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Original Article

Prevalence of Hypertension among Children Based on the New American Academy of Pediatrics Clinical Practice Guidelines

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Abstract

Background: In 2017, the American Academy of Pediatrics (AAP) updated clinical practice guidelines for the diagnosis and management of hypertension in children. The present study aimed to assess the prevalence of hypertension in Iranian children based on the latest guidelines.

Methods: Data on 7301 student participants (3589 boys and 3712 girls) aged between 7-12 yr were assessed. The data were extracted from the fifth Childhood and Adolescence Surveillance and Prevention of Adult Non-communicable Disease (CASPIAN V) school-based study conducted in the 30 provinces of Iran in 2015. Blood pressure (BP) was classified as normal, elevated BP, and stage 1 and 2 hypertension using weighted analysis and the 2017 AAP guidelines. All analyses were performed in STATA 14.0 statistical software, with findings presented in terms of prevalence.

Results: The overall prevalence of high BP in Iranian children was 14.7%. In addition, 15.1% of boys had high BP, with 9.4% and 1.7% of them with stage 1 and 2 hypertension, respectively. Moreover, 14.3% of girls had high BP, of which 10% had stage 1 and 1.3% with stage 2 hypertension. For elevated hypertension, it was observed in 4% of boys and 3% of girls.

Conclusion: Using the 2017 AAP guidelines demonstrated a higher prevalence of hypertension in children (14.7%) in Iran. The prevalence of hypertension in boys was slightly higher compared to girls.

Keywords: Hypertension; Children; Prevalence; Blood pressure; Iran

Introduction

Hypertension as one of the major risk factors for cardiovascular disease (1) causes about 7 million deaths annually worldwide and many of its underlying causes are formed at childhood (2). Although the disease is more common in adulthood, its roots have been traced to childhood and adolescence (3). The prevalence of hypertension worldwide has been reported differently (4). In children, it is 1% and it is between 3% and 11% in teens (5). Although, blood pressure (BP) in children is usually measured for the first time by being admitted to a pediatric center or during pre-school examinations, it measurement often omitted from routine child examinations (6). This is due to practical problems in assessing BP in infants and young children. In addition, BP levels are also age-dependent, and hypertension is an adult disease (7).

In adults, the cut offs for definition of hypertension are constant, while in children BP changes physiologically with sex, age, and height. In the National American Hypertension Study, they compared the percentages of 50^{th}, 90^{th}, 95^{th} and 99^{th} percentiles in children based on age, sex, and height (8). In this study, hypertension was defined as the degree by which normal BP is less than the 90^{th} percentile. Values between the 90^{th} and 95^{th} percentiles were called pre hypertension. Furthermore, BPs between 95^{th} and 99^{th} percentiles plus 5 mmHg were classified as second stage hypertension with each having its own special treatment (8).

Most children develop primary hypertension until adulthood. The prognosis of secondary hypertension in children depends on the nature of the underlying disease and its response to specific treatment (4). Hypertension in childhood is a risk factor for future atherosclerotic disease. Severe hypertension causes hypertrophy of the left ventricle, which could lead to future coronary artery disease (5).

Timely diagnosis and treatment of hypertension can prevent its long-lasting complications. Moreover, since it is possible to control and treat hypertension in children compared to adults, the American Academy of Medicine emphasizes screening for hypertension in children. Regular BP measurement should be started every six months from the age of three and then continued every year. In fact, recognizing and the timely prevention of hypertension to modify the lifestyle is one of the essentials of primary health care in children (9).

In 2017, the American Academy of Pediatrics (AAP) and the American Heart Association (AHA) published an updated guideline for the diagnosis and management of hypertension in children (6), replacing the previous 2004 fourth report from the National Institutes of Health's National Heart, Lung, and Blood Institute (NIH/NHLBI) (10). Thus, using the latest AAP guidelines, we aimed to examine the prevalence of hypertension in Iranian children.

Methods

Study design and setting

The data of fifth Childhood and Adolescence Surveillance and Prevention of Adult Non-communicable Disease (CASPIAN V) study was used. The methodology, eligibility criteria and sampling details of this national wide study was reported previously (11).

Survey Instruments

The questionnaire was obtained from the WHO-GSHS. For students and their parents, two sets of questionnaires were considered. The students filled out the WHO-GSHS questionnaire at school that was translated into Persian. To assess the validity of the scale, face, content validities were assessed. The face validity by approved an expert panel and content validity assessment the questions were affirmed (12). To assess the reliability of the scale, the internal consistency of the scale was measured. Reliability of questionnaires was evaluated by Cronbach's α coefficient. Cronbach's α coefficient of 0.97 and Pearson's correlation coefficient of the test–retest phase was 0.94.

