Blood Pressure Percentiles for the Children Between 11-17 Years of Age in Kayseri

Kayseri'de 11-17 Yaş Arası Çocuklar İçin Kan Basıncı Persantil Değerleri

Cengiz BAL, MD[a]
Bektaş Murat YALÇIN, MD[b]
M. Mümtaz MAZICIOĞLU, MD[c]
Ahmet ÖZTÜRK, MD[d]
Meral BAYAT, MD[e]
Hasan Bahri ÜSTÜNBAŞ, MD[c]
Selim KURTOĞLU, MD[f]

[a]Department of Biostatistics, Eskişehir Osmangazi University Faculty of Medicine, Eskişehir
[b]Department of Family Practice, Ondokuz Mayıs University Faculty of Medicine, Samsun
Departments of [c]Family Practice, [d]Biostatistics, [f]Pediatric Endocrinology, Erciyes University Faculty of Medicine, [e]Department of Nursery, Erciyes University Atatürk Health School, Kayseri

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Yazışma Adresi/*Correspondence:*
B. Murat YALÇIN, MD
Ondokuz Mayıs University Faculty of Medicine, Department of Family Medicine, Samsun, TÜRKİYE/TURKEY
myalcin@omu.edu.tr

ABSTRACT Objective: There is limited data about the blood pressure percentiles in children and adolescents in different parts of Turkey. In this study, we aimed to determine accurate charts of blood pressure percentiles for, children between 11 to 17 years. **Material and Methods:** This cross sectional study was conducted in 2 urban and 10 subrural areas that were randomized in order to represent 11 to 17 year olds. The study included students (n= 2.592; 1.336 girls, 1.256 boys) from 35 primary schools and high schools. Blood pressure was measured in each participant and the measurements were used to calculate the blood pressure percentiles for each age and gender. **Results:** The mean systolic blood pressures in boys between the ages 11 to 17 were, 113.6, 110.9, 113.8, 115.0, 115.5, 115.3 and 114.6 mmHg respectively. The mean systolic blood pressure in girls between the ages 11 to 17 were 111.7, 111.4, 112.9, 110.9, 111.8, 112.3 and 111.5 mmHg respectively. The mean diastolic blood pressure in boys between the ages 11 to 17 were 71.5, 70.2, 71.1, 71.4, 72.1, 72.6 and 72.5 mmHg respectively and the corresponding values for girls were 69.9, 69.6, 71.2, 71.2, 71.2, 71.9, and 72.5 mmHg. There was no statistically significant difference between the measurements in girls and boys at any age ($p > 0.05$). **Conclusion:** Nationwide studies of more children and adolescents are needed to extend the age spectrum in order to represent a wider cross-section of the Turkish population.

Key Words: Blood pressure, child, adolescent, primary health care

ÖZET Amaç: Ülkemizde çocuk veya adölesanlar için kan basıncı persantil değerleri için sınırlı veri mevcuttur. Bu çalışmada 11-17 yaş arası çocuklar için kan basıncı persantil değeri tabloları oluşturma amaçlanmıştır. **Gereç ve Yöntemler:** Bu tanımlayıcı çalışma Kayseri'nin 11-17 yaş aralığını temsil eden randomize seçilmiş 2 şehir merkezi ve 10 banliyö bölgesinde gerçekleştirilmiştir. Çalışma 35 ilk ve ortaokuldan seçilmiş 2.592 öğrenciyi kapsamaktadır (1.336 kız, 1256 erkek). Her bir katılımcının kan basıncı ölçüldükten sonra bu ölçümler yaşa ve cinsiyete uygun kan basıncı persantil değerlerinin hesaplanması için kullanılmıştır. **Bulgular:** Ortalama sistolik kan basıncı 11-17 yaş aralığı için erkeklerde sırasıyla 113.6, 110.9, 113.8, 115.0, 115.5, 115.3 ve 114.6 mmHg iken kızlarda 111.7, 111.4, 112.9, 110.9, 111.8, 112.3 ve 111.5 mmHg idi. Ortalama diyastolik kan basıncı 11-17 yaş aralığı için erkeklerde sırasıyla 71.5, 70.2, 71.1, 71.4, 72.1, 72.6 ve 72.5 mmHg iken, bu değerler kızlarda 69.9, 69.6, 71.2, 71.2, 71.2, 71.9 ve 72.5 mmHg idi. Her iki cinsiyetin sistolik ve diyastolik kan basınçları herhangi bir yaşta birbirinden farklı değildi ($p > 0.05$). **Sonuç:** Türk çocuk ve adölesanlarını temsil etmek için daha fazla bölgesel çalışmaya ihtiyaç vardır.

