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Establishment of blood pressure nomograms representative for Egyptian children and adolescents: a cross-sectional study

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ABSTRACT

Objective To define nomograms for blood pressure in Egyptian children and adolescents.

Methods and study design A total of 60 025 Egyptian children from birth to 19 years were enrolled in this cross-sectional randomised study from December 2015 to March 2017. They were selected from diverse geographical districts in Egypt. Healthy children who fulfilled the inclusion criteria, which included good nutritional history, absence of fever or documented underlying disease at the time of examination, no evidence of haemodynamically significant illness, and no antihypertensive drugs or other chronic drug administration, were included in the study. Body weight, recumbent length (for less than 24 months) and height (from 2 years to 19 years), and blood pressure were measured using standard mercury sphygmomanometers.

Results Blood pressure increases with age in both boys and girls. The 90th percentile of systolic and diastolic blood pressure among Egyptian children was different from other ethnic populations (American and Turkish children) in both sexes. Systolic and diastolic blood pressure showed a positive correlation with weight and height in both sexes ($p<0.001$).

Conclusion We assumed that normal blood pressure curves should be used cautiously during childhood, and it is recommended that every population have its own normal standard curve to define measured blood pressure levels in children. These centiles increased our knowledge and awareness of normal blood pressure among Egyptian children and adolescents. The percentiles will distinguish children and young adolescents with increased blood pressure and will be of value to both medical practice and scientific research.

Strengths and limitations of this study

- The study has appropriate sample size estimation.
- Another strength of the study is its multicentre representation of diverse geographical districts in Egypt.
- The study used standard accurate mercury sphygmomanometers to record blood pressure (BP).
- BP measurements were obtained in usual settings for children such as school and home, overcoming the phenomenon of white coat hypertension.
- This is the first study to specify BP values and curves in Egyptian boys and girls.

INTRODUCTION

Blood pressure (BP) is regulated by an array of physiological mechanisms, including neuronal and hormonal impulses of the heart, blood vessels, brain, renal system and digestive tissues.[1] Age is considered one of the main determinants of BP values. BP increases more and more with age and more precipitously during puberty.[2] The additional contributing factor is sex, as the occurrence of hypertension is higher among boys than girls. BP values, particularly beyond 12–14 years, are greater in boys than girls, and this is similar to the findings in adults.[3]

As with adults, BP in children is determined by both height and weight; however, in the paediatric setting, the fraction attributable to height may be physiological, and may not be influenced by excess weight.[4]

There is considerable proof that BP measured in childhood predicts future BP. Those with BP levels in the higher sections of the distribution curve have a tendency to sustain this level over time, which is uncovering of BP tracking.[5] Hence, BP estimation has to be included in regular physical assessments during childhood and elucidated

Table 1 Age groups with the mean weight and height for both boys and girls

	Boys					Girls				
Age (years)	n	Mean weight (kg)	Deviations	Mean height (cm)	Deviations	n	Mean weight (kg)	Deviations	Mean height (cm)	Deviations
1	1344	10	0.10991	75	2.43733	1348	9	0.12203	73	2.78564
2	5716	13	0.11425	87	3.29913	5685	12	0.12523	85	3.57202
3	2406	15	0.12023	95	3.75950	2333	15	0.12899	94	3.77889
4	2223	17	0.12603	103	4.13071	2148	17	0.13145	102	4.28939
5	2199	19	0.13555	109	4.77980	2135	18	0.14005	109	4.65815
6	1259	21	0.14399	115	4.96748	1096	21	0.15255	114	5.31711
7	1288	23	0.15487	121	5.34940	1082	23	0.16145	120	5.39606
8	1290	25	0.16588	127	5.86112	1050	25	0.17122	126	5.76132
9	1244	28	0.17211	132	5.94979	1026	29	0.17455	132	6.03576
10	1283	31	0.17781	137	6.28514	1088	32	0.17933	138	6.26325
11	1305	35	0.18022	142	6.93480	1030	35	0.18015	144	7.22371
12	1254	39	0.18253	148	7.11191	1047	40	0.18244	151	6.91346
13	1284	44	0.18972	155	7.43915	1063	44	0.18475	156	7.02548
14	1247	48	0.18881	162	7.69325	1053	47	0.18952	159	6.93250
15	1299	50	0.19035	168	7.64829	1036	49	0.19134	161	6.82588
16	1261	52	0.19683	172	7.88363	1049	52	0.19735	162	6.52740
17	1248	53	0.19874	175	7.51475	1.073	52	0.20175	162	6.39211
18	1210	53	0.20051	175	7.31851	1034	54	0.24520	162	6.15977
19	1243	54	0.20472	176	7.25872	1046	54	0.25780	162	6.47949
Total	31603	–		–		28422	–		–	

according to the standards of the normal childhood BP distribution curve.[6] The distribution of BP levels and hypertension differs in various racial and ethnic clusters. This difference is determined by multiple factors, both genetic and environmental determinants. Grounded on these disparities, reference standards established for one population may not be appropriate in others.[2 7–12] Regional native reference norms are needed to evaluate estimated BP values. Thus, this work aimed to establish representative BP percentile charts for Egyptian children and adolescents for the early detection and accurate recognition of BP fluctuations and/or abnormalities.

