The National Ribat University

Faculty of Graduate Students & Scientific research

Relationship between Blood Pressure and Body Mass Index among Adult Sudanese population

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Relationship between Blood Pressure and Body Mass Index among Adult Sudanese population

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Abstract

Introduction The relationship between blood pressure and body mass index has been observed consistently, but not clearly understood. This study was carried out to show the relationship between blood pressure and body mass index among Sudanese adult population in medical colleges of Karary University, Khartoum, Sudan. . The study was conducted between February 2016 and December 2016.

Methods A random sample of 150 (101 male and 49 female) Sudanese adult students (civilian and military) and employee in medical colleges of Karary University were obtained, aged between 16-60 years. Military male students are 56, civilian students and employee are 95(45 male and 49 female) Body weight, height, BMI, systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean arterial pressure (MAP) were assessed using standard methods.

Results Subjects with BMI <18.5 kg/m2, 18.5–25 kg/m2, 25-30 kg/m2 and >30 kg/m2 were classified as underweight (13 males and 7 females), normal weight (70males and 30 females), overweight (15 males and 8 females) and obese (3male and 4female) respectively, while in military students underweight(9males), normal weight(45males),overweight(2males), no obese individuals were reported, this classification category is according to World Health Organization (WHO) BMI classification. Analysis of variance (ANOVA) is used to compare differences between the four BMI categories. Correlation between BMI and other indices was tested using Pearson's correlation coefficient. . A P value <0.05& 0.01 was considered statistically significant.

Among participants 15.3%were overweight (BMI 25-29.9) and4.7% were obese (BMI >30),while the majority of them were normal weight 66.7%(BMI18.5-24.9) and

underweight were13.3%(BMI <18.5).Their mean age was calculated to be (m±sd) (25.3±11.1 for male and 24.08±9.3 for female, 19.1±1.1 for military) the correlation between age and gender is not significant (P-value 0.741). The mean height(cm) was(176.9±6.0 for male and 162.7±6.2 for female, 177±5.1 for military) the correlation between height and gender is significant (P-value 0.000**).The mean weight(kg) was(70.2±12.0 for male and 62.1±13.1 for female, 64.3±6.0 for military) there is significant correlation between weight and gender (P-value 0.001**) There is apparent difference between the two gender in the systolic blood pressure (115.3±10.9 for male and 109.7±8.7 for female,112.2±7.8 for military) the P-value 0.015* and in the mean arterial blood pressure(89.7±7.9 for male and85.1±6.9for female, 85.0±5.1 for military) P-value 0.019*), while no difference appear in the relation between diastolic blood pressure and gender (77.2±8.6 for male and 73.2±7.2 for female, 71.6±5.6 for military, P-value 0.089) . BMI has significant correlation with Systolic blood pressure(P-value .004(Correlation is significant at the 0.01 level)),Diastolic blood pressure(P-value .000) and main arterial pressure (P-value .000) in whole participants ,while in military students no positive correlation is found except with weight. .

Conclusion There is positive correlation between BMI, blood pressure and age, while no clear relation between BMI and gender.

Introduction

Blood pressure is defined as a force of blood pushing against the arterial walls as blood circulates throughout the body, so blood must circulate at an appropriate pressure in order to sustain life. Blood pressure in healthy adult is normally **≤ 120/80 mmHg.** However the first number is the systolic pressure which represents the pressure of the heart during contraction, while the second number is the diastolic pressure which represents the pressure of the heart during resting period.(1)

In the industrialized world , high blood pressure is a major determinant of risk for Coronary heart disease and stroke, which are leading causes of death there (1). Also the developing countries are increasingly faced with the double burden of hypertension and other cardiovascular diseases along with infection and malnutrition. (2)

The definition of Hypertension has evolved over the time, though the present definition being a blood pressure greater than 140/90 mmHg in adults. (1)Hyper tension often has several contributing factors which include obesity, excessive salt, renin homeostasis , insulin resistance, genetics ,age and also strongly correlated with BMI(3) The cause of essential hypertension remains unknown, although, body fat is thought to be a major casual factor of increased blood pressure, the true relationship between high blood pressure and body mass remains obscure (1) However some studies suggested that the association of blood pressure with body weight could be due to increased total body mass or some special underlying relationship between blood pressure and body fat(4) Furthermore the identification and monitoring of the amount of body fat have been receiving special attention in aspects related to health promotion, for its action in prevention and control of cardiovascular diseases as well as induction and association with risk factors, especially, lipid profile and blood pressure (4) The obesity, which represents the major body fat related problem, is defined as an un necessary accumulation of fat in the body resulting in an increase in weight beyond the considered desirable with regard to age, height and weight (3)The prevalence of obesity is increasing worldwide, and is currently regarded as one of the most important public health problems of modern society. It is considered to be a major risk factor for cardiovascular disorder according to the American Heart Association.(4)

