

Blood Pressure Standards for Shiraz (Southern Iran) School Children in Relation to Height

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Abstract

Objective: This study aims at providing local reference values for blood pressure by height and determining distribution pattern of systolic and diastolic blood pressure in 6.5-11.5 elementary school children for the first time in Shiraz (Southern Iran).

Methods: Height, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured with standard methods in 2270 healthy school children (1174 boys, 1096 girls) who were selected by multi-stage random sampling in 2003-2004 academic years. We produced blood pressure percentiles by height percentiles using Healy-Rasbash-Yang method.

Findings: The blood pressure (both systolic and diastolic) tends to increase with age, but after adjusting the measurements for height, no significant correlation was found between either systolic blood pressure or diastolic blood pressure and age ($r=-0.03$ and $P=0.15$ for systolic blood pressure, $r=-0.005$ and $P=0.8$ for diastolic blood pressure). Then systolic and diastolic blood pressure percentile values by age and height percentiles, and blood pressure smoothed centiles by height in 6.5-11.5 years school children were derived.

Conclusion: Due to genetic, cultural and environmental differences among populations, it is suggested to use local blood pressure standards in Iran. We produced blood pressure percentiles by height instead of age because it seems that it would lead to better evaluation for real hypertensive diagnosis.

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Key Words: Blood pressure; Height; Age; Children; Local Reference Value; Percentile

Introduction

Childhood high blood pressure (BP) is a risk factor of hypertension in adolescence and early adulthood [1], which can be associated with an increased incidence of stroke, coronary heart disease, congestive heart failure and renal insufficiency in adults [2]. It has also fundamental influence on adulthood increased hospitalization and mortality. Current understanding of childhood

blood pressure not only recognizes the importance of identification of children with hypertension due to secondary conditions but also the realization that mild elevations in blood pressure during childhood (and particularly adolescence) are more common than previously thought. Elevated blood pressure in some children may represent the early onset of essential hypertension. Therefore, the fourth report from the National High Blood Pressure Education

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Program (NHBPEP) working group on children and adolescents, suggested that children over three years of age should have their BP been measured at least once during every health care visit [3]. Many studies show an increased age related BP from birth to 18 years [2-8]. However, height is identified as the most important determinant of BP in childhood and adolescence. Therefore, a few studies present height related BP, whose normal range varies between 5th and 95th percentiles [3-4]. BP levels may also vary from one community to the other due to genetic, cultural and environmental differences [2].

At present there is no data available on local children BP standards adjusted for height, and using an external standard may be quite misleading. Therefore, this paper provides, local height-related as well as age and sex-specific BP reference values for Shirazi (Iran) school children.

Subjects and Methods

Administratively, Shiraz is divided into four educational districts, each with discrete social, cultural, economic and health characteristics. Since an adequate sampling frame of population was unavailable, a multistage systematic random sampling was applied. A 10% systematic sample of schools in each district was drawn from public and private schools (43 schools out of 426 schools). Within each selected school, a 1 in 5 sample of children aged between 6.5 and 11.5 years (grade I to grade V) was selected, using table of random numbers. Elementary schooling is compulsory in Iran, a 2 percent random sample of about 113500 school children in Shiraz, the capital of Fars province and one of the five principal cities of Iran with a population of 1.5 million, were selected. Demographic structures of them were similar to developed urban cities of Iran, giving us a representative sample of Iranian urban children. Applying this sampling procedure, 2270 healthy school attendees (1174 boys, 1096 girls) aged 6-5-11.5 years (Grade I \approx age group 7: 6.5-7.49, Grade II \approx age group 8: 7.5-8.49, Grade III \approx age group 9: 8.5-9.49, Grade IV \approx age group 10: 9.5-10.49 and Grade V \approx age group 11: 10.5-11.5 years) having

valid measurements on both height and BP were selected in 2003-2004 academic year, in a cross-sectional study.