Anahtar Kelimeler: Kan basıncı; çocuk; adölesan; birinci basamak

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Children and adolescent hypertension is a neglected problem in primary care.[1] Hypertension is defined as having three separate measurements of systolic blood pressure (SBP) or diastolic blood pressure (DBP) above the 95th percentiles.[2] The prevalence of childhood and adoles-

cent hypertension is reported to be 1-5%.[3-8] In a recent study the prevalence of hypertension is reported as high as 13.4% in adolescents and children between 6-15 ages in Aydın.[9] Although the most frequent cause of hypertension in early childhood is renovascular disease, essential hypertension is more common for children > 11 years of age.[10-12] The prevalence of childhood and adolescent hypertension is expected to increase along with the trend of increasing childhood obesity.[13] Obese children have approximately 3-fold higher risk of hypertension compared to non-obese children. A combination of factors, including sympathetic nervous system overeactivity, insulin resistance, and abnormalities in vascular structure and function may contribute to obesity-related hypertension in children.[14] A sedentary lifestyle, increased time spent watching television or at computers and unhealthy dietary habits (e.g. fast food and increased salt intake) all contribute to obesity in children and adolescents.

Childhood hypertension can lead to serious health problems.[15] Children or adolescents with hypertension have an increased risk of hypertension and premature coronary artery disease as adults.[16] The most prominent clinical evidence of end organ damage in childhood hypertension is left ventricular hypertrophy (LVH), which seen in as many as 41% of patients with childhood hypertension.[17] To prevent these complications, it is essential to detect, treat, and follow-up childhood and adolescent hypertension in the primary care.

Blood pressure measurements vary in different populations and are influenced by both genetic and environmental factors.[18] In order to evaluate their patients' blood pressure measurements, it is important for the primary care physician in Turkey to have standardized nomogram and percentile tables for the blood pressure values of children and adolescents; however, there are limited data avaible for the different regions of Turkey, and this unique study was not updated for a decade.[19]

In this study we aimed to obtain blood pressure data of Turkish children and adolescents' aged 11-17 years, and prepared blood pressure distribution curves according to age and gender.

MATERIAL AND METHODS

STUDY DESIGN

This is a cross-sectional study conducted in the primary and secondary schools of the 2 urban and 10 suburban districts of Kayseri province, Turkey. Kayseri, a major city in Central Anatolia, has a population > 1.000.000 people. Data were obtained from the study of the Determination of Anthropometric Measurements of Turkish Children an Adolescents (DAMTCA) from February to April, 2005. The study protocol was approved by the Erciyes University Faculty of Medicine Ethics Committee and the Kayseri Province Education Board.

SAMPLES AND SAMPLING

The methods DAMTCA study had been published in somewhere else.[20] In the study, a stratified multistage probability sampling design was employed. The first stage was the random selection of state and private schools, which represent the city center and districts by the stratified sampling method according to socioeconomic levels. A total of 35 schools were selected randomly among 699 schools in Kayseri. The second stage was the random sampling of children and adolescents aged 11 to 17 years, from schools enrolment. A total of 2.592 students (1.336 girls and 1.256 boys) were chosen for the study. The chronological age was calculated as the decimal age by subtracting the observation date from the birth date. To calculate the age of the subjects in days, their birthday was used. Each year elapsed from their birthday weight noted as one age. We excluded subjects who had a regular use of medication, had growth or development disorders (143 subjects), and whose BMI values were below than 5 percentiles or higher than 95 percentiles (268 subjects) (We aimed to neutralize the effect of obesity on our results). We received permission from local representatives of the Ministery of Education to conduct this study. In addition, all of the participants and their parents were informed for the aim of the study. Sociodemographic data, anthropometric data and blood pressure measurements were obtained by 10 trained investigators.

