

Prevalence of Prehypertension and Hypertension in a Nationally Representative Sample of Iranian Children and Adolescents: The CASPIAN-IV Study

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ABSTRACT

Background: The global health burden has faced toward non-communicable diseases (NCDs). It is suggested that adulthood blood pressure (BP) is tracked from childhood. This study aims to evaluate the mean BP and the prevalence of prehypertension and hypertension in the Iranian pediatric population.

Methods: In a national survey as the 4th phase of Childhood and Adolescence Surveillance and Prevention of Adult Non-communicable diseases study and through random multistage cluster sampling, a national sample of Iranian school students, aged 6-18 years, were recruited. Data gathered by means of modified World Health Organization Global school-based student health survey questionnaire, a weight disorders determinants questionnaire and anthropometric and BP measurements. Prehypertension (HTN) was defined as BP equal or greater than 90th age and sex specific percentile or $\geq 120/80$ mmHg and HTN was defined as BP $\geq 95^{\text{th}}$ percentile.

Results: A total of 13486 students entered the study (49.2% girls, 75.6% urban). Mean age of participants was 11.47 ± 3.36 years. A total rate of 4.17% (3.84-4.52 95% CI) for high systolic BP (SBP), 4.33% (3.99-4.68) for high diastolic BP (DBP) and 6.88% (6.45-7.32) for high SBP and/or DBP was depicted.

Conclusions: The prevalence rate of high BP (pre-HTN together with HTN) is substantially high in this population. It is needed to study the causative situations and implement relevant interventions.

Keywords: Adolescent, blood pressure, child, hypertension, Iran, pre-hypertension

INTRODUCTION

High blood pressure (HBP) is the top global disease burden risk factor.^[1] The action plan of the World Health Organization (WHO) for prevention and control of non-communicable diseases (NCDs) in 2013-2020 has aimed a 25% relative reduction in the prevalence of HBP.^[2]

Research derived evidences have proposed the idea of

developmental origins of health and disease.^[3] In addition to the effects of fetal programming, several factors determine the blood pressure (BP) level in childhood, which is associated with the adult BP level through the “tracking” phenomenon. Hence, the prevention of NCDs, namely cardiovascular diseases in adulthood should begin from childhood.^[4-7] In addition, HBP in childhood may induce target organ damages, such as left ventricular hypertrophy, thickening of the carotid vessel wall, retinal vascular changes, subtle cognitive changes,^[8] and even premature development of atherosclerosis.^[9]

Prevalence of HBP is increasing in the pediatric population in accordance with the childhood obesity epidemic and life-style widespread changes.^[8] Alarming data exist on the considerable prevalence of childhood overweight and its metabolic consequences, not only in industrialized countries, but also in developing countries.^[10] The strong relationship of even early stages of HBP (pre-hypertension [HTN], pre HTN) with obesity and environmental factors, as air pollution, noise pollution and passive smoking suggest that its prevalence will be escalating.^[11] In the transitional state communities with rapid urbanization, most risk factors identified for pediatric HBP are modifiable by life-style change, moreover monitoring of their time-trend is of significant importance.^[12,13]

Iran is a developing country of the Middle East and North Africa region. The country health burden is facing from communicable diseases to NCDs and road accidents.^[14] NCDs have a remarkable prevalence among Iranian adults,^[15,16] and the risk factors of NCDs are quite prevalent in Iranian children and adolescents.^[17-19] High systolic blood pressure (SBP) has been recognized responsible for most deaths in all regions of Iran.^[20] Limited experience exists on evaluating NCDs risk factors such as HBP in Iranian pediatric population at national level. Considering the aforementioned importance of pediatric health status and inspired by WHO recommendations, a national ongoing school based surveillance system for health risk and protective factors named Childhood and Adolescence Surveillance and Prevention of Adult Non-communicable diseases (CASPIAN) study was established in Iran. The current study aims to determine the BP mean and percentiles, as well as and

the prevalence of HBP in a nationally representative sample of Iranian children and adolescents.

METHODS

Study design, population and sampling

CASPIAN study is a school-based surveillance program.^[21,22] It has been conducted in four succeeding phases from 2003 to 2012.^[17,23-25] We have previously described the methods of the 4th phase in details,^[25] and here we present it in brief.

CASPIAN-IV study is a national cross-sectional survey conducted during the year 2011-2012 in 30 provinces of Iran. The study population comprised of 19 to 18-year old school students equally from both genders. A total sample size of 14,880 was determined to cover all study objectives and then was divided proportionally to population size of urban and rural areas and equally in three educational levels (elementary, intermediate and high school). Multistage random cluster sampling was used to recruit subjects. Clusters were the individual schools and it was scheduled to obtain 10 sampling units (students with their parents) in each of 48 randomly selected schools for every province.

