A STUDY TO CORRELATE BODY FAT PARAMETERS WITH BLOOD PRESSURE IN NORMAL HEALTHY INDIVIDUALS – AN OBSERVATIONAL CROSS-SECTIONAL STUDY

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Abstract: **Background & Objective :** High blood pressure is one of the most important causes of premature death killing nearly 9.4 million people every year globally. Numerous variables are related to blood pressure, but associations are particularly strong with body size and fatness. Obesity is a complex heterogenous condition, with varying amounts of ectopic fat distribution despite similar BMI among individuals. Objective is to study the correlation of visceral fat, total body fat, subcutaneous fat, skeletal muscle mass and regional body fat with blood pressure and anthropometric parameters. **Methods:** Fifty healthy participants who volunteered to participate of age 18-45 years, with no history of hypertension were recruited. Height, weight, neck circumference and waist hip ratio recorded . Total body fat, visceral fat, subcutaneous fat, skeletal muscle mass, and regional body fat of arm, trunk and leg were measured by Body Fat Analyser based on Bioelectrical Impedance principle and correlated with systolic, diastolic and Mean Arterial Pressure(MAP) taken by Mercury Sphygmomanometer for statistical significance. **Results:** SBP(120.6± 8.62), DBP(83.39±8.60) and MAP(95.78± 8.11), are increasing with mean values of weight(63.8±15.56), neck circumference(35.43±3.93),waist hip ratio(0.84±0.07) and BMI(23.3±4.45),total body Fat (25.2±7.84),visceral fat(6.76±5.03), subcutaneous fat(18.74± 7.17)and skeletal muscle mass(30.72±4.84). A statistically significant correlation of SBP,DBP,MAP with visceral fat ($p<0.005$) found. **Interpretation &Conclusion:** Study reveals that there is statistically significant correlation of systolic, diastolic and mean arterial blood pressure with body fat parameters. Body Fat Analyser can be included as a primary care strategy to motivate lifestyle modifications while managing metabolic derangements due to high blood pressure.Neck Circumference can also be taken as a reliable indicator along with other anthropometric variables.

Key Words: Body Fat Analyser, Bioelectrical Impedence,Visceral fat, Blood Pressure, Neck circumference

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Introduction: High blood pressure is one of the most important causes of premature death killing nearly 9.4 million people every year globally,and the problem is growing[1].Over 1 billion people are living with high blood pressure.In 2008, globally, the overall prevalence of high blood pressure(including those on medication for high blood pressure)in adults age 25 and above was around 40%.[1,3]In India, the prevalence of high blood pressure-Grade 1 HT, SBP(140-159mmHg)and DBP(90-99mmHg) among women is 6.7% and men is 10.4%. Grade 2 HT,SBP(160-179 mmHg)and DBP(100-109mmHg) among women is 1.4% and men is 2.3%. Grade 3 HT,SBP(≥180 mmHg)and DBP(≥110mmHg) among women is 0.7% and men is 0.9% respectively[5]. Numerous variables are related to blood pressure, but associations are particularly strong with body size and fatness.[2]It is well established, however, that elevated blood

pressure alone is an important risk factor for coronary heart disease, and there are strong, positive associations of obesity with hypertension and mortality from cardiovascular disease in adults. Increased body fat is a threat to global health, especially as a precursor and risk factor for fatal and nonfatal cardiovascular disease[6].Risk of metabolic syndrome is 2-3 times more in persons with high visceral fat[7].Visceral fat contributes a major fraction to central obesity and is located in the abdomen and intra-abdominal contents, in contrast to subcutaneous fat abundant in the buttocks and lower limbs. BMI is an measurement tool used to define total body mass, and it indicates, at high levels, that there is an excessive fat deposition.The confirmation that a high BMI value is due to an excess of fat can be achieved by measuring the distribution of body fat, as approximately half the total body fat is deposited under the skin, or waist circumference, which reveals fat deposition in the visceral region[4]. Abdominal or visceral fat, which primarily serves to quickly and easily mobilize energy reserves, is closely related to an increase in the prevalence of metabolic diseases, including cardiovascular illnesses. Aim of the study is to determine relation of body fat parameters with blood pressure. Our objective was to measure body fat parameters - total body fat, visceral fat, subcutaneous fat, skeletal muscle mass and regional body fat and To measure anthropometric parameters- Height,weight,neck circumference,waist circumference,hip circumference,waist hip ratio in all subjects and correlate with systolic, diastolic and mean arterial blood pressure. Many population studies examining the relationship between obesity and blood pressure have used body mass index (BMI)as a measure of adiposity.However, obesity is a complex and heterogeneous condition, with varying amounts of ectopic fat distribution(eg.visceral fat, subcutaneous fat, regional body fat) despite similar BMI among individuals. Therefore previous studies assessing BMI alone may not accurately characterize the impact of adiposity on BP.How individual variation in body fat parameters contributes to BP levels remain uncertain because previous studies have focused primarily on the relationship of BMI with BP levels. In the present study, body weight was partitioned into total body fat, visceral fat, subcutaneous fat, skeletal muscle mass and regional body fat of arm, trunk and leg.The relationship between each of these factors and blood pressure were investigated in order to establish correlation between them.

