The Effect of Blood Pressure Risk Factors (Packed Cell Volume and Body Mass Index) on the Incidence of Hypertension

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Abstract: ***Hypertension is a worldwide epidemic in many countries, 50% of the population > 60 years of age has hypertension. Hypertension is defined as a repeatedly elevated blood pressure exceeding 140/90 mmHg. The prevalence of hypertension is steadily increasing, even with the expanded use of antihypertensive medications. It is widely recognized that hypertension is associated with increased cardiovascular and all-cause mortality independently of other risk factors. In several reports, packed cell volume (PCV) and body mass index (BMI) have been identified as risk factors that significantly contribute to blood pressure increase. Therefore, there is necessity to investigate the correlation between PCV and BMI in hypertensive and normotensive subjects. In this study, a total of 100 subjects of age between 20 and 70 years were examined, 50 subjects (25 male and 25 female) were hypertensive and 50 subjects (25 male and 25 female) were normotensive. In all subjects, blood pressure, BMI and PCV were measured.There was a positive correlation between BMI and PCV in hypertensive subjects (male and female). This relation was strongly significant linear positive in males, where the r = 0.921 (ANOVA *P = ≤ 0.01) and also in females, where r = 0.952 (ANOVA *P = ≤ 0.01). Unlike in normotensive subjects the correlation was non-significant between BMI and PCV in males, where, r = 0.026 and in females, where r = 0.103.***

Keywords: Packed Cell Volume (PCV), Body Mass Index (BMI), Normotension and Hypertension (Systolic and Diastolic Blood Pressure SBP, DBP

1. Introduction

Hypertension also known as high blood pressure (HBP) is a non-communicable disease, which is associated with high morbidityand mortality.The disease is a silent threat to the health of peopleall over the world (Gyamfi *et al*., 2018).Hypertension prevalence is increasing, constituting a major public health problem. It is considered one of the most common chronic medical conditions in the United States, affecting about one third of the population (Tawfik 2018).Hypertension is a global public health challenge due toits high prevalence and the concomitant increase in riskof stroke and cardiovascular diseases. In 2007, accordingto the World Health Organization (WHO), cardiovascular diseases caused 33.7% of alldeaths in the world, while other chronic diseases were responsible for 26.5% (Thawornchaisitet *et al.*, 2013).

Several significant risk factors have been identified to be associated tightly withhypertension amongpatients, these risk factors include, Age, alcohol, smoking and chewing tobacco, centralobesity, BMI, high hematocrit or PCV, consumption of low vegetables/fruits,high consumption of dietary fat and salt, (Anchala*et al.*, 2014). Packed cell volume (PCV) and body mass index (BMI) are listed among the risk factors of hypertension.

Packed cell volume (PCV) also known as hematocrit (HCT) is the volume percentage (%) of red blood cells in the blood. It is considered an integral part of a person's complete blood count results, along with hemoglobin concentration, white blood cell count, and platelet count (Purves *et al.*, 2003).Packed cell volume (PCV) is the single most important determinant of whole blood viscosity with the body mass index. Together are risk factors for concomitant diseasessuch as hypertension and diabetes mellitus (Akinnuga, Bamidele and Chukwuebuka 2011).

Akinnuga, Bamidele and Chukwuebuka (2011) stated that, packed cell volume (PCV) or hematocrit (HCT) and body mass index (BMI) estimations are essential risk factors thathave been traceable to the etiology of cardiovascular diseases especially hypertension (Felix *et al.*, 2018).In men and women, the risk of hypertension increasedwith an increased BMI. The risk of hypertensionincreased in both men and women who had diabetesmellitus, high blood lipids and kidney disease (Thawornchaisit *et al.*, 2013).

Obesity is a major influence on the development of cardiovascular disease (CVD) and affects physical andsocial functioning and quality of life (Kumanyika *et al.*, 2008). Yazdanyar and Newman (2009) say that, obesity is a significant risk factor for CVD andother diseases such as hypertension, type II diabetesmellitus, and dyslipidemia. The prevalence ofsome obesity-related CVD risk factors (eg, elevated cholesterol and high blood pressure) remained higher in overweight and obese than non-overweight individuals in the United States (US) during the period from 1960 to 2000 (Kumanyika *et al.*, 2008). Body mass index (BMI) is a reasonably good measure of general adiposity (obesity) (Wu *et al.*, 2014).

