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BLOOD PRESSURE PERCENTILES BY AGE AND BODY MASS INDEX FOR ADULTS

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ABSTRACT

Since no comprehensive study has been conducted on blood pressure (BP) percentiles established upon nationally representative sample population of adults, the present study aimed to construct the blood pressure percentiles by age, sex and body mass index (BMI) of the subjects. Analyses were based on data collected in 2011 from 8,425 adults aged 25 to 69 years old. Data on demographic characteristics, anthropometric measurements, and blood pressure was recorded for each subject. Linear Regression analysis was used to assess the adjusted relationship of age-sex-specific standard deviation scores of BMI, height, and weight with blood pressure. Four separate models for systolic blood pressure (SBP) and diastolic blood pressure (DBP) of men and women were constructed for BP percentiles according to age and BMI. Blood pressure increased with the rise in BMI and weight, but showed a negative correlation with height. SBP and DBP rose steadily with increasing age, but the rise in SBP was greater than DBP. Overweight and obese population, seem to fall into the category of hypertensive. The findings of present study show that BP percentiles are steadily increased by age and BMI. In addition, most obese or overweight adults are hypertensive.

Keywords: Blood pressure percentile, age, body mass index, nomograms, adults

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INTRODUCTION

A great deal of the worldwide burden of disease is attributed to high blood pressure, including about 13.5 % of the premature deaths and 6 % of the total global Disability Adjusted Life years (DALYs) (Lawes et al., 2008). Therefore, hypertension in adults and children has drawn attention of many researchers and controlling it has become as a worldwide priority among health policies. Because early detection of hypertension can help control its various complications, blood pressure measurement is now regarded as an important part of routine physical examination (Somu et al., 2003). To interpret measurements precisely, they should be compared to the standard blood pressure (BP) nomograms. However, the distribution of BP values vary based on ethnicities and races, thus standard values derived from a specific population might not be applicable to others; consequently, local reference data could be a better choice to evaluate the BP measurements properly (Goonasekera and Dillon. 2000). In addition, several studies show that overweight and obesity are associated with higher levels of blood pressure and subsequently higher prevalence of hypertension (Robinson et al., 2004; McGavock et al., 2007; Hosseini et al., 2010). So, it is important for each population to develop national BP percentiles for age, sex, and potential anthropometric characteristics which may influence BP levels. In recent years few studies have been conducted to develop blood pressure nomograms for age and anthropometric characteristics, simultaneously, only for children and adolescents (Neuhauser et al., 2011; Yan et al., 2013). But none of them have evaluated adult populations. Janghorbani et al. in 2007 reported age-adjusted BP for Body Mass Index (BMI) categories based on a nationally representative population of 89404 subjects. However, they only presented the mean of systolic blood pressure (SBP) and diastolic blood pressure (DBP) and did not model BP percentile for adults' population according to age and BMI, simultaneously. In 2009, Esteghamati et al. reported that the prevalence of hypertension to be 25 % in a population with 5287 subjects (15-64 years), based on the seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure (JNC-7) guideline. Moreover, a meta-analysis by Haghdoost et al. in 2008 also reported the prevalence of 23 % for adults aged 30-55 years and 50 % for subjects older than 55 years. Therefore, this study aimed to present blood pressure percentiles by age, sex, and BMI of a nationally representative sample population of adults.

MATERIALS AND METHODS

Study population

Data were collected by Iran's Center for Disease Control and Prevention through the sixth round of national surveillance of Non Communicable Diseases Risk Factors in 2011. A sample of 8425 Iranian adults aged between 25 to 69 years was chosen by a multi-stage cluster random sampling scheme. Fifty counties were randomly selected as the primary sampling units by using the systematic proportional-to-size probability technique. Each of these units included twelve clusters each containing 20-person, chosen via the same method from rural and urban areas. Households were the sample listing units. A maximum of two persons, one younger than 55 years and the other older than 55 years, were selected in each household using a KISH randomization method.

The study questionnaire, initially proposed by World Health Organization and validated in Iran, was completed for each subject through a face-to-face interview by trained staff from 51 medical schools across the country. An informed consent was obtained from the subjects. The study was approved by local Ethical Committee.

Measurements

Blood pressure measurements

The blood pressures were measured after at least a 5 minute rest by a standard mercury

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sphygmomanometer (Model 1002/Presameter, Riester, Germany) with the subjects in a comfortable sitting position, a wakeful state and the right arm positioned at the heart level.

