Blood pressure distribution among healthy schoolchildren aged 6–13 years in Tehran

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توزُّع ضغط الدم بين تلاميذ المدارس الأصحاء في عمر 6-13 عاما، في طهران

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الخلاصة: للحصول على توزُّع ضغط الدم لدى الأطفال الإيرانيِّين، قام الباحثون بتقييم حالة 10288 تلميذاً، تراوحت أعمارهم بين السادسة والثالثة عشرة (4871 تلميذاً و5417 تلميذة) في مدينة طهران. وقد أظهر متوسط ضغط الدم الانقباضي وضغط الدم الانبساطي، زيادة مطَّردة مع تزايُد السن والوزن والطول لدى كلا الجنسين. وكان متوسط الزيادات في ضغط الدم الانقباضي لدى الذكور والإناث، 1.7 و0.8 مم زئبقي لكل سنة من العمر، على التوالي. أما بالنسبة لضغط الدم الانبساطي، فقد كان متوسط الزيادات 0.7 و0.9 مم زئبقي، على التوالي. ووفقاً لمعايير «فريق العمل الثاني»، فقد كان لدى 4.9٪ من الذكور و3.5٪ من الإناث ارتفاع يُعْتَدُّ به إحصائياً في ضغط الدم الانقباضي، وكان لدى 10.1٪ من الذكور و3.3٪ من الإناث ارتفاع يُعْتَدُّ به إحصائياً في ضغط الدم الانبساطي. وكان متوسط ضغط الدم الانقباضي والانبساطي أعلى ممَّا هو وارد في تقارير «فريق العمل الثاني»، ولاسيَّما بين التلاميذ الذكور. وتؤكِّد هذه الدراسة ما ورد في توصيات «فريق العمل الثاني» من ضرورة إجراء قياس دوري ومنتظم لضغط الدم لدى الأطفال الطبيعيِّين.

ABSTRACT To obtain blood pressure distribution for Iranian children, we assessed 10 288 students aged 6–13 years (4871 boys and 5417 girls) in Tehran. Mean systolic and diastolic blood pressure showed incremental increases with age, weight and height in both sexes. Mean increases in systolic blood pressure for boys and girls were 1.7 and 0.8 mmHg per year respectively and for diastolic blood pressure were 0.7 and 0.9 mmHg respectively. According to Second Task Force (STF) criteria, 4.9% of boys and 3.5% of girls had significant systolic hypertension and 10.1% of boys and 3.3% of girls had significant diastolic hypertension. Mean systolic and diastolic blood pressures were higher than STF reports, especially among boys.

Distribution de la pression artérielle chez des écoliers en bonne santé âgés de 6 à 13 ans à Téhéran

RÉSUMÉ Afin d'obtenir la distribution de la pression artérielle pour les enfants iraniens, nous avons évalué 10 288 élèves âgés de 6 à 13 ans (4871 garçons et 5417 filles) à Téhéran. La pression artérielle systolique et diastolique moyenne montrait une augmentation progressive avec l'âge, le poids et la taille chez les deux sexes. L'augmentation moyenne de la pression artérielle chez les garçons et les filles était de 1,7 et 0,8 mmHg par an respectivement pour la pression systolique et de 0,7 et 0,9 mmHg respectivement pour la pression diastolique. Selon les critères du deuxième Groupe de travail, 4,9 % des garçons et 3,5 % des filles présentaient une hypertension systolique significative et 10,1 % des garçons et 3,3 % des filles présentaient une hypertension diastolique significative. La pression artérielle systolique et diastolique moyenne était supérieure aux valeurs indiquées par le deuxième Groupe de travail, notamment chez les garçons.

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Introduction

Systemic hypertension occurs commonly in adults and if untreated is a major risk factor for myocardial infarction, stroke and renal failure [*1*]. Although the prevalence of clinical hypertension is of far lesser magnitude in children than adults, there is ample evidence to support the concept that the roots of essential hypertension extend back into childhood, and if hypertension exists, it may track into adulthood [*1–4*]. Children and young adolescents with blood pressure greater than the 90th percentile for age are 3 times more likely to become adults with hypertension than are children with blood pressure at the 50th percentile [*1*].