The need to evaluate the body fat and evaluate the relationship between blood pressure and body fat appeared clearly. There is no universal procedure for measuring body fat, but there are different anthropometric measures which are use for body fat evaluation worldwide. The common types that are commonly used are:

- Body Mass Index (BMI).
- Bioelectric Impedance Analysis (BIA).
- Skin Fold.
- Waist to Hip Ratio (WHR).
- Weight –Height Ratio.

Although the Bioelectrical Impedance Analysis (BIA) is the appropriate method for monitoring the body fat and superior to Body Mass Index as measurement of the body composition as it measures the content of fat in corporal mass , the most common estimation of body composition in population is done by the Body Mass Index(BMI)(4), (1).

The Body Mass Index (BMI) is the parameter most frequently used for the screening of excess body fat in both children and adolescents, and its values vary during childhood and adolescence depending on age and gender [7].In order to measure and monitor levels of body fat ,accurate methods of determining body composition are needed. Therefore because the weight and height standard measures of a physical examination, Body Mass Index (BMI) has been the most common method for use. Controversies over the value of estimation of body fat has led to recommendations of the use of new methods to directly measure body fat as mentioned before, but these methods has not been universally adopted[1].

Several variations of weight-height measures have been developed including, Ponderal Index (weight{kg}/height{m}3), Benn Index (weight{kg}/height{m}p)…etc, but, Body Mass Index= ($\frac{weight\{kg\}}{height\{m\}2}$ **)** however, sometimes called the Quetelet Index, is the most common weight-height index, because, it is cheap and easy to collect [1].

According to Body Mass Index (BMI) values, individuals are categorized into four groups [1-5]

- **Underweight (BMI ≤18.5).**
- **Normal weight (BMI 18.5-24.9).**
- **Overweight (BMI 25.0-29.9).**
- **Obese (BMI ≥ 30).**

Body Mass Index itself appears to be useful as an index of excess body fat, but it isn't able to accurately predict a specific individual's percentage of body mass. [7]One of its limitations is that it does not take lean body mass, muscle mass or bone density into account when measuring obesity. As a result, muscular individuals are often misclassified as overweight; similarly, a person with a small skeletal frame could be underestimated and categorized as underweight. Furthermore, body composition is thought to be varying substantially by race, so it is suggested that Body Mass Index cut points should be ethnic specific. [1]

However, Body Mass Index is positively associated with morbidity and mortality from hypertension and other chronic diseases. In Caucasian population a strong association has been depicted between Body Mass Index and mortality similar association has also been demonstrated among Asian population.[2]

Exploratory analysis indicates an occasionally strong, but quite variable relationship between blood pressure and Body Mass Index which differs by age, gender and the particular blood pressure measures under consideration.[6]This relationship has so far been the subject of epidemiological research.[2]Also some studies clarified that this relationship has been perceived to be linear and strong.[1]

Ravisankar et al performed study in India in Jawaharlal Institute of Post graduate Medical Education and Research, they investigated the correlation between blood pressure indices and Body Mass Index and indices of physical fitness in apparently healthy subjects (14-18 years)their results concluded that there is positive correlation between blood pressure and Body Mass Index and that there are gender variation differences in the correlation between blood pressure and Body Mass Index especially in underweight and overweight subject.[5]

Another study was conducted in S*ao Paulo* , in Brazil on 2014, 57 physio therapy white female students (age from18-26years)in order to establish the relation of anthropometric measurement with Blood pressure and lipid profile in young women. Body Mass Index (BMI) and Body Fat Percentage (BF %) by Bioelectrical Impedance Analysis (BIA) were done, Blood pressure was measured and lipid profile was also estimated. Body Mass Index (BMI) and Body Fat Percentage (BF %) were positively correlated with both Blood pressure and lipid profile. Their results suggested that Body Fat Percentage (BF %) is a good indicator of occult obesity in subjects with normal body mass [(4)].

