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ORIGINAL ARTICLE / ÖZGÜN ARAŞTIRMA

Blood Pressure Percentiles for School Children

Okul Çağı Çocukları için Kan Basıncı Persentilleri

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ABSTRACT

Objective: The prevalence of hypertension in childhood and adolescence is gradually increasing. We aimed to investigate the blood pressure (BP) values of children aged 7-18 years.

Methods: This study was conducted in a total of 3375 (1777 females, 1598 males) children from 27 schools. Blood pressures of children were measured using sphygmomanometer appropriate to arm circumference.

Results: A positive relationship was found between systolic blood pressure (SBP) and diastolic blood pressure (DBP) and the body weight, height, age and body mass index (BMI) in male and female children. SBP was higher in males than females after the age of 13. DBP was higher in males than the females after the age of 14. The mean annual increase of SBP was 2.06 mmHg in males and 1.54 mmHg in females. The mean annual increase of DBP was 1.52 mmHg in males and 1.38 mmHg in females.

Conclusion: In this study, we identified the threshold values for blood pressure in children between the age of 7 and 18 years in Erzurum province. It is necessary to combine and evaluate data obtained from various regions for the identification of BP percentiles according to the age, gender and height percentiles of Turkish children.

Key words: Blood pressure, percentile, children

ÖZET

Amaç: Çocukluk çağında ve adölesan dönemde hipertansiyon prevalansı gittikçe artmaktadır. 7-18 yaş arası çocukların kan basıncı değerlerini incelemeyi amaçladık.

Yöntemler: Bu çalışmaya 27 okuldan toplam 3375 (1777 kız, 1598 erkek) çocuk dahil edildi. Çocukların kan basınçları kol çevresine uygun sfigmomanometre ile ölçüldü.

Bulgular: Erkek ve kız çocuklarında sistolik ve diastolik kan basıncı ile vücut ağırlığı, boy, yaş ve vücut kitle indeksi arasında pozitif bir ilişki bulundu. Sistolik kan basıncı, 13 yaşından sonra erkeklerde kızlardan daha yüksekti. Diastolik kan basıncı 14 yaşından sonra erkeklerde kızlardan daha yüksekti. Sistolik kan basıncında ortalama yıllık artış erkeklerde 2.06 mmHg ve kızlarda 1.54 mmHg idi. Diastolik kan basıncında ortalama yıllık artış erkeklerde 1.52 mmHg ve kızlarda 1.38 mmHg idi.

Sonuç: Bu çalışmada, Erzurum şehrinde 7-18 yaş arasındaki çocuklarda kan basıncı için eşik değerleri belirledik. Türk çocuklarının yaş, cinsiyet ve boy persentillerine göre kan basıncı persentillerini belirlemek için farklı bölgelerden elde edilen verilerin değerlendirilmesi ve kombine edilmesi gereklidir.

Anahtar kelimeler: Kan basıncı, persentil, çocuk

INTRODUCTION

Hypertension (HT) is a significant public health problem affecting 20% of adults. HT prevalence in childhood is 1-3% but gradually increasing. HT can lead to many complications such as heart failure, retinopathy, coronary artery disease, kidney

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failure, stroke and peripheral artery disease [1]. Childhood BP values are an indicator of the values in adulthood [2-4]. Early diagnosis and treatment of HT is important for the prevention of the potential complications [5,6]. A limit value for HT has been identified in adults but there is no single threshold for BP in children [5]. BP values of children have been identified with Task Force reports published in 1977, 1987, 1996 and finally in 2004 [2,7-9]. These values are known to change with age, gender and body development and also differ depending on the society and according to ethnical and environmental factors. It is therefore important that all countries identify their own blood pressure values in childhood [5,8,10-13]. BP was measured in 5599 children and adolescents between the ages of 0 and 18 years and normal BP was determined for Turkish children in a study conducted in our country between 1990 and 1995 [14]. There is a limited number of studies on this subject [14,15]. In our study, we aimed to determine the blood pressure percentile values in healthy children aged 7 to 18 years living in Erzurum province, altitude of which is 1757 m.

