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Prevalence of Hypertension and Prehypertension in Iranian Children

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Abstract

Background: Hypertension (HTN) is a significant public health problem worldwide. Early diagnosis of HTN and its related risk factors has been considered as one of the main requirements of general healthcare in children.
Objectives: This study aimed to examine the nomograms of normal systolic and diastolic blood pressure (BP) and the prevalence of asymptomatic HTN and pre-HTN in a population of school-aged children.
Methods: Systolic and diastolic BP, height, and weight were measured in 5811 healthy school-aged children (2904 males and 2907 females) during healthcare visits. HTN was defined as systolic or diastolic BP $\geq$ 95th percentile for age, gender, and height of the screened population on $\geq$ 3 occasions. Pre-HTN was considered as systolic or diastolic BP between 90 - 95 percentile.
Results: HTN and pre-HTN were detected in 8.4% and 7.8% of the children, respectively. The prevalence of HTN was 8.6% among the males and 8.2% among the females. Systolic HTN and pre-HTN were detected in 5.8 and 6.4% of the cases compared to diastolic HTN and pre-HTN observed in 5.9 and 6.1% of the participants, respectively. In addition, HTN was detected in 27.9% of children with obesity.
Conclusions: According to the high incidence of asymptomatic HTN and pre-HTN in asymptomatic children, it is recommended to perform routine BP measurement during medical care visits of all healthy school children and to prevent and treat obesity in childhood.

Keywords: Children, Blood Pressure, Hypertension, Weight, Obesity

1. Background

The prevalence of pediatric hypertension (HTN) has been increasing throughout the world. In total, about 1 - 10% of children and adolescents suffer from HTN, and pre-HTN has been reported in 2 - 16% of children (1-4). HTN has also become increasingly recognized in 0.2 - 3% of newborn infants, particularly those requiring intensive care (5).

Primary HTN is highly prevalent in older children and adolescents. It is usually mild and asymptomatic, with potential cardiovascular and renal complications in untreated long-term patients (1, 4).

Increased body weight has been recognized as one of the potential risk factors of incipient and future HTN. The incidence of elevated blood pressure (BP) is over 15% in overweight and obese children. The increased consumption of a high calorie diet, lifestyle modification, and lack of physical activity are the major risk factors of increasing body weight and HTN (6).

2. Objectives

Limited studies have been conducted to identify the trend of increased blood pressure (BP) in children. Since early diagnosis and management of HTN might prevent further complications, this study was performed to identify the prevalence of HTN and pre-HTN in apparently healthy school-aged children.

3. Methods

This cross-sectional study was conducted on 5811 school children (7 - 11 years) admitted to the healthcare offices for routine clinical visits and referred to the

nephrology clinics. The Local Ethics Committee of Gorgan University approved the study, and informed consent was obtained from the patients' legal guardians.

3.1. Inclusion Criteria

Asymptomatic healthy school-aged children with normal physical conditions without associated disorders were included in the study.

3.2. Exclusion Criteria

Children with a history of physical, mental, cardiac, renal, endocrine, nervous, and psychologic disorders, in addition to those on any medical treatments, were excluded from the study.

A single trained observer measured height, weight, and BP in all the children. Height for age standards was determined using the CDC 2000 growth charts and classified based on age and gender as short ($\leq$ 25th percentile), average (25 - 75 percentile), and tall ($\geq$ 75th percentile) stature.

Body mass index (BMI) was calculated by weight (kg)/height (m^2) and classified as underweight (BMI< 5th percentile), normal (BMI: 5 - 85 percentile), overweight (BMI: 85 - 95 percentile), and obese (BMI > 95th percentile) (7). BP was determined after 3 - 5 minutes of rest in the sitting position, using the standard mercury sphygmomanometer, with an appropriate cuff covering two-thirds of the right arm. BP measurements was repeated within 2 weeks of the initial high BP value.

Systolic BP was determined by the onset of the first Korotkoff-1 sound, and diastolic BP was measured with the disappearance of Korotkoff-5. According to the Fourth Report on BP in Children and Adolescents (2004), normal BP is defined as the mean systolic and diastolic BP < 90th percentile for age, gender, and height on at least three occasions. Values between 90 - 95 percentile or > 120/80 mmHg in adolescents were defined as pre-HTN, and HTN was considered as BP $\geq$ 95th percentile on $\geq$ 3 different occasions (1, 7).