METHODS AND DESIGN

Participants

Egypt is a great country consists of 27 governorates. The multistage random sampling technique was used to conduct the study. Out of the 27 governorates, 2 big governorates from Upper Egypt and 6 big governorates from Lower Egypt were chosen. Then 20 districts and cities were randomly chosen out of the previously chosen governorates. Within the districts and cities, facilities including a nursery, Primary care units (PCU) , vaccination centres, basic education schools and secondary training schools were counted, and 160 facilities in the selected 8 governorates were randomly chosen, as demonstrated in the sampling flow chart (online supplementary file). The study was conducted 3 days a week. The crowded days were taken in order to obtain and gather more information. In the nursery, primary health care (PHC) units and vaccination centres, the study was conducted in the morning in private rooms immediately after receiving medical advice or vaccination. In schools, the measurements were taken between the educational courses, during breaktime. The total number of children who were eligible for the study was 64500. After applying the inclusion and exclusion criteria, 4475 children were excluded, giving a final total sample of 60025. The children who fulfilled the criteria of the study from birth to 19 years were examined from December 2015 to March 2017, and are representative of the children in Egypt. Verbal consents were obtained from parents or guardians, and they were informed about the objectives of the study, its benefits and the absence of any risk associated with the participation of their children.

Inclusion and exclusion criteria

Healthy children who fulfilled the inclusion criteria, which included good nutritional history, absence of fever or documented underlying disease at the time of examination, no evidence of haemodynamically significant

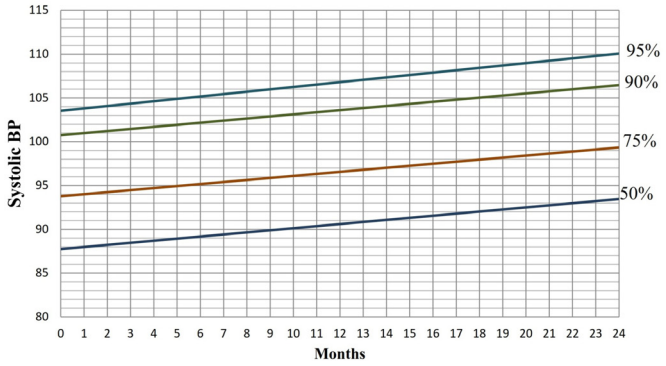

Figure 1 Smoothed percentile of systolic blood pressure (BP) measurements in Egyptian boys from birth to 24 months of age.

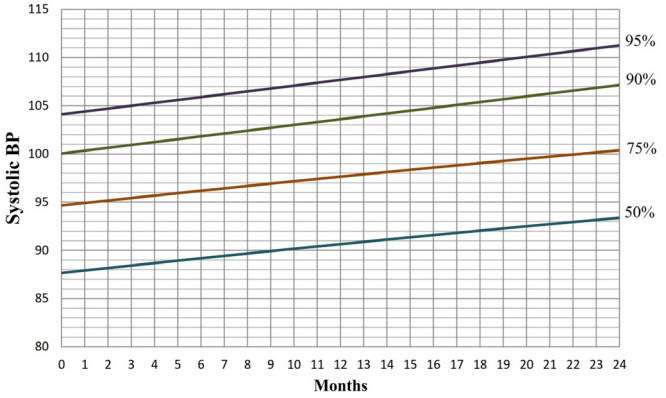

Figure 3 Smoothed percentile of systolic blood pressure (BP) measurements in Egyptian girls from birth to 24 months of age.

illness such as congenital heart disease, or thoracic surgery, and no antihypertensive drugs or other chronic drug administration, were included. Children and adolescents with obesity were excluded. There were 807 obese children: 338 boys (9 from birth to 1 year and 329 from 1 year to 19 years) and 469 girls (12 from birth to 1 year and 457 from 1 year to 19 years).

Measurements and data collection

Records were assembled by qualified medical personnel. Weight, recumbent length (for less than 24 months) and height (from 2 years to 19 years) were measured, as well as BP. All BP measuring instruments were calibrated on a daily basis. Standard mercury sphygmomanometers (Model 1002/Presameter, Riester, Germany) with different cuff sizes were used for all measurements.[13] In the present study, 60 025 children were examined in 160 facilities in 8 governorates using the standard mercury sphygmomanometer. Training was conducted with the working team for 3 days, along with invited children of different age and gender. This training was followed by testing to assess the degree of response to training and the quality of the measurement. The mean differences among the working observer team on 100 children of different age and sex as a pilot study were small (±0–3 mm Hg).