METHODS

This study was conducted in a total of 3887 students from 27 schools randomly selected from Erzurum province center and districts. The exclusion criteria were as follows: (a) over the age of 18; and (b) with a disorder such as obesity and weakness. Obesity and weakness were determined according to the cut offs of Cole et al. [16,17]. A total of 3375 (1777 females, 1598 males) children were included in the study. The BP of each included child was measured twice following a 5-minute rest period from the right arm with a 30-second interval and the mean value was calculated. A blood pressure cuff appropriate for the child's age was used. The study was completed between October 2012 and December 2012. Permission was granted by the Erzurum Region Training and Research Hospital Ethics Committee and informed consent was obtained from the families. The sample was selected by using the simple and cluster sampling method. Blood pressure measurements were performed with an aneroid sphygmomanometer after five minutes of resting by healthcare practitioners (physicians and nurses). The measurements were taken at the heart level from the right arm while sitting. A properly sized cuff [with the width of the cuff bladder (inflating part) 40% of the mid arm circumference and the length minimum 80% of the arm] was used for correct measurement. The cuff bladder was inflated up to approximately 20-30 mmHg over the point where the pulse disappeared. Deflation was performed at a rate of 2-3 mmHg per second. The measurements were taken from the right arm twice with a minimum interval of 30 seconds and the average of two measurements was calculated. Korotkoff phase 1 was recorded as SBP and Korotkoff phase 5 as DBP during the measurements. Re-measurement was performed in cases where the fifth Korotkoff sound could be heard down to 0 mmHg and was recorded as Korotkoff phase 4 DBP. The height and body weight of the children were measured and recorded in addition to blood pressures.

The SPSS 20.0 statistical software program was used for the analysis of the data obtained. Percentile values of SBP and DBP were calculated over the average of two measurements. The LMS (Least Median Squares) method was used in the analysis of blood pressure percentile according to the age and gender. Student's t test was used for the comparison of the data of both genders. Pearson correlation analysis was used to investigate the relationship of SBP and DBP with the other variables. Single-way variance analysis (ANOVA) was used to determine whether a difference was present for BP according to age. The comparison of the groups whose ANOVA result was different was performed with the "Tukey test. A P value < 0.05 was accepted as statistically significant in all analyses."

RESULTS

The 50th, 90th and 95th percentile values were obtained for SBP and DBP according to age for female and male children (Table-1, Table-2). The children were compared in terms of height, body weight, BMI, SBP and DBP according to age group (Table-3). When female and male children were compared in terms of SBP, no statistical difference was found in the 7, 9, 10, 11, 12 and 13 years age groups. SBP values in males were statistically significantly higher than females in the group over the age of 14 (Table-3). SBP showed an increase with age in male and female children. The mean annual increase was

2.06 mmHg in males and 1.54 mmHg in females. When the values of males and females were compared in terms of DBP, no statistically significant difference was found in the 7 to 14 year age groups. DBP in males was statistically significantly higher than the females in the group aged 15 years and above (Table-3). DBP in male and female children showed an increase with age. The mean annual increase was 1.52 mmHg in males and 1.38 mmHg in females. When female and male children were compared according to the age groups in terms of height, body weight, and BMI values, no significant difference was found in the 7, 9, 10, 11 and 12 years of age groups. The height and body weights of males were found to be statistically significantly higher than the females in the age group of 8 years. While the heights of the males in the 13 and 14 years age groups were statistically significantly higher than the females, their BMIs were lower. Both the heights and body weights of the males in the 15-17 years age groups were found to be higher than the females (Table-3). The 90th percentile SBP and DBP values in our study were compared with the results of the Second Task Force study and the Ankara study conducted by Tümer et al (Figure 1-4). The SBP and DBP values in all age groups in both the females and males in our study were lower than the Second Task Force and Ankara study results.

Table 1. Systolic blood pressure percentile values according to age in girls and boys (mmHg)

Age (year)	Girls				Boys			
	n	50p	90p	95p	n	50p	90p	95p
7	229	90.0	102.2	105.6	169	90.1	101.5	104.9
8	179	92.6	104.5	107.8	151	93.6	105.1	108.4
9	139	95.3	107.1	110.3	108	96.3	107.8	111.0
10	144	97.9	109.8	113.0	127	98.1	109.5	112.7
11	178	100.1	112.1	115.4	151	99.5	111.0	114.1
12	159	101.6	113.9	117.3	159	101.3	113.0	116.1
13	120	102.5	115.0	118.4	130	103.5	115.3	118.5
14	128	102.8	115.4	118.9	122	105.6	117.5	120.7
15	193	103.3	116.0	119.5	159	107.5	119.1	122.4
16	149	104.3	117.0	120.6	172	108.9	120.3	123.6
17	159	105.5	118.3	121.8	150	110.1	121.4	124.6

