

Research Article

# Is one measurement enough to evaluate blood pressure among adolescents? A blood pressure screening experience in more than 9000 children with a subset comparison of auscultatory to mercury measurements



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## Abstract

Evaluation of blood pressure is recommended in all children older than 3 years. Auscultatory devices are the recommended method to assess blood pressure in pediatrics, but automated oscillometric devices are increasingly common. A retrospective analysis of our school-based blood pressure screening was performed to determine if multiple oscillometric blood pressure measurements are needed to approach true blood pressure. All children had 4 oscillometric measurements of blood pressures and a random subset of 287 had an additional auscultatory measurement. Among 9870 participants, we observed a nonlinear decrease in blood pressure over time. The largest decrease in systolic blood pressure was between first and second (−3.8 mm Hg) and in diastolic from second to third (−3.3 mm Hg) measurement. For systolic blood pressure, the second oscillometric measurement, the average of second to third and the average of first to third were statistically similar to a single auscultatory measurement. We conclude that assessment of blood pressure using oscillometric devices should include at least 3 measurements in the same sitting to avoid inaccurate assessment. *J Am Soc Hypertens* 2016;10(2):95–100. © 2016 American Society of Hypertension. All rights reserved.

**Keywords:** Blood pressure measurement; adolescent; oscillometric; auscultatory.

## Background

Although the American Academy of Pediatrics and the National Working Group on High Blood Pressure in Children and Adolescents (Working Group) recommend regular assessment of blood pressure (BP) in children older than the age of 3 years, in a recent survey, only 50%–60% of pediatricians evaluate BP annually in their patients.<sup>1,2</sup> Among health care providers who do assess BP, measurement techniques vary in the device used (oscillometric vs. auscultatory) and in the number of measurements taken in a single sitting.<sup>3</sup> The preferred technique

is auscultatory measurement using a stethoscope at the antecubital fossa and a mercury or aneroid sphygmomanometer to determine systolic and diastolic BP by Korotkoff sounds.<sup>1</sup> Although Working Group percentiles that define pediatric hypertension are based on auscultatory measures, automatic oscillometric measurement devices are more common today because of ease of use and less observer bias. However, there are many known issues that can lead to inaccurate BP measurement by oscillometric devices.<sup>4</sup> Some known modifiable problems are cuff inflation rate, which may vary among different devices and could give different BP values for the same patient. In addition, the fact that mean arterial pressure is directly measured with oscillometric devices, and then systolic and diastolic BP are calculated using proprietary algorithms which vary from manufacturer to manufacturer. Unsurprisingly, these proprietary algorithms can lead to a discrepancy between the BP measurements obtained by automatic devices compared to auscultation.<sup>5</sup>

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**Table 1**

Study population (N = 9870)

Age in years, mean $\pm$ standard deviation (yr)	13 $\pm$ 2
Gender, N (%)	
Female	5079 (52)
Male	4791 (48)
Race, N (%)	
Caucasian	3546 (36)
Hispanic	3079 (31)
Black	2340 (24)
Asian	726 (7)
Other	179 (2)
Weight category, N (%)	
Not obese	7724 (78)
Obese	2146 (22)

Current adult guidelines recommend at least two measurements at every visit which are then averaged to assess BP.<sup>6,7</sup> Although the pediatric guidelines for diagnosis, evaluation, and treatment of hypertension do not specify the number of BP measurements in a single sitting, in our institution multiple oscillometric BPs are performed at each visit due to the overinflation observed in the first measurement.<sup>1,4</sup> To our knowledge, only one previously published study describes BP behavior at repeated oscillometric measurements in a single sitting among children.<sup>8</sup> In this study, a series of six oscillometric BP measurements were recorded at 1-minute intervals in 2000 Canadian children. The analysis did not report the behavior of BP within each individual child, but instead compared the mean BP measurements at each time point for each of two age groups (6–11 years old and 12–19 years old). They found that for each age group, the BP tended to decrease over than the six measurements. No formal statistical test was used to evaluate the decreasing trend observed in the means. Eliasdottir et al measured BP in a total of 979 healthy 9- to 10-year-old Icelandic children.<sup>9</sup> Children were divided in

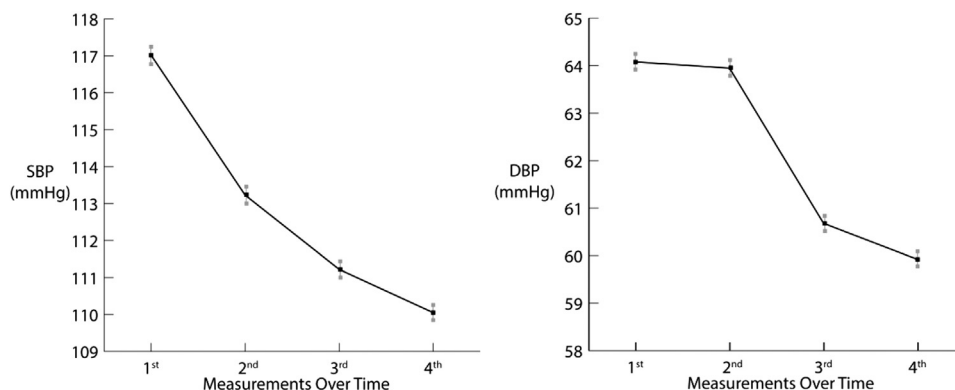
two groups; one group had two oscillometric measurements followed by two auscultatory and the other group in reverse order. In this study, a significant downward trend was observed with each consecutive BP measurement as well.

Our hypothesis is that among healthy adolescents, early BP readings using oscillometric devices are artificially elevated and it takes multiple reading to approach the true BP.

## Methods

This study was a retrospective analysis of data from multiple cross-sectional screenings done by the Houston Pediatric and Adolescent Hypertension Program (HPAHP) at the University of Texas Health Science Center at Houston. HPAHP was established in 1999 with the purpose of patient care and clinical research. The program combines pediatric nephrologist and cardiologist for evaluation of BP and other cardiovascular risk factors in children of all ages. HPAHP BP screenings were conducted at 15 urban and suburban public secondary schools from 2003 to 2012. Schools were selected to represent a racial or ethnic distribution that was similar to the Houston population. All students from each school were invited to participate, and school staff was responsible for distributing and collecting parental consent forms. Only children who returned the signed consent form and voluntarily participated in the screening were included in this study. This study was approved by the University of Texas Health Science Center at Houston Institutional Review Board.

Participating students completed a questionnaire including birth date, gender, self-identified race, and self-reported current or past diagnosis of hypertension or use of any medication known to affect BP. At the initial screening visit, screening personnel measured height, weight, and nondominant arm circumference. Appropriate BP cuff size was



**Figure 1.** Mean and standard deviation for oscillometric SBP and DBP at repeated measurements. SBP, systolic blood pressure; DBP, diastolic blood pressure.

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