Children heights were measured by two trained auxologists using a digital stadiometer (SECA model 707, Germany) and methods given by Cameron [9] and recorded to the nearest 0.1 cm.

The criteria for healthy children were: 1) being well or apparently normal; 2) absence of identified disease; 3) no evidence of taking antihypertensive medication or other drugs at the time of study. If a child had a problem as above, he/she was excluded from the study.

An informed consent was sought from the subject's parents and guardians and the procedure was explained to the child before measuring his/her BP by the trained nurses or health workers of the research team. Standard and calibrated aneroid manometers (Model 500-c, Japan) (to avoid mercury toxicity) were used for all readings. Blood pressure was measured in regular schooldays while the child sitting quietly for at least 5 minutes, feet on the floor and right arm supported, cubital fossa at heart level. Children were excluded if they had stress or were taking any stimulant foods or drugs (eating any food or drinking tea or coffee before the measurement or having any activity). Ages were recorded exactly as the difference between their birth dates and the dates of measurements.

BP measurements are based on auscultatory method. An appropriate cuff size was used with an inflatable bladder length that was covering at least 80-100 percent of the arm circumference at the point midway. The stethoscope was placed over the brachial artery pulse and below the bottom edge of the cuff without any contact between cuff and stethoscope. The cuff was being inflated until brachial pulse disappeared. Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) were determined by the onset of the tapping Korotkoff sounds (K1) and established the fifth Korotkoff sound (K5), respectively. BP of each school child was measured once. However, they were randomly checked for second or third time. Time interval between two measurements was at least 30 minutes.

Height related BP charts as adjusted for age and sex were calculated from the following regression formula as used by NHBPEP [3].

Table 1: Summary measures of blood pressure of Shirazi school children

Blood Pressure	Sex	Number	Mean	CV	SD	95% CI	P-value sex difference
Systolic	Boys	1174	92.7	11.2	10.4	92.1-93.3	0.07
	Girls	1096	93.5	12.2	11.5	92.8-94.1	
	All	2270	93.1	11.8	11	92.7-93.6	
Diastolic	Boys	1174	59.1	14.7	8.7	58.6-59.7	0.001
	Girls	1096	60.6	15.1	9.2	60-61.6	
	All	2270	59.8	15	9	59.4-60.2	

SD: standard Deviation; CI: Confidence interval; CV:

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

Where α ; β_1, \dots, β_4 ; $\gamma_1, \dots, \gamma_4$ are the regression model coefficients. μ is the expected SBP or DBP for boys or girls of age y years and height h centimeter. k and j are the multinomial powers that vary from 1 through 4.

Healy-Rasbash-Yang (HRY) [10] nonparametric method was applied to estimate height related smoothed BP percentiles and the goodness of fit of the models were examined and validated. This method makes no assumption about the nature of distribution of the measurement at ages.

Findings

Table 1 presents summary measures of BP of Shirazi school children. Girls' BP including systolic

or diastolic were higher than that of boys and more variable.

Tables 2 and 3 present SBP and tables 4 and 5 present DBP percentile values by age group and height percentiles in Shiraz for boys and girls, respectively. As can be seen from these tables, BP increases by height and age. Correlation coefficients of SBP and DBP by age were calculated as 0.26 ($P < 0.001$) and 0.20 ($P < 0.001$) respectively. A positive correlation between BP and height was estimated at 0.36 ($P < 0.001$) for SBP and 0.27 ($P < 0.001$) for DBP.

