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A survey of blood pressure in Lebanese children and adolescence

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Abstract

Background: Blood pressure varies between populations due to ethnic and environmental factors. Therefore, normal blood pressure values should be determined for different populations. **Aims**: The aim of this survey was to produce blood pressure nomograms for Lebanese children in order to establish distribution curves of blood pressure by age and sex. **Subjects and Methods:** We conducted a survey of blood pressure in 5710 Lebanese schoolchildren aged 5 to 15 years (2918 boys and 2792 girls), and studied the distribution of systolic and diastolic blood pressure in these children and adolescents. Blood pressure was measured with a mercury sphygmomanometer using a standardized technique. **Results:** Both systolic and diastolic blood pressure had a positive correlation with weight, height, age, and body mass index (r= 0.648, 0.643, 0.582, and 0.44, respectively) ($P < .001$). There was no significant difference in the systolic and diastolic blood pressure in boys compared to girls of corresponding ages. However, the average annual increase in systolic blood pressure was 2.86 mm Hg in boys and 2.63 mm Hg in girls, whereas the annual increase in diastolic blood pressure was 1.72 mm Hg in boys and 1.48 mm Hg in girls. The prevalence of high and high-normal blood pressure at the upper limit of normal (between the 90th and 95th percentile, at risk of future hypertension if not managed adequately), was 10.5% in boys and 6.9% in girls, with similar distributions among the two sexes. **Conclusions:** We present the first age-specific reference values for blood pressure of Lebanese children aged 5 to 15 years based on a good representative sample. The use of these reference values should help pediatricians identify children with normal, high-normal and high blood pressure.

Keywords: Blood pressure, nomograms, children, adolescents.

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Introduction

Blood pressure (BP) varies with age, sex, and body maturation [1-10]. It also varies between populations according to ethnic and environmental factors [2-6, 9-13]. Blood pressure in children is a predictor of adult values, and elevated BP in childhood may be an early sign of essential hypertension in adults [2-4]. Therefore, BP should be an integral part of routine physical examinations, and interpreted according to national standards for normal childhood BP distribution. The Task Force on Blood Pressure Control in Children in the United States established the first BP nomograms related to age, sex, height, and weight from birth to 18 years [2, 14]. In addition, several epidemiological studies have been done in different populations and various geographic areas, and have reported variation in the distribution of BP and the prevalence of hypertension in different ethnic groups [4, 6, 8, 9, 11-13, 15, 16].

In Lebanon, there are no national standard levels for BP in children and adolescents. Pediatricians have depended on standards adopted worldwide. Hence, the establishment of Lebanese national BP standards in children is essential to determine the levels at which children and adolescents are considered hypertensive (above 95th percentile) or high-normal or at risk (between the 90th and 95th

percentiles).

The aim of this cross-sectional survey was to obtain nomograms on BP distribution among Lebanese children based on a good representative sampling procedure in order to establish distribution curves of BP by age and sex.

Subjects and Methods

A representative random sample of 5781 Lebanese children aged between 5 and 15 years, selected as healthy school subjects, was recruited for this cross-sectional survey. Children were collected from 19 schools located throughout the five districts of Lebanon with different socioeconomic status. Following the approval of the Research Ethics Committee, and written consent forms obtained from their parents, a questionnaire collected information from the students including the following items: name, date and place of birth, address, school, class, sex, and presence of chronic disease (asthma or lung diseases, cardiac diseases, diabetes mellitus, kidney diseases, and scoliosis). A team consisting of a pediatrician and two pediatric nurses visited the schools. Each child underwent a complete physical examination in the presence of a school teacher including height in centimeters (without shoes), weight in kilograms (wearing light clothes), pulse (beats per minute), temperature (using skin forehead sensor thermometer in degree centigrade), heart examination (for regularity and presence of murmur), chest sounds (for good bilateral air entry and additional sounds), abdomen (for presence of organomegaly or palpable mass), extremities (for pulsation and color).

