Changes in Prevalence and Phenotype of Hypertension in Children Suspected of Hypertension Using the 2022 American Heart Association Guidelines

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Abstract

Objective. The American Heart Association (AHA) launched the 2022 guidelines for the diagnosis of hypertension (HT) by ambulatory blood pressure monitoring (ABPM). The present study aimed to evaluate the impacts of the 2022 AHA guidelines on the changes in the prevalence and phenotype of HT in children suspected of HT. *Methods.* Consecutive 100 children aged 6 to 20 suspected of HT who underwent 24-hour ABPM were recruited. The patients were separated into 3 groups: escalated, de-escalated, and unchanged. Demographic data were compared between the 3 groups. Logistic regression analysis was performed to evaluate the factors associated with the escalation in the diagnosis of HT. *Results.* The present study revealed that the prevalence of HT, including sustained and masked HT, increased from 48% by the 2014 AHA guidelines to 65% by the 2022 AHA guidelines. Patients in the escalated group tended to have a higher proportion of male gender, with an older age and a taller height compared to those in the de-escalated group. Multivariate analysis showed that height was the only factor associated with the escalation in the diagnosis of HT [OR 1.09 (1.01-1.19), *P*-value .04]. Five out of 6 (83.3%) patients in the escalated group with available echocardiographic results had left ventricular hypertrophy (LVH). *Conclusion.* Using the 2022 AHA guidelines resulted in more detection of patients with HT, and almost 30% of the escalated group had LVH. This finding supports using the 2022 AHA guidelines to detect children at risk of developing cardiovascular diseases early.

Introduction

The global prevalence of pediatric hypertension (HT) has been increasing.[1] In Thailand, the prevalence of HT was reported to be 2.6% in children and 9.4% in adolescents.[2,3] Several studies have shown that pediatric HT increases the likelihood of acquiring cardiovascular diseases later in life. As a result, early detection and treatment of childhood HT would contribute to lowering the risk of adult cardiovascular diseases.[4-8]

The American Academy of Pediatrics (AAP) clinical practice guidelines recommended that ambulatory blood pressure monitoring (ABPM) be used to confirm sustained HT in pediatric patients suspected of HT due to persistently high office blood pressure.[5] For the diagnosis of HT by ABPM, the 2014 American Heart Association (AHA) pediatric guidelines recommended

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using the 95th percentile criteria for gender and height.[9] In 2017, the American Academy of Pediatrics modified the HT cut-off for office blood pressure (BP) measurement to be 130/80 mmHg for all pediatric patients ages 13 years and older as same as the HT cut-off for office BP measurement in adults ages 18 years and older recommended by the 2017 AHA adult guidelines.[5,10] Correspondingly, the 2022 pediatric AHA guidelines recommended the HT cut-off for ABPM in children ages 13 years and older as the HT cut-off for ABPM in adults ages 18 years and older. Still, the 95th percentile criteria remained for children ages 12 and younger. Additionally, BP loads from the previous 2014 AHA guidelines were eliminated, and the classifications of HT phenotypes were simplified. The new 2022 AHA guidelines were thought to be more predictive of target organ damage such as left ventricular hypertrophy (LVH), an independent risk factor for cardiovascular morbidity in adults, and more sensitive to HT diagnosis in most studies.[11-16] On the contrary, a study in children with chronic kidney disease showed the opposite result: the 2014 AHA guidelines slightly better discrimination of LVH.[15] To our knowledge, no study has compared the effect of changes in the classification of HT by the new 2022 AHA guidelines in pediatric Southeast Asian populations. The present study aimed to evaluate the impact of the 2022 AHA guidelines on the changes in the prevalence and phenotype of HT in children suspected of HT.

