

**The National Ribat University**

**Faculty of Graduate Studies and Scientific Research**



**Body mass index and blood pressure levels among adult  
Sudanese in Khartoum state.**

**(Sudan 2016)**

**A Thesis Submitted for Partial Fulfilment of the Requirements for the  
Degree of M.Sc. in Human Physiology**

**By: Mazin SalahEldin Abdalla Mohamed**

**Supervisor: Prof. Omer Abdel Aziz Musa**

**2016**

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### **Verse**

“Allah - there is no deity except Him, the Ever-Living, the Sustainer of [all] existence. Neither drowsiness overtakes Him nor sleep. To Him belongs whatever is in the heavens and whatever is on the earth. Who is it that can intercede with Him except by His permission? He knows what is [presently] before them and what will be after them, and they encompass not a thing of His knowledge except for what He wills. His Kursi extends over the heavens and the earth, and their preservation tires Him not. And He is the Most High, the Most Great.”

## DEDICATIONS

I dedicate my work to almighty Allah, thanking Him for everything that I am

I dedicate my work to my family and friends. A special feeling of gratitude to my loving parents, *Alawia Ragab and Salaheldin Abdalla*, whose words of encouragement and push for tenacity ring in my ears.

I also dedicate this work to my mentor, professor, *Omer Abdel Aziz* who was and still is more than willing to help and give advice whenever I need one.

I shall not forget my late professor *Mansour*, who gave us everything and more and showed me the man I aspire to be.

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I give my deepest thanks to ustaza Najat, without whom the organization of the program was doomed to fail, thank you ever so much.

My friends and colleagues: I thank you so desperately so much.

# Body mass index and blood pressure levels among adult Sudanese in Khartoum State, 2016

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## **Abstract:**

### **Background:**

There is a world-wide increase in the prevalence of obesity and it is comorbid conditions such as increased blood pressure. Numerous studies have been conducted to establish the nature of the relationship between the body mass index (BMI) and both systolic and diastolic blood pressures.

**Methods:** An extensive internet PubMed search has been conducted for researches concerning the relationship between the blood pressure and body mass index

**Result:** During the period from 2006 up to 2016 using the key words (body mass index, blood pressure) 20 scientific papers have been retrieved and 8 of them covered the relation in question. The results from the retrieved papers suggest a relationship between the body mass index and tendency for blood pressure increment. However, this association might not be linear, in fact it may be reversed as one study suggests.

**Conclusion:** Body mass index is an important factor influencing the values of blood pressure among ethnicities

## **Background:**

Currently, there are no known studies investigating the relationship between blood pressure and the body mass index among Sudanese populations. The values of the systolic and diastolic blood pressures used in clinics and hospitals are taken from non-Sudanese subjects based on international recommendations.

These values are expected to be different due to the difference of diet, climate, genetic makeup and exercise schedule among individuals.

## **Objective (s):**

The objective of this review is to investigate the relationship between BMI and values of blood pressure

## **Methods**

An extensive internet search has been conducted or research concerning the relationship between the blood pressure and the body mass index

Web site used: National Center for Biotechnology Information using the Google Scholar

Key words used for the research: Body mass index, blood pressure levels.

The research covered the period from 2006-2016 and 8 papers were retrieved.

## **Results:**

The papers covered the relationship between the body mass index and blood pressure among different ethnic backgrounds (Africans, Asians and Caucasians). The trend of the association observed was an upward trend (the higher the body mass, the higher the blood pressure) [2, 3, 4, 6, 7, 8]. One study concluded that the correlation was not statistically significant [5] and the final one suggested that the relationship was not linear. [1]