Emilola J.Abayomi, in Florida State in USA, performed a statistical study in order to establish the relationship between Body Mass Index (BMI) and blood pressure in diverse populations. About 30 observational studies from all around the world were studied and analyzed. Meta-analysis was conducted to explore heterogenecity that may be present among the relationship in diverse population; a Meta-regression was conducted to determine if characteristics, such as race and gender explain the differences among the studies. Body Mass Index (BMI) was found to be significantly different across cohorts for males and females. . So that blood pressure is affected at different levels of Body Mass Index for different populations. Though, the differences of Body Mass Index (BMI) could not be explained completely, age was a factor that helped to explain the differences in Body Mass Index (BMI) partially. [(1)]

F. Tesfaye et al performed a study to examine the association between Body Mass Index (BMI) and Blood Pressure in three populations across Africa and Asia. Data on Body Mass Index (BMI), Blood Pressure and other background characteristics of study participants were generated using the World Health Organization STEPwise approach to surveillance (STEPS), at three demographic surveillance sites in Ethiopia Vietnam and Indonesia. The study concluded that Body Mass Index (BMI) was significantly and positively correlated with both Systolic Blood Pressure and Diastolic Blood Pressure in all the three populations, correlation coefficient(r)ranging between 0.23and0.27,P0.01.High BP exists in a background of under nutrition in populations at early stages of the epidemiologic transition[(2).]

Another study was conducted between Dec 2011-May 2012 among student population of 3rd year at the Institute of Medical Technology in Karachi, Pakistan. It focused on the relationship between Body Mass Index (BMI) and Blood Pressure. They concluded that the prevalence of high Blood Pressure was observed with increased Body Mass Index (BMI) among students .[(3)]

It is clear from these studies that the blood pressure is positively correlated with BMI.(1-)If the blood pressure increased with increased BMI,then the normal values should depend on the BMI and consequently the definition of hypertension.

This study was designed to investigate the correlation of BMI and blood pressure in Sudanese adult in an attempt to derive a concrete equation for normal blood pressure depending on BMI, which can be a base to generate a chart of normal blood pressure according to age, sex and Our study was carried out in Karary University /Khartoum State/Sudan, our target subjects are the students and employee in the age (16-60 years old).

Materials and Methods

This is a cross sectional study carried in the medical colleges of Karary University in Omdurman, Khartoum state, Sudan. It was conducted between February 2016 -December 2016, including 150 of students and employee. The students of the university were divided into 2 different types. Civilian students, who were represented by both, male and female and who have different life styles. The others were military students whom were males, they live in the same residence, the same nutritional status, and have special exercise program. The study is covered both students types from different classes, but most of them are from 1st and 2nd class. The study also covered the university employee. Participants aged 16-60years from both sexes..

A structured questionnaire was filled by participants. The questionnaire covered personal data, chronic diseases (DM, HTN, and Asthma), chronic medication, nutrition status, smoking and exercise. After taking written informed consent, data was collected through structured questionnaire.

The measurements of blood pressure were taken through pre-checked and reliable apparatus i.e. mercury sphygmomanometer. The students were seated calm and quiet for at least 5 minutes prior to measurement on comfortable chairs. For categorization of blood pressure WHO classification was used, according to which students having blood pressure of 140/90 mmHg were labeled as hypertensive. Three consecutive readings of BP were recorded at the interval of 3 minutes between consecutive measurements in sitting position. Weight and height were measured with subjects standing without shoes and wearing light clothes. Students stood upright with the head in Frankfort plane for height measurement. Height was recorded to the nearest 0.5cm and weight was recorded nearest 100g. BMI was then calculated through the standard formula i.e. weight (kg)/height (m2)

The collected data was analyzed using IBM SPSS (Statistical Package for Social Sciences), VERSION 21 software. . Descriptive analysis of BP, weight, height and BMI were calculated. Comparison of BP among BMI groups was made by ANOVA.

Ethical approval was guaranteed from the Faculty of Medicine, Karary University, and consent was taken from the participants before the data collection process.

Results

In this study a total of 150 subjects were included, 101 males (67.3%)(56 are military students (37.3%), 45 are civilian (30%)) and female of 49 (32.7%) all were civilian .The sex ratio, male to female ratio, was (2.06:1). The mean age was not differ significantly between both sex (m±sd) (25.3±11.1 for male and 24.08±9.3 for female), while military students the mean age was(19.1±1.1),because most of the military participant are from the 1st and the 2nd class (table-1&table- 2). The male subjects were significantly taller and heavier than the female subjects. The mean height(cm) was(176.9±6.0 for male and 162.7±6.2 for female) ,while the mean weight(kg) was(70.2±12.0 for male and 62.1±13.1 for female).Though this explain the significant correlation between height and gender (P-value 0.000**) ,and between weight and gender (P-value 0.001**)., although there was no difference between their BMI(22.7±3.9 for male and 22.9±4.2 for female), the male subjects also had significantly higher SBP(115.3±10.9) and DBP(77.2±8.6) than the female subjects SBP(109.7±8.7) and DBP(73.2±7.2) .) There is apparent difference between the two genders in the SBP, the P-value 0.015*, and in the Mean arterial blood pressure (89.7±7.9 for male and85.1±6.9for female P-value 0.019*), while no difference appear in the relation between DBP and gender (P-value 0.089), and between age and gender (P-value 0.741) (table-1).