BLOOD PRESSURE MEASUREMENTS

Blood pressure was measured according to the recommendations of the Fourth Report of the National High Blood Pressure Education Program (NHBPEP) Working Group on High Blood Pressure in Children and Adolescents.[8] All blood pressure measurements were recorded with an aneroid sphygmomanometer (ERKA Anaroid Sfingomonometer® Germany) when the subject was in a comfortable seated position with the right arm fully exposed and resting on a supportive surface at heart level. A cuff was selected with a width that covered at least two-thirds of the upper arm (between olecranon and acromion) and a length that exceeded the biceps circumference at least 50%. The cuff was inflated to a level that occluded the pulse at the wrist, the stethoscope was placed over the antecubital fossa, and the cuff was deflated. The onset of the first Korotkoff sound was used to measure SBP, while the fifth was used for DBP. Two readings from one arm (the subjects' dominant arm) at least 5-10 minutes apart were obtained in each participant, and the mean of these two measurements was calculated.

STATISTICAL ANALYSES

Construction of the centile curves was performed using the LMS Chart Maker Pro software program (version 2.3; The Institute of Child Health, London). The smoothed blood pressure centile curves were constructed by the LMS method. This method summarizes percentiles at each age based on the power of age-specific Box-Cox power transformations, which are used to normalize data. The three quantities (L, M, and S) are age-dependent. The final percentile curves are produced by three smooth curves representing L (lambda; skewness), M (mu; median) and S (sigma; the coefficent of variation). The LMS equation is: $X= M (1 + LSz)^{1/L}$ $L\neq 0$ or $X= M \exp (Sz)$ $L= 0$. X is the blood pressure measurement and z is the z-score that corresponds to the percentile.

The key task of the transformation is to estimate the parameters L, M, and S. With the estimates of L, M, and S, values of X are connected to the z values with the equation shown above. The percentile is obtained from a normal distribution table, where the z-score corresponds to the percentile of the interest.[21] Descriptive statistics for each age within a gender, and the comparison of SBP and DBP by an independent sample t-test was performed using SPSS version 13.0 (Illinois, Chicago, USA). A p value< 0.05 was considered as statistically significant.

TABLE 1: Socioeconomic and demographic characteristics of the study population.

	Boys	Girls
Mean age (years)	14.54 ± 1.7	14.38 ± 1.7
Age group (years)		
11	79 (6.3%)	89 (6.7%)
12	138 (11.0%)	143 (10.75)
13	133 (10.6%)	144 (10.8%)
14	209 (16.6%)	262 (19.6%)
15	310 (24.5%)	318 (23.4%)
16	241 (19.2%)	260 (19.5%)
17	146 (11.2%)	120 (9.0%)
Rural	671 (53.4%)	666 (49.9%)
Urban	585 (46.6%)	670 (50.1%)
Mother's educational status		
University	14 (1.1%)	18 (1.3%)
High school	105 (8.4%)	109 (8.2%)
Secondary school	155 (12.3%)	144 (10.8%)
Elementary school	982 (78.2%)	1.065 (79.7%)
Mother's occupation		
Housewife	1.195 (95.1%)	1.285 (96.2%)
Other	61 (4.9%)	51 (3.8 %)
Father's educational status		
University	107 (8.5%)	134 (10.2%)
High school	272 (21.7%)	317 (23.7%)
Secondaty school	294 (23.4%)	313 (23.4%)
Elementary school	583 (46.4%)	572 (42.8%)
Father's occupation		
Office worker	218 (17.4%)	287 (21.5%)
Worker	406 (32.3%)	386 (28.9%)
Retired	181 (14.4%)	197 (14.7%)
Farmer	124 (9.9%)	116 (8.7%)
Merchant	186 (14.8%)	192 (14.4%)
Unemployed	65 (5.2%)	66 (4.6%)
Other	76 (6.5%)	92 (6.9%)
Family income per month*	$ 501.4	$ 503.1

*(self-reported and converted to American Dollars. The exchange rate 1 YTL= 1,24 $ at 11th 6 2008)

TABLE 2: Mean blood pressure according to gender and age.