Table 2. Diastolic blood pressure percentile values according to age in girls and boys (mmHg)

Age (year)	Girls			Boys		
	50p	90p	95p	50p	90p	95p
7	51.3	60.6	63.1	51.5	61.9	64.9
8	53.6	62.8	65.4	54.0	64.2	67.1
9	56.1	65.3	67.9	56.2	66.3	69.2
10	58.5	67.9	70.6	58.1	68.0	70.9
11	60.8	70.5	73.4	59.7	69.5	72.4
12	62.4	72.4	75.5	61.1	70.9	73.9
13	63.0	73.3	76.5	62.2	72.0	75.1
14	63.0	73.4	76.8	63.3	73.2	76.3
15	63.1	73.6	77.1	64.5	74.3	77.4
16	63.4	74.1	77.8	65.5	75.3	78.4
17	63.9	74.8	78.5	66.3	75.9	79.0

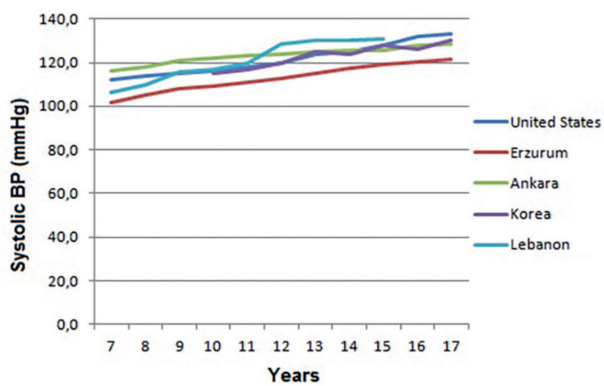

Figure 1. Comparison of United States, Ankara, Korea, and Lebanon studies versus present study in terms of the 90th percentile for SBP for boys

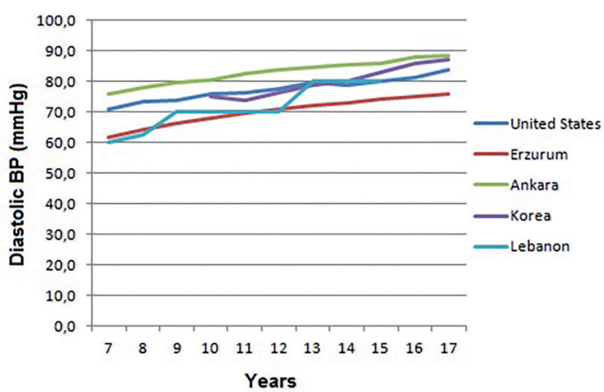

Figure 2. Comparison of United States, Ankara, Korea, and Lebanon studies versus present study in terms of the 90th percentile for DBP for boys

Table 3. Height, body weight, body mass index (BMI) , systolic blood pressure (SBP), diastolic blood pressure (DBP) values according to age in girls and boys