## Results

<u>Author</u>	<u>Type of Study &amp; Year</u>	<u>Sample Size</u>	<u>Results &amp; Conclusions</u>
Nadia Danon-Hersch (1)	Cross sectional study in Seychelles. 2007	1989 (n=1081), 2004 (n=1255)	<p><b>Results:</b> Among untreated persons, a BMI increment of 1 kg/m<sup>2</sup> was associated with an elevation of 2.0/1.5 mm Hg of systolic/diastolic BP in 1989 but only 1.3/1.0 mmHg in 2004</p> <p><b>Conclusion:</b> The linear relationship between BMI and BP was markedly weaker in 2004 than in 1989, irrespective of antihypertensive treatment and age, and among both lean and overweight participants.</p>
F Tesfaye (2)	cross-sectional descriptive design in Ethiopia, Vietnam and Indonesia, 2007	7675	<p><b>Results:</b> BMI and BP increased along the socioeconomic gradient across the three countries. A high prevalence of overweight/obesity was noted among Indonesian women (25%) and men (10%), whereas low BMI was widely prevalent in Ethiopia and Vietnam, ranging from 33 to 43%.</p> <p><b>Conclusion:</b> BMI was significantly and positively correlated with both SBP and DBP in all the three populations, correlation coefficient (r) ranging between 0.23 and 0.27, Po0.01. High BP exists in a background of under nutrition in populations at early stages of the epidemiologic transition</p>
Francesco P. Cappuccino (3)	Cross section, Africa, Caribbean, the United Kingdom and the United States. 2008	18,072 participants	<p><b>Results:</b> There was a positive relationship between both systolic and diastolic blood pressure and BMI.</p> <p><b>Conclusion:</b> Blood pressure and BMI levels vary among African population. The effect of BMI on blood pressure levels diminishes as BMI increases.</p>

Violet Kankane Moselagomo (4)	Cross section, South Africa. 2012	1,172	<p><b>Results:</b> Blood pressure correlated positively with the <b>body mass index</b>, (<math>p &lt; 0.001</math>)</p> <p><b>Conclusion:</b> Blood pressure increased with age in both genders</p>
L.N. Achie (5)	Cross sectional study in Zaria, Northern Nigeria. 2012	165	<p><b>Results:</b> There was a significant positive correlation observed between waist circumference and the body mass index (<math>p &lt; 0.05</math>).</p> <p><b>Conclusion:</b> The BMI showed a positive correlation with the diastolic blood pressure, however it was not significant (<math>p &gt; 0.05</math>)</p>
Aina Emaus (6)	Cross sectional study, Norway. 2011	12,900	<p><b>Results:</b> Among men and women participating in both studies, the mean BMI was 27.1 kg/m<sup>2</sup> for men and 25.1 kg/m<sup>2</sup> for women. Mean arterial blood pressure (MAP) was 92.4 mm Hg for men and 86.0 mm Hg for women. The proportion defined as pre-hypertensive/hypertensive (systolic/diastolic blood pressure &gt; 120/80) were 33% and 56% for women and men, respectively. The proportion of low, medium and high <b>cardiorespiratory fitness (CRF)</b> for both sexes combined differed significantly (<math>p &lt; 0.0001</math>) by BMI level (<math>&lt; 25</math> or <math>\geq 25</math> kg/m<sup>2</sup>). Increased fitness tended to reduce blood pressure among overweight and obese men (<math>p</math> trend = 0.03), whereas increased fitness tended to reduce blood pressure among normal weighted women (<math>p</math> trend = 0.01).</p> <p><b>Conclusion:</b> Among healthy 40-44 year old men and women in this study, BMI was positively associated and CRF was negatively associated with blood pressure. <b>Moreover, the results suggest that BMI may be a more important factor than CRF in predicting systolic blood pressure in both sexes.</b> However, cardiorespiratory fitness and weight control may both be important targets for</p>