	Boys		Girls	
Age (Years)	SBP Mean (SD)	DBP Mean (SD)	SBP Mean (SD)	DBP Mean (SD)
11	113.6 (11.6)	71.5 (9.9)	111.7 (13.6)	69.9 (10.1)
12	110.9 (12.8)	70.32 (10.9)	111.4 (14.1)	69.6 (11.2)
13	113.8 (12.8)	71.1 (8.4)	112.9 (12.2)	71.2 (9.9)
14	115.1 (12.5)	71.4 (10.1)	110.9 (11.3)	71.2 (9.5)
15	115.5 (13.3)	72.1 (9.6)	111.6 (13.0)	71.2 (9.5)
16	115.3 (13.3)	72.6 (10.4)	112.3 (12.7)	71.9 (9.1)
17	114.6 (13.5)	72.5 (10.4)	111.5 (12.5)	72.5 (8.7)

SBP: Systolic blood pressure, DBP: Diastolic blood pressure.

RESULTS

The socioeconomic and demographic characteristics of the study population are shown in Table 1. Table 2 shows the weighted means and standard deviations of SBP and DBP of the study population according to age and gender. There were no statistically significant differences between the SBP and DBP ($p > 0.05$) values for subject's ages 11-17 years old. The SBP and DBP percentiles (50, 90, 95 and 99) in girls and boys are calculated according to their age and height with LMS method are represented in Table 3 and 4. The height and age distri-

TABLE 3: Blood pressure distribution by age and height in boys (50th, 90th, 95th and 99th percentiles).

	SBP								DBP							
	Percentiles	Percentile of height (cm)							Percentiles	Percentile of height (cm)						
Age	(mm/Hg)	5	10	25	50	75	90	95	(mm/Hg)	5	10	25	50	75	90	95
11	50	108	112	116	115	113	112	108	50	71	69	70	71	71	72	76
	90	113	123	129	129	126	125	113	90	74	76	79	81	81	83	89
	95	115	125	132	132	130	129	115	95	75	78	81	84	84	87	92
	99	118	131	139	139	136	136	118	99	77	82	86	90	90	93	100
12	50	112	113	112	110	111	111	112	50	70	70	69	69	69	70	73
	90	125	126	126	125	126	127	125	90	85	86	85	84	84	84	85
	95	128	130	130	129	131	131	128	95	90	91	90	89	89	88	88
	99	133	136	137	136	138	139	133	99	99	101	101	100	98	96	95
13	50	116	116	114	112	115	118	116	50	69	71	71	71	72	72	71
	90	125	126	125	124	128	132	125	90	81	83	83	82	82	81	77
	95	127	129	128	127	131	136	127	95	85	86	86	86	85	84	79
	99	131	133	132	132	137	143	131	99	91	93	93	92	92	88	82
14	50	111	111	113	115	116	118	111	50	69	69	70	70	71	73	75
	90	126	126	128	131	132	133	126	90	79	80	82	83	85	88	90
	95	131	130	133	135	136	137	131	95	82	83	85	87	90	93	96
	99	139	139	141	143	143	144	139	99	87	88	92	95	99	104	109
15	50	110	112	113	116	117	114	110	50	70	70	71	73	73	73	73
	90	124	127	129	133	134	133	124	90	84	82	83	84	84	84	86
	95	128	131	133	138	139	139	128	95	87	86	86	88	88	88	90
	99	135	139	141	148	149	152	135	99	94	92	91	93	93	94	99
16	50	112	112	114	116	115	114	112	50	72	72	72	73	73	73	75
	90	125	126	130	134	134	132	125	90	84	84	85	86	85	85	88
	95	129	130	135	139	140	138	129	95	87	87	88	89	88	89	91
	99	135	138	143	150	151	150	135	99	93	93	94	96	95	95	97
17	50	121	117	115	114	113	111	121	50	75	73	72	72	73	73	74
	90	141	135	132	131	130	127	141	90	88	85	84	84	84	85	84
	95	148	141	137	136	135	132	148	95	92	89	87	87	87	88	87
	99	162	152	147	145	145	141	162	99	100	96	93	92	93	93	92

SBP: Systolic blood pressure, DBP: Diastolic blood pressure.

TABLE 4: Blood pressure distribution by age and height in girls (50th, 90th, 95th and 99th percentiles).