3.3. Statistical Analysis

The data were analyzed using IBM SPSS Statistics for Windows version 22.0. Continuous variables were expressed as mean $\pm$ standard deviation, and categorical variables were expressed as percentages. A $P < 0.05$ was considered statistically significant.

4. Results

A total of 5811 children (2904 males and 2907 females) aged between 7 - 11 years were enrolled in the study. Each age group consisted of about 20% of the cases. Systolic and diastolic BP based on weight and height in both genders are shown in Tables 1 - 4.

Mean systolic and diastolic BP were 101.41 mmHg (57.5 - 125 mmHg) and 62.51 mmHg (44.5 - 85.0 mmHg) in all the cases, respectively. Mean systolic/diastolic BP was 101.5/62.7 mmHg in the males and 101.2/62.3 mmHg in the females. Overall, mean systolic and diastolic BP increased with age, weight, height, and BMI in both genders.

The majority of the patients had normal BP (83.8%), followed by pre-HTN (7.8%) and HTN (8.4%). Most of the patients had normal systolic BP (87.8%), followed by systolic pre-HTN (6.4%) and systolic HTN (5.8%). In addition, the patients mostly had normal diastolic BP (88%), followed by diastolic pre-HTN (6.1%) and diastolic HTN (5.9%).

The majority of the males (82.9%) and the females (84.7%) had normal BP. However, 8.6% of the males and 8.2% of the females had HTN, while 8.5% of the males and 7.1% of the females had pre-HTN. The distribution of systolic and diastolic BP in both genders is shown in Table 5.

Of the children, 22.5% were short, 55% were average, and 22.5% were tall. The prevalence of HTN was 5.5%, 7.9%, and 10.1% in short, average, and tall patients, respectively.

The mean BMI was 16.65 kg/m^2 (10.24 - 31.74). Of the children, 5.2% were underweight, 80.1% were normal, 10% were overweight, and 4.7% were obese. Further, the prevalence of HTN was 6.6, 6.3, 16.7, and 27.9% in underweight, normal, overweight, and obese children, respectively. Of children with pre-HTN, about 4.7% were underweight, 7.3% were normal, 11.7% were overweight, and 11.2% were obese (Table 6, Figures 1 - 4).

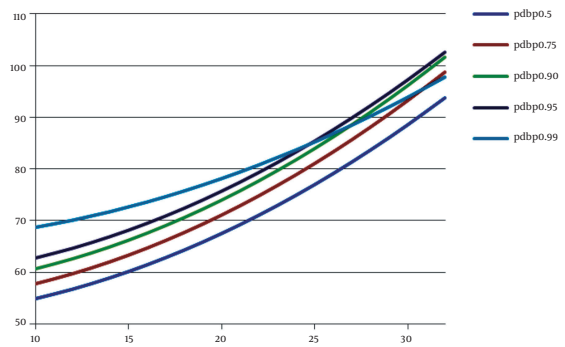

Figure 1. Nomogram of diastolic BP by BMI in girls

Table 1. BP Levels for Girls by Age and Height Percentile

Age (y)/BP percentile	SBP, mm Hg							DBP, mm Hg						
	Height Percentile													
	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90tht	95th
7														
50th	90	92	95	97	100	102	105	51	54	56	58	61	63	65
90th	96	98	100	102	104	106	108	56	58	61	63	65	67	69
95th	98	99	101	103	105	107	108	59	61	63	65	66	68	70
99th	99	101	103	105	107	109	111	61	63	65	67	69	71	72
8														
50th	91	92	95	98	102	106	110	52	53	56	59	63	67	70
90th	95	96	99	102	105	109	112	55	56	59	62	66	70	74
95th	96	97	99	102	106	110	113	57	58	61	63	67	70	74
99th	98	99	102	105	108	112	116	62	63	65	67	69	72	75
9														
50th	94	95	97	101	105	107	109	55	56	58	62	66	69	70
90th	96	98	99	105	109	112	114	58	59	61	66	70	72	74
95th	97	99	101	106	111	114	116	58	60	62	67	72	74	76
99th	100	102	104	109	113	116	118	61	63	65	70	74	77	79
10														
50th	96	97	100	103	106	109	111	57	58	61	65	67	71	73
90th	99	101	103	107	109	112	114	60	61	64	68	71	74	76
95th	100	101	104	108	110	114	115	61	63	65	69	72	75	77
99th	105	106	108	111	113	115	117	65	66	69	72	74	77	79
11														
50th	97	99	102	106	111	114	116	59	61	64	68	72	75	76
90th	100	102	105	109	114	117	118	63	64	67	71	75	78	79
95th	102	104	107	110	114	117	119	64	66	68	72	76	79	80
99th	105	106	108	112	116	118	119	67	68	70	73	77	79	81