Materials and Methods

Participating Patients

This retrospective study enrolled consecutive pediatric and adolescent patients aged 6 to 20 years referred to the pediatric HT clinic at Ramathibodi Hospital due to high office BP on 3 occasions or clinical suspicion of HT. The study was approved by the Ethics Committee for Human Research of the Faculty of Medicine Ramathibodi Hospital (MURA 2020/1792). The study was granted exemption from informed consent due to its retrospective design. Some patients in the present study were included in the previous study examining the performance of waist circumference to height ratio to predict sustained HT.[17]

All pediatric patients who underwent ABPM for 24 hours to confirm the diagnosis of HT were included. Patients were separated into 3 groups: escalated, de-escalated, and unchanged. The escalated group included patients with normotension, pre-HT, or unclassified diagnosis by the 2014 AHA guidelines but were escalated into masked HT or sustained HT by the 2022 AHA

guidelines. The de-escalated group included patients with pre-HT or unclassified diagnoses by the 2014 AHA guidelines but were de-escalated into normotension or white-coat HT by the 2022 AHA guidelines. The unchanged group included patients who had the same diagnosis from both guidelines.

Baseline characteristics, anthropometric data, office BP, and ABPM results were collected. Body mass index (BMI) was calculated using the following formula: Weight (kg)/height (m).[2] BMI was adjusted to BMI z-score using the World Health Organization Anthroplus software, which is the growth reference data for children and adolescents ages 5 to 19 years.[18] Left ventricular hypertrophy (LVH) was evaluated using an echocardiographic study by an experienced pediatric cardiologist. LVH was defined as left ventricular mass index $(LVMI) > 51 \, g/m^{27}$ or LVMI is $>115 \, g/body$ surface area (BSA) in males and $>95 \, g/BSA$ in females.[5]

Blood Pressure Measurement

Office BP was measured twice in the right arm in a seated position with an oscillometric device, using standard BP measurement practice and appropriate cuff size. A BP value for each occasion was determined by taking the average of the 2 BP readings. According to current pediatric guidelines, high office BP is defined as a systolic blood pressure (SBP) or a diastolic blood pressure (DBP) ≥95th percentile for gender, age, and height in children aged < 13 years or 130/80 mmHg in children aged ≥ 13 years over the 3 occasions.[5] Mean office BP was an average of the BP values from 3 occasions, whereas maximum BP was the highest among the 3 values. Office BP parameters were converted to BP indices using the following formula: BP value/BP cut-off value for high BP for each patient. BP indices were used to compare BP parameters among patients of different ages, genders, and heights.

ABPM was performed using a TM-2430 (A&D, Japan) device, which has been validated for use in pediatric patients.[19] The qualified healthcare provider placed an appropriate cuff on each patient's non-dominant arm. The device was programmed to measure BP every 20 minutes while awake and every 30 minutes while sleeping for 24 hours. Patients were advised to go through their daily routines, avoid strenuous activities, and record their activities, including their sleep and awake periods. ABPM data were considered valid in each patient if there were ≥40 valid BP readings over 24 hours. Definitions of ABPM HT phenotypes by 2014 AHA guidelines and 2022 AHA guidelines are presented in Table 1.

Table 1. AHA 2014 and AHA 2022 Hypertension Phenotypes.

Category	2014 AHA guidelines			2022 AHA guidelines		
	Office BP	ABPM	BP load (%)	Age (years)	Office BP	ABPM
Sustained HT	>P95th	>P95th	25-50	<13	≥P95th	≥P95th[a]
				≥13	≥130/80	≥Adult cut-off[b]
Masked HT	<P95th	>P95th	≥25	<13	<P95th	≥P95th[a]
				≥13	<130/80	≥Adult cut-off[b]
White coat HT	≥P95th	<P95th	<25	<13	≥P95th	<P95th
				≥13	≥130/80	<Adult cut-off[b]
Normotension	<P90th	<P95th	<25	<13	<P95th	<P95th
				≥13	<130/80	<Adult cut-off[b]
Pre-hypertension	≥P90th or >120/80	<P95th	≥25			
Severe ambulatory HT	>P95th	>P95th	>50			

Source. Adapted from Chung et al[8] and Flynn et al.[9]
Abbreviations: BP, blood pressure; HT, hypertension; P90th, 90th percentile; P95th, 95th percentile.
[a]ABPM P95th or the adult cut-off.
[b]Adult cut-off: 24 hours, 125/75 mmHg; awake, 130/80 mmHg; sleep, 110/65 mmHg.