The mission and purpose of the interview was explained after identifying eligible students. Afterwards, they were asked questions related to their health status and health-related behaviors. They were also asked to state what they knew and to simply say what they did not know. Interviews were conducted in a peaceful environment, away from busy classrooms. The students could not see the questions and the questions were read in simple words. The whole process was conducted by a team of health-care professionals.

Physical measurements

Weight was assessed using a calibrated set while participants wearing a light cloth and height was measured without shoes (12). We used the WHO growth charts to categorize BMI (13). Body mass index (BMI) was calculated by dividing weight (kg) by height squared (m^2).

A mercury Sphygmomanometer with an appropriate cuff size was used to measure blood reassure (BP). Two consecutive measurements of BP with a 5 min interval were recorded and the average was registered (8).

Definitions

Stages of hypertension was defined according to 2017 APP/AHA guidelines for screening and management of high BP in children and adolescents. The cut offs for definition of elevated BP, stage 1 and stage 2 hypertension were presented in Table 1.

Table 1: Blood pressure cut offs for Elevated BP, stage 1 and stage 2 hypertension based on American Academy of Pediatrics guideline (2017)*

Definition	***Age 1 to 13 yr***	***Age≥13 yr***
	Cut offs	Cut offs
Normal	SBP and DBP lower than 90th percentile of BP	SBP lower than 120 mmHg and DBP lower than 80 mmHg
Elevated BP	SBP or DBP ≥90th to <95th percentile OR SBP of 120 mmHg or DBP 80 mmHg to <95th percentile (whichever is lower)	SBP between 120 to 129 mmHg and DBP lower than 80 mmHg
Stage 1 hypertension	SBP or DBP ≥95th percentile to <95th percentile + 12 mmHg OR SBP 130 to 139 mmHg or DBP 80 to 89 mmHg (whichever is lower)	SBP between 130 to 139 mmHg or DBP between 80 to 89 mmHg
Stage 2 hypertension	SBP or DBP ≥95th percentile + 12 mmHg OR SBP of 140 mmHg or higher or DBP 90 mmHg or higher (whichever is lower)	SBP of 140 mmHg or higher of DBP of 90 mmHg or higher

*, Adopted from table 3 of Flyn et al. study (6).
BP: Blood pressure; DBP: Diastolic blood pressure; SBP: Systolic blood pressure

Statistical analysis

Data were analyzed using STATA 15.0 (STATA Corp LP. Package, College Station, TX, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical data as number and percentage. The classification of stages of hypertension were accomplished by new 2017 guidelines published by the American Academy of Pediatrics (AAP), to do that we needed to compute systolic and diastolic BPs percentiles for each child according to his/her sex, age, and height. For example, to compute the systolic BP (SBP) percentile of a boy who is age "y" years and height "h" centimeter with SBP = x mmHg:

First, we used freeware version of the LMSchartmaker 2.54 [a program to fit smooth gentile curves to reference data using the Cole's LMS method (14)] to convert the height of h centimeter to a height Z-score relative to boys of the same age; this is named by Zht below.

Second, we compute the expected SBP (μ) for boys of age y years and height h centimeter using following formula:

$$\mu = \alpha + \sum_{j=1}^{4} \beta_j (y-10)^j + \sum_{k=1}^{4} \gamma_k (Zht)^k$$

and by performing a regression analysis we computed α, β_1…, β_4 and γ1…, γ4 to convert the boy's observed SBP to a Z-score (Zbp) given by Zbp = (x – μ)/σ. Where σ is age, sex and height specific standard deviation estimated from the above model.

Third, to convert the bp Z-score to a percentile (P), compute P = Φ (Zbp) x 100% where Φ (Z) = area under a standard normal distribution to the left of Z.

Thus, if Zbp = 1.28, then Φ (Zbp) = 0.90 and the bp percentile = 0.90 x 100% = 90%.

For example, a 12-year-old boy, with height at the 90th percentile for his age-sex group, has a height Z-score = 1.28, and suppose his expected SBP (μ) is μ = 109.46 (SD=10.7128) mmHg (when used the coefficients estimated from the above model for boys). Now, if his actual SBP is 120 mmHg (x); his SBP Z-score is then:

SBP Z-score = (x – μ)/σ = (120–109.46)/10.7128 = 0.984

Therefore, his corresponding SBP percentile = Φ (0.984) x 100% = 83.7th percentile.