Table 2. BP Levels for Boys by Age and Height Percentile

Age (y)/BP Percentile	SBP, mm Hg							DBP, mm Hg						
	Percentile of Height													
	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
7														
50th	89	90	92	96	99	102	105	52	53	54	58	60	63	65
90th	94	95	96	100	103	106	108	56	57	59	62	65	67	70
95th	97	98	99	102	104	107	109	57	59	60	63	66	68	71
99th	100	101	102	105	106	108	110	61	62	63	66	68	70	73
8														
50th	91	93	96	99	103	107	110	52	54	57	60	63	67	70
90th	95	97	100	103	107	111	114	56	58	61	64	67	71	74
95th	97	99	102	105	108	112	115	57	59	62	65	69	73	76
99th	99	101	104	106	109	112	115	59	61	64	67	70	74	77
9														
50th	93	94	97	102	106	109	111	54	56	59	63	67	70	72
90th	95	97	100	105	110	113	115	57	59	62	66	71	74	76
95th	96	98	101	106	111	114	116	58	60	63	68	72	75	77
99th	100	102	105	109	114	116	118	62	64	67	71	76	79	81
10														
50th	95	96	101	104	107	110	111	56	57	62	65	68	71	72
90th	98	99	104	107	110	113	115	59	61	65	69	71	74	76
95th	100	101	105	109	111	114	116	61	62	66	70	73	75	77
99th	101	103	108	112	115	118	120	62	64	68	72	75	79	80
11														
50th	97	100	103	107	111	114	116	59	61	64	68	72	75	77
90th	101	103	106	110	114	117	119	63	65	68	71	75	78	80
95th	103	105	108	111	115	118	120	65	67	70	73	76	79	80
99th	106	109	111	115	119	121	124	68	70	73	76	79	82	84

Table 3. BP Levels for Girls by Age and Weight Percentile

Age (y)/BP Percentile	SBP, mm Hg							DBP, mm Hg						
	Percentile of Weight													
	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
7														
50th	92	93	95	97	100	102	105	53	54	56	58	61	63	65
90th	99	100	101	103	105	107	109	59	60	61	63	66	68	70
95th	101	102	102	104	106	107	109	61	62	63	65	67	69	71
99th	103	104	105	106	107	108	110	65	66	67	68	70	72	73
8														
50th	92	94	96	99	102	105	107	53	55	57	60	63	66	68
90th	98	100	101	104	106	109	110	58	60	62	64	67	69	71
95th	100	102	103	105	108	110	111	61	62	64	66	68	70	72
99th	103	105	106	108	110	113	114	64	65	67	68	70	72	73
9														
50th	95	96	97	101	104	108	110	56	57	58	63	66	69	72
90th	99	100	101	106	109	113	115	60	61	63	67	70	73	76
95th	101	102	103	107	110	114	116	62	62	64	68	72	75	78
99th	103	104	105	109	113	116	118	64	65	66	70	73	76	79
10														
50th	98	99	98	103	106	109	112	59	60	59	64	67	71	73
90th	101	102	102	107	110	113	115	62	63	63	68	71	75	77
95th	103	104	104	108	111	114	116	64	65	65	70	73	76	78
99th	106	107	107	111	114	116	118	67	68	68	72	75	77	79
11														
50th	100	101	102	106	109	113	115	61	62	64	67	70	73	76
90th	104	105	107	110	114	118	120	67	67	69	72	75	78	80
95th	107	108	110	112	116	119	121	69	70	71	74	76	79	81
99th	112	112	113	115	117	120	121	75	75	76	77	79	80	81