The selected cuff had a bladder with the width of approximately 40 % of the arm length, long enough to cover 80 % - 100 % of the arm circumference. The cuff was placed 1 inch above the antecubital fossa, and inflated to occlude the wrist pulse. With the stethoscope placed over the brachial artery, the cuff was deflated. The first Korotkoff (K1) sound was considered to be correlated with the systolic BP and the fifth phase of Korotkoff sounds with the diastolic BP. BPs were measured twice with an interval of at least 30 seconds and the mean of the two recordings was used for data analysis. The differences were insignificant.

Height and weight measurements

The subjects' height (cm) was measured barefoot in a standing upright position with the heels and back against a vertical scale, using a stadiometer (Seca Model 207 Germany). To measure the weight, a balanced scale (Seca Model 710 Germany) was used with the subject barefoot without heavy outer clothing.

BMI was calculated as body weight (kg) divided by the square of the subject's height (m). Having passed a training course for anthropometric measurements, a team of field technicians in each administrative district measured all the required data.

Age-sex-specific standard deviation (SD) scores

To compare the relationships of BMI, weight, and height with blood pressure we used the following formula to change them into age- and sex-specific SD scores (or z-scores):

$$\text{SD score} = \frac{\text{Observed value - Age and sex specific mean}}{\text{Age and sex specific SD}}$$

The relationship between each variable and blood pressure was described as the change in BP in response to an increase of the variable by 1 SD. Linear regression analysis was used to estimate the changes in blood pressure. The coefficient of this analysis represented the estimated change in response to 1 SD increase. The changes in BP in relation to BMI were calculated for men and women, separately, as well as for each of the age- and sex-specific groups. To assess the relationship between BP and weight, the height was adjusted and for its relationship with height, the weight was adjusted, as well.

Construction of the BP level nomograms according to age, sex, and BMI

Four separate models for SBP and DBP of men and women were constructed for BP percentiles as a function of both age and BMI. First, the Lambda-Mu-Sigma (LMS) method was used to model the BMI percentiles with age for men and women. Then, the reference curves for adults by age and BMI were fitted, simultaneously, using an extension of the LMS method for two covariates. The generalized additive models for location scale and shape (GAMLSS) with the Box-Cox-Cole- Green distribution family (Rigby and Stasinopoulos, 2005; Stanojevic et al., 2008,;, Cole et al., 2009) fitted with GAMLSS 4.2-0 in the free statistical software R 2.15.2 (http://www.R-project.org). Assumption of normality or a constant variance of BP values with age and/or BMI was not required for neither of them. The skewness parameter L, the median M, and the coefficient of variation S, were modeled as a function of age and/or BMI either as polynomials or non-parametrically by cubic splines. The generalized Akaike information criterion and the percentage of data outside the smoothed percentiles were investigated to examine the goodness of fit.

In LMS modeling of BMI with age, the skewness parameter L, the median M and the coefficient of variation S, were 2, 3, 3, both for men and women.

Median of SBP varied with age and BMI. Median of DBP was given by a quadratic function in age and linear in BMI. For SBP

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in men and women, the model of medians included cubic spline of age, a linear term for BMI, the interaction terms BMI×age, and BMI×age2. Similar models were used for the median of DBP in both genders; however, for the DBP of women, the interaction term of BMI×age2 was excluded as non-significant. Coefficient of variation (S) of SBP and DBP varied as a linear function of age.

In this study, only the mentioned percentiles were reported, but any (100α) percentile Pα can be calculated by the following formula:

$$P_\alpha = M(1+LSZ_\alpha)^{1/L} \text{ for } L\neq 0$$

or

$$P_\alpha = M\times\exp(SZ_\alpha) \text{ for } L=0,$$

with Z_α the α quantile of a standard normal distribution.

RESULTS

Blood pressure was measured in a nationally representative sample of 8,425 adults aged 25 to 69 years old in Tehran. Table 1 shows the baseline demographic characteristics of the study population. Of the 3,381 male subjects, 1289 (38.1 %) subjects were aged 55-69, 970 (28.7 %) aged 25 to 34, 607 (18.0 %) aged 35-44, and 515 (15.2 %) aged 45-54. The studied population included 5044 women, 1705 (33.8 %) of whom were aged 55 to 69, 1409 (27.9 %) subjects were 25 to 34 years old, 983 (19.5 %) 45 to 54, and 947 (18.8 %) aged between 35 to 44 years old.

