Prevalence of Persistent Prehypertension in Adolescents

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Objective To measure the prevalence of persistent prehypertension in adolescents.

Study design We collected demographic and anthropometric data and 4 oscillometric blood pressure (BP) measurements on 1020 students. The mean of the second, third, and fourth BP measurements determined each student's BP status per visit, with up to 3 total visits. Final BP status was classified as normal (BP <90th percentile and 120/80 mm Hg at the first visit), variable (BP ≥90th percentile or 120/80 mm Hg at the first visit and subsequently normal), abnormal (BP ≥90th percentile or 120/80 mm Hg at 3 visits but not hypertensive), or hypertensive (BP ≥95th percentile at 3 visits). The abnormal group included those with persistent prehypertension (BP ≥90th percentile or 120/80 mm Hg and <95th percentile on 3 visits). Statistical analysis allowed for comparison of groups and identification of characteristics associated with final BP classification.

Results Of 1010 students analyzed, 71.1% were classified as normal, 15.0% as variable, 11.5% as abnormal, and 2.5% as hypertensive. The prevalence of persistent prehypertension was 4.0%. Obesity similarly affected the odds for variable BP (OR, 3.9; 95% CI, 2.5-6.0) and abnormal BP (OR, 3.4; 95% CI, 2.0-5.9), and dramatically increased the odds for hypertension (OR, 38.4; 95% CI, 9.4-156.6).

Conclusion Almost 30% of the students had at least one elevated BP measurement significantly influenced by obesity. Treating obesity may be essential to preventing prehypertension and/or hypertension. *(J Pediatr 2012;160:757-61)*.

In 2003, the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure recommended classifying adults with a systolic blood pressure (BP) between 120 and 139 mm Hg and/or a diastolic BP between 80-89 mm Hg as prehypertensive.[1] The term "prehypertension" was coined to alert clinicians and patients of the elevated BP and the risk for progression to hypertension and cardiovascular disease. The report also recommended initiating lifestyle modifications at this level of BP.

In 2004, the National High Blood Pressure Education Program Working Group updated the classification system of BP in children and adolescents to parallel the adult classification system, changing the terminology from "high normal" to "prehypertension" for BP between the 90th percentile (or 120/80 mm Hg if the 90th percentile is >120/80 mm Hg) and the 95th percentile.[2] Similar to the rationale behind the Joint National Committee's Seventh Report, the classification "prehypertension" was developed to alert clinicians and justify initiating lifestyle modifications in those who may be at risk for the development of hypertension at a young age. Currently, long-term cardiovascular disease risks are unknown for hypertensive youth, but it is known that children with hypertension are more likely to become adults with hypertension.[3] Moreover, there is evidence that nonhypertensive children with mildly elevated BP are at increased risk for developing adult hypertension.[4] Recent evidence also suggests that prehypertensive children may develop hypertension even before reaching adulthood.[5]

Estimates on the prevalence of prehypertension in children range from 9.5% to 24%[5-10]; however, all of these estimates are based on BP measurements obtained on only a single occasion. Contrary to the definition of hypertension in children, the Working Group does not require an elevated BP on 3 separate occasions for the classification of prehypertension.[2] Because of the inherent variability of BP, measurements on multiple occasions may be a more accurate approach to assigning a classification of prehypertension rather than a single measurement. The objective of the present study was to evaluate the prevalence of persistent prehypertension in adolescents.

Methods

School-based BP screens were performed in a Houston area high school in the spring and fall of 2007. The screens were conducted during physical education classes, health classes, and athletic physical examinations, and all students were eligible to participate. If a student participated in both screening encounters (spring and fall), only information from the second screen was included in the

BMI	Body mass index
BP	Blood pressure

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analysis. Students taking an antihypertensive agent or with incomplete follow-up were excluded from the analysis. The screening protocol was approved by local school personnel and the Committee for the Protection of Human Subjects at the University of Texas Health Science Center at Houston. Informed consent was obtained from the students and their guardians before the students' participation in the BP screening program.

At the initial screening visit, students self-reported age, sex, race/ethnicity, and use of "medicine or drugs for high BP." Race/ethnicity was categorized as Caucasian, African American, Hispanic, or other. Study personnel measured height, weight, and mid-arm circumference. The proper-sized BP cuff was chosen, with a bladder width at least 40% of the mid-arm circumference and bladder length encircling 80%-100% of the mid-arm circumference. For students with a mid-arm circumference falling within the range of 2 overlapping BP cuffs, the larger of the 2 cuffs was chosen.[2] Body mass index (BMI) and BMI *z*-scores were calculated and then converted to exact BMI percentage. Participants were further classified by BMI percentage into the following weight categories: underweight (BMI <5th percentile), healthy weight (BMI ≥5th but <85th percentile), overweight (BMI ≥85th but <95th percentile), or obese (BMI ≥95th percentile).[11] Seven students with BMI <5th percentile were included in the healthy weight group for analysis.