Table 4. BP Levels for Boys by Age and Weight Percentile

Age (y)/BP Percentile	SBP, mm Hg							DBP, mm Hg						
	Percentile of Weight													
	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
7														
50th	89	91	93	96	98	101	104	52	54	55	58	60	63	65
90th	96	98	99	101	104	106	108	58	60	61	63	65	68	70
95th	98	100	101	103	105	107	109	59	61	62	64	67	69	71
99th	100	102	103	105	107	109	111	62	64	65	67	69	71	74
8														
50th	94	94	96	99	101	106	109	55	55	57	59	62	66	70
90th	101	101	103	104	106	110	112	61	61	63	65	67	71	74
95th	102	102	104	106	107	110	113	63	63	65	66	68	71	74
99th	105	105	107	108	109	111	113	65	65	67	68	70	73	76
9														
50th	95	96	98	101	106	110	111	57	57	60	63	67	71	72
90th	99	99	102	106	111	115	117	60	61	64	67	71	76	77
95th	100	101	104	108	112	117	119	62	62	65	69	73	78	79
99th	105	105	108	111	114	118	119	66	67	69	72	76	79	81
10														
50th	97	98	100	103	107	110	112	59	60	62	64	68	71	73
90th	102	102	105	107	111	115	117	63	64	66	69	72	76	78
95th	103	104	106	109	112	116	118	64	65	67	70	73	77	78
99th	104	105	108	112	117	122	125	66	67	70	73	78	83	85
11														
50th	100	101	103	106	110	114	116	61	62	64	67	71	75	76
90th	105	106	108	111	114	117	119	68	68	70	72	75	78	79
95th	108	109	110	113	115	118	119	71	72	73	74	76	78	79
99th	111	111	113	115	117	120	121	74	74	75	77	78	80	81

Table 5. Frequency of Normal BP, Systolic and Diastolic HTN, and pre-HTN in Both Genders (%)

Gender	Normal BP	Total HTN	Total Pre-HTN	SHTN	DHTN	S Pre-HTN	D Pre-HTN
Males	82.9	8.6	8.5	5.8	6	7	6.4
Females	84.7	8.2	7.1	5.9	5.7	5.7	5.8

Abbreviations: SHTN, systolic HTN; DHTN, diastolic HTN; SPre-HTN, systolic pre-HTN; Dpre-HTN, diastolic pre-HTN.

Table 6. Frequency of Normal BP, pre-HTN, and HTN Based on Weight in Both Genders (%)

Weight	Normal BP		Pre-HTN		HTN	
	Male	Female	Male	Female	Male	Female
Underweight	89.7	87.8	5.5	3.8	4.8	8.3
Normal	85.7	87.1	8	6.6	6.3	6.3
Overweight	70.1	73	12.8	10.6	17.1	16.3
Obese	56	65.5	11.2	11.3	32.8	23.2

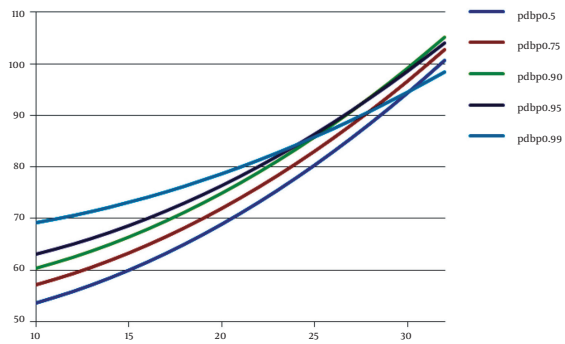

Figure 2. Nomogram of diastolic BP by BMI in boys

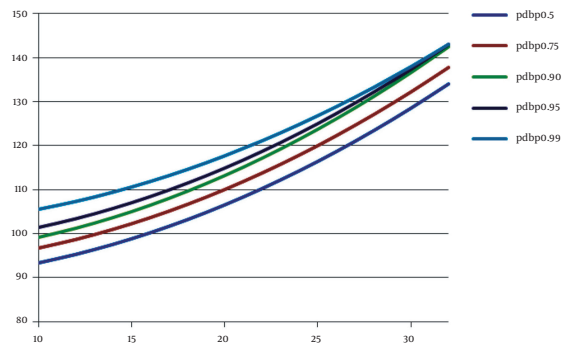

Figure 3. Nomogram of systolic BP by BMI in girls

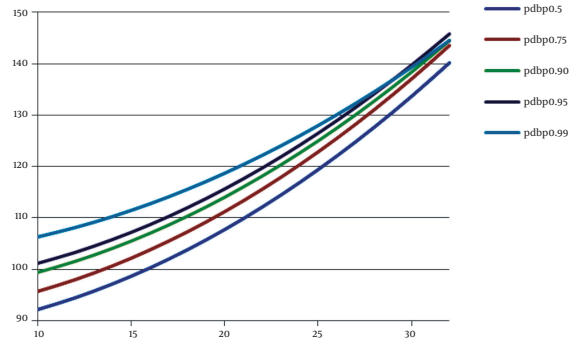

Figure 4. Nomogram of systolic BP by BMI in boys

5. Discussion

The development of adult HTN may start early in life (8). Persistent HTN during infancy and early childhood is the primary cause of cardiovascular events, chronic kidney disease, and stroke in adulthood. Accordingly, early detection of HTN and its risk factors in different communities seems necessary to prevent future HTN-related complications and morbidity (4, 5).