Statistical Analysis

Statistical analysis was performed using IBM SPSS® Software, Version 26. The distribution of each parameter was tested with the Kolmogorov-Smirnov test. Descriptive data were presented as number (percentage), mean ± standard deviation (SD), or median (interquartile range, IQR) as appropriate. Demographic data were compared among 3 groups. For comparative analysis, the chi-square test or Fisher's exact test was used for categorical data, and the student t-test, ANOVA, or Mann–Whitney U-test was used for continuous data, as appropriate. According to different guidelines, the prevalence of ABPM phenotypes was compared using the McNemar test. Univariate logistic regression analysis was used to test the parameters associated with the escalated group compared to the non-escalated group. The parameters significantly associated with the escalated group from the univariate analysis were added to the multivariate logistic regression model. A P-value ≤.05 was defined as statistical significance.

Results

ABPM Phenotypes

Among 100 patients, abnormal ABPM results were detected in 48 and 65 children according to the 2014 and 2022 AHA guidelines, respectively. The prevalences of sustained HT, masked HT, and white-coat HT were increased when using the 2022 AHA guidelines compared to the 2014 AHA guidelines: 43% to 50% (p-value=.02), 5% to 15% (P < .01), and 12% to 27% (P < .01), respectively. Additionally, the prevalence of awake HT and nocturnal HT increased from 30% to 36% (P=.03) and 35% to 59% (P < .01), respectively (Table 2).

Hypertension Classification

Patients were classified as escalated group, de-escalated group, and unchanged group according to changes in diagnosis by the 2014 and 2022 AHA guidelines (Table 3). Escalated group consisted of 17 individuals, which included patients who had previously been diagnosed with normotension (N=1), pre-HT (N=7), or unclassified (N=9) according to the 2014 AHA guideline but who were escalated to have masked HT (N=10) or sustained HT (N=7) with the 2022 AHA guidelines.

Three patients with office BP and ABPM results in less than the 95th percentile and BP load less than 25% were previously diagnosed as having normotension or unclassified group. However, the ABPM results exceeded the cut-off of the 2022 AHA guidelines and were reclassified as having masked HT.

Fourteen patients with office BP greater than the 90th percentile, ABPM results were less than the 95th percentile, and BP loads greater than 25% were previously diagnosed with pre-HT or unclassified group. Still, they were reclassified as having masked or sustained HT by the ABPM results that exceeded the cut-off of the 2022 AHA guidelines.

The de-escalated group had 16 patients. In this group, the ABPM cut-off remained unchanged. All patients in this group had office BP over the 90th percentile, ABPM results were less than the 95th percentile, and BP loads were more than 25%. They were previously diagnosed

Table 2. ABPM Phenotypes According to the 2014 and 2022 AHA Guidelines.

Categories	2014 AHA guidelines (N = 100)	2022 AHA guidelines (N = 100)	*P*-value
Normal ABPM	52	35	**<.01**
Normotension	8	8	1.00
White-coat HT	12	27	**<.01**
Pre-HT	8		
Unclassified	24		
Abnormal ABPM	48	65	**<.01**
Masked HT	5	15	**<.01**
Sustained HT	43	50	**.02**
Systolic HT	42	63	**<.01**
Diastolic HT	18	24	**.02**
Awake HT	30	36	**.03**
Awake systolic HT	30	36	**.03**
Awake diastolic HT	5	6	1.00
Nocturnal HT	35	59	**<.01**
Nocturnal systolic HT	28	56	**<.01**
Nocturnal diastolic HT	18	23	**.03**

Abbreviation: HT, hypertension.
Bold texts indicate statistical significance.

Table 3. Patient Classifications and ABPM Phenotypes.

