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Blood Pressure Values in Apparently Healthy Sudanese Population

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Blood pressure is one of the most often measured clinical parameters, and assessment of blood pressure has a considerable impact on diagnostic decisions.
Objectives: To establish blood pressure normal reference values in Sudanese.
Methods: A cross-sectional study was conducted from September 2016 to November 2018. Eight hundred eighty-eight healthy adult Sudanese between the ages of 18 and 60 (203 men and 685

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women) were randomly selected from the states of Khartoum, Northern, Gezira, Red Sea, and North Darfur. Clinical, anthropometric, and blood pressure measurement data were collected.
Results: The mean for all volunteers was 113.93 ± 9.917 mmHg, systolic blood pressure (SBP) and 75.29 ± 6.79 mmHg, diastolic blood pressure (DBP). SBP in men was 118.6 ± 7.642 mmHg compared to 112.53 ± 9.121 mmHg in women, while DBP in men was 77.51 ± 5.984 mmHg compared to 74.63 ± 6.844 mmHg in women. Beside the gender variations, blood pressure values also showed geographical variability. There was a positive connection between blood pressures (SBP and DBP), BMI, and age. ($P < 0.05$) was used for significance.
Conclusion: Blood pressure of Sudanese was found to be within the normal international range with gender and geographical variability. It showed positive correlation with age and BMI.

Keywords: Blood pressure; Sudanese; normal reference values.

1. INTRODUCTION

Blood pressure is the pressure within the major arterial system of the body and measured in millimeters of mercury. SBP is the maximum blood pressure during systole; DBP is the minimum pressure during diastole [1]. One in every two persons ≥20 years in the USA has hypertension with only 39.64% on medications having well-controlled hypertension [2]. High blood pressure is a major risk of cardiovascular and renal diseases [3]. Hypertension requires the heart to work harder than normal to circulate blood through the blood vessels [4]. Hypertension is defined when SBP is equal to or above 140 mm Hg and/or a DBP equal to or above 90 mm Hg [5]. Globally, the prevalence of adult hypertension was estimated to be over 40% in 2008; this number is expected to rise to above 60% by 2025 [6]. The association of a high BMI with cardiovascular disease is at least partly explained by the association of BMI with hypertension and elevated serum cholesterol [7]. Numerous factors, such as advanced age, smoking, black race, low potassium and high sodium intake, inactivity, alcohol intake, stress, some chronic illnesses, overweight, and obesity, among others, have an impact on normal blood pressure [8]. Davy and Hall reported a linear relationship between adiposity and hypertension [9]. In developing countries, high blood pressure is one of the risk factors for cardiovascular diseases, and the estimated 7.1million deaths especially among middle, and old-age adults is due to high BP [10]. To establish reference BP values for Sudanese and compare them to international values, a study was conducted on 1100 individuals in Wad Medani city, Sudan. The findings indicated that while the mean BP (SBP/DBP) for women was 133 ±19/73 ± 9 mmHg, the mean for men was 134 ±18/71± 10 mmHg [11]. According to a study done in Khartoum, Sudan, by Elnagi Y. Hago et al., the mean (SBP) is greater in men (120 ± 8.8) compared to women (113 ± 9.7) and the DBP of men (79.3 ± 5.9 mmHg) is higher than that of women (74.8 ± 7.1 mmHg). In all participants, BMI was significantly positively correlated with both SBP and DBP ($P = 0.01$) [12]. The average blood pressure was within the international range, and men's blood pressure was noticeably higher than that of women.

Rationale: From the fact that high blood pressure is a risk of for cardiovascular diseases in developing countries and the evidences of ethnic and environmental variability in blood pressure values in regional communities, plus the need to establish correlation between BMI and age with blood pressure, It is important to study normal blood pressure values in Sudanese and to derive prediction equations based on BMI and age.

2. METHODS

A cross-sectional study done between 2016 and 2018 on 888 adult healthy Sudanese (685 females and 203 males), 18–60 years old, and the study covered the states of Khartoum (392 participants), Northern (130), Gezira (82), Red Sea (160), and North Darfur (124). All participants were selected randomly from students and employees at different universities all over Sudan. The inclusion criteria were age range between 18 and 60 years old, absence of chronic diseases, and absence of acute illness at the time of data collection. Sample size was determined based on Monkey-Survey computer equation. All volunteers had completed a questionnaire covering personal, habitual, and health data. Then anthropometric blood pressure measurements were performed. The auscultation method was used for blood pressure measurements using the mercury sphygmomanometer and the stethoscope. Five

minutes separated the two readings. A third reading was taken if there was a 10 mmHg or greater discrepancy between the first two values. Validity and reliability of readings were checked, and the instruments were standardized using other standard ones. All People performing the tests were qualified doctors. The final reading was the average. Weight and height were measured to determine the body mass index (BMI) as weight in kilograms divided by height in square meters. Statistical Package for the Social Sciences (SPSS) was used to analyze the collected data, which was then be displayed in tables and graphs.