	SBP								DBP							
	Percentiles			Percentile of height (cm)					Percentiles			Percentile of height (cm)				
Age	(mm/Hg)	5	10	25	50	75	90	95	(mm/Hg)	5	10	25	50	75	90	95
11	50	110	110	109	110	111	113	114	50	76	73	72	70	69	69	68
	90	115	120	124	129	132	134	136	90	80	81	82	82	83	85	87
	95	116	122	128	135	139	142	143	95	81	83	85	86	87	91	96
	99	119	128	137	147	154	157	158	99	83	87	90	92	95	104	127
12	50	110	106	107	111	112	113	115	50	65	65	66	69	69	70	73
	90	135	127	126	128	129	129	130	90	85	83	83	84	83	84	84
	95	143	133	131	133	134	134	134	95	91	90	89	90	88	88	88
	99	158	145	140	142	143	143	143	99	104	103	101	101	98	97	96
13	50	113	114	114	112	112	115	115	50	73	72	69	69	70	74	75
	90	128	129	129	127	127	130	130	90	84	83	82	82	83	88	88
	95	133	134	134	131	131	134	134	95	87	87	85	86	87	92	92
	99	142	143	142	139	139	142	141	99	93	94	93	94	94	99	100
14	50	109	111	111	111	112	112	112	50	65	68	69	71	72	73	72
	90	125	125	124	124	125	125	127	90	82	82	82	83	83	84	85
	95	130	129	128	128	128	129	131	95	88	87	86	86	87	88	88
	99	138	137	135	134	134	136	138	99	101	97	94	93	93	94	95
15	50	109	111	111	111	112	112	112	50	73	73	72	71	70	71	72
	90	125	125	124	124	125	125	127	90	83	84	83	83	83	84	85
	95	130	129	128	128	128	129	131	95	86	86	86	86	86	88	89
	99	138	137	135	134	134	136	138	99	90	92	92	92	93	95	97
16	50	109	111	111	111	112	114	114	50	70	72	73	72	71	71	71
	90	124	127	129	129	129	130	128	90	81	84	85	84	84	83	82
	95	128	132	135	135	134	134	132	95	84	87	88	88	87	87	86
	99	137	143	147	147	145	143	140	99	90	93	95	95	94	94	92
17	50	104	108	111	112	112	111	110	50	70	74	74	73	74	74	75
	90	123	125	127	128	129	128	127	90	79	83	83	82	83	84	85
	95	130	132	133	134	134	133	131	95	82	85	86	84	85	86	87
	99	150	149	148	147	146	142	139	99	86	89	90	88	89	90	913

SBP: Systolic blood pressure, DBP: Diastolic blood pressure.

bution in both genders are shown in Table 5. Smoothed percentile curves for 3rd, 5th, 10th, 25th, 50th, 75th, 90th, 95th, 97th and 99th percentiles according to the age are shown in the Figures 1, 2, 3, and 4 by gender. Smoothed percentile curves for 3rd, 5th, 10th, 25th, 50th, 75th, 90th, 95th, 97th and 99th percentiles according to the age are shown in the Figures 5, 6, 7, and 8 by height groups.

DISCUSSION

The purpose of this study was to supply accurate blood pressure data from children and adolescents to Turkish physicians, so they can determine and monitor high blood pressure in their patients. Tümer et al. conducted an important blood pressure percentile study in 5.599 children and adolescents between the ages of 0 and 18 in Ankara region.[19] When the 90th percentile SBP and DBP values of boys and girls with the same age from that report were compared with the values we obtained in this study, it is seen that our subjects' SBP and DBP measurements were higher (The means of the 90th percentile SBP and DBP values of the subjects from both studies are shown in Figures 9 and 10). This difference is very striking: The SBP measurements in the boys in our study were 30 mmHg and

TABLE 5: Height distribution by age and sex.

