

PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Simple Table to Identify Children and Adolescents Needing Further Evaluation of Blood Pressure

David C. Kaelber and Frieda Pickett
Pediatrics published online May 4, 2009;
DOI: 10.1542/peds.2008-2680

The online version of this article, along with updated information and services, is
located on the World Wide Web at:

<http://www.pediatrics.org/cgi/content/full/peds.2008-2680v1>

PEDIATRICS is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. PEDIATRICS is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2009 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 0031-4005. Online ISSN: 1098-4275.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™



Simple Table to Identify Children and Adolescents Needing Further Evaluation of Blood Pressure

David C. Kaelber, MD, PhD, MPH^{a,b,c,d}, Frieda Pickett, RDH, MS^e

Departments of ^aPediatrics, ^bInternal Medicine, and ^cInformation Services, MetroHealth System, and ^dDepartments of Internal Medicine and Pediatrics, School of Medicine, Case Western Reserve University, Cleveland, Ohio; ^eTexas A&M Health Science Center-Baylor College of Dentistry, Dallas, Texas

The authors have indicated they have no financial relationships relevant to this article to disclose.

What's Known on This Subject

Pediatric hypertension and prehypertension are significantly underdiagnosed. Part of this underdiagnosis may be related to the complexity of the current pediatric blood pressure tables and their requirement for knowledge of the patient's height percentile.

What This Study Adds

This study presents a simplified pediatric blood pressure table, based on the National Heart, Lung, and Blood Institute pediatric blood pressure tables, that should simplify the screening for potentially abnormal blood pressures in children and adolescents.

ABSTRACT

OBJECTIVE. The goal was to create a tool to screen more easily for children and adolescents who might have hypertension or prehypertension.

METHODS: We took the existing tables from *The Fourth Report on the Diagnosis, Evaluation and Treatment of High Blood Pressure in Children and Adolescents*, which contain hundreds of normal and abnormal blood pressure values based on gender, age, and height percentile, and analyzed this data to develop a much simplified table based only on gender and age.

RESULTS. In our simplified table we reduced the number of values from 476 to 64 and have only one threshold value of abnormal systolic and diastolic blood pressure, by gender, for each year of life (ages 3 to ≥ 18). This table makes it easy to identify abnormal blood pressure values in almost any potential care or screening setting. This approach is ideal when blood pressure is measured outside a physician's office or even at intake in a pediatrician's office, when the height percentile (which is required for the use of current tables) may not be easily obtainable.

CONCLUSIONS. This screening tool can quickly and easily identify children and adolescents whose blood pressure readings merit further evaluation by a physician and rule out abnormal blood pressure in children and adolescents. *Pediatrics* 2009;123:e000

www.pediatrics.org/cgi/doi/10.1542/peds.2008-2680

doi:10.1542/peds.2008-2680

Key Words

hypertension, prehypertension, primary care, screening

Accepted for publication Feb 4, 2009

Address correspondence to David C. Kaelber, MD, PhD, MPH, 3158 Kingsley Rd, Shaker Heights, OH 44122. E-mail: david.kaelber@case.edu

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275). Copyright © 2009 by the American Academy of Pediatrics

WE DOCUMENTED PREVIOUSLY that almost 75% of cases of hypertension and 90% of cases of prehypertension in children and adolescents are undiagnosed.¹ Evidence suggests that hypertension in childhood can lead to cardiovascular disease in adulthood.²⁻⁴ Tools and strategies need to be developed to aid health care professionals in detecting children and adolescents who have blood pressures above the normal limits. Although the American Academy of Pediatrics and the American Heart Association recommend that screening blood pressure measurements be taken at all pediatric visits for health care (including dental and optometric appointments) at 3 to 18 years of age,⁴ one of the complexities of identifying abnormal blood pressure values in children and adolescents is that hundreds of normal and abnormal values exist and differentiation of abnormal values depends on the child's gender, age, and height percentile. The ability of providers to remember the variety of normal and abnormal blood pressure ranges may be limited, and obtaining information, especially height percentile, at the time of the encounter when the blood pressure is being measured may be difficult. Although blood pressure tables exist, these tables typically rely on knowledge of the patient's height percentile,^{4,5} which may not be readily available in many care settings. This is especially true when the blood pressure is measured outside a general pediatrician's office, such as at a pediatric psychiatrist's office, pediatric dental clinic, emergency department, or community health care screening. Here, we propose an approach to easily identify abnormal pediatric blood pressure values that require further evaluation.