In order to reduce bias regarding the measurement of height and weight, we used the same scale for all children. Measurements of BP were taken while a child was awake and at rest in a comfortable sitting position with the right arm exposed and resting at the level of the heart. A mercury sphygmomanometer was used with the appropriate cuff size. The sphygmomanometer cuff was selected with a width that covered at least two-thirds of the upper arm, and a length exceeding at least 50% of the biceps circumference. The cuff was inflated to about 20 mm Hg above the point at which the radial pulse disappeared. The stethoscope was placed over the antecubital fossa. The pressure within the cuff was then released at a rate of approximately 2 mm Hg per second. The onset of sound (Korotkof phase I) was indicative of systolic pressure, and low pitched, muffled sound (Korotkof phase IV) of diastolic pressure in 5 to 9 year-old children, while the disappearance of sound (Korotkof phase V) was taken as indicative of diastolic pressure for those aged 10 to 15 years. Three measurements were recorded for each child with an interval of 5 to 10 minutes in between. The mean of these three readings was used for the final data analysis. All efforts were made to minimize factors which might affect blood pressure, such as anxiety, fear, stress, crying, laughing, and recent activity.

A total of 71 children were excluded based on the information obtained from the questionnaire or after the physical examination. A total of 65 children were excluded due to the following diseases: diabetes mellitus (n=3), cardiac diseases (n=23), epilepsy (n=25), renal diseases (n=8), hypothyroidism (n=2), hydrocephalus (n=1), liver cirrhosis (n=1), or scoliosis (n=2). A total of 6 children were excluded after the physical examination due to the following: fever (n=2), decreased air entry (n=3), and hepatosplenomegaly (n=1). All these diseases or abnormalities may affect blood pressure measurements.

Statistical Analysis

Systolic and diastolic BPs were statistically analyzed by regression analysis for various percentiles (5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, 95^{th}). The criteria used to establish the normal (between $5^{th}$and 90^{th} percentile), high-normal or at risk (between 90^{th} and 95^{th} percentile), and high BP (> 95^{th} percentile) were similar to those of the Second Task Force on Blood Pressure Control in Children [2]. The predicted average BP was smoothed by a least squares cubic spline-fitting procedure. This was done separately for boys and girls for each systolic BP (SBP) and diastolic BP (DBP). These procedures enable the fitting of smooth curves over the age ranges without making prior assumptions as to the nature of the relationship between BP and age. The p^{th} BP percentile for age j was estimated using the equation: $\mathbf{y}_{\mathbf{j}}\mathbf{*} \pm \mathbf{z_p}\sqrt{\boldsymbol{\sigma_j}^2}$, where $\mathbf{y}_{\mathbf{j}}\mathbf{*}$ is the estimated mean BP for ages **j** from the above spline-fitting procedures, $\mathbf{z_p}$ is the p^{th} percentile of a standard normal distribution, and σj^2 is the estimated variance. This procedure was used because BPs were approximately normal and showed little variation with regard to between-person standard deviations within specific age-sex groups. These smooth curves were then plotted using the software program Microsoft Excel.

All values were related to the age and sex of the children. The data were further analyzed using Student's t-test for unpaired values between boys and girls as well as between different groups. The correlation coefficients of systolic and diastolic BP with weight, height, body mass index (BMI), elevation, and pulse were studied. The statistical analysis was carried out at the Department of Biostatistics using SPSS for Windows Release 11.

Results

A total of 5710 healthy children were included in the final data analysis (2918 boys, 2792 girls) representing the 5 districts of Lebanon. The percent of the students from different regions were: Beirut 45.65%, Mount Lebanon 11.22%, North 14.71%, Bekaa 12.9%, and South 15.41%.

The mean ± standard deviation (mean ± SD) of height, weight, and BMI of the Lebanese schoolchildren by age in both sexes are presented in Table 1. This data shows that at 10 to 12 years, girls were taller than boys ($P < .05$), and at 14 to 15 years boys were taller than girls ($P < .05$).Girls were heavier than boys at 12 years old ($P < .05$), while boys were heavier than girls at 14 years old ($P < .05$). There was no significant difference in BMI between the sexes at different ages.