Body Mass Index (BMI) is an indicator of relative weight for height (kg/m²) and a frequently used forassessment of excess body fat (Zafrir *et al.*, 2013). Although measuring totalbody mass does not measure fat distribution directly, BMI isadopted by the World Health Organization (WHO) as valuable measure of obesity (Lainscak *et al.*,2012). The United States is currently facing a very real obesity epidemic and the most recent National Health (NH) and Nutrition Examination Survey (NES) indicates that approximately two thirds of US adults are presently classified as overweight (BMI≥ 25) and one third as obese (BMI ≥ 30) (Flegal *et al.*, 2012).

Given the frequent concurrence of obesity and hypertension, it is no accident thatas the rate of obesity continues to rise, so too does therate of hypertension. It is estimated that at least 75%of the incidence of hypertension is related directly to obesity (Landsberg *et al.*, 2013). Zafrir et *al.*, (2013) pointed out that the relationship between BMI and total mortality risk is controversial. Obesity is a well-recognized independent cardiovascular risk factor. In the general population, a higher BMI is associated with an increased risk for cardiovascular events and death, and obesity has reached epidemic proportions in developed countries (Zafrir*et al.*, 2013).

The prevention of hypertension is a public health challenge and the primary precaution to limit of the incidence of hypertension isassociated tightly with its risk factors, where the elimination of the elevated risk factors of hypertension might largely reduce the incidence of CVD.These would be applicable and helpful for all people who at risk factors such as elevated HCT and obesity (Anchala *et al.*, 2014).

2. The Aim

The aim of this study was to investigate the relation between the hypertension risk factors (BMI and PCV) in hypertensive and normotensive individuals.

3. Literature Review

Hypertension is a public health problem and obesity is becoming an epidemic, increasing the risk of hypertension. Both are risk factors for cardiovascular diseases (CVD) (Tawfik 2018).Several studies have been done on factors affecting cardiovascular functions, obesity or excess relative weight is found to be associated with increased risk of disease morbidity and mortality (Dua *et al.*, 2014). Obesity is perhaps the most prevalent form of malnutrition in developing countries, among both adults and children. Studies have demonstrated that obesity is related to elevated systolic blood pressure (SBP) and diastolic blood pressure (DBP) elevation, dyslipidemia, diabetes, etc (Dua*et al.*, 2014).

Body mass index (BMI) is widely accepted as one of the best indicator of nutritional status in adults (Dua*et al.*, 2014). The importance of BMI and skinfolds has been recognized for estimating cardiovascular disease (CVD) risk factors, particularly due to their positive association with hypertension (Dua*et al.*, 2014). Linear correlations between both SBP and DBP for all anthropometric measurements (particularly BMI) among males were found to be significant in the adult Brazilian men. Also, blood pressure found to be increased with higher BMI, Waist Circumference (WC), and various skinfold locations (Dua *et al.*, 2014).

HT is believed to result from obesity,which is exacerbated by a high-energy, high-fat, highsaltdiet, inadequate exercise and stress (Polat, *et al.*, 2014).Although, most studies have proved that, the BMI has positive relation with the blood pressure, where the increased BMI results in increased blood pressure (Polat, *et al.*, 2014). However, the relationship between Blood Pressure, body weight, and age is complex and controversial (Martins *et al.*, 2002).It has been suggested that the blood pressure continues to decrease with increasing BMI. Also, obesity may mitigate the cardiovascular risk of hypertension and a low body mass index (BMI) was associated with increased risk of death and stroke in the elderly program (Martins *et al.* 2002).

Hematocrit (Hct), is the proportion of blood volume occupied by red blood cells, is a major determinant of blood viscosity, blood pressure (BP), venous return, cardiac output, and platelet adhesiveness (Paul *et al.*, 2012). Increase in blood viscosity, defined as resistance toflow, is one factor in hypertension andatherosclerosis that contributes to the morbidityand mortality associated with tissue ischemia (Cinar*et al.*, 1999). It has been stated that a lowered blood viscosity level mayconstitute a lesser blood pressure, friction and damage on the vessel lumen, also it may slow the atherosclerotic process (Cinar *et al.*, 1999).Additionally, increased blood viscosity and increased body weight (BMI) contribute immensely to increase blood pressure (Akinnuga, Bamidele and Chukwuebuka 2011).

Several prospective studies have demonstrated associations between HCT and risk of cardiovascular disease, including coronary heart disease (CHD) and stroke (Paul *et al.*, 2012).It has been reported that hematocrit is increased or normal inhuman who have high hypertension (Akinnuga, Bamidele and Chukwuebuka 2011). Jae *et al.*, (2013) demonstrated that high hematocrit levels were causally associated with the incidence of hypertensionindependent of other risk factors in men. Vazquez *et al.*, (2008) proved that, increased hematocrit above baseline is usually associatedwith elevation of systemic blood pressure due to the increase inblood viscosity.