			prevention of hypertension.
Olumide Abiodun (7)	Cross sectional study, Nigeria 2014	776	<p><b>Results:</b> The mean BMI was in the overweight range, <math>25.49 \pm 5.15</math> kg/m<sup>2</sup> and was higher in females. About two-thirds (62.8%) of the participants had abnormally elevated waist hip ratio (WHR). Random blood sugar (RBS), systolic blood pressure (SBP) and diastolic blood pressure (DBP) increased significantly with increasing BMI status (<math>p=0.000</math>, <math>p=0.000</math> and <math>p=0.007</math> respectively) and were significantly higher with abnormally elevated WHR than in participants with normal WHR (<math>p=0.000</math>, <math>p=0.000</math> and <math>p=0.000</math> respectively). However, overweight individuals tended to have a higher RBS than the obese. There was a significant correlation between BMI and RBS (0.083, <math>p=0.020</math>), SBP (0.206, <math>p=0.000</math>) and DBP (0.152, <math>p=0.000</math>). There was a slightly stronger correlation between WHR and RBS (0.093, <math>p=0.009</math>), SBP (0.273, <math>p=0.000</math>) and DBP (0.217, <math>p=0.000</math>).</p> <p><b>Conclusion:</b> BMI and WHR are positively correlated with RBS and blood pressure in Nigeria. The Nigerian population is therefore at risk of Obesity and its related conditions (hyperglycemia and hypertension)</p>
Varshitha A (8)	Cross section, India. 2015	100	<p><b>Results:</b> The study showed that the mean systolic and diastolic blood pressure was found to be higher in males when compared to females. Also, the mean BMI was higher in males than females. Systolic, diastolic blood pressure and BMI of males was found to be statistically higher than females.</p> <p><b>Conclusion:</b> There is a significant Correlation (<math>p&lt;0.01</math>) between the systolic, diastolic BP and BMI values.</p>

**Discussion:** the blood pressure is affected by many factors including BMI, physical activity, age, ethnicity, diet and smoking. The statistical association between the three variables (BMI, Systolic and Diastolic blood pressure) was significant. However, the observed correlation between the BMI and the blood pressure (systolic and diastolic) is not always linear as some papers suggest, it might get weakened [1], or even reversed (lower BMI and higher blood pressure [2]. This observation might be explained by the presence of many confounding factors (genetics, diet, environments, response to treatment, etc.)

**Conclusion:** Body mass index is an important factor influencing the values of blood pressure among ethnicities. There is a need for establishing the relation with a mathematical formula so as to calculate the normal blood pressure for an adult according to the BMI.

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## **Abstract**

**Introduction:** The blood pressure (systolic and diastolic) has been found to increase with increased weight. This relationship is well advocated in many solid researches around the world. However, the relationship does not account to a cause and effect relation, the increment in the body weight may only raise the risk of increasing blood pressure

**Objectives:** The objective of this study is to investigate the relationship between the body mass index and blood pressure levels in healthy Sudanese population residing in Khartoum State

**Materials and methods:** A Cross sectional study was conducted during July-August, 2016 in Khartoum state on a sample size of 200 subjects adult males/females of ages between 20-60 years and who were not known to be hypertensive.

All the participants were assessed by a questionnaire covering age, gender, physical activity, daily salt intake and smoking history. Blood pressure was measured using the manual sphygmomanometer. Weight was measure using the standard scale. BMI was calculated according to the formula:

$$\text{Weight (kg)} / [\text{height (m)}]^2$$

Correlations between the variables were estimated and P value < 0.05 was considered statistically significant.

## **Results:**

There is a significant positive relationship between the BMI and the systolic blood pressure (p value = 0.01), the statistical analysis also showed a significant positive relationship between the BMI and the diastolic blood pressure (p value = 0.01)

## **Discussion:**

This study has demonstrated that the association between the body mass index and the blood pressure is significant. However, further studies on a larger sample size are required so as to establish a mathematical formula to predict the blood pressure given the body mass index

## **Conclusion:**

There is positive correlation between systolic, diastolic blood pressure and BMI. Increased blood pressure was seen in individuals with higher BMI when compared with individuals with lower BMI.