Table 1 Mean (±SD) of height, weight, and BMI of Lebanese schoolchildren by age and sex

	Boys			*Girls*		
Age (years)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Height (cm)	Weight (kg)	BMI (kg/m^2)
5	113.2 (4.7)	21.8 (3.2)	17.0 (1.7)	112.2 (5.9)	21.2 (3.6)	16.8 (1.7)
6	117.8 (5.1)	23.5 (4.1)	16.9 (2.2)	117.5 (5.2)	23.4 (4.1)	16.8 (2.2)
7	122.9 (6.0)	26.1 (5.3)	17.2 (2.4)	123.0 (6.2)	26.1 (5.8)	17.1 (2.5)
8	128.7 (6.0)	29.7 (6.4)	17.8 (2.7)	128.4 (5.9)	29.6 (7.1)	17.8 (3.2)
9	134.0 (5.9)	33.4 (8.2)	18.5 (3.6)	134.2 (6.7)	32.7 (8.1)	18.0 (3.3)
10	138.6 (6.2)	37.0 (9.4)	19.1 (3.8)	140.3 (7.0)	37.5 (8.1)	18.9 (3.3)
11	143.9 (6.9)	41.3 (10.5)	19.8 (3.9)	147.1 (7.4)	42.8 (10.6)	19.6 (3.8)
12	150.2 (7.5)	47.5 (13.6)	20.8 (4.7)	152.4 (6.5)	50.4 (11.6)	21.6 (4.4)
13	157.1 (8.1)	54.0 (14.3)	21.7 (4.6)	156.4 (6.6)	54.4 (12.0)	22.1 (4.2)
14	163.6 (9.0)	60.3 (15.6)	22.4 (4.7)	158.2 (5.2)	56.5 10.7)	22.5 (3.9)
15	168.6 (9.4)	62.9 (16.3)	21.8 (4.0)	157.8 (5.1)	57.9 (14.8)	23.2 (5.8)

Table 2 Mean values (±SD) of SBP and DBP by sex and age

	Boys			*Girls*		
Age(years)	Number	SBP	DBP	Number	SBP	DBP
5	128	89.4 (8.2)	51.0 (3.9)	131	87.3 (7.8)	50.8 (3.2)
6	320	92.0 (7.4)	53.1 (4.3)	315	90.6 (8.2)	53.5 (4.9)
7	366	94.3 (8.4)	54.0 (5.5)	378	92.4 (8.6)	53.9 (5.5)
8	388	97.9 (8.6)	55.9 (6.1)	344	96.0 (9.3)	55.4 (6.4)
9	364	100.0 (10.6)	57.1 (7.5)	356	97.0 (9.9)	55.7 (6.7)
10	394	101.7 (10.9)	58.2 (8.1)	359	99.8 (10.7)	57.3 (7.7)
11	364	103.6 (10.6)	59.4 (8.4)	375	104.0 (11.3)	60.0 (8.5)
12	199	108.7 (11.9)	62.8 (8.6)	215	107.7 (11.4)	61.9 (8.3)
13	193	113.6 (13.7)	65.1 (8.5)	140	110.9 (11.7)	64.8 (8.3)
14	164	117.0 (11.8)	66.9 (8.1)	161	112.0 (12.0)	65.6 (8.7)
15	38	115.4 (10.1)	67.8 (6.6)	18	110.6 (15.0)	63.6 (8.4)

Table 3 90th Percentile of systolic and diastolic blood pressure, height and weight in schoolchildren in Lebanon by age and sex

	Systolic		*Diastolic*		*Height*		*Weight*	
Age (years)	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
5	100.0	100.0	58.0	54.8	119.6	118.8	28.9	25.7
6	100.0	100.0	60.0	60.0	124.1	124.2	32.2	29.0
7	106.3	100.9	60.0	60.0	130.9	129.5	36.0	33.0
8	110.0	110.0	62.6	60.0	136.6	135.6	42.7	39.0
9	115.5	110.0	70.0	61.3	142.0	144.0	50.8	44.1
10	117.1	115.0	70.0	70.0	146.0	149.6	56.6	49.5
11	120.0	120.0	70.0	71.3	153.0	156.6	62.7	56.7
12	128.7	120.0	70.0	70.3	160.0	160.8	78.0	66.0
13	130.0	120.6	80.0	80.0	168.6	163.9	82.6	70.9
14	130.0	130.0	80.0	80.0	175.0	165.0	90.0	70.0
15	131.0	131.0	80.0	80.0	181.0	163.7	95.9	82.7

Table 4 Correlations of SBP and DBP in boys and girls

	SBP		DBP	
	Boys	Girls	Boys	Girls
	r*	r*	r*	r*
Weight	0.648	0.603	0.591	0.545
Height	0.643	0.605	0.560	0.521
Age	0.582	0.568	0.511	0.480
BMI	0.475	0.441	0.471	0.422
Elevation	- 0.111	- 0.066	- 0.239	- 0.216
Pulse	- 0.313	- 0.269	- 0.147	- 0.099