It has been demonstrated that hematological parameters including hematocrit (HCT), were higher in the hypertensive group compared to the control group, which strongly suggested that among these parameters, hematocrit was the independent risk factor for hypertension in the population (Emamian *et al.*, 2017). Interestingly, since there is significant correlation between PCVand blood pressure in obeseindividuals according to the previous studies, therefore it is reasonable to suggest thatsuch significant correlation may be due to high PCV, high body weight BMI, less physical activities, highfat storage of the hypertensive subjects (Akinnuga, Bamidele and Chukwuebuka 2011).

4. Materials and Methods

A total of 100 subjects of age ranging between 20 and 70 years from Dai Elhelal Clinic were selected, 50 subjects were hypertensive anddivided (25 males and 25 females) and 50 subjects were normotensive and divided (25 males and 25 females).

4.1 Blood pressure measurement

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) of all subjects (normotensive and hypertensive individuals) were measured using Comfort blood pressure monitor (RIESTER). The data obtained were used to classify the subjects as hypertensive and non-hypertensive subjects.

4.2 Body mass index (BMI) measurement

Variables such as weight and height were measured with the help of (FAZZINI) weight and height scale. Body mass index (BMI) was calculated using formula dividing weight in kilograms with height taken in meter squares (weight (kg)/Height (m^2)).

4.3 Packed cell volume (PCV) measurement

Blood samples were collected by capital venipuncture from all of the subjects using 5ml disposable syringe and the blood samples were dispensed into EDTA anticoagulant tube. PCV was estimated using an automated hematologyanalyzer (MINDARY), it performs speedy and accurate analysis of blood parameters and detects the normal and abnormal samples. PCV or (HCT) wascalculated by the percentage (%).

5. Statistical analysis

All data obtained were analysed by Microsoft Office Excel 2010 and all parameters are reported as means ± SEM. With the help of the SPSS 19.0 software (statistical package for statistical analysis).Pearson Correlations (r) were performed at each time period to ascertain possible associations among all parameters. Also, A probability value of ANOVA was utilized where a probability value of less than 0.01 ($p<0.01$) is taken to be significant.

6. Result

6.1 The relation between PCV andblood pressure (SBP and DBP) in normotensive and hypertensive males

Sex	Sample number	Sample type	PCV (%)	Systolic (mmHg)	Correlation coefficient (r) of SBP	Diastolic (mmHg)	Correlation coefficient (r) of DSP
M	25	Normotensive	39.87±2.3	116.80±9.45	0.181	75.60±6.34	0.229
M	25	Hypertensive	47.04±4.86	173.20±21.30	0.643	104.40±6.50	0.257

Table 1 showed the relation between PCV, systolic and diastolic blood pressure in normotensive and hypertensive individuals (males); and correlation coefficient(r).

Table1: represents that, the mean value of PCV in normotensive males result was 39.8760±2.3% (normal) as well as the systolic and the diastolic blood pressure was 116.80 ±9.45 mmHg and 75.60± 6.34 mmHg respectively (normal). However, the mean value of PCV in hypertensive males result was relatively high 47.04±4.86%, also the mean values of the systolic blood pressure was 173.20±21.30mmHg and the diastolic blood pressure was 104.40±6.50 mmHg which is above the normal range.