		Percentile of height (cm)									
Sex	**Age (years)**	**3**	**5**	**10**	**25**	**50**	**75**	**90**	**95**	**97**	**99**
Boys	11	133.2	135.0	136.0	140.0	146.0	151.0	154.0	158.0	159.6	160.0
	12	138.1	140.4	142.0	144.0	150.0	158.0	162.1	165.1	167.8	172.6
	13	140.0	141.0	145.0	150.0	156.0	163.0	170.0	172.0	173.0	175.3
	14	149.0	150.0	154.0	160.0	167.0	171.0	175.0	178.0	179.0	180.9
	15	156.0	156.8	160.1	165.2	170.0	175.0	178.0	180.0	181.3	183.9
	16	160.0	160.1	164.0	168.0	172.0	176.0	180.0	181.9	183.0	187.0
	17	160.0	162.0	166.7	171.0	175.0	179.0	182.0	184.0	184.0	186.5
Girls	11	134.4	136.1	139.0	142.0	148.0	151.0	156.0	159.5	160.3	164.0
	12	141.3	142.0	144.0	148.0	153.5	157.5	161.0	164.0	164.0	166.6
	13	144.1	147.0	150.0	153.1	156.0	160.0	164.0	165.8	168.0	170.7
	14	148.9	150.1	152.0	155.0	159.0	163.0	166.0	168.9	170.1	172.7
	15	148.6	150.0	152.0	156.0	159.0	163.0	166.0	170.0	171.4	174.8
	16	149.8	151.0	153.0	155.2	159.3	163.1	167.2	169.0	170.0	172.8
	17	138.0	139.8	141.2	148.0	156.0	161.0	166.0	169.0	170.0	172.0

their DBP measurements were 20 mmHg higher in every age group compared with the subjects that have been reported by Tümer et al. For girls 11 and older, the DBP was higher than comparable values from the Ankara study. However, both sexes had similar blood pressure measurement means in our study (in every percentile). Tümer et al. have reported a positive parabolic curve increase for blood pressure measurements with increasing age in both boys and girls. This was explained by the subjects' growth and development (i.e. increased height and weight). In contrast, the increase was not uniform in our subjects, and some older subjects had lower blood pressure measurements than younger subjects. We believe that the difference is due to the developmental properties of the children to the age of puberty. This result may be due to the irregular pattern of developmental (either increasing weight or height) patterns of children to the puberty in this region. This point also needs to be studied in further studies. However, our results are in agreement with some other studies in other populations. Studies from the USA, India, Hungary and Iran reported a similar irregular parabolic curve for subjects of different ages.[5,7,8,22] Compared to other population nomograms, SBP and DBP for both genders were lower in our study than those in American youth, while they were higher than Indian values and were similar to Hungarian children and adolescents at the 90th percentile. It is not surprising that the values are different in different regions, since growth and developmental charac-

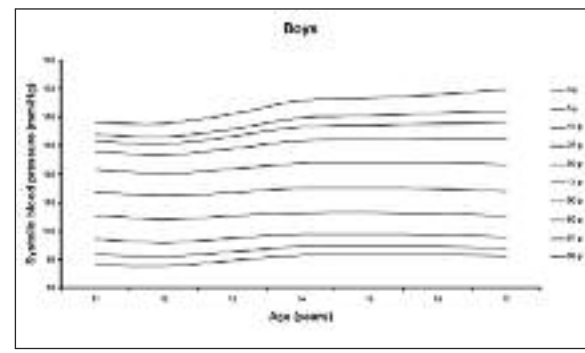

FIGURE 1: Percentile curves for systolic blood pressure in boys according to age.

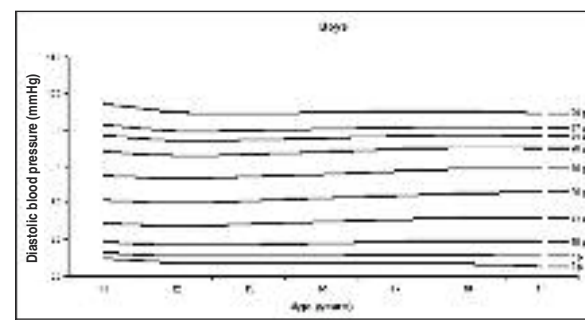

FIGURE 2: Percentile curves for diastolic blood pressure in boys according to age.

