by Nishibata et al25), for evaluation of ethnic predispositions for hypertension in later life (as per Harshfield et al19,20), for evaluation of antihypertensive drug efficacy, or for risk analyses related to specific disease states. The results of this study will provide some basis (albeit in a small number of subjects) for comparison.

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REFERENCES