The mean of BMI among men was highest in the age group of 55 to 69 with 26.3 kg/m^2. Unlike the men, mean of BMI in women did not increase with age and the highest mean of BMI was calculated 29.0 kg/m^2 for the age group of 45 to 54. It was 28.6 kg/m^2 for the age group of 55 to 69.

The mean of SBP and DBP measurements in both genders increased with age. Except for the age group of 25 to 34, the mean of DBP measurements was higher in women compared to men. On the other hand, men had higher SBP means in all age groups except for the age group of 55 to 69.

950 men were categorized as hypertensive; that is 28.1 % (95 % CI: 26.6 % - 29.6 %) of the study population. 1478 (29.3 %) female subjects were categorized as hypertensive (95 % CI: 28.0 %-30.6 %).

The effects of BMI, weight and height on BP are shown in Table 2. As can be seen, BP increased with the rise of BMI and weight, but it showed a negative correlation with height. Systolic BP increased 2.77 and 3.19 mmHg for women and men, respectively, with 1 SD increase in BMI when adjusted for age. Similarly, diastolic BP increased 1.69 and 2.28 mmHg with 1 SD increase in BMI. After adjusting for height and age, weight remained to be substantially associated with BP. We found an increase of 2.64 mmHg for systolic BP and 1.77 mmHg for diastolic BP in women, and 3.66 mmHg for systolic BP and 2.56 mmHg for diastolic BP in men, corresponding to 1 SD increase in weight. However, 1 SD increase in height found to decrease systolic and diastolic BP 1.50 and 1.09 mmHg in women and 0.88 and 0.99 mmHg in men, respectively, when it was adjusted for weight and age. All 95 % confidence interval (CI) of the above estimates of effect were narrow, as shown in Table 2.

The standardized coefficients (|t|) of BP in relation to BMI in women were higher than the coefficients of its relation to weight. As for the men these coefficients were similar for BMI and weight. Since the interpretation of BP norms according to BMI (obesity) seems to be more convenient, it was decided to present blood pressure percentiles by age and BMI for adults.

Tables 3 and 4 demonstrate the 50th, 90th, 95th, and 99th percentiles of SBP and DBP for the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles of BMI in specific selected ages of both genders. To create a better perception of data presented in Tables 3 and 4, four line graphs were designed to show the trend of changes in 90th, 95th, and 99th of SBP and DBP percentiles by age for the 75th and 95th

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Table 1: Baseline characteristics of the adults study population (3381 men and 5044 women aged 25 - 69 years)

Characteristics	Age (years)			
	25-34	35-44	45-54	55-69
Adults studied, *n*				
Men	970	607	515	1,289
Women	1,409	947	983	1,705
Weight, mean (SD), kg				
Men	75.45 (16.61)	76.25 (15.65)	75.25 (14.02)	73.61 (14.71)
Women	64.87 (14.39)	70.40 (15.72)	71.05 (14.18)	67.76 (14.28)
Height, mean (SD), cm				
Men	173.1 (7.9)	171.2 (8.5)	169.4 (9.0)	167.3 (8.6)
Women	159.1 (7.0)	157.7 (6.0)	156.6 (6.6)	154.1 (7.5)
BMI, mean (SD), kg/m2				
Men	25.2 (5.2)	26.0 (5.0)	26.3 (5.1)	26.3 (5.5)
Women	25.6 (5.3)	28.2 (5.8)	29.0 (5.5)	28.6 (6.0)
Mean (SD) of 3 SBP measurements, mmHg				
Men	121.3 (12.9)	123.4 (13.6)	130.7 (18.4)	135.7 (20.5)
Women	114.0 (12.9)	121.1 (16.9)	130.2 (20.3)	138.2 (22.4)
Mean (SD) of 3 DBP measurements, mmHg				
Men	76.0 (10.1)	78.6 (10.6)	81.9 (11.3)	82.5 (12.5)
Women	75.6 (10.0)	79.9 (11.8)	82.7 (12.1)	83.8 (12.6)
Hypertension, n (%)				
Men	118 (12.16)	104 (17.13)	185 (35.92)	543 (42.13)
Women	130 (9.23)	207 (21.86)	343 (34.89)	798 (46. 80)