## ملخص الدراسة

### مقدمة:

كشفت دراسات عديدة حول العالم عن ارتباط ضغط الدم بمؤشر كتلة الجسم. ولكن هذه الدراسات لا ترتقى لان تجعل من زيادة مؤشر كتلة الجسم سببا مباشرا لارتفاع الضغط.

### الطريقة:

تم جمع 200 عينة (107 من فئة الرجال و93 من النساء) بين ال20-60 عاما. على اساس شروط معينة يتم على اساسها استبعاد من كان يعاني من اي مرض مزمن او يستخدم ادوية قد تزيد من ضغط الدم. وقد تم ملء استبيان وأخذ موافقة من المشاركين.

تم كذلك قياس ضغط الدم ومؤشر كتلة الجسم لكل المشاركين في البحث.

### النتائج:

وجدت الدراسة أن هناك علاقة بين كتلة الجسم وضغط الدم. أشارت النتائج أيضا الى أن هناك زيادة بين نسبة الرجال المصابين بالسمنة بناء على مؤشر كتلة الجسم مقارنة بالنساء.

أظهرت الدراسة أن هناك شبابا بين سني ال20 وال40 مصابين بارتفاع في ضغط الدم

### الخلاصة:

أظهرت نتائج الدراسة ان هناك علاقة ايجابية بين زيادة مؤشر كتلة الجسم وارتفاع ضغطي الدم (الانقباضي والانبساطي). ولكي تظهر العلاقة في شكل معادلة رياضية لابد من توسيع قاعدة المشاركة في الدراسة لعددية أكبر

## **Introduction**

Blood pressure (BP) is regulated by activity in the autonomic nervous system. Obesity is associated with sympathetic activation and is the leading risk factor for development of hypertension. <sup>(1)</sup>

Hypertension is one of the most common medical disorders and data from observational studies have demonstrated increasing risk of stroke, myocardial infarction, cardiovascular death, site specific cancer and all-cause mortality associated with high blood pressure <sup>(2-4)</sup>

There is a positive association between measures of obesity and blood pressure in both developed and less developed countries <sup>(5)</sup>

BMI is defined as body mass index which is a value calculated using the height and weight of the person. BMI ranging from 18-25 is considered as normal. Obesity and overweight in the age around adolescence are the global problems on the rise especially very common in developing countries. Obesity is evolving as one of the major burdens as it results in many chronic diseases. <sup>(6)</sup>

Globally, high blood pressure (BP) is estimated to cause 7.1 million deaths, about 13% of the total. About 62% of cerebrovascular disease and 49% of ischemic heart disease are attributable to suboptimal BP (systolic >115mm Hg). Overweight and obesity increase the risks of high BP, coronary heart disease, ischemic stroke, type II diabetes mellitus and certain cancers. Worldwide about 58% of diabetes mellitus and 21% of ischemic heart disease are attributable to BMI above 21 <sup>(7)</sup>

Not only physical activity, but also other lifestyle factors are associated with hypertension, most notably bodyweight <sup>(8, 9)</sup>

Cross sectional and observational studies have documented a positive association between blood pressure and body weight <sup>(10)</sup> and blood pressure increases over time among subjects who experience weight gain <sup>(11)</sup>

There is an increasing trend in both blood pressure and body mass index in the recent years. Studies on general population have demonstrated that the prevalence of hypertension in overweight subjects is more when compared to that in normal subjects <sup>(12)</sup>

Some studies state that blood pressure does not increase in obese patients, instead high blood pressure was stated in subjects who are underweight <sup>(13)</sup>  
The neighborhood environment may also influence on the food habits, which leads to increased BP and BMI <sup>(14)</sup>

Hypertension in Africa is a widespread problem of immense economic importance because of its high prevalence in urban areas; it's frequent under diagnosis, and the severity of its complications <sup>(15)</sup>



It is becoming a public health emergency worldwide, especially in developing countries, where studies have projected an increase by 80% in the number of hypertensive by the year 2025. In Africa, more than 30 million people have hypertension. World health Organization (WHO) predicts that, if nothing is done about it, by 2020 three quarters of all deaths in Africa will be attributable to hypertension <sup>(15)</sup>