Regression analysis showed that on the average SBP increased by 2 mmHg and DBP by 1.3 mmHg ($P < 0.001$) per one year of age. Also on average SBP and DBP increased by 4 mmHg and 2.5 mmHg per each decimeter of the subject's height respectively. However, once the measurements were adjusted for height, no significant correlation was found between either SBP or DBP and age ($r = -0.03$ and $P = 0.15$ for SBP, $r = -0.005$ and $P = 0.8$

Table2: Systolic blood pressure percentiles values by age and height percentiles in 6.5-11.5 years boys Shirazi children

Boys age group	Boys BP percentile	Boys height percentile						
		5	10	25	50	75	90	95
7	90	98.7	99.3	99.8	100.8	102.6	105.1	106.7
	95	102.2	102.8	103.4	104.3	106.2	108.6	110.3
	99	108.9	109.5	110.0	111.0	112.8	115.2	116.9
8	90	99.3	99.9	100.4	101.3	103.1	105.6	107.3
	95	102.8	103.4	103.9	104.8	106.6	109.1	110.8
	99	109.5	110.1	110.6	111.5	113.3	115.8	117.5
9	90	101.9	102.5	103.0	103.9	105.7	108.2	109.8
	95	105.4	106.0	106.5	107.4	109.2	111.7	113.3
	99	112.0	112.6	113.1	114.0	115.8	118.3	119.9
10	90	105.3	105.9	106.5	107.4	109.2	111.7	113.5
	95	108.9	109.5	110.1	111.0	112.8	115.3	117.1
	99	115.5	116.1	116.7	117.6	119.4	121.9	123.7
11	90	105.4	106.0	106.6	107.5	109.3	111.8	113.6
	95	109.0	109.6	110.2	111.1	112.9	115.4	117.2
	99	115.6	116.2	116.8	117.7	119.5	122.0	123.8

BP: Blood Pressure

Table3: Systolic blood pressure percentiles values by age and height percentiles in 6.5-11.5 years girls Shirazi children

Girls age group	Girls BP percentile	Girls height percentile						
		5	10	25	50	75	90	95
7	90	97	98.6	100.4	102.1	104.0	105.9	106.9
	95	100.9	102.5	104.3	106.0	107.9	109.8	110.8
	99	108.2	109.8	111.6	113.3	115.2	117.1	118.1
8	90	99.3	100.8	102.7	104.4	106.3	108.2	109.2
	95	103.0	104.5	106.6	108.3	110.2	112.1	113.1
	99	110.5	112.0	113.9	115.6	117.5	119.4	120.4
9	90	102.4	103.9	105.8	107.5	109.4	111.3	112.3
	95	106.3	107.8	109.7	111.4	113.3	115.2	116.2
	99	114.6	116.1	117.0	118.7	120.6	122.5	123.5
10	90	104.5	106.0	107.9	109.5	111.5	113.4	114.4
	95	108.4	109.9	111.8	113.4	115.4	117.3	118.3
	99	115.7	117.2	119.1	120.7	122.7	124.6	126.6
11	90	105.2	106.8	108.6	110.3	112.3	114.1	115.1
	95	109.1	110.7	112.5	114.2	116.2	118.0	119.0
	99	116.4	118.0	119.8	121.5	123.5	125.3	126.3

BP: Blood Pressure

for DBP). Therefore, BP by height charts was produced to provide BP border of healthiness which should be more realistic, yet reliable than BP by age centiles. Figs 1a and 1b present SBP by height charts of boys and girls respectively. Fig 1c compares boys and girls charts for median and extreme centiles, which shows that boys BP lies under girls BP. Fig. 2a and 2b show DBP by height charts of boys and girls respectively. A comparison of boys and girls DBP is shown in Fig 2c, showing that DBP of girls were higher than that of boys.

Discussion

The assessment of blood pressure and prevention of hypertension in children and adolescents have become a worldwide priority. Because of predictability of adult blood pressure from childhood blood pressure, standard values of blood pressure in childhood were considered in some developed countries. To define a standard for blood pressure in children, the Task Force on Blood Pressure Control in Children in the United

Table 4: Diastolic blood pressure percentiles values by age and height percentiles in 6-12 years boys Shirazi children