Procedures and measurements

Questionnaires

The students' questionnaires were based on the WHO Global School-based student Health Survey (GSHS) program^[21] by adding some questions. A questionnaire was also designed for parents. Details regarding the questionnaires are described before.^[22,24-26] These scales are comprehensive and can assess many different aspects of students' health as demographic data, diet, physical activity, smoking, violence and other risky behaviors, medical history, family characteristics, relation with parents and peers, etc., Supervision on the whole project was considered by principal investigators at national and sub-national levels.

Physical measurements

Anthropometric measures consisting height, weight, hip, waist and wrist circumferences were measured according to the standard protocols. Then, body mass index, waist to hip and waist to height ratios were calculated.

BP was measured by expert health care professionals using standardized and calibrated mercury sphygmomanometers in a sitting position from the right arm. With the zero point of manometer at the level of the student's heart, appropriate size cuffs were used considering cuff bladders covering 80-100% of the arm circumference and approximately two-thirds of the length of the upper arm without overlapping. After enough rest for the subject to calm down, BP readings were taken twice for each person with 5 min interval. The readings at the first Korotkoff sound were considered as the SBP and at the fifth sound as the diastolic blood pressure (DBP). The average of duplicate measurements was recorded and included in the analysis.^[25]

Definitions

HBP was categorized as pre HTN and HTN. Pre HTN was considered as BP equal or greater than the age- and gender-specific 90th percentile after adjusting for weight and height or BP equal or more than 120/80 mmHg according to the Fourth Report of the working group (formerly task force) on Blood Pressure Control in Children, commissioned by the National Heart, Lung and Blood Institute of the National Institutes of Health of America. When BP was equal or over the age- and gender-specific 95th percentile value, it was considered as HTN.^[27]

Ethical considerations

The study was approved by national and discrete regulatory organizations of the ministry of education and institutional ethical and scientific review boards. Clear explanation of the study aims and methods anteceded taking written informed consent from parents and verbal assent from students. Data were handled confidentially and de-identified. Each subject had the right to withdraw his/her consent at any time. The project was completely free of charge for all participants

Statistical analysis

Statistical analysis was performed using survey data analysis methods by the Stata software: StataCorp. 2011. Stata statistical software: Release 12. College Station, TX: StataCorp LP. $P < 0.05$ was considered as the level of significance. For quantitative measures, mean and standard deviations (SD) with 95% confidence intervals (CIs) were calculated. For nominal or categorical variables, frequencies and prevalence rates with the same CI were recorded. Student *t*-test and Chi-square tests were used for

comparing that data between relevant groups, where applicable. Missing data were not included in the analyses.

RESULTS

Overall, 13486 out of 14880 invited students with a response rate of 90.6% participated in the study. Participants consisted of 6640 girls (49.2%) and 6846 boys (50.8%) with one of their parents, 75.6% from urban areas. Nearly 46% of them were elementary school, 25.9% intermediate school and 28.1% high school students. Mean (SD) age of participants was 11.47 (3.36) years, without significant difference between boys (12.36 [3.39] years) and girls (12.58 [3.32] years).

As you can be seen in Table 1, the mean (SD) SBP of all participants was 101.52 (13.46) mmHg and their mean DBP was 64.88 (11.41) mmHg. The BP percentiles of participants are also presented in this table.

Overall, the prevalence rate (95% CI) of pre HTN was 3.25% (2.79-3.8) for SBP (in 13367 measures), 1.25% (0.98-1.6) for DBP (in 13349 measures) and 3.13% (2.71-3.62) for SBP and/or DBP (in 13350 measures). The corresponding figures for HTN were 0.92% (0.73-1.16), 3.08% (2.58-3.67) and 3.75% (3.21-4.36), respectively. These together yield a total rate of 4.17% (3.84-4.52) for elevated SBP, 4.33% (3.99-4.68) for elevated DBP and 6.88% (6.45-7.32) for elevated SBP and/or DBP.

As shown in Table 2, Chi-square test showed that the prevalence rates of pre HTN and HTN were different in terms of gender and were significantly higher in boys than in girls.

The prevalence rates of elevated levels of SBP and SBP and/or DBP were significantly higher in urban than in rural residents too [Table 3].