BMI=Body mass index; SD=Standard deviation; SBP=Systolic blood pressure; DBP=Diastolic blood pressure

Table 2: Effects of body size on systolic and diastolic blood pressure measurements

Sex	Systolic blood pressure			Diastolic blood pressure		
	Effect (95% CI)	|t|	P value	Effect (95 % CI)	|t|	P value
Women						
BMI*	2.77 (2.05-3.50)	7.68	< 0.0001	1.69 (0.84-2.54)	3.99	< 0.0001
Weight†	2.64 (1.55-3.73)	4.86	< 0.0001	1.77 (0.83-2.71)	3.78	< 0.0001
Height‡	-1.50 (-2.20- -0.79)	4.27	< 0.0001	-1.09 (-1.54–0.64)	4.91	< 0.0001
Men						
BMI*	3.19 (2.08-4.29)	5.81	< 0.0001	2.28 (1.44-3.12)	5.45	< 0.0001
Weight†	3.66 (2.51-4.81)	6.41	< 0.0001	2.56 (1.69-3.42)	5.91	< 0.0001
Height‡	-0.88 (-1.74- -0.01)	2.04	< 0.0001	-0.99 (-1.80--0 .17)	2.44	0.018

Blood pressure change (mmHg) corresponding to 1 standard deviation increase in BMI, weight and height. *Adjusted for age; †Adjusted for age and height; ‡Adjusted for age and weight. CI=Confidence interval; BMI=Body mass index

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Table 3: BP Levels for males according to age and BMI

Age (year)	BMI (kg/m^2)	SBP Percentile (mm Hg)				DBP Percentile (mm Hg)			
		50th	90th	95th	99th	50th	90th	95th	99th
25	17.8	114	129	134	145	71	83	87	94
	18.8	114	130	135	146	71	83	87	95
	20.7	116	131	136	147	72	85	89	96
	23.1	117	133	138	149	74	86	90	98
	25.9	118	135	140	151	75	88	92	100
	28.7	120	137	142	153	77	90	94	102
	30.6	121	138	143	154	78	91	95	104
30	18.8	116	133	138	149	72	85	89	96
	19.9	117	134	139	150	73	85	89	97
	22.0	118	135	141	152	74	87	91	99
	24.7	120	137	143	154	75	89	93	101
	27.7	122	139	145	157	77	91	95	103
	30.8	124	142	147	159	79	93	97	106
	32.9	125	143	149	161	80	94	99	107
35	19.0	117	136	141	154	73	86	90	98
	20.2	118	137	143	155	74	87	91	99
	22.5	120	138	144	157	75	88	93	101
	25.2	122	141	147	160	77	90	95	103
	28.3	124	143	149	162	78	93	97	106
	31.4	126	146	152	165	80	95	99	108
	33.4	128	147	154	167	81	96	101	110
40	19.0	119	138	145	158	74	87	92	100
	20.3	120	140	146	159	75	88	93	101
	22.7	122	142	148	162	76	90	94	103
	25.6	124	144	151	165	78	92	96	105
	28.7	126	147	154	168	80	94	99	108
	31.6	129	150	157	171	81	96	101	110
	33.5	130	151	158	173	83	98	102	112
45	19.2	121	141	148	163	75	89	93	102
	20.6	122	143	150	165	76	90	94	103
	23.0	124	145	152	167	77	92	96	105
	25.8	126	148	155	170	79	94	98	107
	28.9	129	151	158	174	81	96	100	110
	31.8	131	154	161	177	83	98	103	112
	33.6	133	156	163	179	84	99	104	114

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Table 3 (cont.): BP Levels for males according to age and BMI

