Prevalence and Incidence of Hypertension in Adolescent Girls

Eva Obarzanek, PhD, Colin O. Wu, PhD, Jeffrey A. Cutler, MD, Rae-Ellen W. Kavey, MD, MPH,
Gail D. Pearson, MD, ScD, and Stephen R. Daniels, MD, PhD

Objective To estimate the prevalence and incidence of hypertension and prehypertension and associated factors in adolescent girls.

Study design A total of 2368 girls (49% Caucasian, 51% African-American) aged 9 or 10 years enrolled in the National Heart, Lung, and Blood Institute Growth and Health Study had blood pressure, height, and weight measured at annual visits through age 18 to 19 years. Prevalence and incidence of hypertension and prehypertension were calculated.

Results On the basis of 2 visits, hypertension prevalence was approximately 1% to 2% in African-American girls and 0.5% in Caucasian girls. Incidence in 8 years was 5.0% and 2.1%, respectively. Obese girls had higher prevalence (approximately 6-fold higher) and incidence (aprroximately 2- to 3-fold higher) compared with girls of normal weight. Similar patterns were found for prehypertension, except that prehypertension occurred more in older girls than younger girls. Dietary factors (lower intake of fiber, potassium, magnesium, and calcium, and higher intake of caffeine and calories) were each associated with hypertension incidence (all $P < .05$). In multivariate analysis, higher body mass index ($P < .001$) and lower potassium intake ($P = .023$) were independently associated with incidence of hypertension.

Conclusions Hypertension occurred early in childhood and was related to obesity and other modifiable lifestyle factors. Clinicians should monitor blood pressure during childhood and provide focused diet and physical activity guidance to minimize the development of hypertension. *(J Pediatr 2010;157:461-7).*

Hypertension in adults has its roots in childhood.[1,2] With continuing high obesity rates in children,[3,4] hypertension incidence/prevalence and the attendant higher adult cardiovascular disease (CVD) risk[5,6] may increase in the future. Therefore, blood pressure (BP) measurement during childhood is a necessary component of preventive health care targeted to this problem in children and adolescents.[7]

A national working group has defined 2 levels of elevated BP in children that may lead to increased CVD risk—hypertension and prehypertension.[7] Prehypertension is important clinically because it indicates increased risk for hypertension in children[7,8] and has recently been linked to disease in adults,[9] including young adults.[10] The working group recommended that BP should be assessed on 3 separate visits to address the common phenomenon of high BP values falling on subsequent measures and random variability of BP measurements. Cohort and cross-sectional studies of children typically have only 1 visit for BP assessment, including the studies providing the data for the working group report. Thus, prevalence and incidence of high BP on the basis of >1 visit have not been adequately estimated.

The National Heart, Lung, and Blood Institute Growth and Health Study (NGHS) was a 3-center population-based cohort study that enrolled girls aged 9 or 10 years and measured height, weight, and BP annually for a total number of 10 visits. The NGHS data set therefore provided an unusual opportunity to apply to population-based data the definitions established by the national working group. In this report, we used data from either 1 or 2 visits to estimate for ages 10 to 18 years the prevalence rates of hypertension and prehypertension. Because no national data are available on hypertension incidence during adolescence, we also estimated cumulative incidence in 8 years of follow-up from age 10 years. We additionally addressed the relationship of hypertension incidence with categories of overweight and other expected predictors.

BMI	Body mass index
BP	Blood pressure
CDC	Centers for Disease Control and Prevention
CVD	Cardiovascular disease
DBP	Diastolic blood pressure
NHANES	National Health and Nutrition Examination Survey
NGHS	National Heart, Lung, and Blood Institute Growth and Health Study
SBP	Systolic blood pressure

Methods

Three centers, University of California, Berkeley, University of Cincinnati/Cincinnati Children's Hospital Medical Center, and Westat, Rockville, Maryland, enrolled 2379 girls (1213 African-American, 1166 Caucasian). Areas were selected on the basis of census tract data to include a wide distribution of household income and parental education within each race. The main eligibility criteria were age 9 or 10 years at entry, self-identification as non-Hispanic African-American or Caucasian, and racially concordant parents or guardians. Parents or guardians gave written informed consent, and girls gave assent. The protocol was approved by the institutional review boards of all participating institutions. An independent observational study monitoring board provided study oversight.

Data collection occurred at clinic centers or home visits between 1986 and 1997 with a standardized protocol.[11] The study design and main results were reported.[11-13] Ten annual visits were conducted, with follow-up rates of 74% to 95% through the years (Table I; available at www.jpeds.com). Overall, girls attended an average of 8.8 visits (8.6 for Caucasian girls, 9.0 for African-American girls).