While in military participants the mean height (177.9±5.1), the mean weight (64.3±6.7),the mean SBP(112.2±7.8) , the mean DBP (71.6±5.6),and the MAP (85.0±5.1) (table -2).

According to the BMI classification for all participants 15.3%were overweight (BMI 25-29.9) and4.7% were obese (BMI >30), while the majority of them were normal weight 66.7 %(BMI18.5-24.9) and underweight were13.3 %(BMI <18.5) (table-3). In spite of the result that there was no statistical significant difference in the means of BMI between the two sexes (22.7±3.9 for male and22.9±4.2 for female) (table-5), but some variation can be noticed between them in comparison between BMI categories in civilian and military students (by cross tabulation in between them the P-value **0.002(table-7)).

In civilian both females and males had high percentage of overweight, obesity and underweight in comparison with military students. In civilian female(overweight16.3%,obese8.2%,underweight14.3%) while civilian male subjects (overweight28.9%,obese 6.7%,underweight8.8%) in comparison with military students (overweight3.6%,obese 0%,underweight 16.1%)(table-3). This result can be explained by the fact that in military group they have good nutritional status (regular healthy meal under nutritionist supervision given according to their body needs), regular daily exercise doses and they had been chosen with certain criteria (weight, height and general health), while in both civilian male and female irregular meals, unhealthy food and lack of exercise can be attributed to the cause.

There is significant difference in SBP values in different BMI categories (P-value .045*) for all participants (P-value.045*) high number of the participants were found to be in the 110-129mmHg range (114), elsewhere about 10 of them are hypertensive, whom 6 of them are overweight and obese(table-5). In comparison with military students significant difference also appear (P-value .003**) while most of them are in the normal range (110-

120), only 2 have a high reading. In DPB, no significant difference found by cross tabulation in different BMI categories (table-6), in all participants as in military students
There is positive correlation between BMI and age (fig-4), weight, SBP (fig-1), DBP (fig-2) and MAP (fig-3). Meanwhile negative correlation is obtained between BMI with sex (table-8) and height (fig-5) .This results attributed to all participants, while in military students no positive correlation is found except with weight. This result can be attributed to that the whole of them are from the same age group and their body weight and height values are similar to each other.

Table (1) Characteristics of participants in relation to gender

Characteristics	Male (m±sd)	Female (m±sd)	P-value
Number of subject	101	49	
Age	25.3±11.1	24.08±9.3	0.741
Height(cm)	176.9±6.0	162.7±6.2	0.000**
Weight(kg)	70.2±12.0	62.1±13.1	0.001**
Body mass index (kg/m^2)	22.7±3.9	22.9±4.2	0.136
Systolic blood pressure	115.3±10.9	109.7±8.7	0.015*
Diastolic blood pressure	77.2±8.6	73.2±7.2	0.089
Mean arterial blood pressure	89.7±7.9	85±6.9	0.019*

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

Correlation is significant at the 0.05 level (2-tailed).*

Table (2) Characteristics of Military related to Body mass index:

Characteristics	Military (m±sd)	P-value
Number of subject	56	
Age	19.1±1.1	0.830
Height(cm)	177±5.1	0.075
Weight(kg)	64.3±6.0	0.000**
Body mass index (kg/m^2)	20.6±2.2	
Systolic blood pressure	112.2±7.8	0.192
Diastolic blood pressure	71.6±5.6	0.593
Mean arterial blood pressure	85.0 ±5.1	0.287

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

Correlation is significant at the 0.05 level (2-tailed).*

Table (3) BMI frequency and percentage for all subjects

BMI Categories	Military		Civilian			
	Male		Male		female	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
<18.5	9	16.1	4	8.8	7	14.3
18.5-24.9	45	80.4	25	55.6	30	61.2
25-30	2	3.6	13	28.9	8	16.3
>30	0	0	3	6.7	4	8.2
Total	56	100.0	45	100.0	49	100.0

Cross tabulation:

Table (4)Gender * body mass index Cross tabulation

		<18.5	18.5-25	25-30	>30	Total
Gender	male	13	70	15	3	101
	female	7	30	8	4	49
Total		20	100	23	7	150

$H_0 : \mu_M = \mu_F$ Means of body mass index between males and females are not differ significantly (not significant).