Age (year)	BMI (kg/m^2)	SBP Percentile (mm Hg)				DBP Percentile (mm Hg)			
		50th	90th	95th	99th	50th	90th	95th	99th
50	19.4	122	145	152	168	76	90	95	104
	20.7	124	146	154	170	77	91	96	105
	23.1	126	149	156	173	78	93	98	107
	25.9	128	152	159	176	80	95	100	109
	28.8	131	155	163	180	82	97	102	112
	31.6	133	158	166	183	83	99	104	114
	33.3	135	159	168	185	84	101	106	115
55	19.5	124	148	156	174	77	92	96	106
	20.9	125	150	158	175	78	93	97	107
	23.3	128	152	161	179	79	94	99	109
	26.1	130	156	164	182	81	97	101	111
	29.0	133	159	168	186	83	99	104	114
	31.8	136	162	171	190	85	101	106	116
	33.4	137	164	173	192	86	102	107	118
60	19.4	125	151	160	179	78	93	98	107
	20.8	127	153	162	181	78	94	99	108
	23.2	129	156	165	185	80	96	101	111
	26.0	132	159	169	189	82	98	103	113
	29.0	135	163	173	193	84	100	105	116
	31.8	138	167	176	197	86	102	108	118
	33.6	140	169	179	200	87	104	109	120
65	19.2	127	154	164	185	78	94	99	109
	20.5	128	156	166	187	79	95	100	110
	22.9	131	159	169	191	81	97	102	112
	25.6	134	163	173	195	83	99	104	115
	28.6	137	167	177	200	84	101	107	117
	31.5	140	171	181	204	86	104	109	120
	33.3	142	173	184	207	87	105	111	122
69	19.3	128	157	168	190	79	95	100	110
	20.5	129	159	169	192	80	96	101	112
	22.8	132	162	173	196	81	98	103	114
	25.5	135	166	177	200	83	100	106	116
	28.4	138	170	181	205	85	103	108	119
	31.2	142	174	185	210	87	105	110	121
	33.0	144	176	188	213	88	106	112	123

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Table 4: BP Levels for females according to age and BMI

Age (year)	BMI (kg/m^2)	SBP Percentile (mm Hg)				DBP Percentile (mm Hg)			
		50th	90th	95th	99th	50th	90th	95th	99th
25	17.8	106	121	127	137	70	83	86	93
	18.9	106	122	127	138	71	83	87	94
	20.9	107	123	129	140	72	85	88	95
	23.6	109	125	130	141	73	86	90	97
	26.9	110	127	132	144	75	88	92	99
	30.4	112	129	135	146	77	90	94	102
	32.8	113	131	136	148	78	91	95	103
30	18.5	109	126	132	144	72	85	89	96
	19.8	110	127	133	145	73	85	89	97
	22	111	129	134	146	74	87	91	98
	24.9	112	130	136	149	75	88	92	100
	28.3	114	133	139	151	77	90	94	102
	31.7	116	135	141	154	78	92	96	104
	34	117	136	142	155	79	94	98	106
35	19.3	112	131	138	151	74	87	91	98
	20.7	113	132	139	152	74	88	92	99
	23.3	114	134	140	154	75	89	93	101
	26.4	116	136	143	156	77	91	95	103
	29.8	118	138	145	159	79	93	97	105
	33.2	120	141	148	162	80	95	99	107
	35.3	122	142	149	163	81	96	100	109
40	20	116	136	143	158	75	89	93	101
	21.6	116	137	144	159	76	90	94	102
	24.3	118	139	147	161	77	91	95	104
	27.5	120	142	149	164	79	93	97	106
	30.9	122	144	152	167	80	95	99	108
	34.1	124	147	154	170	82	97	101	110
	36.1	126	148	156	171	83	98	102	111
45	20.5	119	141	149	165	76	91	95	103
	22.2	120	143	150	167	77	92	96	104
	25	122	145	153	169	79	93	98	106
	28.2	124	147	155	172	80	95	99	108
	31.6	126	150	158	175	82	97	101	110
	34.7	128	152	161	178	83	99	103	112
	36.6	129	154	162	180	84	100	104	113

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Table 4 (cont.): BP Levels for females according to age and BMI