Material and Methods: Prior permission was taken from Institutional Review Board (IRB) of Government Medical College, Bhavnagar. It is an Observational Cross-sectional study. Study was carried out in clinical research lab, Physiology department, Government Medical College, Bhavnagar. 50 individuals of age group of 18-45years with no history of hypertension were enrolled into the study with prior written informed consent. A detailed clinical history of each subject was taken.They were selected after employing the following criteria. Relevant past history ,any family history of diabetes, hypertension, any personal history including smoking, alcoholism ,occupational history and drug history was taken.

INCLUSION CRITERIA was to enroll apparently healthy subjects belonging to the specified age group(18-45 years) and subjects who gave written informed consent.

EXCLUSION CRITERIA were subjects of age <18 & >45 years, subjects with known cardiac disease,known case of Hypertension on drugs, or subjects with any metabolic disorder and those who did not give informed consent.

Before starting the test, each subject was adviced to take rest for 15 minutes in a quiet and comfortable room.Arm sizes were measured and appropriate cuff sizes used.Cuffs to be long enough to completely encircle the arm and wide enough to cover two-thirds the length of the upper arm. Three BP measurements with 5 minutes interval were taken in sitting position with a standard mercury sphygmomanometer during a single examination visit. Average of readings of three BP measurements was taken. Mercury Sphygmomanometer consists of an inflatable cuff, measuring unit(the mercury manometer),and a mechanism for inflation which may be a manually operated bulb and valve.It is considered the gold standard for measuring blood pressure. Height ,weight, neck circumference,waist circumference,hip circumference and waist hip ratio of all the subjects were recorded using standard methodologies. Waist circumference measurement was made at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest. Hip circumference measurement to be taken around the widest portion of the buttocks. The WHO STEPS protocol states that, for both waist and hip, the tape should be snug around the body, but not pulled so tight that it is constricting. It also recommends that the subject stands with arms at the sides, feet positioned close together, and weight evenly distributed across the feet. WHO protocol suggests that the waist circumference should be measured at the end of a normal expiration, when the lungs are at their functional residual capacity. Neck Circumference was measured in the midway of the neck, between mid-cervical spine and midanterior neck, to within 1 mm, with a measuring tape.In men with a laryngeal prominence (Adam's apple), it was measured just below the prominence.It was taken with the subjects sitting upright, with the face directed forwards, and shoulders relaxed. Assessment of body fat parameters by BODY FAT ANALYSER (Karada Scan of Omron, Japan)was done for all the participants. BODY FAT ANALYSER works on the principle of tetra polar BIA It passes electric current 500µA at frequency of 5 kHz to scan the whole body to derive regional body composition. Age, gender and height were enetered, after self calibration of instrument ,subject stood on it and readings were taken. Weight,BMI,Total body fat percentage,Visceral fat ,Subcutaneous fat,Regional Body Fat and Skeletal muscle mass of Arm, Trunk and Leg respectively were recorded by body fat analyser. Results were analysed using GraphPad InStat 3.0 statistical software. The mean, standard deviation, minimum and maximum limits of the variables were obtained from the descriptive and frequency programs.The ANOVA test was used for numerical data analysis. For correlation between parameters, Pearson's and Spearman's correlation test used. Predictors were calculated by multiple linear regression.Differences were regarded as significant when the p value was less than 0.05.

Result: 50 healthy subjects(37 males and 13 females) of age group 18-45 years were recruited in the study.Anthropometric parameters, BMI,Total body fat percentage,Visceral fat ,whole body Subcutaneous fat and Skeletal muscle mass are represented in table 1.