Patient classifications	2014 AHA guidelines	2022 AHA guidelines	Number of patients (N = 100)
Escalated group			17
	Pre-HT	Masked HT	7
	Unclassified	Masked HT	2
	Normotension	Masked HT	1
	Unclassified	Sustained HT	7
De-escalated group			16
	Pre-HT	Normotension	1
	Unclassified	White coat HT	15
Unchanged group			67
	Normotension		7
	White coat HT		12
	Masked HT		5
	Sustained HT		43

Abbreviation: HT, hypertension.

as having pre-HT or unclassified group but were reclassified as having normotension or white coat HT because of the elimination of BP load from the 2022 guidelines.

When using the 2022 AHA guidelines, patients in the escalated group had higher proportions of awake systolic HT, nocturnal systolic and diastolic HT, and 24-hour systolic HT more than those in the de-escalated group. The awake DBP index, sleep SBP index, 24-h SBP, and DBP index using the 95th percentile reference from the 2014 AHA guidelines were different between groups (Table 4).

Clinical Data

Patients in the escalated group had higher weight and height than the de-escalated and unchanged group, but the BMI z-score and the other anthropometries were not different (Table 5). In the subgroup analysis of patients ≥13 years old (N = 58), height was the only factor that differed between each group (escalated vs de-escalated vs unchanged group; 172, 160, and 166 cm, respectively; *P* = .04).

Thirty-six patients underwent an echocardiography. Five out of 6 patients (83.3%) in the escalated group had

Table 4. ABPM Values and Phenotypes According to Patient Classifications.

	All patients (N = 100)	Escalated (N = 17)	De-escalated (N = 16)	Unchanged (N = 67)	*P*-value
Awake BP					
Awake SBP	126 (14.8)	127 (15.5)	123 (13)	127 (14)	.28
Awake SBP index[a]	0.96 (0.1)	0.94 (0.05)	0.95 (0.05)	0.98 (0.11)	.17
Awake SHT[b]	36 (36)	5 (29.4)	0	31 (46.3)	<.**01**
Awake DBP	71 (7.75)	71 (11)	71 (7.75)	71 (8)	.07
Awake DBP index[a]	0.87 (0.11)	0.84 (0.06)	0.85 (0.08)	0.88 (0.10)	**.03**
Awake DHT[b]	6 (6)	0	0	6 (9)	.21
Sleep BP					
Sleep SBP	110.5 (12)	112(17)	109 (8.5)	110 (13)	.38
Sleep SBP index[a]	0.96 (0.09)	0.96 (0.04)	0.92 (0.08)	0.97 (0.13)	**.04**
Nocturnal SHT[b]	56 (56)	15 (88.2)	0	41 (61.2)	<.**01**
Sleep DBP	60 (8)	58 (6.5)	60 (4.25)	60 (10)	.13
Sleep DBP index[a]	0.91 (0.12)	0.89 (0.07)	0.88 (0.11)	0.93 (0.14)	.44
Nocturnal DHT[b]	23 (23)	1 (5.9)	0	22 (32.8)	<.**01**
24-h BP					
24-h SBP	121 (13.5)	122 (17)	119.5 (9.25)	122 (13)	.13
24-h SBP index[a]	0.97 (0.09)	0.95 (0.05)	0.94 (0.04)	0.99 (0.12)	<.**01**
24-h SHT[b]	38 (38)	6 (35.3)	0	32 (47.8)	<.**01**
24-h DBP	68 (7)	68 (8)	68 (6)	68 (7)	.21
24-h DBP index[a]	0.88 (0.09)	0.86 (0.05)	0.88 (0.07)	0.91 (0.1)	**.04**
24-h DHT[b]	12 (12)	0	0	12 (17.9)	**.04**

All data are presented as median (IQR).
Abbreviations: BP, blood pressure; SBP, systolic blood pressure; DBP, diastolic blood pressure; HT, hypertension; SHT, systolic hypertension; DHT, diastolic hypertension.
[a]95th percentile reference from 2014 AHA guidelines.
[b]Diagnosis by 2022 AHA guideline.
Bold texts indicate statistical significance.

Table 5. Patient Clinical Data.