The evaluation of the effectiveness of site visits was concluded, and the use of an electronic device for internal standardisation was described. In all facilities, reliability was high and comparable with the observers at the coordinating centre. All the participants were in a comfortable sitting position (infants in supine), in a wakeful state with their right arm fully exposed and resting on a supportive surface at the heart level. A cuff bladder was selected with a width that covered at least two-thirds of the upper arm (the distance between the olecranon and acromion) and a length beyond at best 80% of the biceps' circumference. The cuff was inflated to a level that occluded the pulse at the wrist, the stethoscope was placed over the antecubital fossa, and then the cuff was deflated. The onset of the first Korotkoff (K1) sound was used as a measure for systolic blood pressure (SBP); K4 diastolic blood pressure (DBP) was used as the standard for infants and children 3–12 years of age; and K5 DBP was used as the standard for adolescents 13–19 years of age. Two readings were recorded with an interval of 5–10 min in-between and the mean was calculated for the final analysis.

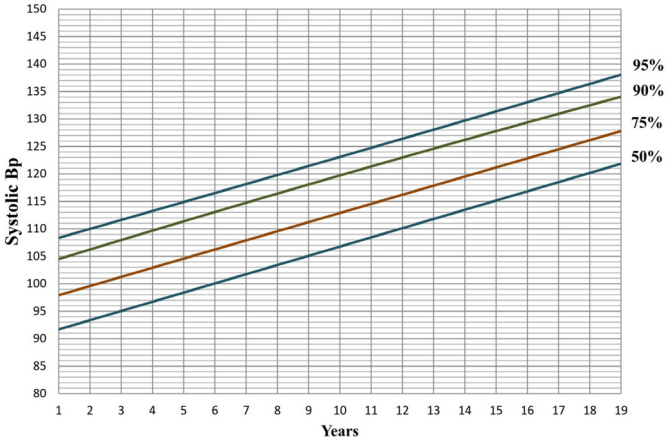

Figure 2 Smoothed percentile of systolic blood pressure (BP) measurements in Egyptian boys from 1 to 19 years of age.

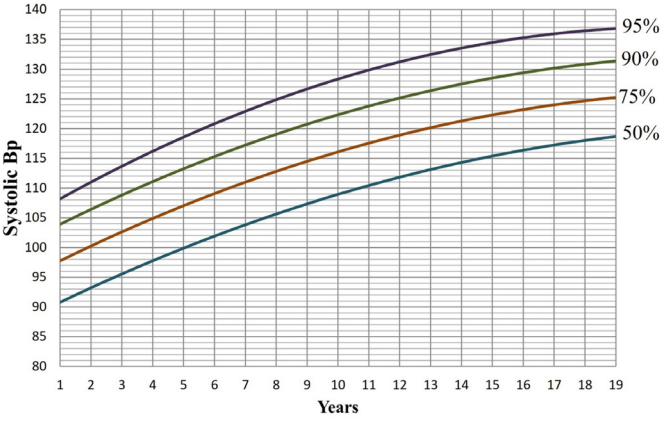

Figure 4 Smoothed percentiles of systolic blood pressure (BP) measurements in Egyptian girls from 1 to 19 years of age.

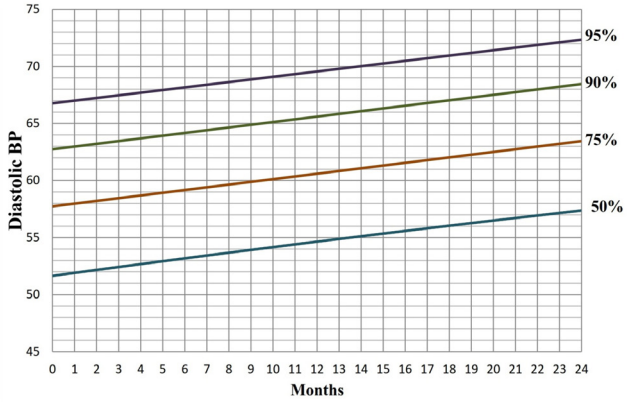

Figure 5 Smoothed percentiles of diastolic blood pressure (BP) measurements in Egyptian boys from birth to 24 months of age.