Table:1 shows baseline data of subjects under study

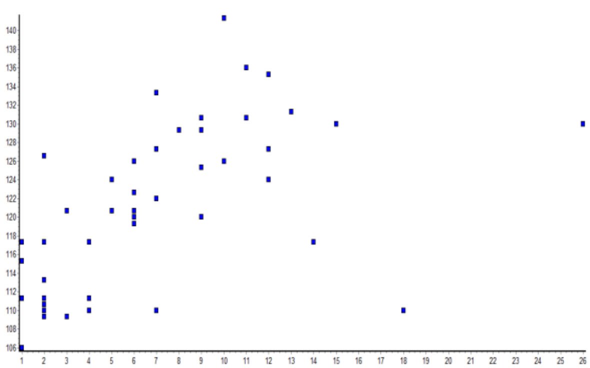
Parameters	Mean±SD
Age (years)	
Male(n=37)	24.78 ± 8.31
Female(n=13)	24.38±8.11
Total (n=50)	24.68 ± 8.18
Height(cms)	165.18±10.01
Weight(kgs)	63.79±15.56
Neck circumference(cms)	35.43±3.93
Waist circumference(cms)	83.06±12.98
Hip circumference(cms)	98.46±10.37
Waist Hip ratio	0.84±0.07
BMI	23.27±4.45
Total body fat(%)	25.16±7.83
Visceral fat	9.76±4.033
Subcutaneous fat(%)	18.74±7.17
Skeletal muscle mass(%)	30.72±4.84
SBP(mm Hg)	120.60±8.62
DBP(mm Hg)	83.39±8.60
MAP(mm Hg)	95.78±8.11

Table:2 shows Correlation Coefficient(r),Coefficient of Determination(r2) and p value of body fat parameters with SBP,DBP and MAP.

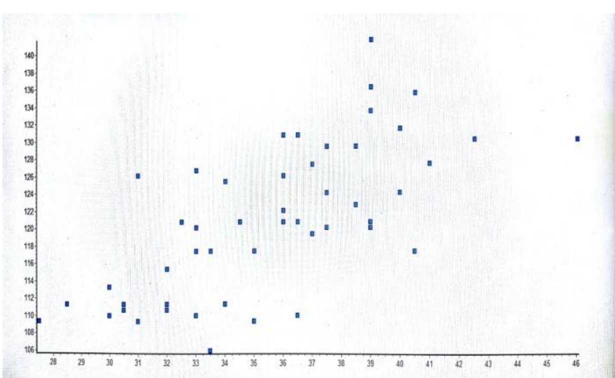
		SBP			DBP			MAP	
	r value	r^2	p value	r value	r^2	P value	r value	r^2	p value
Age(years)	0.15	0.02	0.292	0.07	0.005	0.62	0.10	0.01	0.47
Height(cms)	0.39	0.15	0.004	0.29	0.08	0.04	0.34	0.11	0.01
Weight(kgs)	0.7	0.46	0.0001	0.56	0.32	0.0001	0.64	0.41	0.0001
Neck circumference(cms)	0.7	0.48	0.0001	0.6	0.35	0.0001	0.7	0.44	0.0001
Waist circumference(cms)	0.62	0.38	0.0001	0.55	0.31	0.0001	0.61	0.37	0.0001
Hip circumference(cms)	0.51	0.26	0.0001	0.47	0.22	0.0005	0.51	0.26	0.0001
Waist Hip ratio	0.53	0.22	0.0001	0.47	0.22	0.0005	0.5	0.3	0.0001
BMI	0.6	0.33	0.0001	0.51	0.26	0.0002	0.56	0.31	0.0001
Total body fat(%)	0.26	0.06	0.07	0.23	0.05	0.10	0.25	0.06	0.07
Visceral fat	0.6	0.31	0.0001	0.5	0.42	0.0005	0.53	0.28	0.0001
Subcutaneous fat(%) whole body	0.11	0.01	0.42	0.09	0.008	0.59	0.10	0.01	0.47
Skeletal muscle mass(%)whole body	0.05	0.002	0.73	0.06	0.38	0.99	0.01	0.002	0.9

The statistical analysis of the data clearly shows that Systolic BP(120.6± 8.62), Diastolic BP(83.39±8.60) and Mean Arterial BP(95.78± 8.11), are statistically significant(p value<0.05) when compared with anthropometric parameters-height(165.18± 10.1),weight(63.8±15.56), neck circumference (35.43±3.93),waist circumference(83.06±12.98),hip circumference(98.46±10.37,waist hip ratio(0.84±0.07) and body fat parameters- BMI(23.3±4.45) , and visceral fat(6.76±5.03).

Graph- 1: Scatter plot diagram representing correlation of +0.6 between visceral fat(x axis) and SBP(y axis)



Graph- 2: Scatter plot diagram representing correlation of +0.69 between neck circumference(x axis) and SBP(y axis).