Age (year)	BMI (kg/m^2)	SBP Percentile (mm Hg)				DBP Percentile (mm Hg)			
		50th	90th	95th	99th	50th	90th	95th	99th
50	20.7	122	147	155	173	78	92	97	105
	22.4	123	148	156	175	78	93	98	106
	25.2	125	150	159	177	80	95	99	108
	28.5	127	153	162	180	81	97	101	110
	31.9	129	156	165	184	83	99	103	113
	35	132	158	167	187	84	100	105	114
	36.9	133	160	169	189	85	101	106	116
55	20.6	125	152	161	181	79	94	99	107
	22.2	126	153	162	182	79	95	100	108
	25.1	128	156	165	185	81	97	101	110
	28.4	130	158	168	189	82	98	103	112
	31.8	133	161	171	192	84	100	105	115
	35	135	164	174	196	85	102	107	117
	36.9	136	166	176	197	86	103	108	118
60	20.4	127	157	167	189	80	96	100	109
	22	129	158	168	191	81	96	101	110
	24.8	131	161	171	194	82	98	103	112
	28.1	133	164	174	197	83	100	105	114
	31.6	136	167	178	201	85	102	107	116
	34.7	138	170	181	205	86	103	109	118
	36.7	140	172	183	207	87	105	110	120
65	20.3	130	162	173	198	81	97	102	112
	21.8	132	164	175	200	82	98	103	112
	24.5	134	166	178	203	83	99	104	114
	27.7	136	169	181	206	84	101	106	116
	31.1	139	173	184	210	86	103	108	118
	34.4	141	176	188	214	87	105	110	120
	36.4	143	178	190	217	88	106	111	122
69	20.3	133	167	179	205	82	99	104	113
	21.8	134	168	180	207	82	99	104	114
	24.4	136	171	183	210	84	101	106	116
	27.5	138	174	187	214	85	102	108	118
	30.9	141	177	190	218	87	104	110	120
	34.2	144	181	194	223	88	106	111	122
	36.3	145	183	196	225	89	107	113	123

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BMI percentiles of men and women. The 75th percentile of BMI for the subjects aged 25 to 70 years old ranged from 25.87 to 29.08 kg/m^2 for men and 26.86 to 31.94 kg/m^2 for women.

Therefore, the 75th BMI percentile of men was categorized as overweight and for the women categorized as overweight or obese class I. Moreover, the corresponding values for the 95th percentile of BMI were 30.59 to 33.61 kg/m^2 for men and 32.83 to 36.98 kg/m^2 for women, being classified as obese class I or II. According to the JNC-7 report (Chobanian et al., 2003), the cut off values of 140 mmHg for SBP and 90 mmHg for DBP are shown as red lines in graphs for comparison. While both SBP and DBP rose steadily with increasing age, the rise of SBP was greater than DBP (Figure 1). Most of the adults with BMIs classified as overweight and obese seem to be categorized as hypertensive by the JNC-7 definition.

DISCUSSION

The present study showed that both the SBP and DBP rose steadily with increasing age, for BMI percentiles. Wright et al. in 2011, depicted the rise in mean of SBP and DBP with age in adults 18 years and older in the United States during 2001 to 2008. The rise of SBP with age found in this study, is congruous with the results of their study except for the amount of changes observed with increasing age; such increase seems to be much greater in our population (nearly 30 mmHg) compared to the American population (at most 15 mmHg). As for the DBP, their results demonstrated a curvilinear trend with increasing and then decreasing means with age in both men and women. On the contrary, we found the mean of DBP to be steadily rising with increasing the age. If we had categorized our data like their survey into three groups of untreated hypertensive,