Parameters	All patients (N = 100)	Escalated group (N = 17)	De-escalated group (N = 16)	Unchanged group (N = 67)	*P*-value
Age at diagnosis (year)[a]	13.7 (4.5)	14.8 (5.9)	11.0 (5.1)	13.5 (5.1)	.29
Male, n (%)	66 (66)	15 (88.2)	9 (56.3)	42 (62.7)	.09
Weight (kg)	60.5 ± 22.8	72.6 ± 15.7	48.2 ± 16.5	61.1 ± 25.8	**.02**
Height (m)[a]	1.61 (0.27)	1.70 (0.12)	1.44 (0.20)	1.61 (0.32)	**.03**
BMI	24.5 ± 6.2	25.4 ± 5.2	21.6 ± 4.7	25.4 ± 7.1	.17
BMI z-score[a]	1.66 (2.1)	1.5 (2)	1.4 (2.1)	2.05 (2.3)	.26
Waist circumference (cm)[b]	80.2 ± 17.6	84.9 ± 10.9	70.6 ± 16.8	82.3 ± 18.0	.05
WHtR (cm/m)[b]	52.6 ± 9.6	50.3 ± 6.7	47.8 ± 10.3	54.5 ± 9.4	.05
Prevalence of obesity	42 (42)	8 (47.1)	5 (31.3)	29 (43.3)	.61
LVH[c]	36 (36)	5 (83.3)	1 (33.3)	11 (40.7)	.15
Mean SBP index	1.02 ± 0.07	1.05 ± 0.10	1.02 ± 0.06	1.01 ± 0.07	.76
Mean DBP index	1.01 ± 0.07	0.98 ± 0.09	0.98 ± 0.07	1.02 ± 0.07	.33
Max SBP index	1.07 ± 0.08	1.06 ± 0.11	1.06 ± 0.07	1.07 ± 0.08	.86
Max DBP index[a]	1.06 (0.09)	1.04 (0.15)	1.05 (0.11)	1.07 (0.08)	.48

All data presented as mean ± SD, otherwise indicated.
Abbreviations: WHtR, waist-to-height ratio; SBP, office systolic blood pressure; DBP, office diastolic blood pressure; LVH, left ventricular hypertrophy.
[a]Median (IQR).
[b]n = 72.
[c]N = 36 includes 6, 3, and 27 patients in the escalated, de-escalated, and unchanged groups.
Bold texts indicate statistical significance.

Table 6. Logistic Regression of the Escalated Group (N = 17) Compared to the Non-escalated Group (N = 67).

Parameters	Univariate analysis		Multivariate analysis	
	Exp(ß) (95% CI)	*P*-value	Exp(ß) (95% CI)	*P*-value
Age	1.18 (1.00-1.40)	**.04**	0.90 (0.67-1.21)	.49
Gender	4.71 (1.01-21.9)	**.04**	1.62 (0.27-9.53)	.59
Height (cm)	1.08 (1.03-1.15)	**.01**	**1.09 (1.01-1.19)**	**.04**
Weight (kg)	1.03 (1.01-1.06)	**.01**	1.00 (0.97-1.04)	.99
WHtR (cm/m)	0.97 (0.90-1.05)	.45		

Abbreviation: WHtR, waist-to-height ratio.
Bold texts indicate statistical significance.

left ventricular hypertrophy (LVH). One obese patient in the de-escalated group had LVH. Eleven out of 27 patients (40.7%) in the unchanged group had LVH, and all of them had either sustained or masked HT. When using the 2014 AHA guidelines, LVH was not statistically different between ABPM phenotypes (*P* = .15), with nine patients diagnosed with unclassified HT or pre-HT having LVH. On the contrary, using the AHA 2022 guidelines, different LVH diagnoses were found between each ABPM phenotype (*P* = .04). LVH was present in 11 out of 28 participants with sustained HT. All patients with masked HT (N = 5) also had LVH. Only 1 out of 3 patients with white coat HT had LVH.

Factor Associated With the Escalation in Diagnosis

Age, gender, height, and weight were the demographic data related to the escalation in diagnosis compared to the non-escalated group. After multivariate analysis, height was the only independent factor related to the escalation in the diagnosis of HT with an OR of 1.17 (1.02-1.34, *P* = .03) (Table 6).