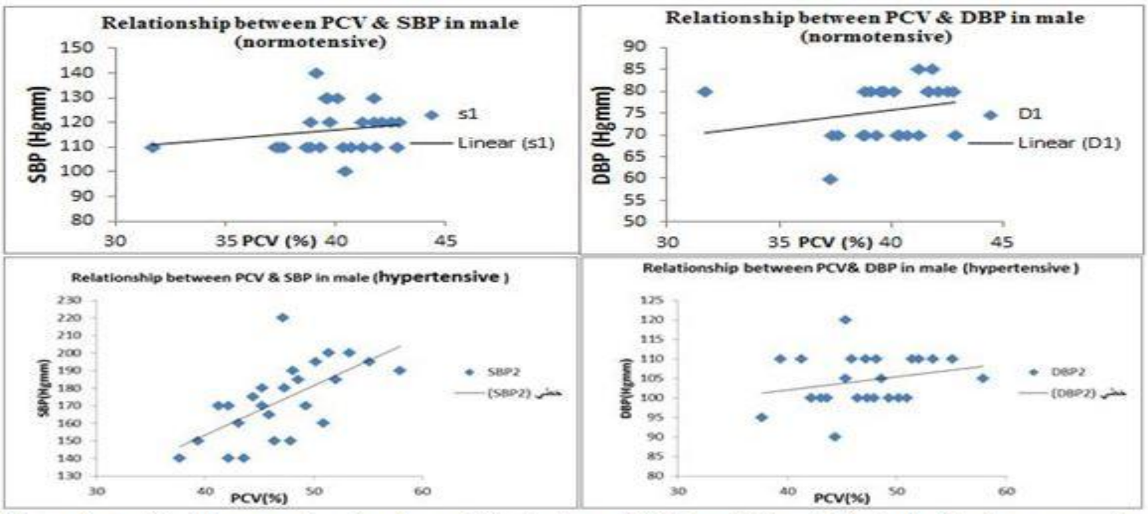

Figure 4: scatter diagram showing the relation between PCV, systolic and diastolic blood pressure in normotensive and hypertensive individuals (males).

Figure 4: shows that there was non-significant relation between PCV and SBP in normotensive males individuals (**r=0.181).** Also, non-significant between PCV and DSP in normotensive males individuals **(r=0.229).** On the other hand, it is seen that there was strongly significant correlation only between PCV and SBP in hypertensive males individuals **(r=0.643**)** where the ****P = ≤0.01**. In contrast, the relation between PCV and DSP in hypertensive male was non-significant (**r=0.257).**

6.2 The relation between PCV and blood pressure (SBP and DBP) in normotensive and hypertensive females

Sex	Sample number	Sample type	PCV (%)	Systolic (mmHg)	Correlation coefficient (r) of SBP	Diastolic (mmHg)	Correlation coefficient (r) of DSP
F	25	Normotensive	34.73±3.2	119.40±9.80	0.202	72.80±6.93	0.011
F	25	Hypertensive	39.81±6.03	173.6±20.99	0.639	105.80±10.27	0.325

Figure 2: showed the relation between PCV, systolic and diastolic blood pressure in normotensive and hypertensive individuals (females); and correlation coefficient(r).

Table 2shows that, the mean value of PCV in normotensive females result was 34.7320±3.2 which is slightly low, and the systolic and the diastolic blood pressure were 119.40±9.80mmHg and72.80±6.93 mmHg respectively, which is within the normal range. However, the mean value of PCV result in hypertensive females was 39.81±6.03 (normal), and the mean values of the systolic blood pressure and the diastolic blood pressure were quite high where they recorded 173.6±20.99 mmHg and 105.80±10.27 mmHg respectively.

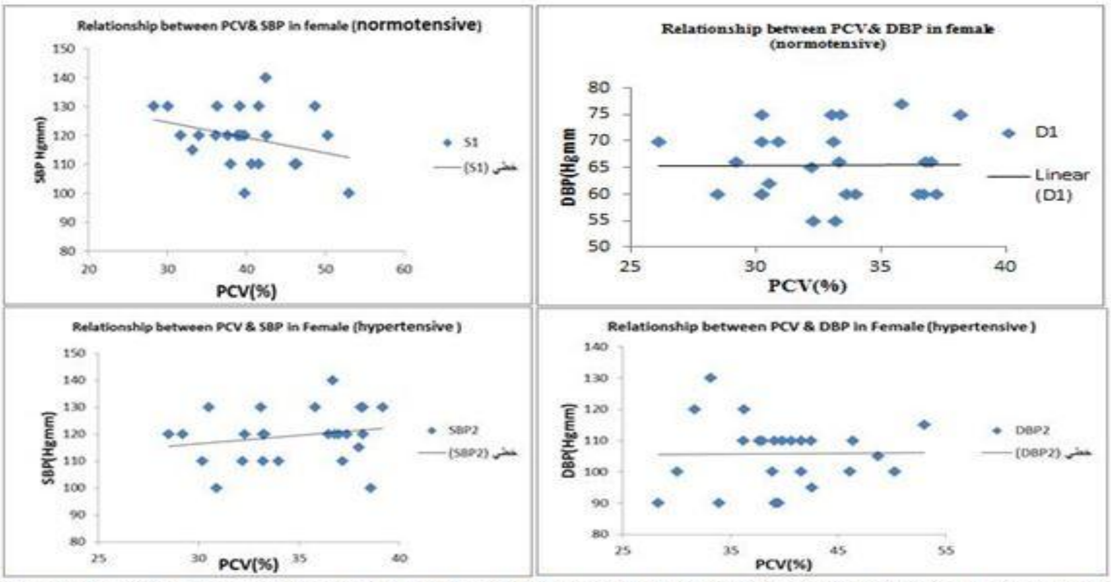

Figure 5: scatter diagram showing the relation between PCV, systolic and diastolic blood pressure in normotensive and hypertensive individuals (Females).