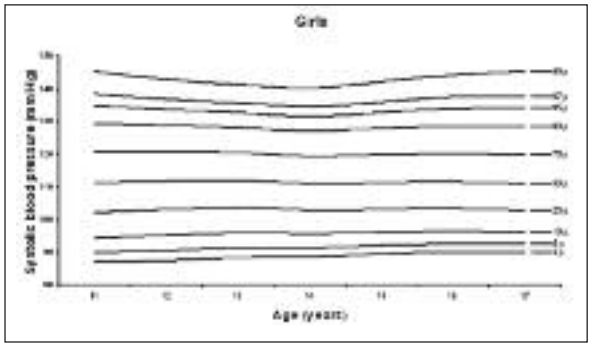

FIGURE 3: Percentile curves for systolic blood pressure in girls according to age.

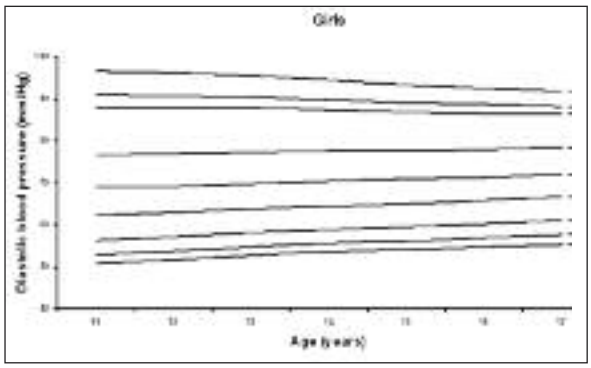

FIGURE 4: Percentile curves for diastolic blood pressure in girls according to age.

teristics, as well as life styles of children and adolescents in Turkish and other countries' populations also differ (e.g. obesity prevalence, dietary habits, salt intake, sedentary life style and so forth).

Our study has some limitations. First of all white coat hypertension is an important factor in these type of studies. In order to minimize this effect, we obtained two readings from the participants. In addition to that, our study includes measurements for, only 11- to 17-years-old; we chose this range, because blood pressure can easily and accurately be measured in children in this age group.

There is no consensus about how often routine blood pressure checks should be conducted in children and adolescents during their periodic physical examinations in the primary care.[8] According to NHBPEP recommendations, children 3 years old and older should have their blood pressure measured whenever they are seen at a medical facility. In contrast, the U.S. Preventive Service Task Force (USPSTF) concluded that there is insufficient evidence to recommend for or against routine screening for childhood hypertension to reduce the risk of coronary artery disease (evidence rating C).[23] However recommendations may change as obesity increases among children and adolescents.[13]

Some primary care physicians may not feel comfortable performing blood pressure measurements on children or adolescents in their daily practice because they lack proper training and knowledge. Under - or post-graduate procedural skills training may help primary care physicians perform these measurements with greater confidence.

In conclusion, in order to prevent children and adolescents from developing hypertension, primary care physicians have the responsibility and opportunity to monitor their patients' blood pressure. As they are in contact with their patients

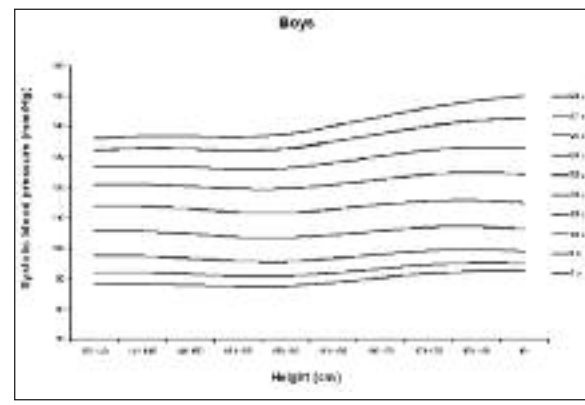

FIGURE 5: Percentile curves for systolic blood pressure in boys according to height groups.

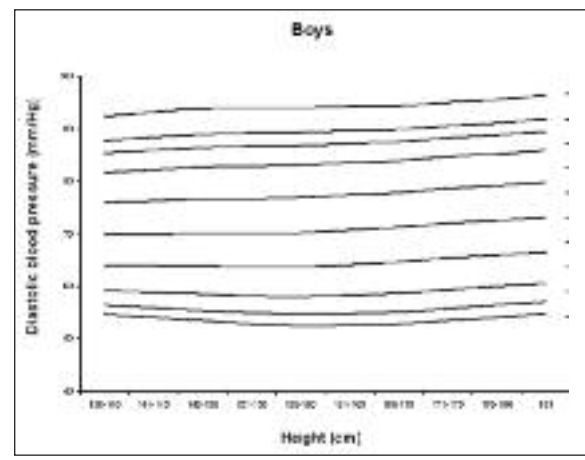

FIGURE 6: Percentile curves for diastolic blood pressure in boys according to height groups.