The present study's findings indicated that the mean systolic and diastolic BP increased in the children with increasing age, height, weight, and BMI in both genders, showing the effect of age, height, weight, and BMI on BP measurement in both genders. Moreover, HTN and pre-HTN were documented in 8.4 and 7.8% of our children, reflecting the need for more attention to this health problem. Similarly, HTN and pre-HTN were detected in 5.9 and 12.3% of children in Sharma et al.'s study, which is considered an alarming condition (8).

The prevalence of pre-HTN and HTN was 31.4 and 2.1% in Koebnick et al.'s study, indicating an average 7% of young children with HTN (9).

In a cohort of 199513 children, including 3 - 5 (24.3%), 6 - 11 (34.5%), and 12 - 17 (41.2%) years old children, about 12.7 and 5.4% had pre-HTN and HTN, respectively, with a positive correlation with age and BMI (10).

About 8.4 and 7.5% of our children with HTN and pre-HTN were males and females, respectively. In total, 5.8 and

6.3% of our children had systolic or diastolic HTN and pre-HTN, respectively.

In another study, 13.6% of boys and 5.7% of girls aged 8 - 17 years were classified as pre-hypertensive, in addition to 2.6% of boys and 3.4% of girls with established HTN (8). However, the prevalence of HTN and pre-HTN was nearly equal in both genders in our study.

Similarly, systolic and diastolic HTN and pre-HTN had nearly equal frequency in our population. Systolic and diastolic HTN were detected in 0.8 and 0.4% of patients in the update of Taskforce Report on BP, with no significant difference between girls and boys regarding the prevalence of systolic HTN (2.7%), but with a higher number of girls with diastolic HTN. In addition, systolic BP was significantly higher in boys than girls, whereas DBP was significantly higher in girls than boys (11).

The prevalence of obesity has been increased secondary to dietary habits, increased salt intake, and decreased physical activity. A strong correlation has been recognized between increased body weight and HTN, and obesity has been considered a significant risk factor of HTN, especially systolic BP (11 - 30%) (6, 12, 13). Therefore, prevention and treatment of obesity might decrease the incidence of HTN.

About 27.9 and 11.2% of our obese children had HTN and pre-HTN, respectively, composing a relatively high number of children with increased BP and emphasizing increased body weight as a major predictor of future HTN.

The prevalence of HTN and pre-HTN was 22.0 and 13.3% in Ramos et al.'s study, with a higher incidence in males (25.4 vs. 18.8%). They documented HTN in 14.7, 24.2, and 42.3% of normal, overweight, and obese female children and 20.4, 35.5, and 41.3% of their male counterparts, respectively (14).

Many children with normal BMI had high BP values in Rahman et al.'s study (6). However, HTN was more severe among obese children with BMI >30. Of them, 37.5% had pre-HTN, and 12.5% had HTN. In their report, age, female gender, and BMI > 25 were independent risk factors of HTN and pre-HTN.

The overall prevalence of systolic or diastolic HTN was 4.2, 5.4, and 7.7% in Kelishadi et al.'s study (15), without a significant difference between genders, similar to our study. In addition, both systolic and diastolic HTN occurred more commonly in overweight and tall children.

5.1. Conclusion

Due to the high incidence of HTN, regular monitoring of BP is recommended in asymptomatic healthy-appearing children to prevent its further risks in adulthood. Further studies with larger populations are suggested to estimate the true incidence of HTN in different communities.

Footnotes

Authors' Contribution: Farshid Kompani developed the original idea and the protocol. Azar Nickavar prepared the manuscript. Behdokht Abouali, Sara Rahafard, and Seyyed Mohammad Hosseiny collected the data.

Conflict of Interests: None to declare.