10-20 million people in sub-Saharan Africa may have hypertension and that treatment could prevent around 250000 deaths each year <sup>(16)</sup>

Regional differences in the prevalence of hypertension within countries have been identified <sup>(16)</sup>

In Sudan, hypertension had a prevalence of 20.1 % .Un-diagnosed hypertension is detected in 38.2% of population in two towns in Northern Sudan <sup>(16)</sup>  
In rural population in Sudan the hypertension prevalence is 23.3% 19.9%, 17.3% in central, northern, and eastern Sudan respectively <sup>(16)</sup>

## **Materials and Methods**

This is an analytical, cross-sectional community based study performed in Khartoum state capital of Sudan during 2016 in Sudanese healthy individuals (males and females) between 20-60 years old, who were not known hypertensive. The population of interest for this study was all adults who fulfilled the inclusion criteria and resided in As Salama area, block 3, Khartoum State. The study included 200 adults (107 males and 93 of the female gender) who were interviewed according to the designed questionnaire during random visits to households.

Ethical approval of this study was obtained from the National Ribat University (NRU).

Questionnaire Interviews with all participants were done covering basic information about age, gender, daily salt intake, smoking and physical activity.

Physical examination of the blood pressure, height, weight and calculation of body mass index was done for every case based on the formula:

Weight (kg) / [height (m)]<sup>2</sup>

### **Inclusion criteria:**

- Sudanese adult males and females (20-60 years old)
- Not known hypertensive.

### **Exclusion criteria:**

- Refusal of participating in the study.
- Age below 20 or above 60 years
- Tea or coffee in the previous hour

All the data collected in this study was analyzed using the SPSS (Statistical Package for Social Sciences) computer program version 16, (t-test for mean and P value for significance).

P value < 0.05 was considered statistically significant.

## **Results**

In this study blood pressure and BMI were measured in 200 adults in Khartoum state. The age of the individuals ranged 20 and 60 years. 53.5% of the participants were males; the majority of the participants (34.5%) were in the range of 30-39 age wise.

The BMI was found to be within the normal range (18.5-25) for most of the individuals (50%). 1.5% of the individuals were underweight (BMI<18). 33.5% of the individuals were overweight (BMI= 25-29.9) and only 15% were obese (BMI>29.9). It is worth noting that 76.7% of the obese category according to the BMI were men as opposed to 23.3% obese females. No underweight females in this study. (Table 1)

The individuals were considered hypertensive when the systolic blood pressure was equal or greater than 140mmHg and/or diastolic blood pressure was equal or greater than 90mmHg. When blood pressure was compared to the gender difference, 46% of females were pre hypertensive as far as the systolic pressure is concerned and only 3.3% were actually hypertensive, whereas 58.8% of the male counterparts were pre hypertensive and less than 14% had an elevated systolic in the range of hypertension (Table 1). Regarding the diastolic blood pressure, the majority of the females were pre hypertensive (59.2%) and most of the males were hypertensive (45.7%) (Table 2). Diastolic hypotension was not encountered in this study.

Cases were found in this study to have a normal body mass index, yet they have either high systolic or high diastolic (Fig. 1, 2); this phenomenon would be a result of other factors (genetic, environmental...), which were not under the scope of the study. When age is taken in comparison to the systolic pressure, the age range of 20-29 had 18 cases out of 65 in the pre hypertensive zone as opposed to only 18 cases from the age 50-59 zone.

When diastolic pressure was taken against the age, 32 pre hypertensives and 17 hypertensives from the 20-29 age category, whereas 17 cases pre hypertensive and only 10 cases were hypertensive in age range of 50-59.

Bivariate correlation analysis was conducted on the relationship between the BMI and systolic blood pressure as well as between the BMI and the diastolic blood pressure. The p value of BMI and systolic pressure is 0.01 and it is statistically significant. The p value of BMI and the diastolic blood pressure is 0.01 which is also statistically significant.