There is strong positive linear correlation (r=0.7) of weight and neck circumference with SBP and also between neck circumference and MAP. Waist circumference, waist hip ratio, BMI and visceral fat has moderately positive correlation(r=0.5) with SBP. Moderately positive correlation(r=0.5) is also found between weight,neck circumference.waist circumference, hip circumference, waist hip ratio, BMI,visceral fat and DBP and MAP respectively. Weakly positive linear correlation(r=0.3) is found between height ,total body fat with SBP,DBP and MAP respectively.

Discussion: High blood pressure and obesity are well known risk factors for cardiovascular diseases.But body fat parameters are more important than BMI for assessing the relationship with blood pressure.Blood pressure is related to various indices of body build and obesity; most of these indices are functions of stature and weight. In our study, weight is positively associated with blood pressure. There is evidence that increased body weight is predominantly due to an increase in the amount of fat. The association of blood pressure with body weight could be due to the increased total body mass or to some special underlying relationship between blood pressure and body fat (e.g., resulting from differences in microcirculation in fat tissue)[2]. Serum leptin is a hormone that is secreted from adipose tissue and increases activation of the SNS in numerous organs such as the kidneys and blood vessels. leptin mediates the relationship between body fat and BP which explains positive relationship .WC and WHR have been used as measures of central adiposity and evidences suggest a greater association of these anthropometric variables with future metabolic syndromes in comparing with BMI.Recently in various studies,WHR has been found to be a better predictor of metabolic complications.This is because the height of an individual influences the distribution of body fat, and this factor should be taken into consideration before adapting any anthropometric variable as a measure of adiposity.[16]Body fat serves a vital role in storing energy and protecting internal organs. We carry two types of fat in our bodies: 1) essential fat which is stored in small amounts to protect the body and 2) stored fat which is stocked for energy during physical activity. While too much body fat may be unhealthy, having too little fat can be just as unhealthy. Also, the distribution of body fat in men and women is different, so the basis for classifying the body fat percentage is different between the genders. In this cross-sectional study we correlated the relationship between body fat parameters and blood pressure.There is direct association of visceral fat with SBP(r value:0.56,p value<0.0001). SBP,DBP and MAP are statistically significant (p value<0.05) with neck circumference,waist hip ratio,BMI and visceral fat.

Our study further tried to find if there was any correlation between neck circumference and blood pressure.An article was published in American Journal of Hypertension written by Liubov (Louba) Ben-Noun et al emphasising on the relationship between the changes in neck circumference and changes in blood pressure. Changes in systolic BP and diastolic BP correlated positively with changes in NC and other components of the metabolic syndrome. Blood pressure changes in parallel with weight changes.Weight loss is associated with reduction in BP, whereas subsequent regaining of weight leads to elevated BP. Thus, similarly to the association between changes in weight and BMI, systolic and diastolic BP, changes in NC lead to changes in systolic and diastolic BP. Greater changes in weight will correspond to greater changes in NC. Therefore, greater changes in NC may contribute to the greater part of the variability of systolic and diastolic BP.[13]Consistent with this hypothesis are the results of studies ,which all support the importance of sympathetic activation during rapid weight gain as a plausible mechanism contributing to the increased blood pressure. Second, endothelial dysfunction caused by insulin resistance and elevated FFA may also lead to sympathetic activation at various levels. When endothelial function is normal, endothelial-derived NO diffuses easily to the adjacent adrenergic varicosities, inhibiting the release of norepinephrine. Increased NO release in certain areas of the brain involved in sympathetic control such as organum vasculosum laminae terminalis (OVLT), paraventricular nucleus of the hypothalamus (PVN) or rostral ventrolateral medulla (RVLM), leads to a decreased sympathetic outflow. Although NO in those areas is produced mainly by neurons and glial cells, the contributory role of endothelium-derived NO in the central nervous system cannot be excluded. One can thus understand that endothelial dysfunction, which leads to an inappropriate low NO release, may no longer suppress sympathetic activity in certain circumstances.[20]Third, obese subjects may have decreased circulating atrial natriuretic peptide (ANP) levels both at the basal level and in response to salt-loading. This could be explained by a greater gene expression of the peptide clearance receptor (NPr-C) in adipose tissues of obese hypertensive.Fourth, hyperinsulinemia of obesity may promote sodium retention by a direct action on the kidney, both on proximal and on distal tubules.Visceral fat is uniquely and selectively correlated with high blood pressure. These findings are consistent with the hypothesis that this pattern of adiposity is the result of overfeeding,such that subcutaneous fat depots have become filled, leading to overflow directed at abdominal and retroperitoneal sites.[6]