Blood pressure measurement of children is important. Hypertension in children is mostly secondary and this may be due to renal disease, coarctation of the aorta, endocrine disorders or medication. The underlying disease process should be controlled in order to prevent and treat hypertension [*1*]. To increase early detection of hypertension, accurate blood pressure measurements should be a part of routine annual physical examinations for all children and not just isolated procedures [*1*].

Hypertension in children is diagnosed as high blood pressure for age, sex and body size [*2*]. Blood pressure increases gradually with age and varies with sex; therefore, standard nomograms for each age–sex group are necessary to interpret blood pressure values [*2*]. Moreover, the distribution of blood pressure levels varies in different ethnic groups [*5,6*]. Using Second Task Force recommended cut-off points, many countries have established curves for different age–sex groups [*2,7–12*].

Since there are only limited data available for blood pressure distribution in the Islamic Republic of Iran [*13*], we determined the distribution of blood pressure among schoolchildren aged 6–13 years in Tehran.

Methods

We selected 10 288 students (4871 boys and 5417 girls) by multistage cluster sampling from 125 schools of all the 19 departments of education and training in Tehran over 18 months during the 1998–1999 and 1999–2000 school years. A protocol was established for the examination of the children according to the Second Task Force and World Health Organization guidelines [*2,3*]. The Ethics Committee of the University of Tehran, the Medical Sciences Research Deputy and the Health Office of the Ministry of Education and Training approved the protocol of our study.

The protocol of our study was explained to the interviewers who were either general practitioners or medical students. In 3 sessions of 2 hours each, one of the investigators (a paediatrician) trained the interviewers so that they could take measurements in the same way and under similar circumstances. The inter-rater variation was determined to be negligible at the end of training. Four teams equipped with the necessary measuring tools visited the schools and a control set of equipment was kept at the university. At about 10-day intervals, measurements were taken with 2 sets, i.e. each team’s set and the set kept at the university, to verify consistency. During the study, differences between the readings were very small and all manometers functioned properly.

Measurements were taken in a quiet room in each school. The aim of the study and the procedure were described to the students. Height was measured to the nearest 0.5 cm without shoes. Weight with minimal clothing was recorded using a bath scale to the nearest 0.5 kg. A mercury sphygmomanometer (Riester, Germany) was used to measure blood pressure on the student's right arm while seated. Two measurements were taken at a 10-minute interval. Small, medium and large children's cuffs were available to the teams to be used as appropriate for the length and circumference of each arm. The systolic blood pressure was recorded when the first Korotkoff (K) sound was heard. Two diastolic blood pressure readings were recorded on hearing K4 and K5 sounds. Pulse rate per minute was recorded twice. The average of the 2 readings was taken as blood pressure and pulse rate.

For children aged 6–9 years, significant hypertension and severe hypertension were defined as systolic blood pressure greater than 122 mmHg and 130 mmHg and diastolic blood pressure greater than 78 mmHg and 86 mmHg respectively [*2*]. Significant and severe hypertension in children aged 10–12 years was defined as systolic blood pressure greater than 126 mmHg and 134 mmHg and diastolic blood pressure greater than 82 mmHg and 90 mmHg respectively [*2*].

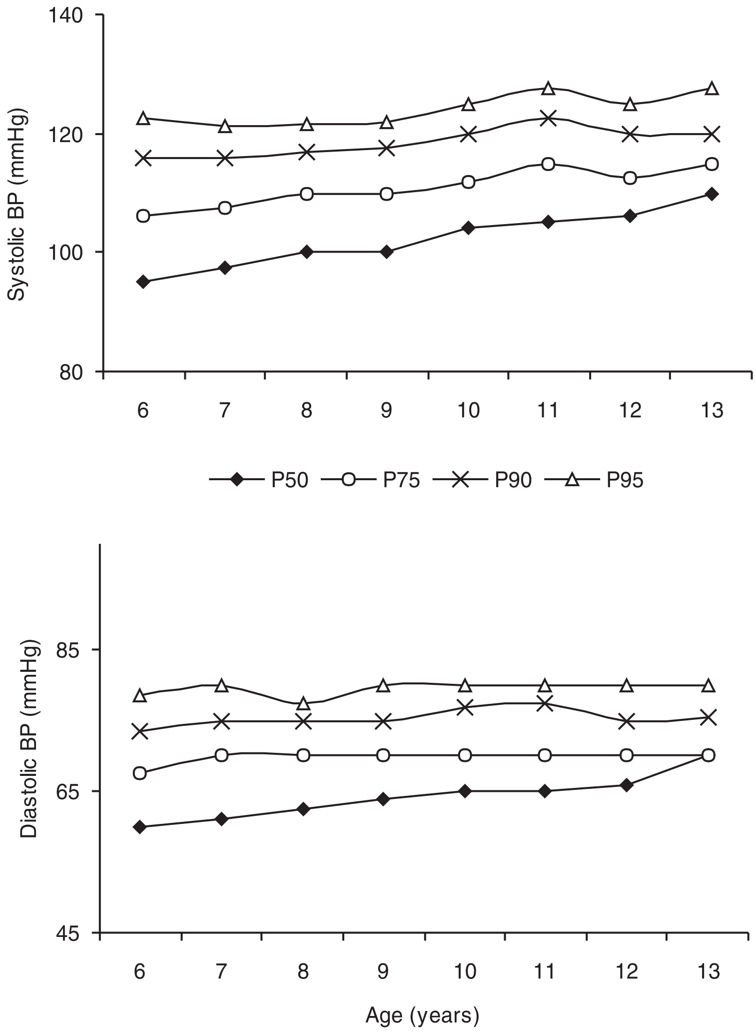
For each child, the data were recorded on a separate form and quality controlled by the investigators. *Epi-Info*, version 6 and *SPSS*, version 10 were used for data entry and statistical analysis.