METHODS

We started with the existing blood pressure tables from *The Fourth Report on the Diagnosis, Evaluation and Treatment of High Blood Pressure in Children and Adolescents*.⁴ These two tables contain 476 normal and abnormal blood pressure values based on gender, age, and height percentile. To develop our simplified abnormal blood pressure screening

table we used the lower limit of height (5th percentile) in the abnormal blood pressure range (≥ 90 th percentile) for a given gender and age. We also only included ages down to 3 years of age, as *The Fourth Report* does not recommend routine blood pressure screening measurements in children less than 3 years of age. Also, if the 90th percentile was ≥ 120 mm Hg for systolic blood pressure or ≥ 80 mm Hg for diastolic blood pressure, 120/80 mm Hg was used for the abnormal blood pressure threshold instead because *The Fourth Report* recommends that any blood pressure ≥ 120 mm Hg systolic or ≥ 80 mm Hg diastolic be considered at least prehypertensive. Finally we also included a row for age ≥ 18 years, based on *The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report*⁶, so that this one table can be used for pediatric and adult populations.

RESULTS

Our simplified abnormal blood pressure screening table appears in Table 1. This simplified abnormal blood pressure screening table reduces the systolic and diastolic blood pressure cutoff values to 1 value for girls and 1 value for boys for each year of life from 3 through ≥ 18 years of age, on the basis of the blood pressure tables presented in *The Fourth Report*. The reduces the total number of values from 476 in *The Fourth Report* tables to 64 in our simplified abnormal blood pressure screening table. The table has systolic and diastolic abnormal blood pressure cut-offs by gender. Each row in the table corresponds to a given year of life (ages 3 to ≥ 18 years). The maximal threshold for abnormal blood pressure in the simplified abnormal blood pressure screening table is

120/80 mm Hg. Any reading equal to or above the readings in the simplified table indicates potentially abnormal blood pressures in one of three ranges - prehypertension, stage 1 hypertension, or stage 2 hypertension - and identifies blood pressures that requires additional evaluation.

DISCUSSION

We chose the systolic and diastolic thresholds to be the lowest abnormal blood pressure values in the prehypertensive range (≥ 90 th percentile for blood pressure; maximum of $\geq 120/80$ mm Hg), regardless of height percentile. This approach provides a screening table that has 100% sensitivity for identifying all abnormal pediatric blood pressure values. Use of the lowest, 5th percentile, height cutoff value for a given gender and age underrepresents the abnormal systolic blood pressure threshold by up to 8 to 9 mm Hg for boys and 6 to 7 mm Hg for girls and the abnormal diastolic blood pressure threshold by up to 4 to 5 mm Hg for boys and 3 to 4 mm Hg for girls, depending on age. Although this simplified table would produce false-positive identification of abnormal blood pressure values for taller children, we propose, given known variations in pediatric blood pressures and the tremendous underdetection of abnormal pediatric blood pressures, that the potential increase in identifications of true-positive abnormal blood pressure values is worth the possibility of some false-positive identifications.

Pediatric blood pressure measurements for an individual are known to vary, for a variety of factors. For example, systolic blood pressure has been shown to vary by 4.59 ± 16.76 mm Hg and diastolic blood pressure by 0.39 ± 14.36 mm Hg between office and ambulatory blood pressure readings for the same person.⁷ Differences between daytime and nighttime blood pressure readings for the same person have been shown to be 13.95 ± 15.4 mm Hg for systolic blood pressure and 7.93 ± 8.89 mm Hg for diastolic blood pressure.⁷ Even blood pressure measurements obtained with a standard vital signs station and by more-rigorously trained personnel can vary by up to 13.2 ± 8.9 mm Hg for systolic blood pressure and 9.6 ± 7.6 mm Hg for diastolic blood pressure.⁸ Depending on the type of office blood pressure measurement (manual versus automatic), systolic blood pressure can vary by 4.39 ± 4.82 mm Hg and diastolic blood pressure by 4.61 ± 9.35 mm Hg.⁹ All of these variations in blood pressure measurements for an individual are in the range of or greater than the height percentile adjustments for abnormal blood pressure thresholds.