Figure 5: shows relation between PCV and SBP in normotensive females individuals which was non-significant (**r=0.202),** also the relation between PCV and DSP in normotensive females individuals was non-significant (**r=0. 011).** On the other hand, the correlation between PCV and SBP in hypertensive females individuals there was strongly significant (**r = 0.639)** where the ****P** = ≤0.01. In contrast, the relation between PCV and DSP in hypertensive females was positive but not significant **(r = 0.325).**

6.3 The relation between BMI and blood pressure (SBP and DBP) in normotensive and hypertensive males.

Sex	Sample number	Sample type	BMI (kg/m2)	Systolic (mmHg)	Correlation coefficient (r) of SBP	Diastolic (mmHg)	Correlation coefficient (r) of DSP
M	25	Normotensive	25.16±2.4	116.80±9.45	0.025	75.60±6.34	0.088
M	25	Hypertensive	31.65±4.74	173.20±21.30	0.644	104.40±6.50	0.216

Table 3: showed the relation between BMI, systolic and diastolic blood pressure in normotensive and hypertensive individuals (males); and correlation coefficient(r).

Table 3: illustrates that, the mean value of BMI in normotensive males result was 25.16±2.4kg/m2 (normal), in addition to that the systolic blood pressure was 116.80±9.45 mmHg and the diastolic blood pressure was 75.60±6.34 mmHg. However, among hypertensive males result the mean value of BMI was somewhat high 31.65±4.74 kg/m2and the mean values of the systolic blood pressure was 173.20±21.30mmHg and the diastolic blood pressure was104.40±6.50 mmHg which is relatively high.

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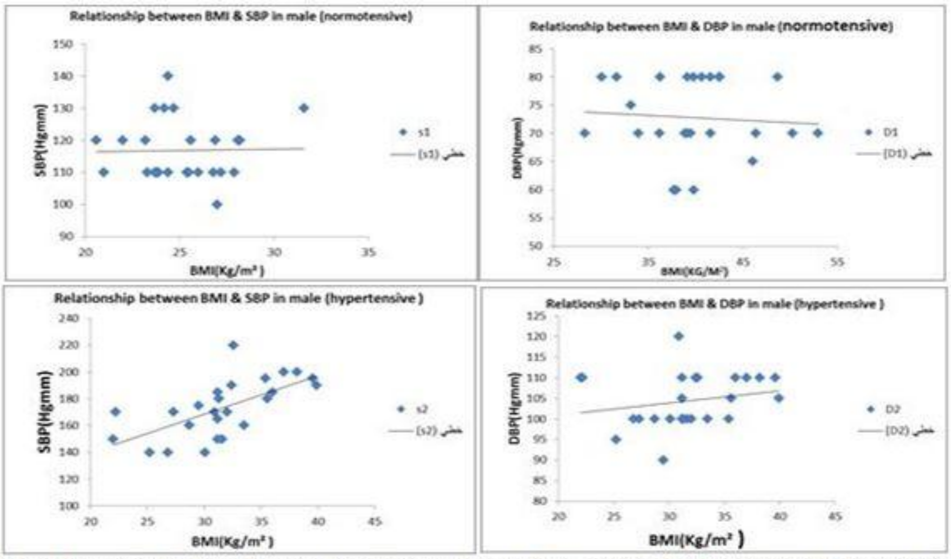

Figure 6: scatter diagram showing the relation between BMI, systolic and diastolic blood pressure in normotensive and hypertensive individuals (males).

Figure 6: displays that there was non-significant relation between BMI and SBP in normotensive males individuals (**r=0.025),** also non-significant relation between BMI and DSP in normotensive males individuals **(r=0.088).** On the other hand, there was strongly significant correlation only between BMI and SBP in hypertensive males individuals **(r = 0644)** where the ****P =≤0.01**, and the relation between BMI and DSP in hypertensive malewas positive but non-significant (**r=0. 216).**

6.4 The relation between BMI and blood pressure (SBP and DBP) in normotensive and hypertensive females

Sex	Sample number	Sample type	BMI (kg/m2)	Systolic (mmHg)	Correlation coefficient (r) of SBP	Diastolic (mmHg)	Correlation coefficient (r) of DSP
F	25	Normotensive	29.25±5.2	119.40±9.80	0.264	72.80±6.93	0.175
F	25	Hypertensive	33.48±5.26	173.6±20.99	0.634	105.80±10.27	0.048

Table 4: showed the relation between BMI, systolic and diastolic blood pressure in normotensive and hypertensive individuals (females); and correlation coefficient(r).