BP was measured with a standard mercury sphygmomanometer (Baum Desktop with V-Lok cuffs; W.A. Baum, Sprague, New York) with a cuff of appropriate size for arm circumference.[11] Participants were seated with feet resting flat on a surface and right arm resting at heart level. After maximum inflation, the cuff was deflated at a rate of 2 mm Hg per second. The first appearance of 2 consecutive beats determined the first Korotkoff sound (K1). The point of sound muffling determined the fourth Korotkoff sound (K4), and the disappearance of sound determined the fifth Korotkoff sound (K5). Three readings were recorded during the first 5 years, and 4 readings were recorded during the last 5 years, with at least 30 seconds of rest between readings. The first reading was not used. The second and third readings in the first 5 years of the study and the closest 2 of the second, third, and fourth readings in the last 5 years were averaged to determine systolic blood pressure (SBP) and diastolic blood pressure (DBP).

Height and weight were measured while girls were wearing socks and light indoor clothing with a stadiometer and calibrated scale. Waist circumference was measured at the narrowest part of the torso.[14] Demographic and socioeconomic information was determined with self-report provided by the parents or guardian. Reported income was based on 9 categories ranging from <$5000 to ≥$75 000, to yield an income score ranging from 1 to 9. Scores for parental education level ranged from 1 to 13, on the basis of 13 categories of education, ranging from 0 to 6 years to graduate school. Age was coded as years. Diet and physical activity were measured with validated methods. Girls provided 3-day food records, which were reviewed by study dietitians at the clinic visit[15,16] and completed a habitual physical activity patterns questionnaire that assessed frequencies of usual activities.[17,18] An activity score was derived on the basis of an activity code ranging from 0 to 5 in order of activity intensity and also took into account duration and frequency of the activity.[17] On this activity questionnaire, girls additionally were asked how many hours per week they usually watched television and videos.

Hypertension and prehypertension were defined according to age-, sex-, and height-specific percentiles from the Fourth Report of the Working Group,[7] and stature-for-age and weight-for-age percentiles were provided by the Centers for Disease Control and Prevention (CDC) growth charts.[19] Stage 1 hypertension is defined as SBP or DBP ≥95th to 99th percentile, and stage 2 hypertension is defined as SBP or DBP >99th percentile. Prehypertension is SBP or DBP from the 90th to <95th percentile or SBP ≥120 mm Hg or DBP ≥80 mm Hg, but <95th percentile. Following the working group recommendations,[7] we used K-5 for DBP unless K-5 <20 mm hg, in which case we used K-4. Three categories of weight status were defined by using BMI percentiles from CDC growth charts[19]: normal weight (<85th percentile), overweight (85th to <95th percentile), and obese (≥95th percentile).

Statistical Analyses

Of 2379 participants enrolled in NGHS, 2368 (49% Caucasian, 51% Arican-American) had measurements of height, weight, and BP taken between ages 10 and 18 years, which comprised our data set for this report. Annual visits were not always regularly spaced because of allowed grace periods, so the average interval between visits was 13 months. We evaluated hypertension status and its baseline covariates, including baseline BMI, diet, and physical activity, at each age from 10 to 18 years. When a girl had >1 visit within a given age, the BP measurements from the first visit within that age were used.

Prevalence of hypertension was evaluated on the based of 2 definitions related to number of visits: (1) "1-visit hypertension" was defined to be the proportion of girls who had stage 1 or stage 2 hypertension among all the girls who had BP and BMI measurements at that age on the basis of BP measurements from a single visit; (2) "2-visit hypertension" was defined to be the proportion of girls who had hypertension at two consecutive visits within 18 months from that age on the basis of BP measurements at those two consecutive visits among all girls who had BP and BMI measurements at that age. For example, a girl had "2-visit hypertension" at age 12 years when she was found to have hypertension at two consecutive visits between age 12.0 and age 13.5 years. One-visit and 2-visit prehypertension prevalence was similarly defined.

Summary statistics, such as percentages, SEs, and 95% CIs, for the prevalence of hypertension and prehypertension were calculated on the basis of both 1-visit and 2-visit definitions, with girls stratified by race (Caucasian, African-American), and baseline BMI strata (BMI <85th percentile, BMI 85th to <95th percentile, and BMI ≥95th percentile) by using CDC BMI-for-age percentiles.[19] Baseline BMI was defined as BMI measured at age 10 years.