CONCLUSIONS

Although a long-term solution for the identification of pediatric hypertension and prehypertension may involve electronic medical records and other electronic tools, this proposed simplified blood pressure table should help in the interim and in circumstances where electronic tools may not be available. Because abnormally elevated blood pressure can result in significant decreases in systemic health over time, it is imperative to identify prehypertension and hypertension in the pediatric population and to evaluate further those children and adolescents who have values at

TABLE 1 Blood Pressure Values Requiring Further Evaluation, According to Age and Gender^{4,6}

Age, y	Blood Pressure, mm Hg			
	Male		Female	
	Systolic	Diastolic	Systolic	Diastolic
3	100	59	100	61
4	102	62	101	64
5	104	65	103	66
6	105	68	104	68
7	106	70	106	69
8	107	71	108	71
9	109	72	110	72
10	111	73	112	73
11	113	74	114	74
12	115	74	116	75
13	117	75	117	76
14	120	75	119	77
15	120	76	120	78
16	120	78	120	78
17	120	80	120	78
≥ 18	120	80	120	80

These values represent the lower limits for abnormal blood pressure ranges, according to age and gender. Any blood pressure readings equal to or greater than these values represent blood pressures in the prehypertensive, stage 1 hypertensive, or stage 2 hypertensive range and should be further evaluated by a physician.

or above those presented in this simplified table. This simplified abnormal blood pressure screening table can be used as a very effective screening tool to rule out abnormal blood pressures.

REFERENCES

1. Hansen ML, Gunn PW, Kaelber DC. Underdiagnosis of hypertension in children and adolescents. *JAMA*. 2007;298(8):874–879
2. Denney-Wilson E, Hardy LL, Dobbins T, Okely AD, Baur LA. Body mass index, waist circumference, and chronic disease risk factors in Australian adolescents. *Arch Pediatr Adolesc Med*. 2008;162(6):566–573
3. Song SH. Early-onset type 2 diabetes mellitus: a condition with elevated cardiovascular risk? *Br J Diabetes Vasc Dis*. 2008;8(2):61–65
4. National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics*. 2004;114(2 suppl 4th report):555–576
5. American Diabetes Association. Standards of medical care in diabetes–2008. *Diabetes Care*. 2008;Jan 31(suppl 1):S12–S54
6. Chobanian AV, Bakris GL, Black HR, et al. The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA*. 2003;289(19):2560–2572
7. Khan IA, Gajaria M, Stephens D, Balfe JW. Ambulatory blood pressure monitoring in children: a large center's experience. *Pediatr Nephrol*. 2000;14(8–9):802–805
8. Podoll A, Grenier M, Croix B, Feig DI. Inaccuracy in pediatric outpatient blood pressure measurement. *Pediatrics*. 2007;119(3). Available at: www.pediatrics.org/cgi/content/full/119/3/e538
9. Wong SN, Tz Sung RY, Leung LC. Validation of three oscillometric blood pressure devices against auscultatory mercury sphygmomanometer in children. *Blood Press Monit*. 2006;11(5):281–291

Simple Table to Identify Children and Adolescents Needing Further Evaluation of Blood Pressure

David C. Kaelber and Frieda Pickett
Pediatrics published online May 4, 2009;
DOI: 10.1542/peds.2008-2680

Updated Information & Services	including high-resolution figures, can be found at: http://www.pediatrics.org/cgi/content/full/peds.2008-2680v1
References	This article cites 7 articles, 5 of which you can access for free at: http://www.pediatrics.org/cgi/content/full/peds.2008-2680v1#BIBL
Subspecialty Collections	This article, along with others on similar topics, appears in the following collection(s): Heart & Blood Vessels http://www.pediatrics.org/cgi/collection/heart_and_blood_vessels
Permissions & Licensing	Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: http://www.pediatrics.org/misc/Permissions.shtml
Reprints	Information about ordering reprints can be found online: http://www.pediatrics.org/misc/reprints.shtml

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