3. RESULTS

Table (1) showed variations in systolic and diastolic blood pressures between different states of Sudan. The mean SBP in male Sudanese was found to be 118.59 ± 7.61mmHg while the mean DBP was found to be 77.54 ± 5.96 mmHg. The female mean SBP was found to be 112.52 ± 9.14 mmHg while the mean DBP was 74.62 ± 6.88 mmHg. Red sea and Northern states showed the highest mean systolic blood pressures in males (120.88 ± 7.75 and 120.00 ± 8.66 mmHg respectively) while the Red Sea state showed the least mean systolic blood pressure in females (109.50 ± 8.49 mmHg). Khartoum and Northern states showed the highest mean DBP values in males (79.45 ± 5.28 and 79.03 ± 6.38 mmHg respectively). The least DBP (72.78 ± 6.54) was obtained by Red Sea states' females.

From Table (2) it was clear that both total mean systolic (118.6 ± 7.642) and diastolic (77.51 ± 5.984) blood pressures in males were higher than in females (SBP of 112.53 ± 9.121 and DBP of 74.63 ± 6.844), but in the group age of 50-60 years old SBP was higher in females. Both SBP and DBP increased with age in both males and females. The positive correlation between age and blood pressure was more clear in females compared to males.

Table (3) showed a statistically significant positive correlation between BMI and both systolic and diastolic blood pressure. This result showed that blood pressure increases along with BMI. The positive correlation between BMI and diastolic BP was less when compared to systolic BP. A strong and positive correlation between age and both systolic and diastolic blood pressure was also found.

From both of Figs. (1) and (2), it was clear that both SBP and DBP had positive correlation with BMI, but the positive correlation of BMI was more linear with SBP compared to DBP.

(a= Age in years, b=BMI)

Making use of the positive correlation between blood pressures and age, and blood pressures and BMI, predictive equations for adult males and females Sudanese from all over Sudan were derived using multiple regression.

Table 1. Mean systolic and diastolic blood pressures in different states of Sudan

Parameter	SBP (Mean ± SD) in mmHg		DBP (Mean ± SD) in mmHg		N
State	Males (n = 203)	Females (n = 685)	Males (n = 203)	Females (n = 685)	
Khartoum	118.88 ± 6.23	113.10 ± 8.93	79.45 ± 5.28	75.08 ± 6.97	392
Red sea	120.88 ± 7.75	109.50 ± 8.49	77.65 ± 4.37	72.78 ± 6.54	160
Gezira	114.63 ±8.76	114.82 ± 8.92	74.89 ± 6.23	77.27 + 6.30	82
Northern	120.00 ± 8.66	114.70±10.05	79.03 ± 6.38	74.75 ± 7.16	130
North Darfur	118.63 ± 7.69	111.51 ± 8.73	75.10 ± 5.79	74.08 ± 6.40	124
Total	118.59 ± 7.61	112.52 ± 9.14	77.54 ± 5.96	74.62 ± 6.88	888

Table 2. Mean SBP and DBP in both sexes with the age group

Gender	Males		Females SBP	
Age group	SBP (Mean ± SD)	DBP (Mean ± SD)	SBP (Mean ± SD)	DBP (Mean ± SD)
20-29	118.26 ± 7.874	76.99 ± 5.977	111.74 ± 8.436	74.18 ± 6.710
30-39	119.64 ± 7.712	78.93 ± 7.641	114.32 ± 10.144	77.57 ± 8.140
40-49	119.36 ± 6.172	80.57 ± 3.715	118.77 ± 10.144	79.10 ± 6.228
50-60	121.36 ± 5.519	79.55 ± 4.719	127.81 ± 10.641	78.13 ± 5.737
Total	118.60 ± 7.642	77.51 ± 5.984	112.53 ± 9.121	74.63 ± 6.844