Age (year)	Boys					Girls				
	Height (cm)	Body weight (Kg)	BMI (Kg/m²)	SBP	DBP	Height (cm)	Body weight (Kg)	BMI (Kg/m²)	SBP	DBP
7	121.8±4.9	23.7±3.8	15.9±1.7	88.9 ±8.3	50.6 ±7.6	121.3±4.6	23.4±3.3	15.9±1.6	89 ±9.1	49.9 ±7.3
8	127.6±5.1[b]	26.5±3.9[a]	16.2±1.6	93.5 ±7.8[b]	53.5 ±8.4	126.1±5.0	25.7±4.0	16.1±1.9	90.6 ±8.9	52.5 ±7.0
9	130.5±5.9	28.3±3.9	16.6±1.6	95.4±8.9	54.8 ±7.6	130.6±5.8	28.1±4.4	16.4±1.9	95.1 ±7.5	55.5 ±5.9
10	138.7±4.9	33.6±5.6	17.4±2.1	97.4 ±8.4	57.8 ±5.9	137.8±5.7	32.5±5.5	17.1±2.2	96.0 ±9.8	57.5 ±6.7
11	142.3±6.0	36.9±6.3	18.2±2.5	96.6 ±8.7	58.3 ±6.2	142.9±6.1	36.8±6.5	17.9±2.3	98.3 ±9.8	59.6 ±6.1
12	148.2±6.2	40.6±7.3	18.4±2.5	99.7 ±9.6	61.3 ±6.2	148.7±5.7	40.9±7.4	18.4±2.6	99.1 ±8.9	62.6±7.0
13	155.8±6.4[a]	45.8±7.8	18.8±2.4[c]	100.6 ±10.5	61.4 ±7.5	154.3±4.5	47.2±6.9	19.8±2.3	102.8 ±8.9	63.0±7.3
14	163.0±6.4[d]	52.8±8.2	19.8±2.3[c]	105.0 ±8.6[d]	63.1 ±6.6	157.2±5.1	50.9±6.6	20.6±2.4	100.8±10.2	63.0±7.1
15	168.3±5.9[d]	58.1±8.1[d]	20.5±2.3	106.7 ±8.8[d]	64.4 ±6.7[b]	158.3±5.1	52.7±7.3	21.0±2.6	102.0 ±10.0	62.3 ±7.0
16	171.2±5.0[d]	62.7±8.8[d]	21.3±2.6	107.8 ±7.7[d]	65.9 ±7.0[b]	158.6±5.0	54.9±7.4	21.8±2.7	103.0 ±9.6	63.6 ±7.0
17	172.9±5.4[d]	65.1±8.7[d]	21.8±2.5	109.5 ±8.5[d]	65.8 ±6.2[b]	158.9±5.1	54.7±7.6	21.6±2.6	104.3 ±9.8	63.7 ±7.3

[a] $p < 0.05$ versus girls; [b] $p < 0.01$ versus girls; [c] $p < 0.001$ versus girls; [d] $p < 0.0001$ versus girls;
Data were expressed as mean ± Standard Deviation

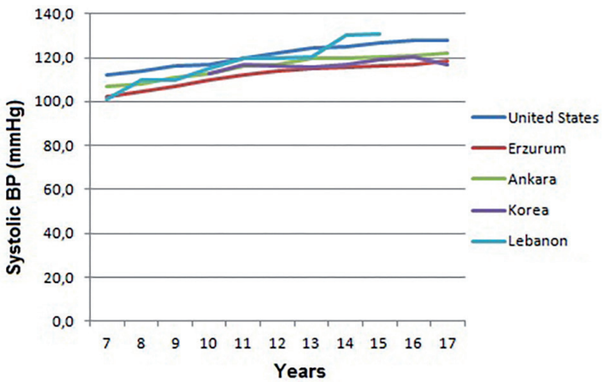

Figure 3. Comparison of United States, Ankara, Korea, and Lebanon studies versus present study in terms of the 90th percentile for SBP for girls

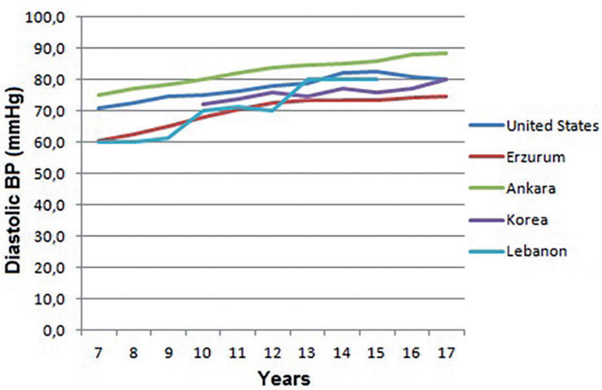

Figure 4. Comparison of United States, Ankara, Korea, and Lebanon studies versus present study in terms of the 90th percentile for DBP for girls

DISCUSSION

Children with more body weight and/or height have higher blood pressure than short and thin ones of the same age [18-20]. BP in those living in high altitudes is also lower than those living at sea level [21]. The decrease in blood pressure at high altitude is thought to be due to reasons such as relaxation of vascular smooth muscle, increase in collateral circulation, increase in vascularization, increase in red blood cell count and hemoglobin level, and hypocaloric stress [22-24]. We found the SBP and DBP values of females and males in our study to be lower than in the study of Tümer et al. [14]. Our 50th percentile height and body weight values were higher than Tümer et al. [14] values except body weight for age of 7 years in male children and body weight for the age of 16 and 17 years in females. Therefore, the lower SBP and DBP values than the study conducted by Tümer et al. [14] might not be due to the height and body weight difference, but to the altitude of our region.