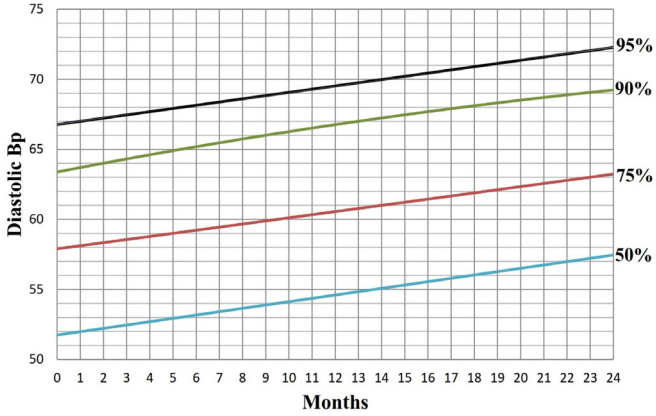

Figure 7 Smoothed percentiles of diastolic blood pressure (BP) measurements in Egyptian girls from birth to 24 months of age.

Patient and public involvement

To improve the relevance of research, research orientation that includes patients and the public is vital. The authors aimed to identify the most important research priorities of patients, caregivers and healthcare providers (paediatricians, nurses and dietitians) for BP measurement. A paper-based survey asked patients, caregivers and care providers to submit their unanswered questions on BP measurement. A priority-setting process then ranked the final top 4 research priorities during an inperson meeting. There were 200 respondents who submitted 360 questions after exclusions. Of the respondents, 50% were patients or caregivers, 60% lived in urban areas, the caregivers were aged 23–45 years, and 85% were women. The 360 questions were reduced to 20 unique questions, and from this list the top 4 research questions that were prioritised included charts that can easily determine normal and abnormal levels of BP, education tools and technologies to improve patient motivation and health behaviours, evaluation of the optimal role of different healthcare providers and caregivers in supporting patients with abnormal change in BP, and development of healthy lifestyle modifications to reduce changes in BP. In areas that are of high priority for BP measurement, these priorities can be used to guide clinicians, researchers and funding bodies for patients, caregivers and healthcare providers. This also highlights priority areas for improved communication, knowledge transfer and delivery of patient-centred care. The children (n=100) of different age and sex who were subjected to BP measurement by observers to assess the degree of response to training and quality of measurement participated in setting the priorities of the research either on their own or by their caregiver. Some of these children, as well as caregivers, in addition to a large number of children from different sites in different governorates, helped us distribute the brochures that encourage BP measurement and invite their peers, for example, from schools, clubs and others, to come to the facilities where BP measurements were conducted. Also, we responded to some of the opinions of the caregivers, especially in addressing concerns with the great governorates and how to make communication with every single governorate, especially that for some of

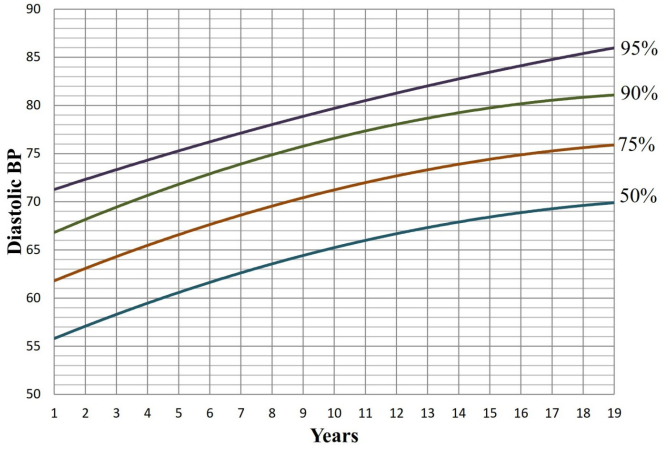

Figure 6 Smoothed percentiles of diastolic blood pressure (BP) measurements in Egyptian boys from 1 to 19 years of age.

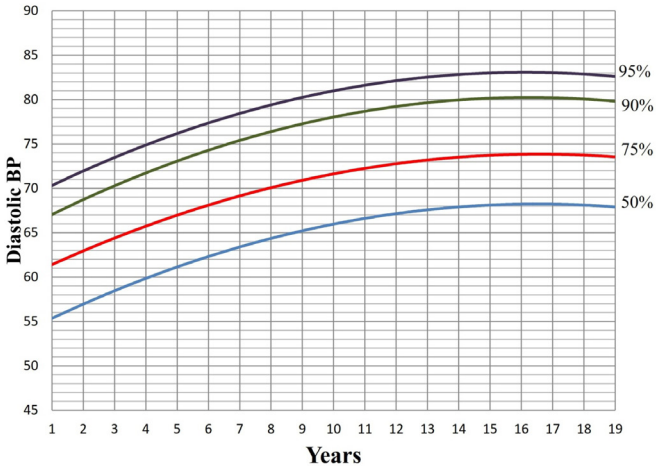

Figure 8 Smoothed percentiles of diastolic blood pressure (BP) measurements in Egyptian girls from 1 to 19 years of age.