The exact mechanism for development of high blood pressure with visceral fat is not explained clearly by scientist but more and more newly diagnosed hypertensives are seen with high visceral fat. Lack of exercise, physical inactivity and excess consumption of calorie dense foods are the main culprit for the development of visceral fat. Abnormal feeding behaviour like, fast eating, meal skipping and over-eating are the main causes for the development of visceral fatness.[7] Too much visceral fat is thought to be closely linked to increased levels of fat in the bloodstream, which may lead to conditions such as high cholesterol, heart disease and type 2 diabetes. [15]

There is growing evidence that visceral fat represents a pathological adipose tissue depot, which accumulates when subcutaneous depots are overwhelmed or otherwise unavailable for storage. Relative to subcutaneous fat, visceral fat is more sensitive to lipolysis and secretes higher amounts of inflammatory cytokines. visceral fat is associated with insulin resistance and predicts incident diabetes among obese adults. visceral fat is associated with a higher atherosclerotic risk profile and also visceral fat recently has been prospectively linked to adverse cardiovascular events. These results suggest that may be the important link between BMI and cardiovascular disease, and that visceral fat may be acting in part by promoting the development of hypertension and insulin resistance.[14]

Another possible explanation for obesity- related cardiometabolic disease is the portal vein hypothesis, which proposes that increased visceral fat leads to higher free fatty acid concentrations in the portal vein, increased systemic fatty acid flux, and increased hepatic lipase activity, which removes lipids from LDL and HDL,and may lead to dyslipidemia.

VAT and Subcutaneous Adipose Tissue (SAT) differ not only in anatomic location but also in cytokine secretion profile. Subcutaneous Adipose Tissue releases 2–3 times more leptin than Visceral Adipose Tissue (VAT), whereas VAT secretes more adiponectin,interleukin-6, interleukin-8, plasminogen activator inhibitor 1, and angiotensin than does Subcutaneous Adipose Tissue. Although the relationships between Visceral Adipose Tissue and Subcutaneous Adipose Tissue secretion profiles and cardiometabolic pathogen at present, unclear, it may be that paracrine and perhaps endocrine factors contribute to the differential effects of Visceral Adipose Tissue and Subcutaneous Adipose Tissue.[16]

Our study was supported by Shweta Parikh et al who reported the relationship between visceral fat and blood pressure in Indian adolescents. Accumulation of intra-abdominal fat is associated with metabolic syndrome in adolescents. A person with high visceral fat has more risk for development of high blood pressure than person with high total body fat.[7]

Surg Cdr S Vijay Bhaskar et al carried out a study about body fat composition as a marker for risk assessment in hypertension. Out of various body composition parameters, it is the visceral fat area (VFA) that could be best associated with risk of a chronic condition like hypertension.The present study endeavored to compare the body composition (including VFA, besides other parameters) of normal subjects using bio electrical impedance based noninvasive body composition analyzer.[18]Madhur Verma et al did a study among adult population in rural block of Haryana to correlate between the percentage of body fat and surrogate indices of obesity. Positive correlation was seen among all the indices except between the WHR and body adiposity index (BAI). Maximum correlation was seen between WHtR and WC (r = 0.923), whereas WHtR depicted maximum correlation (r = 0.810) with BF%.They also suggested that BMI overestimates body fat in males due to their higher muscles and bone mass.[16] Nikita Suresh et al conducted a study on body fat percentage and visceral fat in women with above normal BMI. Weight is a combination of lean mass, fat mass, water, visceral fat etc and an understanding of which factors favour fat mass deposition .The results from this study provide scope to various researchers to study in-depth the various other factors impacting body composition.[19]Thus, the pathogenesis of fat induced high blood pressure is complex. Many factors act together to promote vasoconstriction and sodium retention. Increased levels of leptin, free fatty acids and insulin may stimulate the activity of the sympathetic nervous system and may thus play a pivotal role in linking obesity to hypertension. In addition, increased body fat induced insulin resistance and endothelial dysfunction may act as amplifiers of the vasoconstrictor response. Finally, abnormal sodium handling by the kidney may further promote high blood pressure.[20]

Conclusion: Study reveals that there is statistically significant correlation of systolic, diastolic and mean arterial blood pressure with visceral fat. Though the magnitude of correlation differed, there was positive and significant correlation among BMI, weight,neck circumference.waist circumference, hip circumference, waist hip ratio, BMI and visceral fat with systolic and diastolic blood pressures.

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