Discussion

The present study revealed that the prevalence of HT increased when using the 2022 AHA guidelines compared to the 2014 AHA guidelines. An abnormal ABPM was increased from 48% to 65%. These findings were concordant with the previous studies comparing the 2014 AHA pediatric and 2017 AHA/ACC adult guidelines in adolescent patients, which found an increase in 10% to 30% diagnosis of sustained HT and masked HT.[12,13,15,16,20]

Based on the changes in the ABPM cut-off in ages ≥13 years, the prevalences of sustained and masked HT were increased when using the 202 AHA guidelines from 43% to 50% and 5% to 15%, respectively. In the escalated group, children aged ≥13 years had all types of HT, including awake HT, nocturnal HT, and 24-hour

HT, whereas children aged <13 years had only nocturnal HT. When compared to awake HT, nocturnal HT was more significantly increased from 35% to 59% (*P* < .01) vs 30% to 36% (*P* = .03). These findings were also detected in the previous studies.[13,20] This could be due to the fact that the 2022 AHA nocturnal SBP cut-off (adult's cut-off) was lower than the 95th percentile in males and females ages over 8 and 7 years compared to those ages over 12 and 15 years for the awake SBP cut-off.[9,15]

Both systolic and diastolic HT were increased by 40% to 50% in the present study. Previous studies in CKD patients also found an increase in both systolic and diastolic HT when using the adult ABPM cut-off.[15,21] Due to removing BP load and changes in the ABPM cut-off in the 2022 AHA guidelines, pre-HT and unclassified phenotypes were eliminated (8% and 24% in the present study, respectively). Seven out of 8 patients (87.5%) previously diagnosed with pre-HT were reclassified into masked HT, which was approximate to the previous studies with an escalation in diagnosis of 70%.[20,21] For the unclassified group, 9 out of 24 patients (37.5%) were reclassified into masked or sustained HT.

The prevalence of white coat HT using the 2022 AHA guidelines was increased from 12% to 27% in the present study. This result was different from the previous studies by Hamdani et al,[22] which showed a decrease of 16% prevalence of white coat HT. This could be due to the different patient populations between the 2 studies. In addition, the study by Campbell et al did not include the unclassified phenotype, while it was about 24% in the present study. On the contrary, the present study revealed that 15 of 24 patients (62.5%) were reclassified into white coat HT, which was also seen in the pilot study by Hill-Horowitz et al.[21]

Age, gender, height, and weight were the demographic data related to an escalation in diagnosis compared to the non-escalated group. However, after multivariate analysis, height was the only independent factor related to the escalation in the diagnosis of HT, with an OR of 1.17 in our study. This was consistent with the previous study that showed reclassification in

tall male patients.[16,21] The reason was that the 95th percentile BP for tall adolescents was more than the adult cut-off, seen in male adolescents with heights more than 135 to 155 cm and female adolescents with heights more than 140 to 170 cm.[9]

Based on the present study, it can be inferred that using the 2022 AHA guidelines was more associated with LVH than the 2014 AHA guidelines for the following reasons. First, 5 out of 6 patients who had pre-HT or unclassified phenotypes and LVH were escalated into masked or sustained HT. Only 1 patient, however, was de-escalated into white coat HT. Still, this patient was also obese, which could have contributed to a high left ventricular mass index, according to previous studies.[23,24] This demonstrated that, by the 2022 AHA guidelines, these individuals at risk of developing LVH would be reclassified as having either masked or sustained HT. Second, when using the 2014 AHA guidelines, LVH was not significantly different between the different ABPM phenotypes, while it was significantly different when using the 2022 AHA guidelines. This is consistent with the previous pediatric cohort studies that demonstrated the adult ABPM cut-off to be a more accurate predictor of LVH but the BP loads to be poor indicators of target organ damage.[12-14,21,25,26]

Although the present study was the first study comparing the 2014 and 2022 AHA guidelines in Asian pediatric populations with clearly defined phenotype reclassification, it has several limitations. Firstly, it was a single-center study, and a limited number of patients were included. Secondly, the sample size calculation was not done as the convenient samples were used. Thirdly, data regarding end-organ damages, such as left ventricular mass index, was limited to only 36%. Finally, the etiologies of HT in the participants were mixed between primary and secondary HT. A more extensive study with subgroup analysis between different causes of HT needs to be conducted to explore the performance of the 2022 AHA guideline in predicting end organ damage.