Table 2 Exact percentile values for systolic blood pressure (SBP) measurements in Egyptian boys from birth to 24 months of age

	Percentile values for SBP (mm Hg)			
Age (month)	50%	75%	90%	95%
0	88	94	101	104
1	88	94	101	104
2	88	94	101	104
3	88	94	101	104
4	89	95	102	105
5	89	95	102	105
6	89	95	102	105
7	89	95	102	105
8	90	96	103	106
9	90	96	103	106
10	90	96	103	106
11	90	96	103	106
12	91	97	104	107
13	91	97	104	107
14	91	97	104	107
15	91	97	104	108
16	92	98	105	108
17	92	98	105	108
18	92	98	105	108
19	92	98	105	109
20	93	98	106	109
21	93	99	106	109
22	93	99	106	110
23	93	99	106	110
24	93	99	106	110

Table 3 Exact percentile values for systolic blood pressure (SBP) measurements in Egyptian boys from 1 to 19 years of age

	Percentile values for SBP (mm Hg)			
Age (year)	50%	75%	90%	95%
1	91	97	104	107
2	93	99	106	110
3	95	102	108	112
4	97	103	110	114
5	99	105	112	115
6	101	107	113	117
7	102	108	115	119
8	103	110	116	120
9	105	111	118	121
10	107	113	120	123
11	109	115	122	125
12	110	116	123	126
12	111	117	124	127
14	112	118	125	129
15	114	120	127	130
16	116	122	128	132
17	118	124	131	135
18	121	127	133	137
19	123	129	135	139

us it was the first time to visit some of the involved governorates. Their help will never be forgotten, so besides our role in the dissemination of the results through telephone calls to inform them about their BP measurements, we will also organise an event or a special day in every governorate to thank them and to address the main health problems they have.

Statistical analysis

With a view to accomplishing the reference standard curves (smoothed percentiles), logarithmic and semilogarithmic adjustments of SBP and DBP were statistically valued by regression analysis for different percentiles (50th, 75th, 90th and 95th), and the correlation coefficients of SBP and DBP with weight and height were processed. The statistical analysis was accomplished using IBM SPSS Statistics V.20 and ages were verified in complete years. The benchmarks used to certify the normal (50th–90th percentile), high-normal (90th–95th percentile) and high BP (>95th percentile) were comparable with the Report of the Second Task Force on Blood Pressure Control in Children in 1987.[13]

RESULTS

A total of 60 025 Egyptian children, 31 603 boys (52.6%) and 28 422 girls (47.4%), from birth to 19 years of age were examined in this study on SBP and DBP (table 1). Various smoothed percentile charts of SBP and DBP for both sexes according to age are shown in figures 1–8. In the present study, SBP and DBP rose steadily with age in both boys and girls. The mean annual increase in SBP for boys was 1.68 mm Hg and 1.53 mm Hg for girls (tables 2–5). The SBP increment was 2 mm Hg up to the age of 11 years in girls, and then decreased to 1 mm Hg from 12 to 19 years as the girls showed a sudden increase in height at puberty (table 5).

The average annual increases in DBP for boys and girls were 0.95 mm Hg and 0.74 mm Hg, respectively. There was a sharp increase in DBP from 17 to 19 years of age (tables 6–9).

There was a strong positive correlation between SBP and DBP with height and weight in both sexes. Concerning boys, the coefficients of correlation of SBP and DBP with height were 0.98 ($p<0.001$) and 0.98 ($p<0.001$) and with weight 0.98 ($p<0.001$) and 0.95 ($p<0.001$), respectively, while in girls the coefficients of correlation of SBP and DBP with height were 0.99 ($p<0.001$) and 0.98 ($p<0.001$)

Table 4 Exact percentile values for systolic blood pressure (SBP) measurements in Egyptian girls from birth to 24 months of age

	Percentile values for SBP (mm Hg)			
Age (month)	50%	75%	90%	95%
0	88	95	100	104
1	88	95	100	104
2	88	95	101	105
3	88	95	101	105
4	89	96	101	105
5	89	96	102	106
6	89	96	102	106
7	89	96	102	106
8	90	97	102	107
9	90	97	103	107
10	90	97	103	107
11	90	97	103	107
12	91	98	104	108
13	91	98	104	108
14	91	98	104	108
15	91	98	104	108
16	92	99	105	109
17	92	99	105	109
18	92	99	105	110
19	92	99	106	110
20	93	100	106	110
21	93	100	106	110
22	93	100	107	111
23	93	100	107	111
24	93	100	107	111

Table 5 Exact percentile values for systolic blood pressure (SBP) measurements in Egyptian girls from 1 to 19 years of age

	Percentile values for SBP (mm Hg)			
Age (year)	50%	75%	90%	95%
1	91	98	104	108
2	93	100	107	111
3	96	103	109	115
4	98	105	112	117
5	100	107	114	119
6	102	109	115	121
7	103	111	117	123
8	105	112	119	124
9	107	114	120	126
10	109	116	122	128
11	111	118	124	130
12	112	119	125	131
12	113	120	126	132
14	114	121	127	133
15	115	122	128	134
16	116	123	129	135
17	117	124	130	136
18	118	125	131	137
19	119	125	132	137

and with weight 0.97 (p<0.001) and 0.91 (p<0.001), respectively.