Table4: Shows that, the mean value of BMI in normotensive females result was 29.25±5.2 kg/m2 (as well as the measures of systolic and the diastolic blood pressure was 119.40±9.80 mmHg 72.80±6.93and mmHg respectively. However, the mean value of BMI in hypertensive females result was quite high 33.48±5.26, also the mean measures of the systolic blood pressure was173.6±20.99 mmHg and the diastolic blood pressure was 105.80±10.27mmHg which is above the normal range.

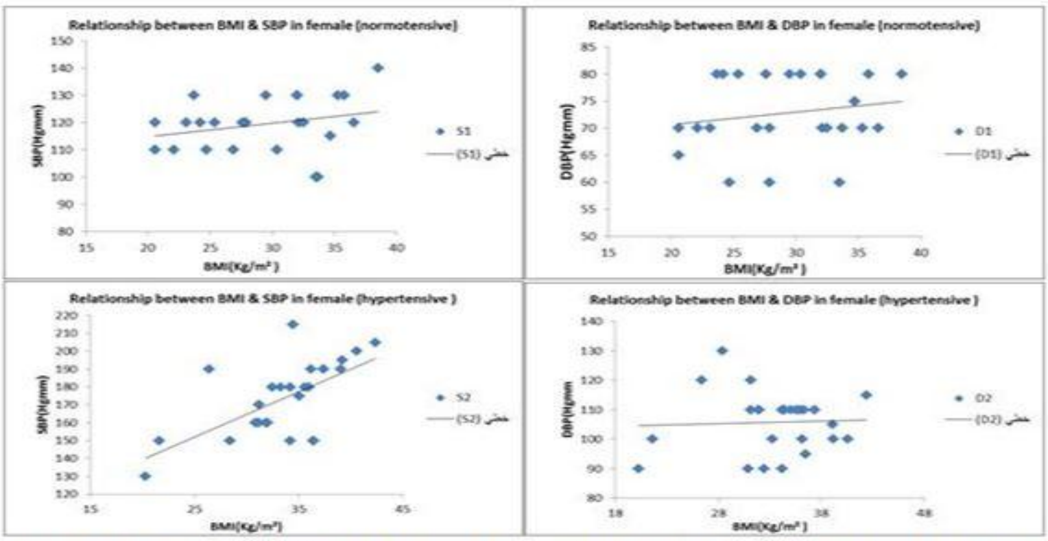

Figure 7: scatter diagram showing the relation between BMI, systolic and diastolic blood pressure in normotensive and hypertensive individuals (Females).

Figure7: Shows that non-significant relation between BMI and SBP in normotensive females individuals **(r=0.264),** also the relation between BMI and DSP in normotensive females individuals was non-significant **(r =0.175).** However, there was strongly significant correlation between PCV and SBP in hypertensive females individuals (**r = 0. 634)** where the ****P = ≤0.01,** unlikethe relation between BMI and DSP in hypertensive females which was non-significant **(r=0. 048).**

6.5 The relation between BMI and PCV in normotensive and hypertensive males.

Sex	Sample number	Sample type	BMI (kg/m2)	PCV (%)	Correlation coefficient (r) of BMI and PCV
M	25	Normotensive	25.16±2.4	39.87±2.3	0.026
M	25	Hypertensive	31.65±4.74	47.04±4.86	0.921

Table 5: Showed the relation between BMI and PCV in normotensive and hypertensive individuals (males); and correlation coefficient(r).

Table5: represents that the mean value of BMI and the PCV in the normotensive males results were 25.16±2.4 kg/m2 and 39.87±2.3% respectively which seem to be normal. However, in hypertensive males the mean values of BMI result was relatively high 31.65±4.74kg/m2, and the mean values of the PCV was elevated as well 47.04±4.86 %, thus PCV is increased with the increase of BMI.