Conclusion

Using the 2022 AHA guidelines increased the prevalence of HT, including both sustained and masked HT. Nocturnal HT was more increased than awake HT because the nocturnal SBP cut-off of the 2022 AHA guidelines in ages ≥13 years was much lower than the 95th percentile of the 2014 AHA guidelines. Most of the pre-HT and some of the unclassified patients were reclassified into masked or sustained HT. The classification by the 2022 AHA guidelines was more related to the target organ damage than the 2014 AHA guidelines, as most patients with LVH were reclassified into masked or sustained HT when using the 2022 AHA guidelines. The escalation in the diagnosis of HT was seen among tall patients.

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References

1. Song P, Zhang Y, Yu J, et al. Global prevalence of hypertension in children: a systematic review and meta-analysis. *JAMA Pediatr*. 2019;173(12):1154-1163. doi:10.1001/jamapediatrics.2019.3310
2. Pirojsakul K, Aekplakorn W, Siwarom S, et al. Sleep duration and risk of high blood pressure in Thai adolescents: the Thai national health examination survey V,

2014 (NHES-V). *BMC Public Health*. 2022;22(1):1983. doi:10.1186/s12889-022-14430-z

3. Twig G, Yaniv G, Levine H, et al. Body-mass index in 2.3 million adolescents and cardiovascular death in adulthood. *New Engl J Med*. 2016;374(25):2430-2440. doi:10.1056/NEJMoa1503840

4. Mozaffarian D, Benjamin E, Go A, et al. Executive summary: heart disease and stroke statistiCS–2016 update: a report from the American heart association. *Circulation*. 2016;133(4):447-454. doi:10.1161/cir.0000000000000366

5. Flynn JT, Kaelber DC, Baker-Smith CM, et al. Clinical practice guideline for screening and management of high blood pressure in children and adolescents. *Pediatrics*. 2017;140(3):e20171904. doi:10.1542/peds.2017-1904

6. Mendizábal B, Urbina EM, Becker R, et al. SHIP-AHOY (study of high blood pressure in pediatrics: adult hypertension onset in youth). *Hypertension*. 2018;72(3):625-631. doi:10.1161/hypertensionaha.118.11434

7. Urbina EM, Khoury PR, Bazzano L, et al. Relation of blood pressure in childhood to self-reported hypertension in adulthood. *Hypertension*. 2019;73(6):1224-1230. doi:10.1161/hypertensionaha.118.12334

8. Chung J, Robinson CH, Yu A, et al. Risk of target organ damage in children with primary ambulatory hypertension: a systematic review and meta-analysis. *Hypertension*. 2023;80(6):1183-1196. doi:10.1161/hypertensionaha.122.20190

9. Flynn JT, Daniels SR, Hayman LL, et al. Update: ambulatory blood pressure monitoring in children and adolescents: a scientific statement from the American heart association. *Hypertension*. 2014;63(5):1116-1135. doi:10.1161/hyp.0000000000000007

10. Whelton PK, Carey RM, Aronow WS. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the Prevention, detection, evaluation, and management of high blood pressure in adults: executive summary: a report of the American college of cardiology/American heart association task force on clinical practice guidelines. *Hypertension*. 2018;71(6):1269-1324. doi:10.1161/hyp.0000000000000075

11. Flynn JT, Urbina EM, Brady TM, et al. Ambulatory blood pressure monitoring in children and adolescents: 2022 update: a scientific statement from the American heart association. *Hypertension*. 2022;79(7):e114-e124. doi:10.1161/hyp.0000000000000215