The 90th percentile of SBP and DBP in the present study was compared for each age with the results reported in the study of the Second Task Force and Turkish children[13] and the Report of the Second Task Force on Blood Pressure Control in Children in the USA.[14] In boys, the 90th percentiles of SBP in Egyptian children were higher than in American children in the first 13 years, then became lower. Turkish children were higher than Egyptian children from 3 to 11 years, then became lower. The 90th percentiles for SBP in Egyptian girls were higher than in both American and Turkish girls of all ages. The DBP of American boys was lower than the Egyptians until the age of 16 years, then the DBP became higher, while the DBP of Turkish boys was lower than the Egyptians until the age of 5 years, then disclosed a significant rise. Both American and Turkish girls showed decreased DBP when compared with Egyptian girls, but this decrease exhibited an increase at the age of 12 years in American girls and at the age of 8 years in Turkish girls (figures 9–12).

DISCUSSION

Hypertension is considered one of the main health problems all over the world due to its high occurrence and its causal relationship with morbidity and mortality.[15] Estimation of BP in children and adolescents should be a chief vital domain of global healthcare. BP in children varied with age and physical mass. BP values should be matched with normal percentile curves before concluding its normality. The distribution of BP levels and the frequency of hypertension vary in different ethnic groups.[10 11] The inclusion of BP measurements in the regular paediatric examination besides the establishment of national norms in children promotes discovery of asymptomatic hypertension attributable to previously unidentified disorders. In addition, it confirms that a slight increase in BP during childhood more commonly occurred than previously realised, predominantly in adolescents.[16] The present study demonstrates that BP increases with age; however, this increase varied with different ages and from boys to girls, especially with the onset of adolescence. These findings are consistent with previous population-based studies.[17 18] There was a sharp increase in DBP from 17 to 19 years, which may

Table 6 Exact percentile values for diastolic blood pressure (DBP) measurements in Egyptian boys from birth to 24 months of age

	Percentile values for DBP (mm Hg)			
Age (month)	50%	75%	90%	95%
0	52	58	63	67
1	52	58	63	67
2	52	58	63	67
3	52	58	63	67
4	53	59	64	68
5	53	59	64	68
6	53	59	64	68
7	53	59	64	68
8	54	60	65	69
9	54	60	65	69
10	54	60	65	69
11	54	60	65	69
12	55	61	66	70
13	55	61	66	70
14	55	61	66	70
15	55	61	66	70
16	56	62	67	71
17	56	62	67	71
18	56	62	67	71
19	56	62	67	71
20	57	63	68	71
21	57	63	68	72
22	57	63	68	72
23	57	63	68	72
24	57	63	68	72

Table 7 Exact percentile values for diastolic blood pressure (DBP) measurements in Egyptian boys from 1 to 19 years of age

	Percentile values for DBP (mm Hg)			
Age (year)	50%	75%	90%	95%
1	57	63	68	72
2	55	61	66	70
3	58	64	70	73
4	60	66	71	75
5	61	67	72	76
6	62	68	73	77
7	63	69	74	78
8	64	70	75	79
9	65	71	76	79
10	65	71	77	80
11	66	72	77	80
12	66	72	78	81
13	67	73	78	81
14	67	73	79	82
15	68	74	79	82
16	68	74	80	83
17	69	75	80	84
18	70	76	81	86
19	71	77	82	88

be attributed to the stress frequently encountered during the period. The rise in BP with increasing age is most probably caused by the growth of the child. Many researchers believed that the most powerful determinants of normal BP are chronological age and body size influenced by height and weight.[19]

Research and challenges to appreciating the field of racial variations and discrepancies in the circulatory standards are encumbered by the little knowledge foundation. In the present study, the trend of SBP and DBP rise was different from that reported by the Turkish and American Second Task Force. The latter Task Force values were based on nine different populations, including African and Mexican Americans. They used the first BP reading and not the average of two readings as in our study. Because of the absence of local data, reference standards based on American children have often been used worldwide and in most low-income and middle-income countries including Egypt. Hence, the standardisation of the American norms can be misleading and BP measurements in children should be compared with local normative BP data.