The children and adolescents living at high altitudes were found to have lower SBP and DBP values compared to those living at low altitudes again in a similar study conducted in Tibet [22]. The difference in the description of DBP also contributes to the difference between the study conducted by Tümer et al. [14] and our study. Tümer et al. [14]

identified DBP according to Korotkoff 4 in children younger than age of 12 years and according to Korotkoff 5 in adolescents older than 12 years while we used the Korotkoff 5 sound in the determination of DBP for all ages in our study. When we compared our data with the study where Bal et al. [15] investigated BP percentiles in the 11-17 years age group in Kayseri, we found SBP and DBP values in our study to be lower in both genders and we thought that these values may have been affected by the altitude difference [the altitude of Kayseri is 1071 m, the altitude of Erzurum is 1757 m). Comparison of our SBP and DBP values with the data from the 2nd Task Force report revealed that the BP values of both female and male children were lower in our study. We then compared our data with data from Iran [25], Lebanon [26] and Korea [27]. Our 50th, 90th and 95th percentile SBP and DBP values were lower than the values of both female and male Iranian and Korean children [25,27]. Although our mean (50th) and 90th percentile DBP values were usually lower than the Lebanese children, the 50th and 90th percentile DBP of our female children aged 12 years and the 90th percentile of our female children aged 7-10 years were higher than that of Lebanese female children [26]. Besides, the 90th percentile results of our male children aged 7, 8 and 12 years were higher than that of Lebanese male children [26].

Blood pressure is reported to be higher in males than females, especially after the age of 12-14 years and in adults. Although the mechanism of this gender difference in BP is not completely known, it could be due to the interaction between the sex hormones and the kidney [28]. We found SBP in males to be higher than the females in the group aged 14 years and above in our study. Besides, DBP in males was found higher than the females in the group aged 15 years and above. The mean SBP in males was found higher than the females after the age of 13 years in a study conducted in Korean children, similar to our study [27]. No statistical difference was found between males and females in terms of BP in the studies conducted in Ankara [14] and Kayseri [15] but SBP tended to be higher in males than females at the age of 14 years and above in the study conducted in Kayseri, similar to our study. An increase was found in BP values with increasing age in our study, consistent with the literature [9,25,26]. We found a mean annual SBP increase of 2.06 mmHg in males and 1.54 mmHg in females and a mean annual DBP increase of 1.52 mmHg in males and 1.38 mmHg in females. This rate of increase slowed down in the adolescent period. SBP was similar in females at the age of 13 years and above and in males at the age of 15 years and above; DBP was similar in females at the age of 12 years and above and in males at the age of 15 years and above. Tümer et al. [14] reported the annual SBP increase as 2.35 mmHg in males and 2.42 mmHg in females and the annual DBP increase as 1.74 mmHg in males and 1.73 mmHg in females. The mean annual increase of BP in the study of Tümer et al [14] being higher than in our study can be explained by their study being conducted in the 0-18 age group as the BP increase is higher in the first two years [28].

We found a statistically significant positive relationship between BP and height, body weight and BMI in our study. Body weight is a strong determinant of BP and could be more important than height [28]. The correlation of body weight and DBP was stronger than that with SBP in females and the correlation of body weight with SBP was stronger than that with DBP in males in our study. The relationship of body weight with SBP was found to be stronger than with DBP in both males and females in the study of Tümer et al. [14] and in studies conducted with Lebanese and Korean children [26,27]. Although there are small differences between these three studies and our study, our results were consistent with the other studies.

We determined BP percentiles of children aged 7-18 years in Erzurum province in our study. The relationship between BP and gender, age, body weight, height and BMI was evaluated. BP in the adolescent period was seen to be higher in males than females and a positive relationship was found between BP and age, body weight, height and BMI. When we compared our results with studies conducted in other countries, we found similarities as well as differences. There were even differences between our study and the two studies conducted in our country as regards determining BP percentiles.

In conclusion, our study is a pioneer study in our region. We determined the threshold values for blood pressure in children aged 7-18 years in Erzurum province in our study. It is necessary to combine the data that will be obtained from various regions to determine and evaluate the BP percentiles of Turkish children according to age, gender and height.

Declaration of Conflicting Interests: The authors declare that they have no conflict of interest.

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