**P*<.0001

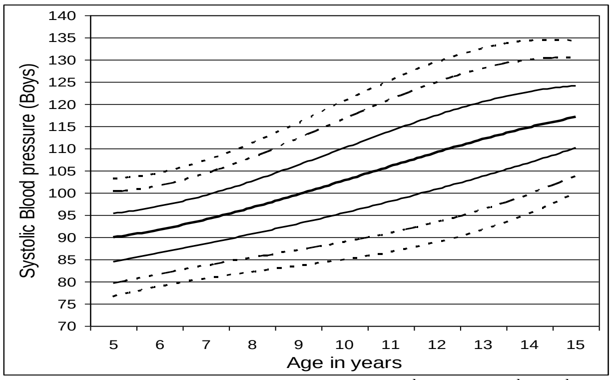

Fig. 1 Percentile curves of SBP for boys (5th, 10th, 25th, 50th, 75th, 90th, and 95th)

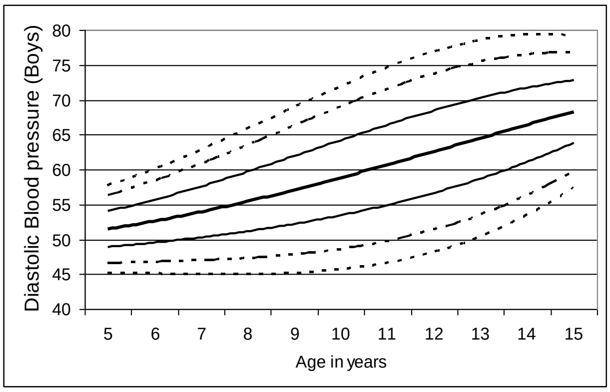

Fig. 2 Percentile curves of DBP for boys (5th, 10th, 25th, 50th, 75th, 90th, and 95th)

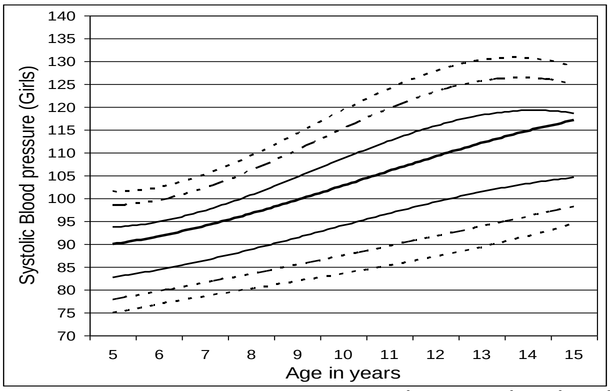

Fig. 3 Percentile curves of SBP for girls (5th, 10th, 25th, 50th, 75th, 90th, and 95th)

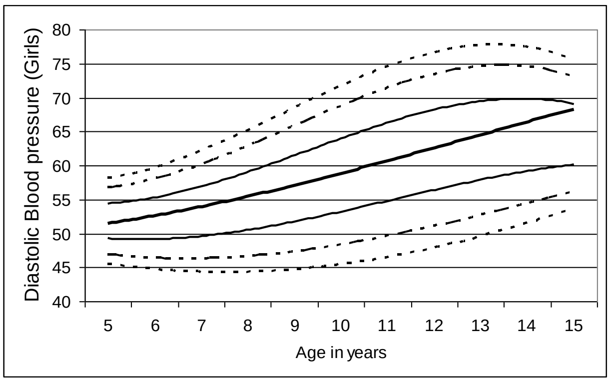

Fig. 4 Percentile curves of DBP for girls (5th, 10th, 25th, 50th, 75th, 90th, and 95th)

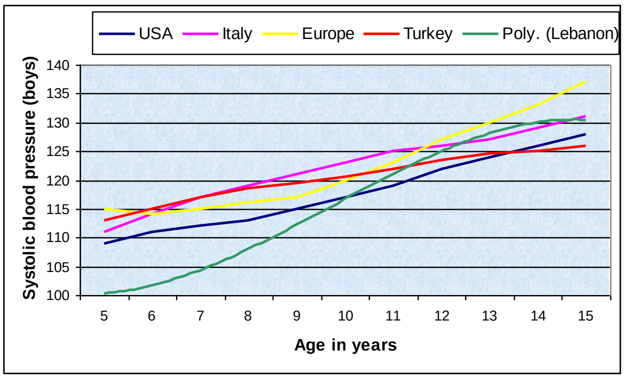

Fig. 5 Lebanese 90th percentile of SBP for boys compared to the USA, Turkey, Italy, and Europe