Results

Table 1 shows the distribution of the children by age and sex. Figures 1 and 2 show that there was an overall incremental increase in diastolic and systolic blood pressure with age, height and weight for both girls and boys. However, among boys, the mean systolic blood pressure dipped slightly at 8 years. Mean systolic blood pressure in girls showed an increasing trend for all ages. Diastolic blood pressure in boys increased with age until 11 years when it dipped slightly, then rose at 12 years and dipped again at 13 years. Also among girls aged 12–13 years, mean diastolic blood pressure was less than among those aged 10 years at the 90th centile. The average increase in systolic blood pressure levels per year was 1.7 mmHg and 0.8 mmHg in girls and boys

Table 1 **Distribution of 10 288 students in Tehran by age and sex**

Age	Boys		Girls		Total	
(years)	No.	%	No.	%	No.	%
6	457	9.4	350	6.5	807	7.8
7	727	14.9	717	13.2	1444	14.0
8	715	14.7	820	15.1	1535	14.9
9	774	15.9	868	16.0	1642	16.0
10	684	14.0	887	16.4	1571	15.3
11	649	13.3	817	15.1	1466	14.2
12	639	13.1	761	14.0	1400	13.6
13	226	4.6	197	3.6	423	4.1
Total	4871	100.0	5417	100.0	10288	100.0