$H_0 : \mu_M \neq \mu_F$ Means of body mass index between males and females are not differ significantly (significant).

Categories of body mass index by Gender are not differ significantly from each other where: (P-Value>0.05).

Table(5) Cross tabulation Body mass index* Systolic blood pressure

Cross tabulation Body mass index* Systolic blood pressure						
		BMI Categories				Total
		<18.5	18.5-25	25-30	>30	
SBP	70-89	0	1	0	0	1
	90-109	1	21	3	0	25
	110-129	18	75	15	6	114
	130-150	1	3	5	1	10
Total		20	100	23	7	150

	Value	Df	P-Value. (2-tailed)
Pearson Chi-Square	40.55	27	.045*

*(P-Value<0.05) They are significantly different from each other at the .05 level.

Table (6) Cross tabulation Body mass index* Diastolic blood pressure

Cross tabulation Body mass index* Diastolic blood pressure						
		BMI Categories				Total
		<18.5	18.5-25	25-30	>30	
DBP	50-64	1	8	0	0	9
	65-79	18	87	15	6	126
	80-94	1	5	6	1	13
	95-110	0	0	2	0	2
Total		20	100	23	7	150

	Value	Df	P-Value. (2-tailed)
Pearson Chi-Square	33.893a	27	.169

(P-Value>0.05) There is no significant difference from each other at the .05 level

Correlations

Table (7) Correlation between Body mass index and type of the students

		<18.5	18.5-25	25-30	>30	Total	P-Value
Student	Military	9	45	2	0	56	0.002**
	Civilian	11	55	21	7	94	
Total		20	100	23	7	150	

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

Table (8) Correlation between Body mass index and Sex

Correlations			
		BMI	SEX
BMI	Pearson Correlation	1	.072
	P-Value. (2-tailed)		.380
	N	150	150
SEX	Pearson Correlation	.072	1
	P-Value. (2-tailed)	.380	
	N	150	150

Correlation is not significant at the level(0.05).

Figure (1)) Correlation between Body mass index and SBP :

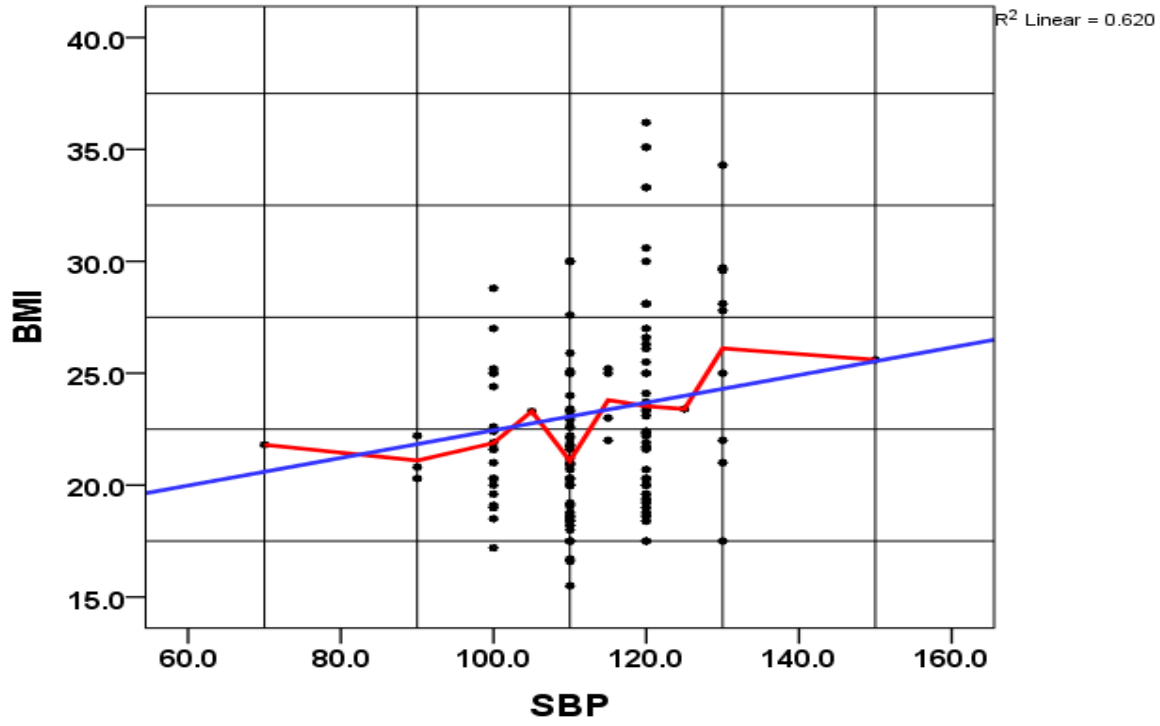


Figure (2)) Correlation between Body mass index and DBP :