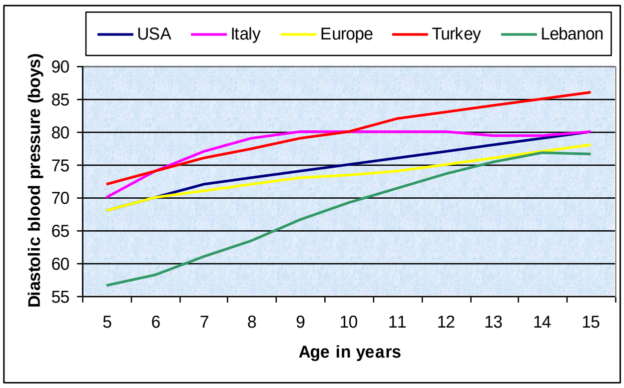

Fig. 6 Lebanese 90th percentile of DBP for Boys Compared to the USA, Turkey, Italy, and Europe

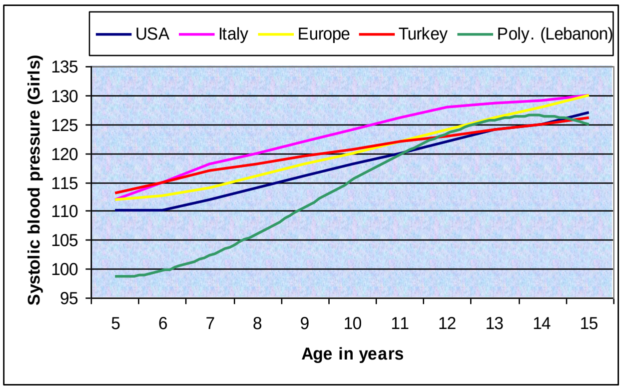

Fig. 7 Lebanese 90th percentile of SBP for girls compared to the USA, Turkey, Italy, and Europe

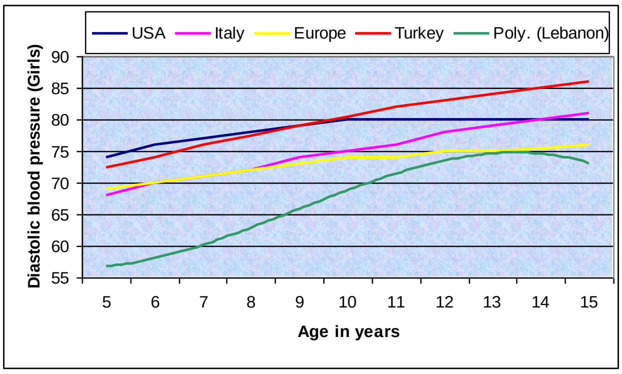

Fig. 8 Lebanese 90th percentile of DBP for girls compared to the USA, Turkey, Italy, and Europe

Table 2 presents the mean ± standard deviation of SBP and DBP by sex and age showing an increase of both SBP and DBP with age. Boys had higher SBP and DBP levels than girls at different ages, but the differences were not statistically significant. The average annual increase in SBP was 2.86 mm Hg in boys and 2.63 mm Hg in girls. The average annual increase in DBP was 1.72 mm Hg in boys and 1.48 mm Hg in girl.

The 90th percentiles by age and sex for SBP and DBP, representing the highest normal percentage for BP standards, height, and weight are listed in Table 3.

In both sexes, both SBP and DBP revealed a highly significant correlation with height, weight, age, and BMI. Other correlations with SBP and DBP for both sexes are listed in Table 4.

Percentile curves (5th, 10th, 25th, 50th, 75th, 90th, and 95th) of SBP and DBP are reported by age in Figures 1 and 2 for boys and in Figures 3 and 4 for girls.

The variation of mean SBP and DBP in both sexes between different districts in Lebanon was clinically significant ($P < .0001$). Beirut had the highest levels of both SBP and DBP in both sexes among the 5 districts. We found that children in Beirut were heavier and taller than the other districts ($P < .0001$).