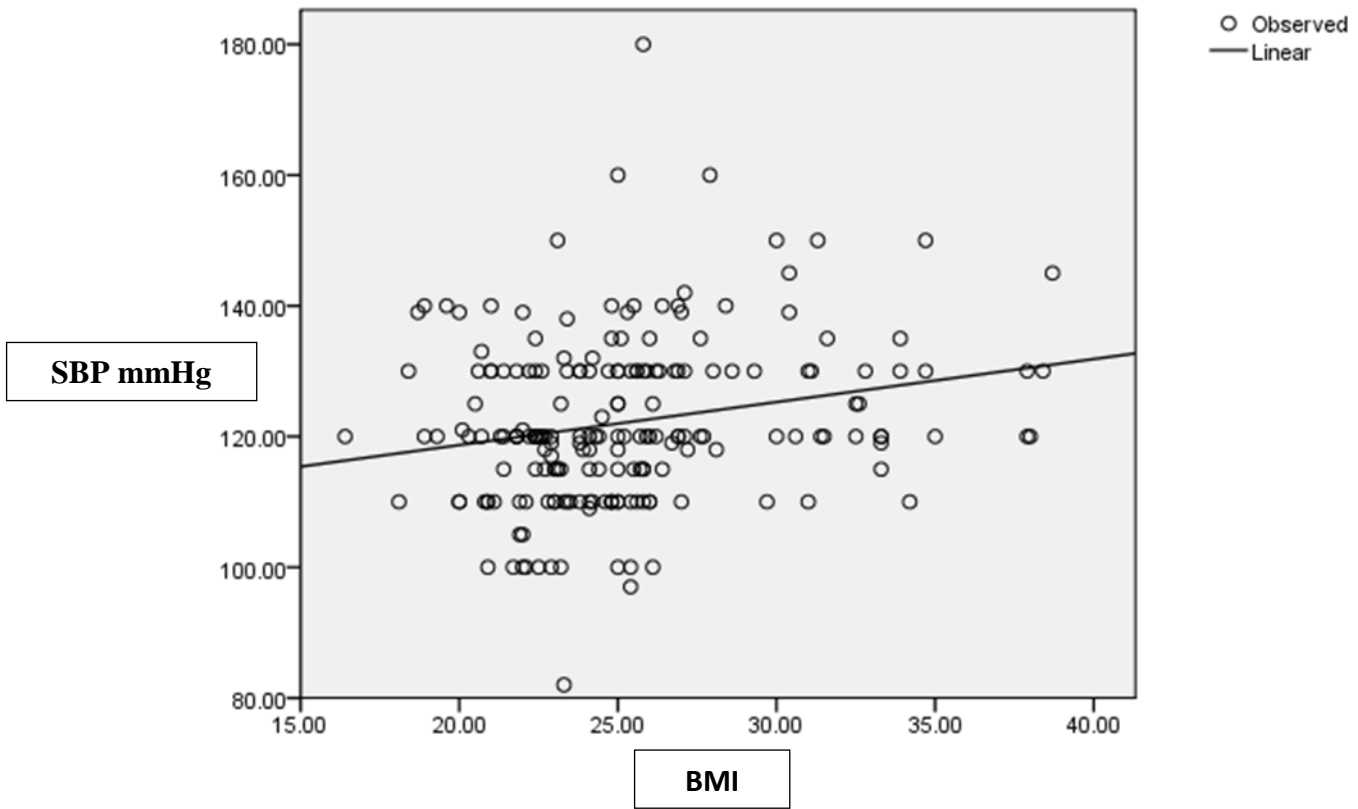
**Table 1****Body mass index in relation to the Systolic BP and gender difference**