DISCUSSION

The current nationwide survey revealed a substantially high prevalence rate for HBP among Iranian children and adolescents. By considering the additive prevalence of pre HTN and HTN, the prevalence rate of high SBP and/or DBP was 6.88%; and isolated high SBP and DBP were documented in 4.17% and 4.33% of participants, respectively. In the previous phase of this nationwide study, 5.35% of children and adolescents had BP levels equal or more than the 90th percentile values.^[18]

Table 1: Blood pressure and anthropometric measures of participants: The CASPIAN-IV study

	DBP (mmHg)	SBP (mmHg)	Wrist circumference (cm)	Hip circumference (cm)	Waist circumference (cm)	Height (cm)	Weight (kg)	Age (year)	Waist to height ratio	BMI (kg/m ²)
Valid number	13349	13367	13350	13384	13405	13379	13412	13482	13368	13350
Mean	88.64	52.101	14.76	80.78	67.02	146.99	42.4	12.47	0.45	18.85
SD	11.41	46.13	1.78	16.57	11.96	18.1	17.06	3.63	0.36	4.41
Minimum value	30	50	10	24	20.5	70	12	6	0.15	10.08
Maximum value	140	200	25	80.9	189	196	152.3	23	1.27	50.9
5 th percentile	50	80	12	61	51.5	118	20	7	0.37	13.61
10 th	50	85	12.5	64	54	122	22.2	8	0.39	14.26
20 th	60	90	13	68	57	129	26	9	0.41	15.18
30 th	60	95	13.7	72	60	135	30	10	0.42	16
40 th	60	100	14	76	62.54	142	35	11	0.43	16.97
50 th	60	100	14.9	80.2	65	149	40	12	0.44	18.02
60 th	70	105	15	85	68.5	154	46	14	0.46	19.1
70 th	70	110	16	88.5	72	158.5	51	15	0.47	20.34
80 th	75	110	16.2	93	76	163	57	16	0.5	22.14
85 th	80	115	17	95	79	166	60	16	0.51	23.12
90 th	80	120	17	98	83	170	65	17	0.53	24.65
95 th	80	120	18	103	89	175	72.5	18	0.56	26.98

CASPIAN=Childhood and adolescence surveillance and prevention of Iranian adult non-communicable diseases, SBP=Systolic blood pressure, DBP=Diastolic blood pressure, BMI=Body mass index, SD=Standard deviation

Table 2: Prevalence of different categories of blood pressure according to gender: the CASPIAN-IV study

Variable	Category	Females			Males		
		N	Prevalence (%)	95% CI	N	Prevalence (%)	95% CI
SBP	Normal	6426	97.69	97.04-98.2	6383	94.02	92.92-94.96
	Prehypertension	114	1.73	1.34-2.24	321	4.73	3.94-5.67
	Hypertension	38	0.58	0.36-0.92	85	1.25	0.97-1.62
	Total	6578	100	-	6789	100	-
	P value	<0.00001					
DBP	Normal	6351	96.58	95.62-97.33	6420	94.79	93.71-95.69
	Prehypertension	61	0.93	0.67-1.28	106	1.57	1.13-3.16
	Hypertension	164	2.49	1.83-3.39	247	3.65	2.96-4.49
	Total	6575	100	-	6773	100	-
	P value	0.01					
Both SBP and DBP	Normal	6246	94.98	93.88-95.9	61.86	91.32	89.99-92.49
	Prehypertension	137	2.08	1.66-2.62	281	4.15	3.47-4.95
	Hypertension	193	2.93	2.23-3.85	307	4.53	3.78-5.43
	Total	2576	100	-	6774	100	-
	P value	<0.00001					

SBP=Systolic blood pressure, DBP=Diastolic blood pressure, CI=Confidence interval, CASPIAN=Childhood and adolescence surveillance and prevention of Iranian adult non-communicable diseases

The increased rate in the current phase of this study may be attributable to unhealthy life-style

and nutritional patterns and low physical activity levels in the pediatric age group.

Table 3: Prevalence of different categories of blood pressure according to the living area: The CASPIAN-IV study

Variable	Category	Rural			Urban		
		N	Prevalence (frequency) (%)	95% CI	N	Prevalence (frequency) (%)	95% CI
SBP	NI	3213	98.35	97.32-98.99	9596	95.01	94.2-95.71
	Prehypertensive	42	1.29	0.73-2.26	393	3.89	3.31-4.57
	Hypertensive	12	0.37	0.19-0.7	111	1.10	0.86-1.4
	Total	3267	100	-	10100	100	-
	P value	<0.00001					
DBP	NI	3140	96.17	94.35-97.42	9631	95.51	94.7-96.19
	Prehypertensive	28	0.86	0.39-1.85	139	1.38	1.06-1.79
	Hypertensive	97	2.97	1.91-4.59	314	3.11	2.58-3.76
	Total	3265	100	-	10084	100	-
	P value	0.52					
Both SBP and DBP	NI	3111	95.28	93.44-96.63	9321	92.42	91.41-93.33
	Prehypertensive	45	1.38	0.85-2.22	373	3.70	3.18-4.3
	Hypertensive	109	3.34	2.23-4.97	391	3.88	3.29-4.57
	Total	3265	100	-	10085	100	-
	P value	0.002					