The prevalence of hypertension (above the 95th percentile) among Lebanese children was 10.5%, from a total of 600 children (307 boys (10.5%), 293 girls (10.5%)). The prevalence of children who are at risk for hypertension (between the 90th and 95th percentiles) was 6.9%, from a total of 394 children (231 boys (7.9%), 163 girls (5.8%)).

The 90th percentile BP levels of our systolic and diastolic values for both sexes were compared to North–American [2], North–European [10], Italian [6], and Turkish [12] children and adolescents reported by age. Figures 5 and 6 show SBP and DBP for boys, and Figures 7 and 8 show SBP and DBP for girls.

Discussion

BP is a physiological parameter that when elevated becomes a risk factor for the development of premature cardiovascular morbidity [2, 12]. The distribution of BP levels and the prevalence of hypertension vary in different ethnic groups [4, 6, 8, 9, 11-13, 15, 16].

As essential hypertension in adults may result from a process that started early in life, BP measurements should be assessed routinely in children's and adolescent's physical examinations [11, 17, 18].

The need for a study on normal pediatric BP levels in Lebanon became urgent due to the widespread use of standards from the United States of America (USA). There standards were too high, especially in the early ages (5 to 8 years). As a result, normotensive Lebanese children were considered hypotensive. Moreover, neither the European normal standards [13] nor the Italian standards [6] were suitable for adoption to Lebanese childhood and adolescent BPs. Previous surveys on childhood BP in Turkey and North West India showed differences at the 90th percentile in comparison with our findings [12, 13]. Among Lebanese boy children, the difference in the SBP decreases at the age of nine years then joins that of the USA at 10 years, Turkey at 11 years, Italy at 12 years, and remains lower than other Europeans. In girls, the differences decrease at 9 years, reaching that of the USA at 11 years, Europe and Turkey at 12 years, but remains lower than Italy. For the DBP, the Lebanese 90th percentile in both sexes remains lower than the others but joins the European's at 13 to 14 years in boys and 12 to 14 years in girls. These variations in children BP readings among different populations might be due to genetic and environmental factors [2-6, 9-13].

Despite the fact that the subjects of both the European and Italian surveys had similar ethnicity and geography, their readings showed intra-variability in childhood BP, raising questions about other factors that could influence the BP readings such as environment, genetics, and the methodologies of measurement. These variations support the validity of each population providing its own normal BP standards.

In accordance with the previous studies performed on different populations, BP in our population rises with age during childhood and adolescence [1, 16-18]. This present study provides the readings of BP on a good representative sample of Lebanese children at different ages demonstrating that both sexes had an average annual increase in SBP and DBP with age similar to the Turkish survey [12].

The rise of BP with the increase in age is most probably caused by the growth of the child. Body size (height and weight) rather than the chronological age must be taken into consideration in assessing BP in children [14]. Many epidemiological studies in children have shown a strong correlation between BP, height, and weight [1, 2, 4, 9, 19]. In the present survey, weight and height have almost equal positive correlations with both SBP and DBP. However, the Turkish survey showed that height had the strongest correlation with children's BP [12], whereas Lauer et al found that weight has the strongest correlation [18].There was no significant difference between the sexes in SBP and DBP by age as reported by other studies [12, 13].

Even though we followed the recommendations of the Second Task Force on Blood Pressure Control in Children in the United States [2] for the analysis of our normative data, two main differences with those values were observed. First, the Task Force values were based on nine different populations including blacks and Mexican Americans. However, our study values were based on one population of the same ethnic group. Secondly, the Task

Force used the first BP reading, but we used the average of three readings performed at 5 to 10 minute intervals.

As children of both sexes in Beirut were significantly heavier and taller than the other districts in Lebanon, this may explain the significant increase in BP in Beirut children in comparison to others. Stress and other factors may also be involved in these results.

The prevalence rate of high BP in this study was similar to rates found in other studies [20, 21]. However, further follow up visits are crucial for such groups of children to reassess their BP and to look for contributing risk factors.

As BP varies between different population with influences such as genetic, environmental, and ethnical factors, the need of every population to define its normal standards is essential to evaluate BP in children and adolescents.

Conclusion

We presented the first age-specific reference values for blood pressure in Lebanese children 5 to 15 years old based on a good representative sample. The use of these standards should help pediatricians identify children with normal, high-normal and high blood pressure.

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