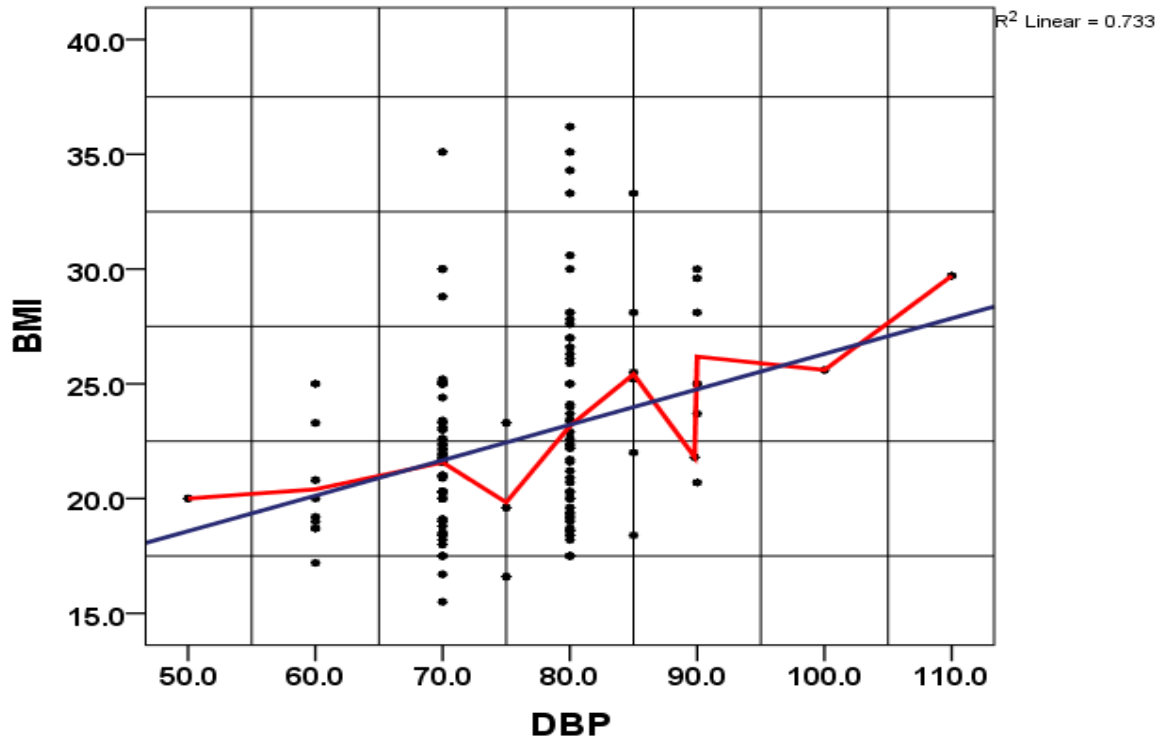


Figure (3)) Correlation between Body mass index and MABP :