BP was measured in the right upper arm at heart level, with the student seated with the feet flat on the floor and resting for 5 minutes. Four oscillometric measurements were recorded using either a Spacelabs 90217 (Spacelabs, Issaquah, Washington) or Critikon 117208 (Critikon, Tampa, Florida) monitor. The average of the second through fourth BP measurements was compared with the Working Group reference values to determine the student's BP status for each visit. Students with an elevated BP (BP ≥90th percentile or 120/80 mm Hg) were remeasured on as many as 2 subsequent visits if BP remained elevated. The final BP status was determined using a modified version of the Working Group criteria to allow classification of all students as normal (BP <90th percentile and 120/80 mm Hg at the first visit), variable (BP ≥90th percentile or 120/80 mm Hg at the first visit [or first and second visits] and normal BP on follow-up), abnormal (BP ≥90th percentile or 120/80 mm Hg at all 3 visits but not fulfilling criteria for hypertension), or hypertension (BP ≥95th percentile on all 3 visits). A subgroup of the abnormal BP group was found to have persistent prehypertension, defined by a BP ≥90th percentile or 120/80 mm Hg and <95th percentile on all 3 visits. The remainder of the students in the abnormal group had an elevated BP (≥90th percentile or 120/80 mm Hg) on all 3 visits, with at least 1 reading ≥95th percentile. Heart rate was concomitantly measured with BP and averaged in a similar manner.

Statistical analyses were performed using Stata 9.2 (Stata Corp, College Station, Texas). Descriptive statistics are presented as percentages or as mean ± SD. The χ^2 test, Fisher exact test, ANOVA, Kruskal-Wallis test, and a nonparametric extension of the Wilcoxon rank-sum test were used to evaluate differences among BP groups. The 2-sample Student *t*-test was applied to further compare differences between individual groups in a paired analysis. Bonferroni correction was applied for the paired analyses by the Student *t*-test because of the multiple combinations, adjusting the level of significance to a *P* value <.004. Each nonnormal BP group was then individually compared with the normotensive subjects by univariate and multivariate logistic regression. Age, sex, heart rate, race, and either BMI percentage (continuous variable) or weight category were included in the final multivariate logistic regression analysis. A *P* value <.05 was used to establish statistical significance.

Results

A total of 1020 students participated in at least one BP screen. Ten participants were excluded (8 for incomplete follow-up and 2 for antihypertensive medication use), leaving 1010 students for the final analysis. The included and excluded children did not differ in terms of age, sex, race/ethnicity, heart rate, and mean BMI percentage. The mean age of the participants was 15.4 ± 1.1 years; 45.2% were male. The racial/ethnic distribution was 49.3% Hispanic, 25.2% Caucasian, and 16.1% African American. The mean BMI percentage was 72.4% ± 24.3%, and 41% of the students were either overweight or obese.

The distribution of the participants' final BP classification is shown in the **Figure**. The prevalence of persistent prehypertension was 4% in the entire study population and 34.5% in the abnormal BP group. If only the first visit were used to determine BP status, then 19.9% (n = 201) would be classified as prehypertensive. More than half (51.7%) of the 292 participants with an elevated BP on the first visit (ie, BP ≥90th percentile or 120/80 mm Hg) had a normal BP on subsequent visits; these students composed the variable BP group.

Demographic characteristics according to final BP status are listed in **Table I**. The 4 BP groups were similar in age

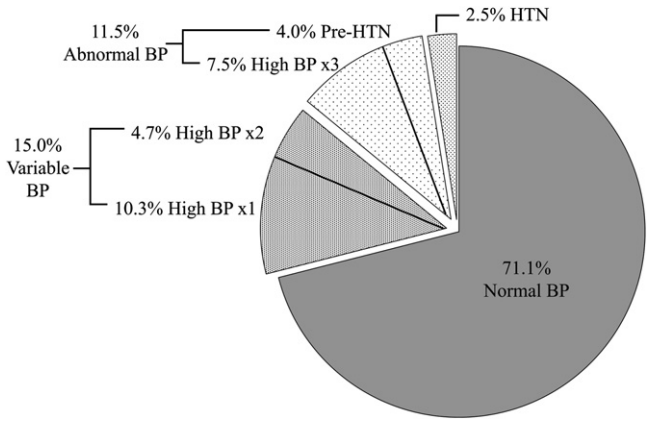

Figure. Distribution of final BP status. HTN, hypertension.