Comparing BP values of African–Americans (AAs) with those of European descent, or European Americans, AAs have higher nocturnal BP as well as a smaller difference between daytime pressures. Also the lack of night-time drop in BP seen in AAs at a very young age and that accelerates during the adolescent years may be associated with increased vascular disease frequencies in AAs and may explain the frequent early onset of vascular disease, which may be attributed to the interaction of multiple influences including genetics, lifestyle regimen and deprivation.[20]

It is hard to define and classify race and ethnicity. The racial differences in BP measurements between Egyptian children compared with Turkish and American values may be driven by multiplex determinants including gene to gene, environment to environment, and gene to environment interfaces. Environmental aspects may include stress, body weight, and sodium and potassium consumption. Among the environmental influences are social concerns that may induce stress and possibly affect many physiological operations that are difficult to be evaluated and result in many biological upsets. Other social issues such as access to insurance coverage, income, education, physical activities and other sociodemographic variables such as age,

Table 8 Exact percentile values for diastolic blood pressure (DBP) measurements in Egyptian girls from birth to 24 months of age

	Percentile values for DBP (mm Hg)			
Age (month)	50%	75%	90%	95%
0	52	58	63	67
1	52	58	64	67
2	52	58	64	67
3	52	59	64	67
4	53	59	65	68
5	53	59	65	68
6	53	59	65	68
7	53	59	66	68
8	54	60	66	69
9	54	60	66	69
10	54	60	66	69
11	54	60	66	69
12	55	61	67	70
13	55	61	67	70
14	55	61	67	70
15	55	61	67	70
16	56	61	68	70
17	56	62	68	71
18	56	62	68	71
19	56	62	68	71
20	57	62	69	71
21	57	63	69	72
22	57	63	69	72
23	57	63	69	72
24	57	63	69	72

Table 9 Exact percentile values for diastolic blood pressure (DBP) measurements in Egyptian girls from 1 to 19 years of age

	Percentile values for DBP (mm Hg)			
Age (year)	50%	75%	90%	95%
1	55	61	67	70
2	57	63	69	72
3	59	65	71	74
4	61	67	73	76
5	62	68	74	77
6	63	69	75	78
7	64	70	76	79
8	65	70	77	80
9	65	71	77	80
10	66	71	78	81
11	66	72	78	81
12	66	72	78	81
12	67	72	79	82
14	67	73	79	82
15	67	73	79	82
16	68	73	80	83
17	68	74	80	83
18	69	74	81	83
19	69	75	81	84

sex and weight (body mass index) may have less interaction with biology, but these factors have certain influences on the outcome.[20 21]

Some researchers used an automated oscillometric device as it was easy to be used in children and to overcome the possibility of human error, but unfortunately it usually overestimates the BP matched with mercury-based sphygmomanometry. The definition of normal BP values in children is based on mercury sphygmomanometry, so in our study mercury sphygmomanometer was used to estimate BP measurements.[22]

Clinical BP recordings lean to be greater than home recordings, known as white coat hypertension.[23] To record the real BP of subjects, the measurements were obtained in the usual settings for children, such as school and home. This variation in BP observed between different countries will postulate notable new suggestion on the variability of BP thresholds for the diagnosis and monitoring of hypertension between different ethnic clusters.

Until now there are no available BP nomograms for children and adolescents in Egypt. So we are one of the few academic scientific research teams to specify BP values and curves for Egyptian girls and boys.

In our study, we performed multicentric representation of diverse geographical districts in Egypt with different environments (rural and urban) and large

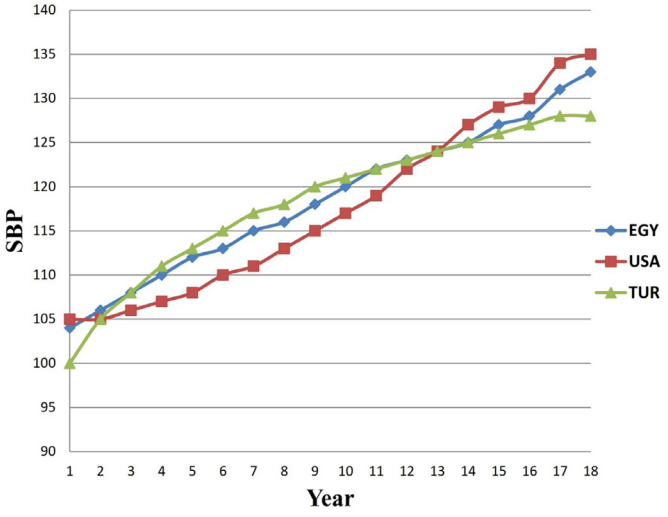

Figure 9 Comparison of the 90th percentile of systolic blood pressure (SBP) measurements of Egyptian (EGY) boys with the values of American (USA) and Turkish (TUR) boys.