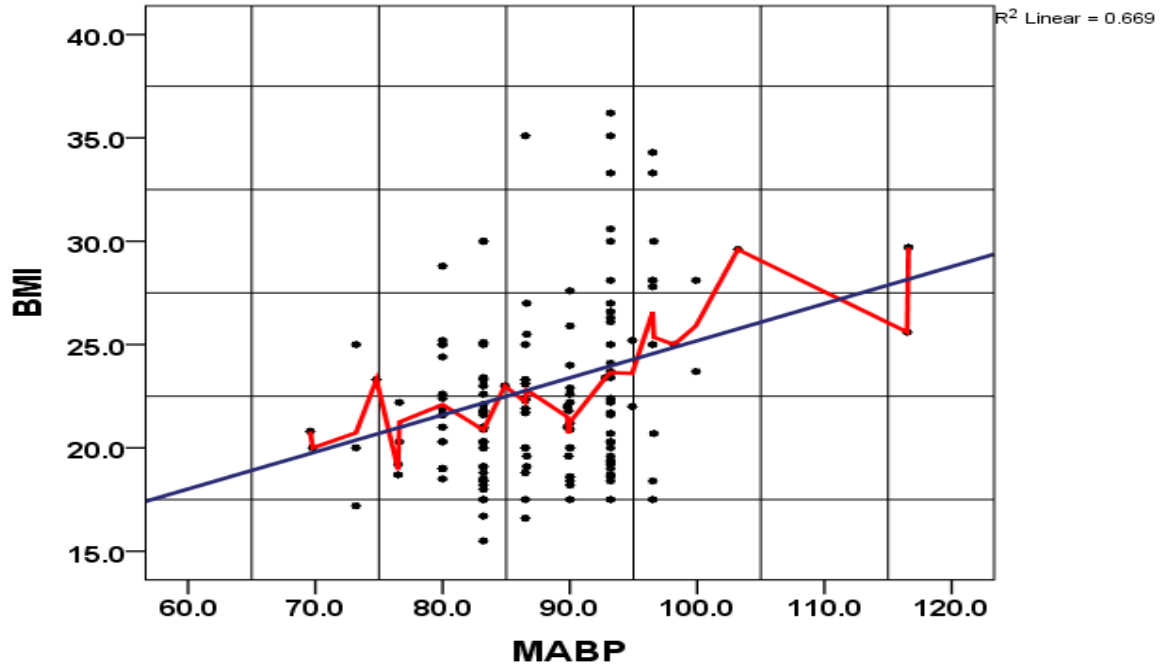


Figure (4)) Correlation between Body mass index and Age :

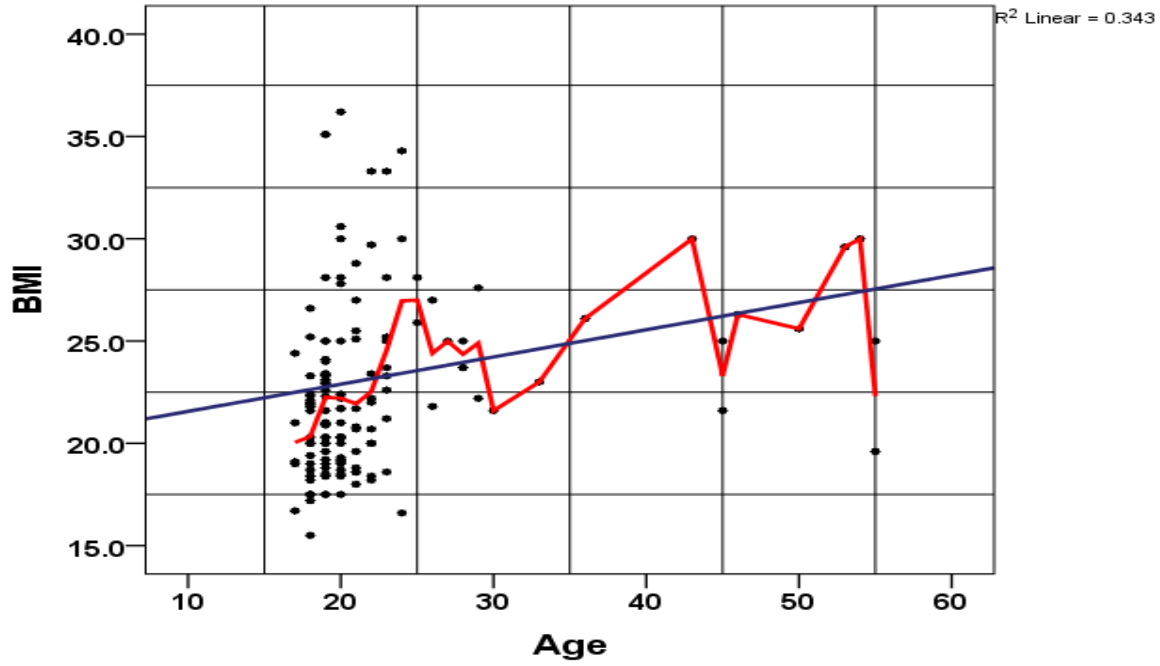
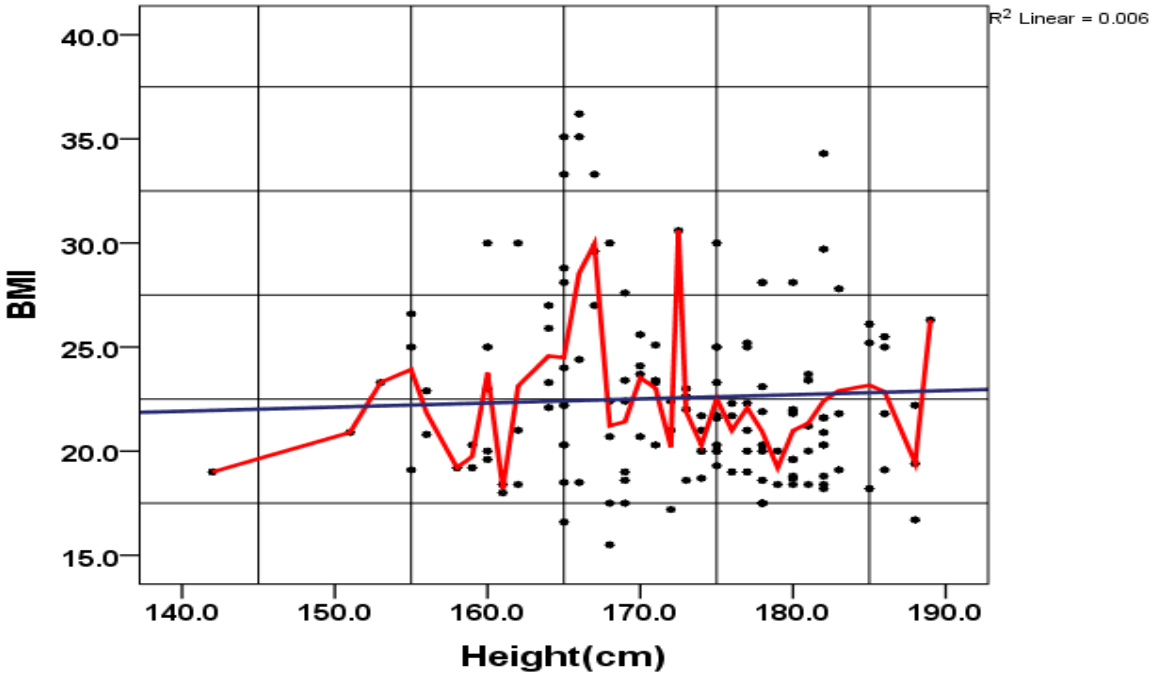