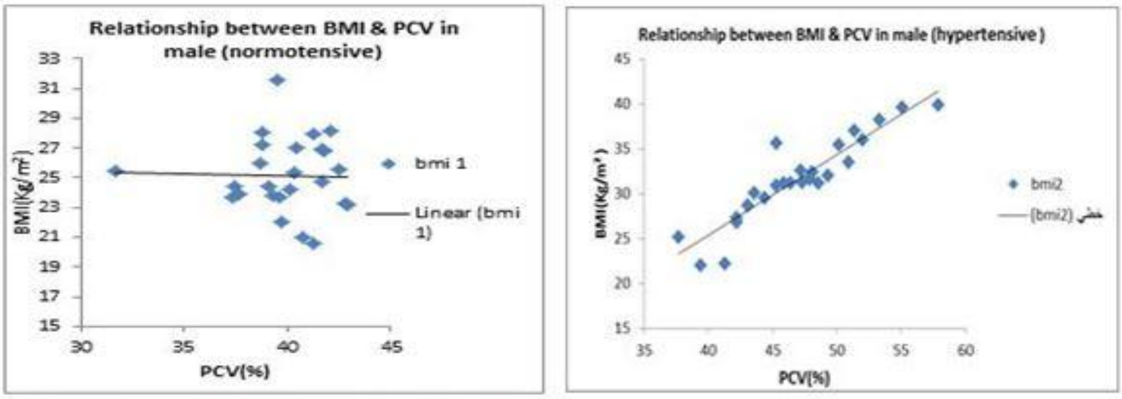

Figure 8: scatter diagram showing the relation between BMI and PCV in normotensive and hypertensive individuals (males).

Figure 8: Shows that there was non-significantrelation between BMI and PCV in normotensive males individuals (r= **0.026).** However**,** therelation between BMI and PCV in hypertensive males was strongly significant linear positive relation (**r = 0.921)** where the ****P = ≤0.01.**

6.6 The relation between BMI and PCV in normotensive and hypertensive females

Sex	Sample number	Sample type	BMI (kg/m2)	PCV (%)	Correlation coefficient (r) of BMI and PCV
F	25	Normotensive	29.25±5.2	34.73±3.2	0.103
F	25	Hypertensive	33.48±5.26	39.81±6.03	0.952

Table 6: showed the relation between BMI and PCV in normotensive and hypertensive individuals (females); and correlation coefficient(r).

Table 6: represents that the mean value of BMI in the normotensive females result 29.25±5.2kg/m2, and also the mean value of PCV in normotensive females result was 34.73±3.2 %, On the other hand, The mean value of BMI in hypertensive females result was abnormal 33.48±5.26 kg/m2, also the mean values of the PCV in hypertensive Females result was normal 39.81±6.03 % , thus PCV increased with increased BMI.

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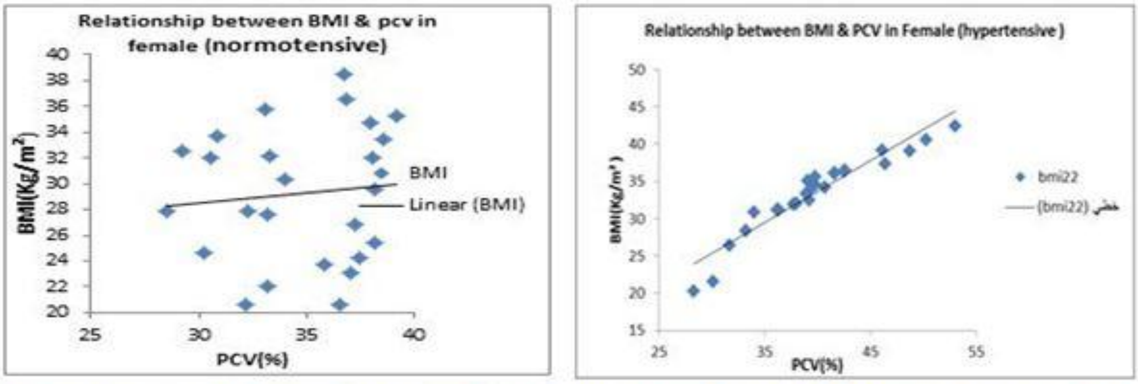

Figure 9: scatter diagram showing the relation between BMI and PCV in normotensive and hypertensive individuals (females).