Boys Age group	Boys BP percentile	Boys Height percentile						
		5	10	25	50	75	90	95
7	90	65.9	66.3	66.4	66.9	68.4	70.3	71.4
	95	68.9	69.3	69.4	69.9	71.4	73.3	74.4
	99	74.6	75.0	75.1	75.6	77.1	79.0	80.1
8	90	66.1	66.5	66.6	67.0	68.5	70.4	71.5
	95	69.1	69.5	69.6	70.0	71.5	73.4	74.5
	99	74.8	75.1	75.2	75.7	77.2	79.1	80.2
9	90	68.0	68.3	68.4	68.9	70.5	72.4	73.5
	95	71.0	71.3	71.4	71.9	73.5	75.4	76.5
	99	76.7	77.0	77.1	77.6	79.1	81.0	82.1
10	90	70.0	70.3	70.4	70.9	72.4	74.3	75.4
	95	73.0	73.3	73.4	73.9	75.4	77.3	78.4
	99	78.7	79.0	79.1	79.6	81.1	83.0	84.1
11	90	70.3	70.6	70.7	71.2	72.8	74.6	75.6
	95	73.3	73.6	73.7	74.2	75.8	77.6	78.6
	99	79.0	79.3	79.4	79.9	81.5	83.3	84.4

BP: Blood Pressure

Table 5: Diastolic blood pressure percentiles values by age and height percentiles in 6-12 years girls Shirazi children

Girls Age group	Girls BP percentile	Girls Height percentile						
		5	10	25	50	75	90	95
7	90	66.0	67.5	68.8	68.5	69.6	70.8	71.5
	95	69.2	70.7	71.0	71.7	72.8	74.0	74.7
	99	75.2	76.7	77.0	77.8	78.9	80.1	80.8
8	90	68.0	69.2	69.5	70.2	71.3	72.5	73.2
	95	71.2	72.4	72.7	73.4	74.5	75.7	76.4
	99	77.3	78.5	78.8	79.5	80.6	81.8	82.5
9	90	68.6	69.8	70.1	70.8	71.9	73.1	73.8
	95	71.8	73.0	73.3	74.0	75.1	76.3	77.0
	99	77.9	79.1	79.4	80.1	81.2	82.4	83.1
10	90	70.2	71.5	71.7	72.4	73.6	74.7	75.4
	95	73.4	74.7	74.9	75.6	76.8	77.9	78.6
	99	79.5	80.8	81.0	81.7	82.9	84.0	84.7
11	90	70.5	71.7	72.0	72.7	73.8	75.0	75.7
	95	73.7	74.9	75.2	75.9	77.0	78.2	78.9
	99	79.9	81.0	81.3	82.0	83.1	84.3	85.0

BP: Blood Pressure

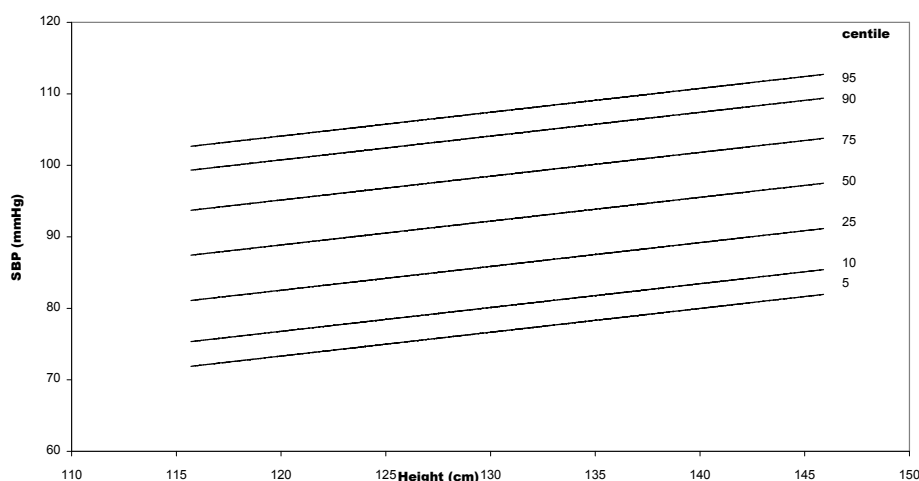
States published a series of reports on blood pressure levels related to age, height and weight from birth to 18 years [1,3]. The distribution of blood pressure levels and the prevalence of hypertension vary with multi factors such as genetic inheritance, dietary habits, life style and environment in different racial and ethnic groups [2,6,8,13]. Based on these variations, reference norms derived for one particular population may not be applicable to others. Local reference data are essential to evaluate observed blood pressure values [17], hence we attempted to provide such standards in this paper.