Figure (5)) Correlation between Body mass index and Height :



Discussion

In this study the relationship between BMI and BP among Sudanese adult in medical colleges in Karary University was examined. The study sample covered both civilian and military students beside the employee.

Significant positive correlations between BMI and SBP, DBP, MAP were observed. These correlations were comparable between the two genders. High values of blood pressure were associated with high BMI in both gender clearly. This significant positive correlation was also found in Pakistan in participants with nearly the same age group[3], Nigeria among students in Calabar University[8],in Greece[9], in India[5],in rural Nigerian dwellers[11] and by Tesfaye et al in three different ethnic groups[2].This correlation is evident in normal subjects, but a study done by Abdulla K.Salahudeen in heamodialysis patients with chronic renal failure, unlike normal subjects, there was no positive correlation between blood pressure and BMI [13] . Meanwhile blood pressure values records in military students were lower compared with civilian.

The relation between gender and blood pressure indices (SBP, DBP, MAP) showed noticeable variation in SBP relation where males have high SBP compared to females, they were more liable to develop Hypertension, while no clear difference in DBP relation. MAP was high in male in compare with female, this result can be justified by that their muscular bulk is greater than female in this young age according to hormonal change. In similar studies this relation is also found but, DBP was also differ unlike our study [9-11] .

Also positive correlation between BMI and age was reordered, this positive correlation is also recorded in similar studies in different ethnic groups, in the Ibos of Nigeria[10],in Tang Khul Nagh tribal in northern India[12],in Calabar University student in Nigeria[8].

Physiologically, we can explain these relations by that, with increase BMI ,the body mass increase leading to increase in the blood demand, consequently increase in cardiac output and however increasing the blood pressure. During exercise the key requirement of the cardio vascular system is to deliver requirements of O_2 and nutrients, one half of this increase due to vasodilatation caused by increase muscle metabolism, while the remained increase attributed to moderate increase in arterial blood pressure which lead to stretching arteriolar wall and reducing vascular resistance. So in athletes the heart champers enlarged about 40%and the heart mass increased 40%or more, enlarged heart increased pumping capacity. Their resting cardiac output is same as normal person, this achieved by large stroke volume and reduced heart rate; the heart pumping effectiveness (40-50%) [14].This explained the relative lower blood pressure values in military students in compare with civilian subjects.

In conclusion there is significant positive correlation between BMI and SBP, DBP and MAP with age and gender variation among Sudanese adult.

Conclusion:

There was evident correlation between BP and BMI, but future large scale research is needed, to examine further the exact association of BMI and blood pressure and consequently the definition of hypertension.

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