BMI	SBP	Gender				Total (200)	
		Male		Female			
Underweight	Normo	1		0		1	
	Prehyper	2	1.9%	0		2	
	Total	3		0		3	1.5%
Normal weight	Hypo	0	0%	1		1	
	Normo	16		31		47	
	Prehyper	23	21.5%	24	25.8	47	
	Hyper	4	3.7%	1	1.1%	5	
	Total	43		57		100	50%
Overweight	Normo	9		14		23	
	Prehyper	22	20.5%	14	15.1	36	
	Hyper	7	6.5%	1	1.1%	8	
	Total	38		29		67	33.5%
Obesity	Normo	3		1		4	
	Prehyper	16	14.9	5	5.4	21	
	Hyper	4	3.7%	1	1.1%	5	
	Total	23	76.7%	7	23.3%	30	15%

The statistical Pearson correlation 2-tailed test for significance is showing significance at the 0.01 level

**Figure 1**

**Linear representation of the BMI and systolic blood pressure relationship**



**Table 2**

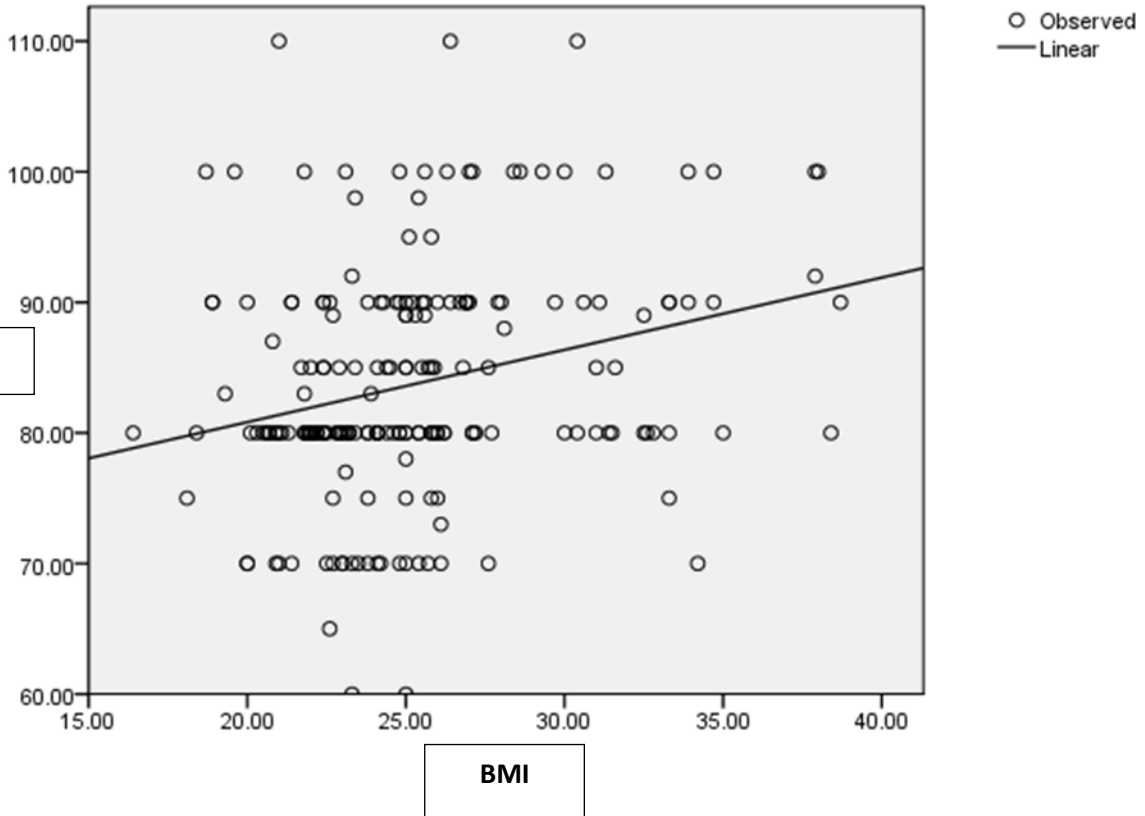
**BMI in relation to Diastolic Blood Pressure and gender difference**