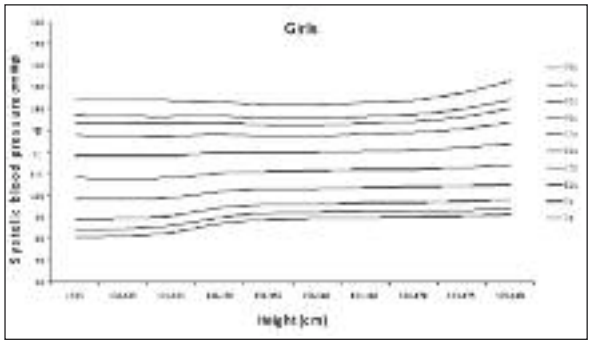

FIGURE 7: Percentile curves for systolic blood pressure in girls according to height groups.

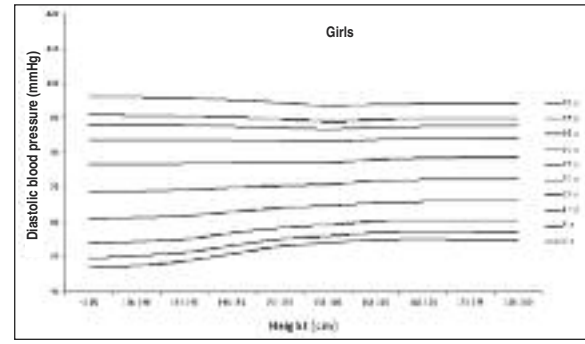

FIGURE 8: Percentile curves for diastolic blood pressure in girls according to height groups.

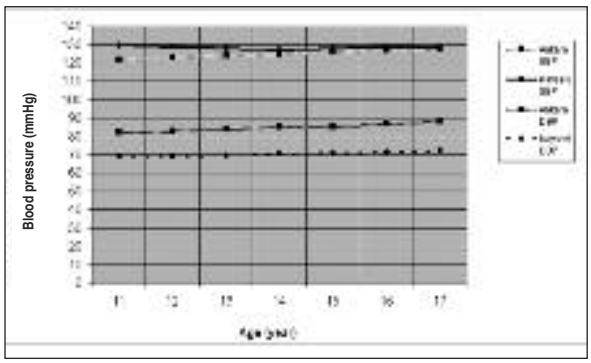

FIGURE 9: The comparision of the 90th percentiles of systolic and diastolic blood pressure measurements in girls of the present study with the subjects reported by Tümer et al.[16]

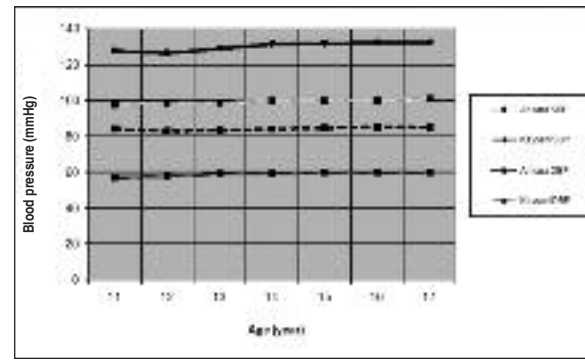

FIGURE 10: The comparision of the 90th percentiles of systolic and diastolic blood pressure measurements in boys of the present study with the subjects reported by Tümer et al.[16]

regularly for periodic physical examinations, physicians can effectively detect, prevent and treat hypertension in its early stages. Preventative care and health promotion activities can easily avert end organ damage in these patients. Nationwide population studies are needed to gather data about blood pressure percentiles in Turkish children and adolescents and to generate nomograms. Efforts should be increased to raise the awareness of the primary care physicians about high blood pressure and risk of hypertension in their pediatric and teen patients.

San Francisco Edit C.O had edited this article for English Language.

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