Figure9: shows that there wasnon-significant relation between BMI and PCV in normotensive females individuals **(r=0.103).**On the other hand, it is seen that there was strongly significant correlation between PCV and BMI in hypertensive females individuals **(r= 0.952)** where the ****P = ≤0.01.**

7. Discussion

The relation between packed cell volume (PCV) andsystolic blood pressure (SBP) and diastolic blood pressure (DBP)in normotensive males and females (the control group) was non-significant (figures 4 and 5).In contrast, in the hypertensive subjects there was strongly significant correlation only between PCV and SBP among males and females subjectswhere the *P = ≤0.01 (figure 4 and 5). This is clear similarity with other studies which stated that the increased PCV above baseline is usually associated with elevation of systemic blood pressure due to the increase in the blood viscosity (Beatriz *et al.*, 2008). Theresults in this research are also supported by a study by Mohammed., (2015) who pointed out that the PCV has more effect on the systolic blood pressure than on diastolic blood pressure.

The relation between packed cell volume (PCV) and diastolic blood pressure (DBP) in normotensive males and females was non-significant (figures 4 and 5). However, the relation between PCV and DBP among hypertensive males and females subjects did not show any significant relation in comparison tothe normotensive group (figure 4 and 5). This finding is in discrepancy with Vázquez *et al.*, (2014) who showed that the hematocrit or PCV was significant independent variable for only diastolic blood pressure (DBP) but not for systolic blood pressure (SBP).

The results regarding the relation between body mass index (BMI), systolic blood pressure (SBP)and diastolic blood pressure (DBP) in normotensive males and females was non-significant (figure 6 and 7). On the other hand, in hypertensive males and females subjects, there was strongly significant correlation only between BMI and SBP in both males and femaleswhereP = ≤0.01,but not between BMI and DBP (figure 6 and 7) in comparison to the normotensive group. The resultsin this research are in agreement with a study by Kumar.,*et al.*, (2008), who states that the systolic blood pressures were found to increase progressively with the increase in BMI in both male and female.This increase was statistically significant increase in the systolic blood pressure and was not statistically significant in diastolic blood pressure Kumar., *et al.*, (2008).

However, other studies showed that there is relation between BMI and both SBP and DBP. For instancea research accomplished by Vaishali, Vinod, and Gauri (2014) indicate that there is a strong association between BMI and hypertension (SBP and DBP). Hypertension is directly related with the BMI and it shows that with the increase in the BMI, the trend of hypertension (SBP and DBP)rises in both males and females (Vaishali, Vinod, and Gauri 2014). Also Gelberet *et al.*, *(*2007)showed that there is a stronggradient relation between higher BMI and hypertension (SBP and DBP) among men, and even men within the normal BMI and men with mildly overweight BMI displayed stronggradient relation.

Furthermore, Afolabi *et al.*, (2015) showed that the relation between BMI and blood pressure (BP) level in adult female was more pronounced than in the male subjects.These findings are in discrepancy with the results in this study, which showed that the relation between BMI and blood pressure was pronounced in both males and females.

The result in this research regarding the relation between BMI and PCV in normotensive males and females was non-significant relation (figure 8 and 9), this supports the evidence thatin the normotensive subjects, a relationship was demonstrated between PCV and BMI but was not significant (Akinnuga, Bamidele and Chukwuebuka2011).

However, the relation between BMI and PCV in hypertensive individuals in this result wasstrongly significant linear positive relation in both male and female (figure 8 and 9) where the P =≤0.01. This flinging is in line with a study done by Akinnuga, Bamidele and Chukwuebuka (2011) who displayed that there was a noticeable significant correlation between PCV and BMIin hypertensive males more than females. On other hand, Salih, Jouda and El-Haboby (2016) demonstrated that there was no detected significant correlation between the PCV value and BMI measuresamong hypertensive males and females, which means that his result is different from the data in this research.

It is notable that from the results in this research, the increase in the body mass index (BMI) leads to increase in packed cell volume (PCV) which is more likely to be mediated by the elevation in the blood viscosity. These are considered as hypertension risk factors and have the opportunity to contribute in increasing the blood pressure particularly among hypertensive individuals.

8. Conclusion

This research study aimed to investigate thepotential effect the blood pressure risk factors: packed cell volume (PCV) and body mass index (BMI) and their associated with the incidence of hypertension. Previous studies had highlighted that PCV and BMI have been identified as risk factors that significantly contribute to blood pressure increase. The final results of this study suggest that the PCV and BMI are strong risk factors for hypertension. Therefore, future research should seek to investigate the relation between PCV and BMI and its impact as risk factors on blood pressure to reduce the incidence of hypertension and prevent the disease related to high blood pressure such as atherosclerosis, strokes and cardiovascular diseases. As soon as the main risk factors among hypertension patients are established (overweight and high PCV), the prevention of this hypertension is highly possible before any dangerous consequences.

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