Our findings show that BP phenomenon should be treated dynamically which may be ethnicity and age dependent. Our results described here are

in support of intermittent updating of BP standards throughout the world.

Ataei and Shajari noted that there was no statistically significant difference between the prevalence of elevated blood pressure between genders [18,19], Hosseini mentioned that mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) were significantly ($P < 0.0001$) higher in boys than in girls especially in older ages [20]. While our findings showed significant difference in diastolic blood pressure (Table 1) that was more salient in the 95th percentile in lower height children (Fig 2c).

Several studies have been carried out on the distribution of BP in relation to age and other determinants. However, a few studies have been

**Fig. 1a:** Systolic blood pressure smoothed centiles by height for Shiraz boys aged 6.5-11.5 years

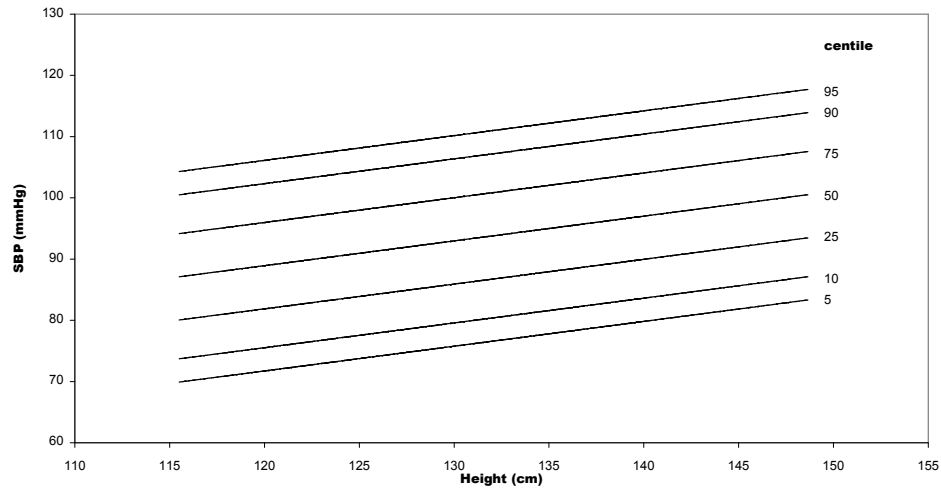


Fig. 1b: Systolic blood pressure smoothed centiles by height for Shiraz girls aged 6.5-11.5 years