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References

1. Collins RT, Alpert BS. Pre-hypertension and hypertension in pediatrics: Don't let the statistics hide the pathology. *J Pediatr*. 2009;**155**(2):165–9. doi: 10.1016/j.jpeds.2009.02.006. [PubMed: 19619748].
2. Menghetti E, Cairella G, Castoro F, Censi L, D'Addesa D, Martone D, et al. [Increase of hypertension among adolescents in Rome]. *Minerva Pediatr*. 2007;**59**(1):1–5. Italian. [PubMed: 17301718].
3. McNiece KL, Poffenbarger TS, Turner JL, Franco KD, Sorof JM, Portman RJ. Prevalence of hypertension and pre-hypertension among adolescents. *J Pediatr*. 2007;**150**(6):640–4. 644 e1. doi: 10.1016/j.jpeds.2007.01.052. [PubMed: 17517252].
4. Al Salloum AA, El Mouzan MI, Al Sharqawi AH, Al Omar AA, Alqurashi MM, Al Herbish AS. Blood pressure standards for pre-school children in Saudi Arabia. *Saudi J Kidney Dis Transpl*. 2020;**31**(6):1281–93. doi: 10.4103/1319-2442.308337. [PubMed: 33565440].
5. Nickavar A, Assadi F. Managing hypertension in the newborn infants. *Int J Prev Med*. 2014;**5**(Suppl 1):S39–43. [PubMed: 24791189]. [PubMed Central: PMC3990926].
6. Rahman AJ, Qamar FN, Ashraf S, Khowaja ZA, Tariq SB, Naeem H. Prevalence of hypertension in healthy school children in Pakistan and its relationship with body mass index, proteinuria and hematuria. *Saudi J Kidney Dis Transpl*. 2013;**24**(2):408–12. doi: 10.4103/1319-2442.109619. [PubMed: 23538376].
7. Batisky DL. Blood pressure variability, prehypertension, and hypertension in adolescents. *Adolesc Health Med Ther*. 2012;**3**:43–50. doi: 10.2147/AHMT.S15942. [PubMed: 24600286]. [PubMed Central: PMC3915787].
8. Sharma A, Grover N, Kaushik S, Bhardwaj R, Sankhyan N. Prevalence of hypertension among schoolchildren in Shimla. *Indian Pediatr*. 2010;**47**(10):873–6. doi: 10.1007/s13312-010-0148-5. [PubMed: 20308762].
9. Koebnick C, Black MH, Wu J, Martinez MP, Smith N, Kuizon BD, et al. The prevalence of primary pediatric prehypertension and hypertension in a real-world managed care system. *J Clin Hypertens (Greenwich)*. 2013;**15**(11):784–92. doi: 10.1111/jch.12173. [PubMed: 24283596]. [PubMed Central: PMC3844934].
10. Lo JC, Sinaiko A, Chandra M, Daley MF, Greenspan LC, Parker ED, et al. Prehypertension and hypertension in community-based pediatric practice. *Pediatrics*. 2013;**131**(2):e415–24. doi: 10.1542/peds.2012-1292. [PubMed: 23359583]. [PubMed Central: PMC3557407].
11. Adrogue HE, Sinaiko AR. Prevalence of hypertension in junior high school-aged children: effect of new recommendations in the 1996 updated task force report. *Am J Hypertens*. 2001;**14**(5 Pt 1):412–4. doi: 10.1016/s0895-7061(00)01277-2. [PubMed: 11368459].

12. Rao S, Kanade A, Kelkar R. Blood pressure among overweight adolescents from urban school children in Pune, India. *Eur J Clin Nutr*. 2007;**61**(5):633–41. doi: 10.1038/sj.ejcn.1602555. [PubMed: 17136039].
13. Akther M, Tabrez MS, Ali MM, Dey PR, Hoque M, Alam ST. Prevalence and common risk factors of hypertension among school children aged 12-16 years in Sylhet Metropolitan City, Bangladesh. *Mymensingh Med J*. 2019;**28**(4):819–25. [PubMed: 31599246].
14. Ramos E, Barros H. Prevalence of hypertension in 13-year-old adolescents in Porto, Portugal. *Rev Port Cardiol*. 2005;**24**(9):1075–87. [PubMed: 16335282].
15. Kelishadi R, Ardalan G, Gheiratmand R, Majdzadeh R, Delavari A, Heshmat R, et al. Blood pressure and its influencing factors in a national representative sample of Iranian children and adolescents: The CASPIAN Study. *Eur J Cardiovasc Prev Rehabil*. 2006;**13**(6):956–63. doi: 10.1097/01.hjr.0000219109.17791.b6. [PubMed: 17143128].