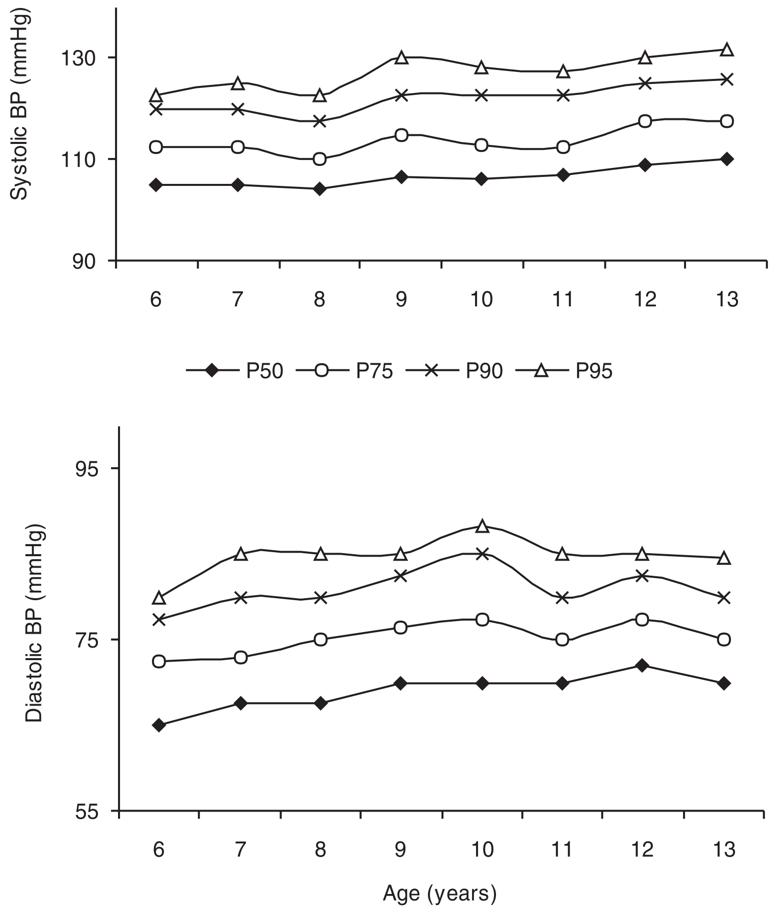


50th percentile								
Weight	22	23.5	25.5	29	31	36	41	41
Height	120	124	128	134	140	146.8	152.5	154.5

Figure 1 **Systolic and diastolic percentiles of blood pressure in girls by age**

respectively and for diastolic blood pressure it was 0.7 mmHg and 0.9 mmHg for boys and girls respectively.

Frequencies of significant and of severe hypertension were calculated according to Second Task Force report criteria (Tables



50th percentile								
Weight	22	23.5	25.5	29	31	36	41	41
Height	121	124	129	134	139	144	150	152

Figure 2 **Systolic and diastolic percentiles of blood pressure in boys by age**

2 and 3) [*2*]. In our study, 4.9% of boys and 3.5% of girls had significant systolic hypertension; 10.1% of boys and 3.3% of girls had significant diastolic hypertension respectively. Severe systolic hypertension was found in 2.0% and 0.9% of boys and girls respectively and severe diastolic hypertension in 2.3% and 0.5% of boys and girls respectively.

The correlation coefficients for systolic and diastolic blood pressure with weight, height, age and pulse rate were calculated for each sex individually (Table 4). A significant correlation was found between

Table 2 **Frequency of significant and severe hypertension in girls**

Age (years)	Number	Significant hypertension Systolic		Significant hypertension Diastolic		Severe hypertension Systolic		Severe hypertension Diastolic	
		No.	%	No.	%	No.	%	No.	%
6	350	16	4.6	13	3.7	2	0.6	4	1.1
7	717	24	3.3	33	4.6	8	1.1	8	1.1
8	820	27	3.3	36	4.4	7	0.9	3	0.4
9	868	35	4.0	44	5.1	7	0.8	6	0.7
10	887	29	3.3	20	2.3	10	1.1	3	0.3
11	817	39	4.8	19	2.3	8	1.0	1	0.1
12	761	16	2.1	11	1.4	8	1.1	1	0.1
13	197	1	0.5	1	0.5	1	0.5	0	0.0
Total	5417	187	3.5	177	3.3	51	0.9	26	0.5

Table 3 **Frequency of significant and severe hypertension in boys**

Age (years)	Number	Significant hypertension Systolic		Significant hypertension Diastolic		Severe hypertension Systolic		Severe hypertension Diastolic	
		No.	%	No.	%	No.	%	No.	%
6	457	31	6.8	29	6.3	5	1.1	6	1.3
7	727	36	5.0	70	9.6	13	1.8	18	2.5
8	715	29	4.1	78	10.9	8	1.1	17	2.4
9	774	57	7.4	106	13.7	24	3.1	37	4.8
10	684	24	3.5	74	10.8	17	2.5	18	2.6
11	649	25	3.9	53	8.2	10	1.5	8	1.2
12	639	32	5.0	74	11.6	18	2.8	6	0.9
13	226	3	1.3	6	2.7	2	0.9	3	1.3
Total	4871	237	4.9	490	10.1	97	2.0	113	2.3

Table 4 **Correlation coefficients between developmental variables and blood pressure in boys and girls**

Variable	Boys Weight	Boys Height	Boys Age	Boys Pulse	Girls Weight	Girls Height	Girls Age	Girls Pulse
Systolic BP	0.30	0.23	0.14	0.07	0.39	0.33	0.26	0.11
Diastolic BP (K4)	0.24	0.19	0.17	–0.12	0.27	0.21	0.15	0.08
Diastolic BP (K5)	0.24	0.20	0.18	–0.16	0.26	0.21	0.15	–0.01

BP = blood pressure.

Weight, height, age and pulse rate all were significantly correlated with both systolic and diastolic blood pressure for both sexes ($P < 0.05$).