Table 3. Correlation matrix between blood pressure, age, and BMI

Variables	SBP	DBP	Age	BMI
SBP	1.000	0.633**	0.270**	0.253**
DBP	0.633**	1.000	0.202**	0.214**
Age	0.270**	0.202**	1.000	0.307**
BMI	0.253**	0.214**	0.307**	1.000

***. Correlation is significant at the 0.01 level (2-tailed)*

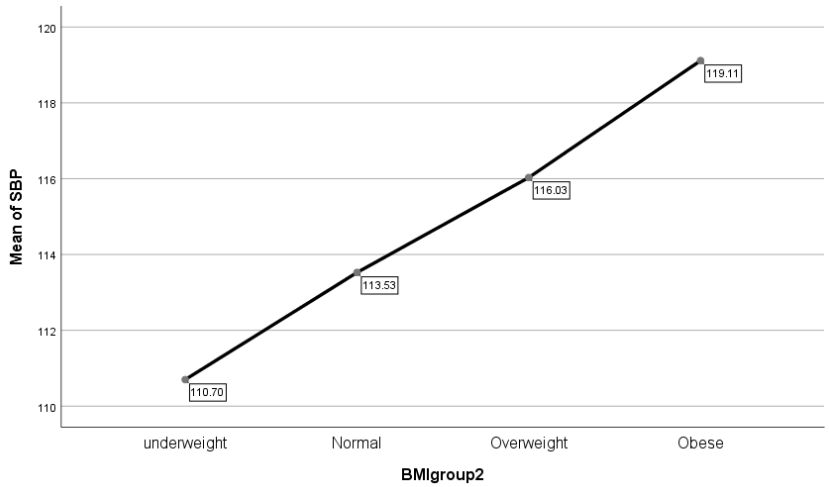

Fig. 1. The correlation between SBP and BMI among Sudanese

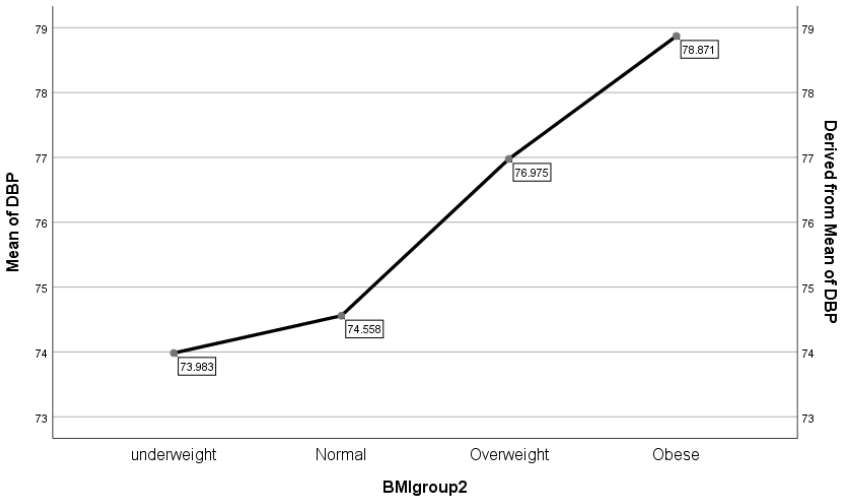

Fig. 2. The correlation between DBP and BMI among Sudanese

Table 4. Prediction equations of blood pressure in adult Sudanese males

Locations	Prediction for SBP males	Prediction for DBP males
Sudan	111.322+ 0.042 a + 0.276 b	73.614 + 0.112 a + 0.042 b
Khartoum state	110.044 + 0.045 a + 0.349 b	74.040 + 0.030 a + 0.210 b
Red sea state	110.623 -0.259 a + 0.735 b	70.946 + 0.181 a + 0.084 b
Gezira state	109.445 -0.041 a + 0.293 b	70.180 + 0.070 a + 0.142 b
North state	118.127 +0.056 a + 0.017 b	75.430 +0.076 a + 0.110 b
North Darfur state	111.648 +0.153 a + 0.138 b	72.276 +0.123 a -0.014 b

a = Age, b = BMI

Table 5. Prediction equations of blood pressure in adult Sudanese females

Locations	Prediction for SBP females	Prediction for DBP females
Sudan	96.695 + 0.258 a + 0.429 b	64.906 + 0.090 a + 0.333 b
Khartoum state	96.882 + 0.319 a + 0.370b	65.383 + 0.125 a + 0.292 b
Red sea state	99.718 - 0.066 a + 0.491 b	60.660 + 0.101 a + 0.430 b
Gezira state	96.150 + 0.215 a + 0.548 b	67.911 - 0.110 a + 0.527 b
North state	100.866 + 0.051 a + 0.554 b	67.897 - 0.036 a + 0.335 b
North Darfur state	97.858+ 0.198 a+ 0.415 b	62.708 + 0.208 a + 0.301 b

a = Age, b = BMI

4. DISCUSSION

The previous trials to establish blood pressure normal reference values for Sudanese had limitations because of the small sample size and the lack of coverage of the whole country, but these limitations had been managed in this study.