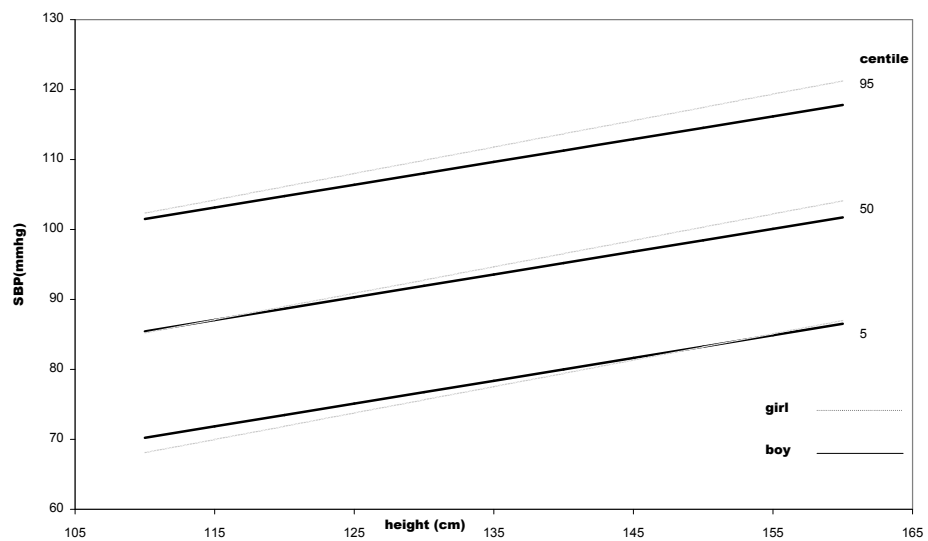


Fig. 1c: Systolic blood pressure smoothed centiles by height comparison between Shiraz boys and girls aged 6.5-11.5 years

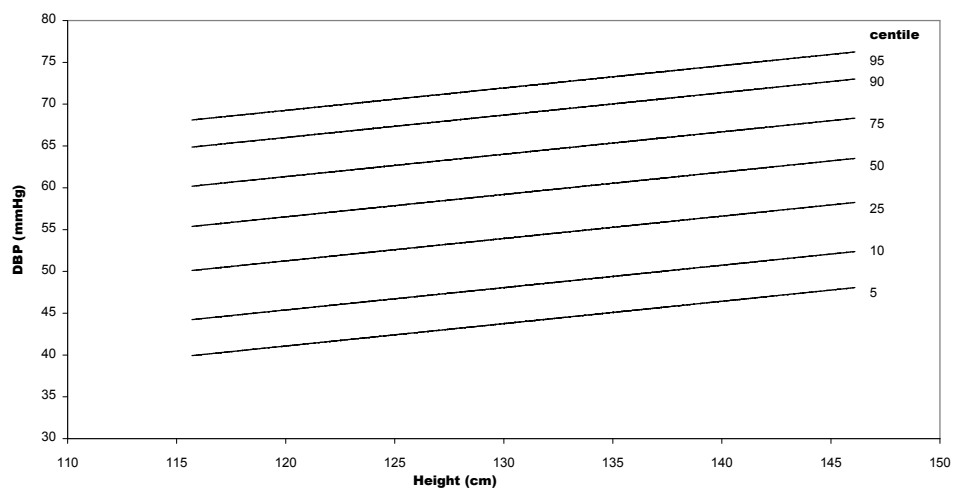


Fig. 2a: Diastolic blood pressure smoothed centiles by height for Shiraz boys aged 6.5-11.5 years

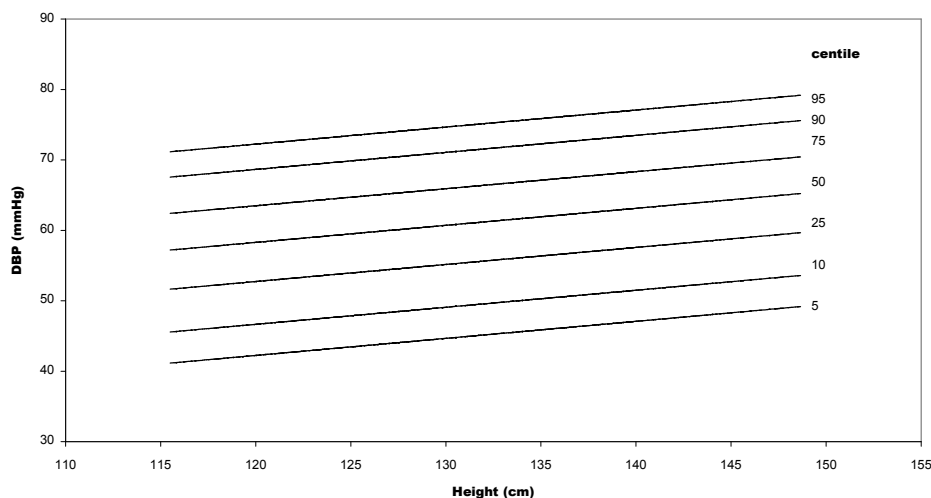


Fig. 2b: Diastolic blood pressure smoothed centiles by height for Shiraz girls aged 6.5-11.5 years