Then, after performing similar computation on DBP of each child to derive his/her DBP percentile, we used 2017 AAP/AHA Guidelines (Table 1) to classify the child BP accordingly.

Ethical approval

The ethics committees and other relevant national and provincial regulatory organizations gave ethical approval (Project Number: 194049). Verbal and written consents were obtained from all participants and their parents. After mentioning the goals and explanations required, all participants were assured that their answers will remain confidential and their participation in the study was voluntary. In addition, for performing the secondary analysis the ethic committee of National Institute for Medical Research Development approved the present study (code: IR.NIMAD.REC.1398.208).

Results

Data on 7301 student participants (3589 boys and 3712 girls) were assessed. Participant's age ranged from 7 to 12 yr. Students were excluded if they were >12 yr old, reported any use of antihypertensive medications, or missing sex, age, height, or weight. The number of participants, mean, standard deviation height, SBP and DBP of study population according to gender are shown in Table 2.

In boys, the means of height, SBP and DBP were 135.7 ±11.9 cm, 95.4 ±12.6 mmHg and 61.6 ±10.3 mmHg, respectively, while in girls were 134.7 ±12.3 cm, 95.5 ±12.6 mmHg, and 61.7 ±10.1 mmHg. According to the study, 12-year olds had the highest systolic and diastolic BPs (boys: SBP 99.3 ± 12.1 mmHg and DBP 64.2 ±10.1 mmHg, girls: SBP 99.3 ±12.2 mmHg and DBP 63.5 ±9.6 mmHg). Furthermore, the lowest DBP was observed in 7-year-old girls (59.8 ± 11.9 mmHg) while that of SBP was recorded in 8-year-old girls (93 ± 13.2 mmHg).

Table 2: Characteristics of study population according to age and gender

Age (yr)	*n*	*Boys*			*n*	*Girls*		
		Height (cm) mean ± SD	SBP (mmHg) mean ± SD	DBP (mmHg) mean ± SD		Height (cm) mean ± SD	SBP (mmHg) mean ± SD	DBP (mmHg) mean ± SD
7	350	123.8 ± 10.5	91.7 ± 13.3	58.1 ± 10.2	332	122.5 ± 10	93.1 ± 13.1	59.8 ± 11.9
8	545	126.8 ± 10.0	93.5 ± 12.7	60.8 ± 10.8	703	125.5 ± 8.0	93 ± 13.2	60.8 ± 10.2
9	634	132.0 ± 8.6	94.6 ± 12.8	61.0 ± 9.9	734	130.9 ± 8.8	94.6 ± 12.8	61.4 ± 10.2
10	747	136.2 ± 9.2	94.6 ± 12.2	61.5 ± 10.2	648	135.0 ± 8.5	95.5 ± 11.8	61.5 ± 9.9
11	660	140.0 ± 10.3	96.7 ± 12.7	62.6 ± 10.1	594	141.6 ± 10.4	96.5 ± 12.1	62.3 ± 9.5
12	675	145.7 ± 9.9	99.3 ± 12.1	64.2 ± 10.1	723	147.3 ± 10.3	99.3 ± 12.2	63.5 ± 9.6
Total	3589	135.7 ± 11.9	95.4 ± 12.6	61.6 ± 10.3	3712	134.7 ± 12.3	95.5 ± 12.6	61.7 ± 10.1

DBP: Diastolic blood pressure; SBP: Systolic blood pressure; SD: Standard deviation

The prevalence of hypertension in Iranian children was classified according to gender. Based on the 2017 AAP guidelines, majority of Iranian girls (85.7%) had normal BP. 14.3% of girls had high BP, from which 3% were elevated hypertension. The prevalence of stages 1 and 2 hypertensions were found to be 10% and 1.3%, respectively.

Similarly, 84.9% of boys had normal BP while 15.1% had high BP. The prevalence of stage 1 hypertension was found to be 9.4% and stage 2 hypertension 1.7% (Table 3). In total, 11.1% of boys and 11.3% girls were confirmed for hypertension in stages 1 and 2 based on the AAP guidelines (Table 3). Moreover, the prevalence of stage 1 hypertension was higher in girls while stage 2 hypertension was more prevalent in boys.