<b>BMI</b>	<b>DBP</b>	<b>Gender</b>				<b>Total (200)</b>	
		<b>Male</b>		<b>Female</b>			
<b>Underweight</b>	<b>Normo</b>	1		0		1	
	<b>Prehyper</b>	2		0		2	
	<b>Total</b>	3		0		3	1.5%
<b>Normal weight</b>	<b>Normo</b>	6		16		22	
	<b>Prehyper</b>	21		36	38.7%	57	
	<b>Hyper</b>	16	14.9%	5		21	
	<b>Total</b>	43		57		100	50%
<b>Overweight</b>	<b>Normo</b>	1		10		11	
	<b>Prehyper</b>	16		14	15.1%	30	
	<b>Hyper</b>	21	19.6%	5		26	
	<b>Total</b>	38		29		67	33.5%
<b>Obesity</b>	<b>Normo</b>	2		1		3	
	<b>Prehyper</b>	9		5	5.4%	14	
	<b>Hyper</b>	12	11.2%	1		13	
	<b>Total</b>	23		7		30	15%

The Pearson correlation test for significance is displaying a level of 0.01 which is considered statistically significant

Figure 2

**The graphical dependency of the diastolic blood pressure on the BMI**



The graphs (figure 1 and 2) show the upward trend in the diastolic blood pressure (the dependent variable) in accordance to the body mass index (the independent variable)

## **Discussion**

The purpose of this study was to investigate the dependency of blood pressure on the body mass index. The study covered some factors that might influence the blood pressure such as dietary salt intake, smoking, age, exercise hours and past or current history of drugs. The main concern was the nature of the BMI effect on the blood pressure. A primary finding was that the relationship was linear in nature (the more the BMI, the more the blood pressure, both systolic and diastolic). This magnitude of the results should come as no surprise due to the fact that BMI is one of the factors that lead to an increment in blood pressure.

This study had some limitations, first of which is that the blood pressure was assessed in a single visit, which might lead to overestimation. Secondly, the study is not designed to explore other factors, most importantly, genetic makeup, which might reverse the BMI-BP correlation. Our results also reflected the relationship between the age and the blood pressure and it is noteworthy that the bulk of individuals with prehypertension (both systolic and diastolic) were between the ages of 20 and 40. This finding was consistent with the study done in Cameron, where it showed that high blood pressure was common among the young, ages 25-39 years <sup>(15)</sup>

Some studies like the one done across Ethiopia, Vietnam and Indonesia in 2007 (in contrary to our results) suggested that severe underweight was in fact associated with increased blood pressure. <sup>(7)</sup>

The prevalence of hypertension and obesity is low in this study compared to other studies <sup>(17)</sup>, but that study in particular investigated the prevalence in diabetic patients.

The study done in Norway, 2011, investigated the relationship between BMI, the physical status represented as the cardiorespiratory fitness (CRF) and the blood pressure. They found out that obesity as a known risk factor for high blood pressure was counteracted by the physical fitness (CRF) <sup>(18)</sup>

However, they suggest that the BMI might be more relevant than CRF in determining the systolic blood pressure. In our study, the BMI has a direct equal influence on both systolic and diastolic pressure



## **CONCLUSION**

The study concludes that there is a strong correlation between the BMI and both the systolic and diastolic blood pressures taken separately.

Correlation was observed between blood pressure and BMI with a p value of 0.01 in regards to both the systolic blood pressure and diastolic pressures, which is considered statistically significant.

An increment in blood pressure was observed in individuals with higher BMI when compared to those with low and normal BMI. If the blood pressure depends on the BMI, then the guidelines for classification of normal blood pressure, pre hypertension and hypertension should take into account the BMI. This assumption needs a larger scale study to derive an equation of the normal BP according to the BMI.

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