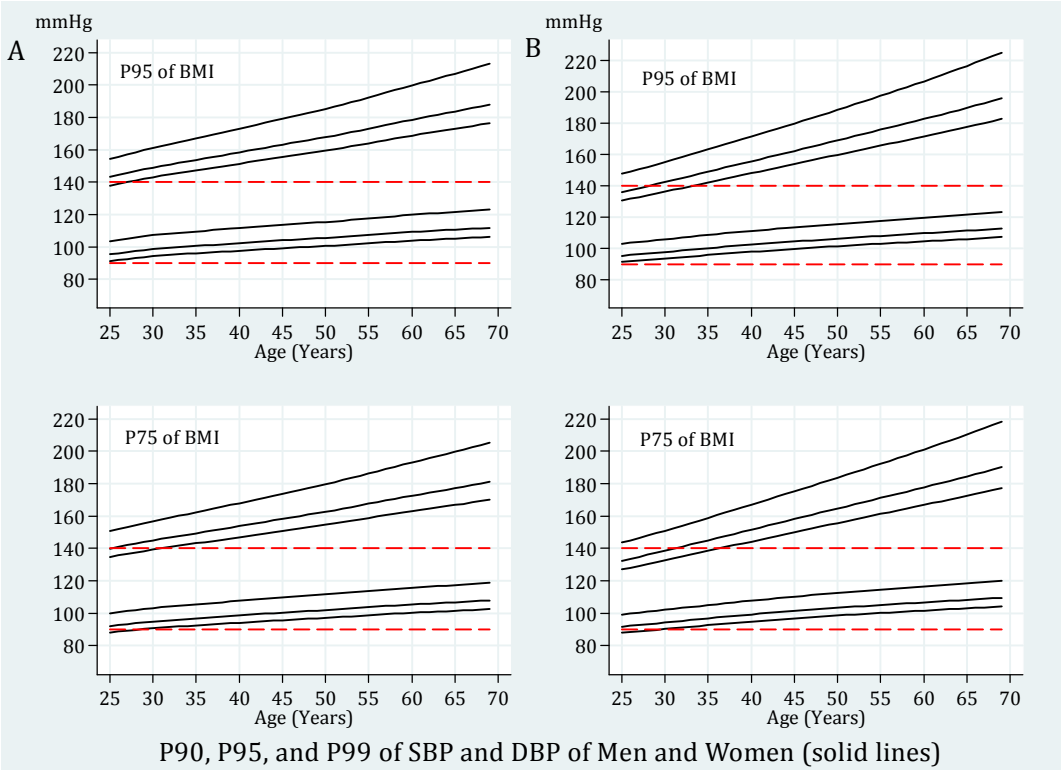

Figure 1: Trend of 90th, 95th, and 99th BP percentiles by age for 75th and 95th BMI percentiles. **A:** men; **B:** women

treated hypertensive and normal, we could have assessed the possibility of treatment differences being responsible for the disagreement observed between these two studies.

According to the cut off values of 140 mmHg for SBP and 90 mmHg for DBP in diagnosis of hypertension presented in the JNC-7 report in 2003 (Chobanian et al., 2003), 26.4 % of the adult population were estimated to have hypertension (He and MacGregor. 2007). This figure is predicted to increase from 1 billion worldwide, to 1.56 billion by 2025 (Kearney et al., 2005). Considering the same cut off values in the present study, the 140 mmHg SBP is approximately at our 80th SBP percentile and the 90 mmHg DBP also nearly at 80th DBP percentile.

As mentioned above, differences in ethnicity, diet, climate, and many other factors can impact the risk of developing hypertension in a population. So it seems reasonable to produce reference blood pressure percentiles for each population individually. In present study, weight, height, and BMI relationship with BP measures were assessed after adjusting for potential confounders and found that the most convenient variable would be BMI; not only because of its stronger association with blood pressure, but also because it is a better representative for some of the factors believed to have an impact on blood pressure such as diet. In evidence based guideline of 2014 for management of high blood pressure in adults, the panel members appointed to the JNC-8 made nine recommendations as when to start medical treatment in hypertensive patients (James et al., 2014). They did not redefine the high blood pressure of 140/90 presented in JNC-7, they recommended to start pharmacological treatment to lower blood pressure at SBP ≥ 150mmHg or DBP ≥ 90mmHg in the general population aged ≥ 60 years. So, changing the cut off values is probable for each population, based on the characteristics and specifications of their people.

The prevalence of hypertension (SBP > 140 or DBP > 90) in Iranian population is high with a total prevalence of 28.8 % that specially increases in old ages. This is similar to the total prevalence of hypertension in the American population older than 18 years, reported as 30.4 % (CDC, 2012). Since the mortality rates of ischemic heart diseases (26 %) and CVAs (10 %) in Iranian population are also similar to the data from developed countries (Forouzanfar et al., 2014), the cut off values of 140 for SBP and 90 for DBP seem to be suitable for our population as well. This high prevalence of hypertension should be a wakeup call for the healthcare system authorities in Iran to take measures in order to prevent the increasing rate of hypertension and its consequent cardiovascular diseases. First level prevention and the most important step is to control for these risk factors. Primary care can also create a foundation for new treatments and medications to control hypertension. These measures can decrease the mortality rate of cardiovascular diseases greatly (He et al., 2005). Such measures are the reason for the decrease in burden of cardiovascular diseases in developed countries during the past few years.

In this study we only presented the nomograms of blood pressure and developed BP percentiles by age, gender, and BMI. But, for these findings to be applicable in medical practice and to be utilized in developing reference values and cut offs for hypertension, they need to be compared with the results of other studies assessing the relation between the risk of cardiovascular diseases with blood pressure. Lack of such studies in Iran limits our ability to interpret the results of the present research.

CONCLUSION

The present study, for the first time, constructs BP standard curves based on age and BMI centiles in Iranian adults. Our results show that BP percentiles steadily increased by age and BMI. In addition, most obese or overweight adults are hypertensive. These

findings strongly support the need for screening of hypertension in overweight and obese population.

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Conflict of interest

None.

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