SBP=Systolic blood pressure, DBP=Diastolic blood pressure, CI=Confidence interval, CASPIAN=Childhood and adolescence surveillance and prevention of Iranian adult non-communicable diseases

Other studies about HBP in Iranian children and adolescents have been conducted in some cities and no other nationwide study has been performed on pediatric cardio-metabolic risk factors. A series of nationwide studies conducted among Iranian adult population, entitled the Survey of Risk Factors of NCDs included individuals with 15-65 years of age.^[28] Their results are reported in 10 years age groups, e.g., 15-24 year-old group and according to adults' definitions, therefore their results are not comparable with the CASPIAN studies.

By considering the cut point $\geq 95^{\text{th}}$ percentile to define HTN, the prevalence of HTN would be expected to be around 5% and in fact 1-3% following the recommended three separate measurements in children with an initial BP measurement $\geq 95^{\text{th}}$ percentile.^[8] However, different prevalence rates in children and adolescents are reported around the world. For instance, the prevalence of systolic and diastolic hypertension in Sousse, Tunisia, was reported as 6.4% and 4.5%, respectively.^[29] In Germany, the prevalence of HBP was 13% according to national standard curves and 2% according to the definition proposed by the International Diabetes Federation for metabolic

syndrome.^[30] In Portugal, pediatric HTN had prevalence of 2-5%.^[31] In adolescents of Texas, United States of America (USA), the prevalence rates of HTN and pre HTN are reported as 3.2% and 15.7%, respectively.^[32] In another study in the USA, a remarkable proportion of youths (6.9%) had HTN or nearly met its definition.^[33] Two other studies in USA reported different prevalence rates, in one of them, 12.7% of youths had pre HTN and 5.4% had HTN,^[34] whereas in another study, these rates were 3.4% and 3.6%, respectively.^[35] These differences between studies can be explained by racial, ethnic^[36] and genetic issues, different socio-economic states, environmental circumstances, as well as dietary and physical activity habits of participants.^[37]

In the current study, significant gender difference was documented in the frequency distribution of HBP, with higher prevalence rates of pre HTN and HTN in boys than in girls. This finding is consistent with a longitudinal study that showed the risk of developing persistent HTN is higher in boys than it is for girls.^[38] However, in the previous survey of the CASPIAN study, the prevalence of HBP was higher in girls than in boys.^[18] Another survey did not detect any difference in terms of

gender for the prevalence of HBP in the pediatric age group.^[30] The gender differences documented in some studies may be explained by various factors as pubertal status, as well as physical activity and dietary patterns.

In the current study, significant differences existed in the frequency distribution of HBP according to the living area. Elevated SBP and elevated SBP and/or DBP were more prevalent in urban than in rural residents. Such difference was not documented for elevated DBP. Some studies in other populations have reported conflicting results in this regard. In a study in India, the prevalence rates of pre HTN and HTN were 2.9% and 2.8% in urban children and 2.8% and 2% in rural children, without statistically significant difference between them.^[39] Likewise, in another region of India, 5.9% of children had HTN and 12.3% had pre HTN, with comparable rates of elevated BP in urban and rural areas.^[40] Contrary to their findings, in Ghana, rural children showed lower rates of HTN than urban children.^[41] In contrast, in a study in children living in the rural area of Alabama, USA, the prevalence rates of pre-HTN and HTN were 6.7% and 14.9%, respectively, which shows much higher rates than our study.^[42] Lower rates of HBP in rural residents is probably due to a better life-style including healthier dietary and physical activity habits and lower mental stress and pollutants levels in rural than in urban areas. However as the Alabama study shows, the situation is not always the same.

It must be remembered that the definition of HBP in the pediatric population is based on the age- and gender-specific BP percentiles. Due to regional differences in the BP percentiles, using various definitions for HBP, different distribution of reference BP data and difficulties in the measurement of BP in children including the necessity of using appropriate cuff size, the findings of different studies may show some variations.^[8,30]

Overall, the level and pattern of HBP in children and adolescents which we studied needs attention.

CONCLUSIONS

The prevalence rate of HBP including pre-HTN and HTN is noteworthy in the pediatric population of Iran. Screening and tracking BP from childhood is of crucial importance. It is necessary to use national standards for BP percentiles and design

and implement targeted interventions based on research findings for various age groups.

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