Table 5 **Mean pulse rates of boys and girls**

Age (years)	Mean pulse rate (beats/min) Boys	Girls
6	99.97	95.18
7	99.03	92.99
8	97.01	93.04
9	94.69	91.66
10	93.40	91.18
11	90.49	89.91
12	88.97	88.67
13	88.22	88.48
Total	94.38	91.40

systolic and diastolic blood pressure and all these factors for both sexes.

Table 5 shows that the mean pulse rate of girls and boys in each age group decreased gradually with age.

Discussion

The prevention of high blood pressure may be viewed as part of the prevention of coronary artery disease and stroke. Blood pressure measurements should be included in physical examinations as part of continuing care for children, and not just as isolated procedures [*1*]. The goal in caring for children is surveillance, possible prevention and identification of fixed hypertension requiring treatment when such cases cannot be prevented [*2*].

In our study, blood pressure, weight, height and pulse rate of children aged 6–13 years were measured according to Second Task Force recommended cut-offs to establish normal blood pressure curves for Iranian children [*2*].

Blood pressure increased gradually with age for both boys and girls in our study. This was consistent with a study in Qazvin, a city near Tehran [*13*]. This also agreed with the Second Task Force report that blood pressure increases with age during the pre-adult years in all study populations [*2*]. Others have also reported that blood pressure increased with age [*14–17*]; however, some Japanese studies have only found correlations between diastolic blood pressure and age [*10,18*].

Systolic blood pressure in our study was higher among boys of all ages than girls (chi-squared test, $P < 0.01$). The mean systolic blood pressure differences between boys and girls in the youngest and oldest age groups were about 5.5 mmHg and 1 mmHg respectively. In a study of children aged 8–16 years, mean blood pressure was higher among girls [*16*]. In contrast, Hansen et al. reported no significant difference in mean blood pressure between the sexes for children aged 8–10 years [*17*]. Others have reported no significant difference in blood pressure between boys and girls from 1 day to 6 years of age or among preschool children [*10,14*].

Blood pressure was positively correlated with weight and height in our study. According to the Second Task Force report in different study populations, larger children, i.e. heavier and/or taller children, had higher blood pressure than smaller children of the same age [*2*]. One study of children aged 8–16 years showed a positive correlation between blood pressure, body weight, height and an index of obesity [*16*]. Hansen et al. found that weight was an important determinant of blood pressure in Danish children aged 8–10 years [*17*]. In a 1992 study among children aged 9–11 years, those with high blood pressure, i.e. higher than or equal to the 95th percentile, were heavier and more obese than the normal group [*19*].

In our study, pulse rate decreased gradually with age. This was consistent with both the findings of a study of school children in Qazvin and a study of preschool children in Japan [*10,13*].

In our study, significant systolic hypertension was prevalent in 4.9% of boys and 3.5% of girls. In the Qazvin study, the prevalence of high blood pressure among children aged 7–12 years was 6.9% using Second Task Force recommended cut-offs [*2,3*]. In a study in Papua New Guinea, 5.1% of children aged 8–10 years had high blood pressure [*16*]. Furthermore, overall prevalence of hypertension has been reported at 2.93% among Indian children aged 5–14 years [*9*].

In our study, mean systolic and diastolic blood pressures of the sample were higher than reported by the Second Task Force, especially among boys. This agreed with reports of higher blood pressure among children of this age in the western part of our country and in Turkey compared with values reported by the Second Task Force [*13,15*]. Those 2 reports also indicated higher blood pressures and prevalence of hypertension among boys than among girls. It may be that the higher blood pressure of adult males compared with adult females originates from this age and may be attributed to different psycho-hormonal structures in males and females. Both the systolic and the diastolic blood pressures of Spanish children aged 2–14 years were lower than means reported by the Second Task Force [*12*]. However, in a study of first-grade schoolchildren in Germany, the data fit very well with Second Task Force recommended cut-offs [*8*].

Conclusion

We measured blood pressure, height and weight of schoolchildren aged 6–13 years in Tehran. Blood pressure was highly associated with age, height and weight. Our findings can help establish normal blood pressure curves to be used in paediatric clinics, because almost 20% of the Iranian population lives in Tehran and the sample of our study may be highly representative of Iranian children. Normal blood pressure values in our study are higher than reported by the Second Task Force, but this difference agrees with the STF recommendation regarding the importance of determining normal blood pressure in each country.

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