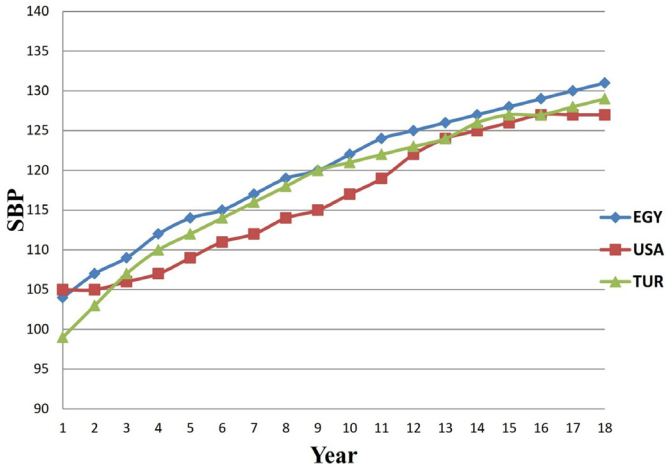

Figure 10 Comparison of the 90th percentile of systolic blood pressure (SBP) measurements of Egyptian (EGY) girls with the values of American (USA) and Turkish (TUR) girls.

sample size, and used the standard accurate mercury sphygmomanometers for BP records in the usual settings for children, such as school and home, overcoming the phenomenon of white coat hypertension and the inclusion of neonatal age and infancy, which were considered limitations in other studies.[24] However, the exclusion of obese children in this study may create some sort of a selection bias, which may be attributed to BP variations between populations. Recent recommendations on the identification of high BP in children and adolescents offer BP standards based on sex, age, weight and height. Therefore, it may be essential to consider these variables during the establishment of reference BP standards in future work.

CONCLUSION

This analysis supports the hypothesis that regional differences, eating habits, differences in morphometric characteristics and other cultural factors may account for differences in BP levels during childhood. Therefore, every population needs to apply its own norms to delineate a measured BP level in childhood. The BP measurements of Egyptian children and adolescents can be evaluated using the standards displayed in this scientific paper.

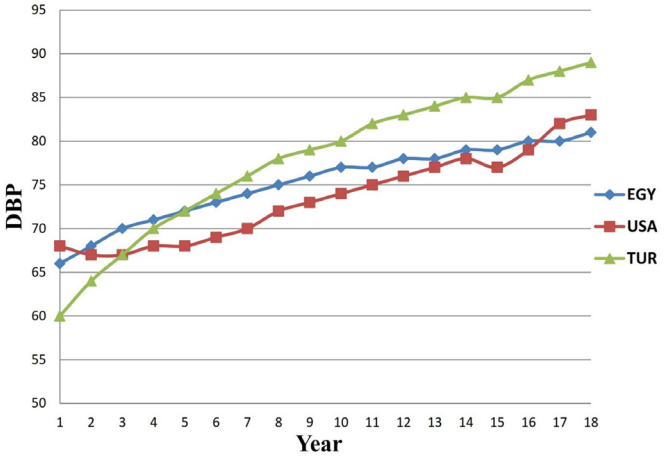

Figure 11 Comparison of the 90th percentile of diastolic blood pressure (DBP) measurements of Egyptian (EGY) boys with the values of American (USA) and Turkish (TUR) boys.

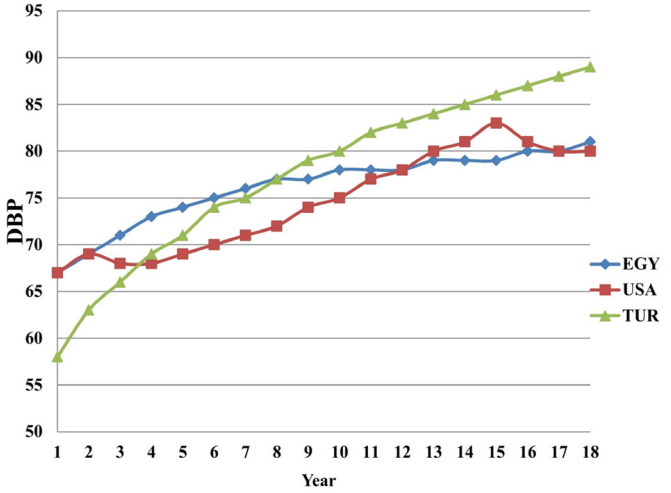

Figure 12 Comparison of the 90th percentile of diastolic blood pressure (DBP) measurements of Egyptian (EGY) girls with the values of American (USA) and Turkish (TUR) girls.

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