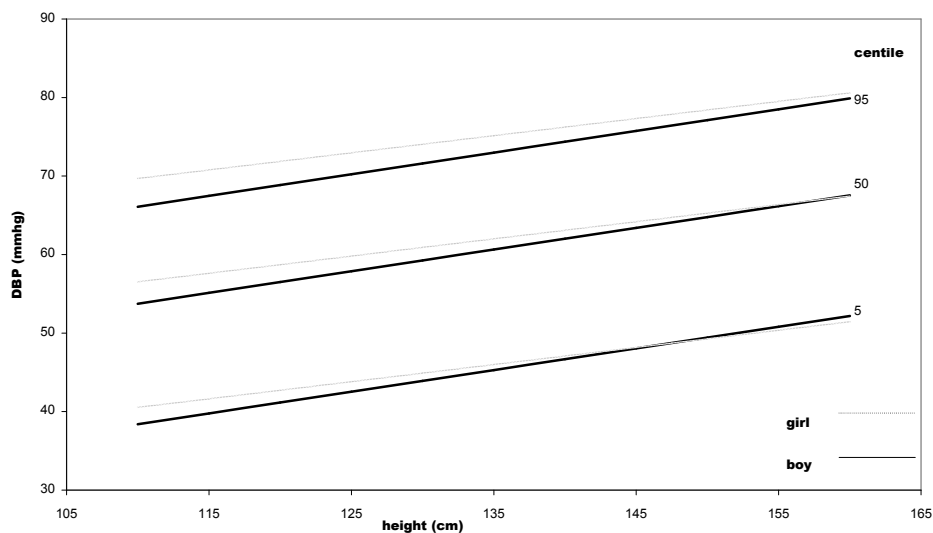


Fig. 2c: Diastolic blood pressure smoothed centiles by height comparison between Shiraz boys and girls aged 6.5-11.5 years

successful in providing height-related BP standards of which our study is one.

Our study showed that SBP and DBP rise as age and height increase in both sexes. This is in agreement with other population-based studies [2,4,5,6]. It can be seen lower height and weight in Shiraz children than American standards [11] and as a result lower BP is expected. However, another study showed that 5-12 years Italian children at 90th and 95th centiles had a BP of 3-5 mmHg higher than the American standards [14]. This is also true for 6.5-11.5 years Turkish boys [15]. However, an Iranian study suggests that BP of 7-12 years children is compatible to their American counterparts [16]. This shows that using an

American standard may be quite misleading, as none of our children would be categorized as hypertensive by the NHBPEP. The height-related BP charts produced in this paper would be an efficient diagnostic tool for clinical work in Iran, which should be validated for other parts of Iran.

Limitations of the study: While it is recommended to use average of multiple blood pressure measurements taken for weeks to months to characterize individual's blood pressure level and standard data for 1-18 year-old population, high cost, limited resources and time, restricted the authors from doing so.

Blood pressure is also influenced by various other factors such as season, time of the day,

ambience, fasting vs. nonfasting state of the subjects etc., which could not be controlled in the study.

Conclusion

This paper provides local reference values and smoothed centiles of blood pressure by height in Shiraz (southern Iran) elementary school children. Ours and other studies show significant variation in BP standards among different populations, supporting the role for the development of individual BP standards throughout the worldwide pediatric population. Because of developing and improvement of health indicator and increasing the level of information and thus changing behavior of population, it is suggested that these reference data should be upgraded periodically. In addition variables such as dietary habits, life style and other blood pressure determinants are suggested for further studies.

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Conflict of Interest: None

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