Table 3: Classification of BP according to 2017 AAP Guideline for Iranian boy and girls 7–12-year-olds

Classification	*Boys n (%)*	*Girls n (%)*
Normal blood pressure	3046 (84.9)	3181 (85.7)
Prehypertension or elevated hypertension	143 (4.0)	113 (3.0)
Stage 1 hypertension	340 (9.4)	372 (10.0)
Stage 2 hypertension	60 (1.7)	46 (1.3)
Total	3589 (100)	3712 (100)
High blood pressure [a]	543 (15.1)	531 (14.3)
Hypertension (overall)[b]	400 (11.1)	418 (11.3)

[a] High blood pressure combines prehypertension, elevated blood pressure, stage 1 hypertension, and stage 2 hypertension.

[b] Category combines stage 1 and stage 2 hypertension

Discussion

Since the introduction of the latest AAP guidelines in 2017, a handful of studies have so far been conducted globally. To the best of our knowledge, this is the first study examining the prevalence of hypertension in Iranian children based on the latest AAP cut offs.

The overall prevalence of high blood pressure was 14.7%, with 3.5% prehypertension or elevated hypertension, 9.8%, and 1.4 as stage 1 and 2 of hypertension, respectively. The overall prevalence was close to a recent study in China (16.7%) (15), however, it was slightly higher compared to that of United States (11.2%) by Al Kibria et al. (16).

The mean SBP and DBP increased with age, which are in agreement with previous studies (17, 18). Furthermore, the prevalence of hypertension in boys was slightly higher in boys, which supports the findings of Sharma et al (19) that boys <13 yr are more likely predisposed to hypertension. A recent meta-analysis (20) also reported slightly higher prevalence of hypertension among Iranian boys than girls.

Due to the significant tracking effect of BP between childhood and adulthood, it is important to examine the effect of the updated guidelines with regards to elevated BP. In the current study, 3.5% of Iranian children had elevated hypertension. Hence, going by the 2017 AAP thresholds, longitudinal observation is recommended for this cohort as a result of their potential future risk of hypertension. In our recent study on the prevalence of hypertension in Iranian adults based on the 2017 American College of Cardiology (ACC) and the American Heart Association (AHA) guidelines (21), we reported an increase in the prevalence of hypertension. This presently increased prevalence of hypertension in Iranian adults should serve as a call to action for effective measures preventing further escalation of hypertension in children to adulthood, a situation which could potentially overwhelm Iran's public health system.

So far, few studies have been conducted to investigate the potential impact of the latest AAP guidelines. Khoury et al (22) reported an increase in the prevalence of high blood pressure using the 2017 report compared to the Fourth Report of 2004 (13% versus 8%). Dong and colleagues (15) showed an overall increase in prevalence of high blood pressure in 16.7% of children aged 6 to 12 yr using the 2017 AAP guidelines in comparison to 10.8% of children for the 2004 report. A single center study in Thailand involving primary school children reported an increase in the prevalence of hypertension by about 4% (23). As a consequence of the 2017 AAP guidelines, more children will be classified hypertensive. Thus, it is important that stricter dietary measures be put in place by parents and guardians to ensure that the public health implications of increased prevalence of hypertension is well managed. Healthy diets including the consumption of fruits and vegetables as well as low intake of sugar, salt and saturated fat, help prevent poor cardio-metabolic profile in children (24, 25). In addition, positive change in lifestyle has been shown to improve metabolic activities in the long run (26).

The prevalence of hypertension in Iranian children is high when compared to other countries (20). This is quite alarming considering the fact that their results were even based on the previous guidelines. Higher socioeconomic status as well as improved education system have a protective effect against high BP and consequently hypertension (27-29). In the recent decade, there has been an increasing trend in the consumption of foreign foods by Iranian children (30). Altogether, these factors could be attributed to the higher prevalence of hypertension in Iranian children compared to their counterparts in developed nations such as USA. To bridge this gap, families, especially those with low socioeconomic situations, adopt a healthy lifestyle as well as improved diet (31).

In terms of limitations, one of such is with regards to the method of taking multiple measurements at one visit instead of multiple visits (32, 33). In addition, zero and five end-digit preference in recording BP is unavoidable. End-digit preference was reported as a prevalent error in other datasets (34-36). Therefore, it can lead to misclassification of the children as normal or hypertensive.

Conclusion

Adopting the 2017 AAP guidelines provided a new prevalence of hypertension among Iranian children. Boys were slightly more hypertensive compared to girls, with overall prevalence of 15.1% and 14.3%, respectively. Both parents and the government have roles to play in decreasing this alarming rates. Thus, preventive or mitigatory measures such as effective health policies, healthy lifestyle, improved diet, regular exercise, sensitization and awareness programs, and regular medical check-ups should be encouraged. Our findings can provide basis for public health policy makers and primary prevention policies in the country.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that they have no competing interests.

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