Our sample size was designed to be statistically representative of the entire Sudanese population, considering all regions. Our results showed that, Sudanese normal blood pressure values were like the international blood pressure norms. One of the limitations in our study was that males sample size was less than females, but the overall sample was statistically representative. Also, there was mismatching of the sample size between the different states considering their population density. Great deal of the sample size was taken from Khartoum, since the researchers stayed more time there, but the positive point was that population of Khartoum were a mixture of all Sudan regions. The regional variability of blood pressure values was investigated by Kiefe CI et al. [13].

Our result in Table (1) Shows that the mean of systolic blood pressure was differ from state to state the highest blood pressure was found in Northern state (115.96 ± 9.96 mmHg) while the lowest SBP was found in the Red sea state (110.71 ± 9.10 mmHg), also the mean of diastolic blood pressure was differs from state to state the highest diastolic blood pressure was found in Gezira state (76.49 ± 6.34 mmHg) while the lowest SBP was found in the Red sea state (73.29 ± 6.51 mmHg), this result was same as study done Kiefe CI and et al, that illustrate there was different result in different region of same country [13]. This variation in the blood pressure may be correlated with socioeconomic class and geographic location due to the emergence of new risk factors for hypertension. Similar to prenatal malnutrition and psychological stress, may disproportionately impact the poor [14,15]. In our study in Tables (2,3) we found there was relationship between blood pressure, sex and age. The males had high blood pressure than females, but at the age above the fifty females become had high systolic this result agree with Jane F. Reckelhoff, he proven that at similar ages, men have higher blood pressure than women. However, after menopause, women's blood pressure rises to levels that are much greater than in men [16]. Increases in androgens in people and animals may be the cause of the higher prevalence of hypertension in men than in women. Women with increased testosterone levels associated with polycystic ovarian syndrome or adrenal virilizing tumors have hypertension. [17-19] Nitric oxide (NO) generation has been demonstrated to be stimulated by estrogen [20,21]. As a result, the loss of estrogen associated with menopause may contribute to the rise in blood pressure in women and this explain why women high blood pressure than men.

BMI and both systolic and diastolic blood pressure were positively correlated with age. Systolic and diastolic blood pressures increased steadily with age, from the youngest to the oldest age groups, demonstrating the age dependence of BP. Previous research has also linked high blood pressure to age [22-24]. In my current study, the relationship between age and systolic and diastolic blood pressures was less strong than the relationship between age and BMI. Thus, the relationship between systolic and diastolic blood pressure and age was less strong than the relationship between BMI and age.

Blood pressure was higher in the elderly strata of the sample with or without a corresponding increase in BMI, implying the presence of other contributory factors to hypertension besides fat accumulation alone. A significant correlation between BP and age was also reported in a study from North India [25].

We found that systolic blood pressure and diastolic blood pressure were highest in overweight subjects, intermediate in normal

weight subjects, and lowest in underweight subjects in both males and females and this result agree with other studies. [26,27] This result could be attributed to differences in sympathetic tone between underweight and overweight individuals. However, plus pressure was comparable. Assuming that arterial compliance did not differ between groups, this implies that stroke volume is also comparable. Heart rate was also comparable. As a result, we have indirect evidence that cardiac output does not differ significantly between the groups. Thus, variations in blood pressure may be largely due to variations in total peripheral resistance, which is heavily influenced by tonic sympathetic control of resistance vessels [28].

5. CONCLUSION

The derived blood pressure values of Sudanese in our study were not significantly different from international values. It showed no significant variations between different parts of the country. Significant positive correlations were found between blood pressure and BMI and between blood pressure and age. So, prediction equations based on BMI and age were derived.

ETHICAL APPROVAL AND CONSENT

Ethical approval was issued from the Federal Ministry of Health in Sudan (FMOH). All study participants have received an explanation of the study's goals. Each participant had signed a written consent after being informed about the study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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