12. Merchant K, Shah PP, Singer P, Castellanos L, Sethna CB. Comparison of pediatric and adult ambulatory blood pressure monitoring criteria for the diagnosis of hypertension and detection of left ventricular hypertrophy in adolescents. *J Pediatr*. 2021;230:161-166. doi:10.1016/j.jpeds.2020.11.003

13. Hamdani G, Mitsnefes MM, Flynn JT, et al. Pediatric and adult ambulatory blood pressure thresholds and blood pressure load as predictors of left ventricular hypertrophy in adolescents. *Hypertension*. 2021;78(1):30-37. doi:10.1161/hypertensionaha.120.16896

14. Lee J, McCulloch CE, Flynn JT, et al. Prognostic value of ambulatory blood pressure load in pediatric CKD. *Clin J Am Soc Nephrol*. 2020;15(4):493-500. doi:10.2215/cjn.10130819

15. Black E, Lee J, Flynn JT, et al. Discordances between pediatric and adult thresholds in the diagnosis of hypertension in adolescents with CKD. *Pediatr Nephrol*. 2022;37(1):179-188. doi:10.1007/s00467-021-05166-w

16. Campbell JF, Shah S, Srivaths P, Acosta AA. Reclassification of adolescent hypertension by ambulatory blood pressure monitoring using adult norms and association with left ventricular hypertrophy. *J Clin Hypertens*. 2021;23(2):265-271. doi:10.1111/jch.14156

17. Nimkarn N, Sewarit A, Pirojsakul K, et al. Waist-to-height-ratio is associated with sustained hypertension in children and adolescents with high office blood pressure. *Front Cardiovasc Med*. 2023;9:1026606. doi:10.3389/fcvm.2022.1026606

18. World Health Organizaiton. Growth reference data for 5-19 years. 2006, Accessed January 18, 2023. https://www.who.int/tools/growth-reference-data-for-5to19-years/application-tools

19. Yip GWK, So HK, Li AM, Tomlinson B, Wong SN, Sung RYT. Validation of A&D TM-2430 upper-arm blood pressure monitor for ambulatory blood pressure monitoring in children and adolescents, according to the British Hypertension Society protocol. *Blood Press Monit*. 2012;17(2):76-79. doi:10.1097/MBP.0b013e328351d4a4

20. Ahlenius M, Koek W, Yamaguchi I. Ambulatory blood pressure monitoring in children: a retrospective single-center study. *Front Pediatr*. 2023;11:1088857. doi:10.3389/fped.2023.1088857

21. Hill-Horowitz T, Merchant K, Abdullah M, et al. Reclassification of adolescent ambulatory prehypertension and unclassified blood pressures by 2022 American heart association pediatric ambulatory blood pressure monitoring guidelines. *J Pediatr*. 2024;266:113895. doi:10.1016/j.jpeds.2023.113895

22. Hamdani G, Nehus EJ, Hanevold CD, et al. Ambulatory blood pressure control in children and young adults after kidney transplantation. *Am J Hypertens*. 2017;30(10):1039-1046. doi:10.1093/ajh/hpx092

23. Jing L, Nevius CD, Friday CM, et al. Ambulatory systolic blood pressure and obesity are independently associated with left ventricular hypertrophic remodeling in children. *J Cardiovasc Magn Reson*. 2017;19(1):86. doi:10.1186/s12968-017-0401-3

24. Brady TM. The role of obesity in the development of left ventricular hypertrophy among children and adolescents. *Curr Hypertens Rep*. 2016;18(1):3. doi:10.1007/s11906-015-0608-3

25. Li Y, Thijs L, Boggia J, et al. Blood pressure load does not add to ambulatory blood pressure level for cardiovascular risk stratification. *Hypertension*. 2014;63(5):925-933. doi:10.1161/hypertensionaha.113.02780

26. Liu M, Li Y, Wei FF, Zhang L, Han JL, Wang JG. Is blood pressure load associated, independently of blood pressure level, with target organ damage? *J Hypertens*. 2013;31(9):1812-1818. doi:10.1097/HJH.0b013e3283624f9b