ASSOCIATION OF BLOOD PRESSURE IN ADULTS WITH SELECTED ANTHROPOMETRIC PARAMETERS AND CRP: A HOSPITAL BASED CROSS SECTIONAL STUDY

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ABSTRACT

BACKGROUND
Hypertension is a major public health problem and a known risk factor for cardiovascular disease. Epidemiological studies from different populations have reported significant association between different anthropometric indicators and hypertension.

AIMS AND OBJECTIVES
The present study was carried out to examine the relationship between C-reactive protein, different anthropometric indices and blood pressure in adults.

MATERIALS AND METHODS
This is a hospital-based cross-sectional study done among 250 patients over 40 years of age, attending Medicine OPD of a tertiary care institution selected based on their willingness and eligibility to participate. Anthropometric measurements, blood pressure examination and laboratory investigations were done and used for this study.

RESULTS
Increased blood pressure was found in both obese and non-obese individuals. BMI, waist circumference, neck circumference, sagittal abdominal diameter and CRP was higher in hypertensive males than normotensives and it was statistically significant. Karl Pearson correlation showed that BMI, WC, HC, NC, SAD and CRP had a positive correlation with systolic and diastolic blood pressure and it was found to be statistically significant.

CONCLUSION
In this study CRP, SAD, HC, WC and NC showed a positive correlation with both systolic and diastolic blood pressure, which means that WC and SAD can be used to get information about visceral obesity in an individual. This also suggests that decrease in intra-abdominal fat could decrease the blood pressure.

KEYWORDS
Hypertension, Anthropometry, CRP.

INTRODUCTION
High Blood Pressure (BP) is a major public health problem in India and its prevalence is rapidly increasing among both urban and rural population.[1,2] The prevalence of hypertension in India ranges between 20-40% in urban adults and 12-17% among rural adults[3]. Reducing blood pressure can decrease cardiovascular risk. Many modifiable and non-modifiable factors are associated with blood pressure such as age, gender, body size, body mass index, physical activity, diet and stress levels. However, the main influencing factors for increased blood pressure as evidenced by many studies are obesity, metabolic syndrome and familial factors of hypertension.[4]

Anthropometry is the most common and accessible technique used to diagnose abdominal obesity in the field.

The common anthropometric measurements in adults are height, weight, waist circumference, hip circumference and thus the BMI and waist hip ratio. Other than these common measurements, Sagittal Abdominal Diameter (SAD) and neck circumference have also been used in certain studies as a measure of fat deposit in the body.[5,6,7]

The association of excess body weight with elevated BP has been demonstrated in several studies.[8] But there are only a few studies, which associate the not so commonly used anthropometric parameters like sagittal abdominal diameter, neck circumference and C-Reactive Protein (CRP) with elevated BP.

The objective of this research paper was to study the relationship between selected common and not so common anthropometric parameters such as waist circumference, sagittal abdominal diameter, neck circumference and CRP among hypertensives and non-hypertensive individuals.

MATERIALS AND METHODS
A cross-sectional study was carried out among patients who visited medicine OPD of a tertiary care teaching hospital in South India between October 2014 and April 2015.

Sample size was calculated based on a pilot study, which showed that the proportion of hypertensives was 20% and using the formula $n=V/d^2$ where $V=P_1 (1- P_1) +P_2 (1-P_2)$

sample size was calculated to be 123, which was rounded off to 125. Thus, 125 hypertensives and 125 non-hypertensives were recruited for this study.

All individuals aged 40 years or older attending the outpatient department during the study period were recruited consecutively based on their willingness and eligibility to participate in the study.

Inclusion Criteria
Individuals with 40 years of age and above who were not on any medications except anti-hypertensives who are willing to be part of our study.

Exclusion Criteria
Subjects with spinal deformity, abdominal tumour, lump, significant ascites, pregnant females, pathological diseases (Cancer, thyroid neck swelling, insufficient renal and chronic inflammatory pathologies) and in whom anthropometry measurements were not feasible.

Patients with conditions known to be associated with increased CRP levels like acute renal failure, bacterial infections, meningitis, smoking, trauma, etc. and patients with severe hepatocellular impairment were excluded from the study.

Data Collection
Detailed history was taken.

DEFINITION OF RISK FACTORS.[9,10,11,12,13]
Measurement of Blood Pressure
Blood pressure was measured thrice with five-minute interval on the left arm using appropriate cuff size and standard mercury sphygmomanometer. The average of three readings was considered for analysis. Systolic BP of >140 mmHg and/or diastolic BP of >90 mmHg and/or those on medication for BP were considered as hypertensives.

Measurement of Weight
Weight was measured with minimum clothing using SECA digital weighing scale (Nearest to 0.1 kg).

Measurement of Height
Height was measured using anthropometric rod with the subject made to stand erect on a flat surface (Without footwear) with feet together.

Calculation of BMI
BMI was calculated as weight (Kg) divided by height in meters square. BMI of less than 18.5 was considered underweight, values between 18.5 and 24.99 was considered normal, between 25 and 29.99 was considered pre-obese and BMI more than or equal to 30 was considered obese.

Measurement of Waist Circumference
Waist Circumference (WC) was measured according to WHO criteria in standing position after normal expiration, midway between the lower rib margin and the iliac crest.

Measurement of Hip Circumference
The anatomical place used for assessment of HC was the height of the greater trochanter as recommended by the WHO.

Calculation of Waist Hip Ratio
WHR was calculated by dividing waist circumference in cms by hip circumference in cms. Waist hip ratio of 0.81 and more in females and 0.88 and more in males was considered as having abdominal obesity.

Measurement of Sagittal Abdominal Diameter
SAD or "Supine Abdominal Height" was measured after a normal expiration to nearest 0.1 cm in supine position with straight legs on a firm examination table using a ruler and water level at the level of iliac crest (L4-5) without clothes. SAD cut-offs were taken as ≥22 cm in men and ≥20 cm in women.

Measurement of Neck Circumference
Neck circumference was measured to within 1 mm by using a tape measure. Participants were asked to stand erect with their head positioned in the Frankfort horizontal plane. The superior border of a tape measure was placed just below the laryngeal prominence and applied perpendicular to the long axis of the neck. Neck circumference of ≥37 cms in male and ≥34 cms in female was considered abnormal.

Relevant Laboratory Work-Up was also Done
1. Serum CRP levels.
2. Lipid profile: Serum total cholesterol, HDL, LDL and triglycerides.
3. Fasting and postprandial plasma glucose.

The level of C-reactive protein was determined by latex-enhanced nephelometry method having sensitivity 0.5—320 mg/L. This method could not detect CRP levels of <0.5 mg/L. As a result, persons with CRP levels of <0.5 mg/L were classified as having "undetectable" CRP levels. (AGAPPE, MISPA-I Autoanalyser). Lipid profile by AGAPE-MISPA Nano Autoanalyser. (TC-cholesterol oxidase method, TG-glycerol 3-phosphate oxidase method, HDL-C by direct qualitative determination, LDL-C by calculation). Blood sugars were determined by Glucose oxidase method.

Ethics Statement
The protocol was approved by the Institutional Ethical Committee and informed consent was obtained from all participants.

Statistical Analysis
The data was entered in Microsoft Excel 2007 and SPSS version 17 was used for analysis.

RESULTS
Of the 250 subjects studied, 180 were males and 70 were females; 36.4% of them belonged to 40-50 years followed by 29.2% belonging to 51-60 years, 25.6% belonged to 61-70 years, 6.8% belonged to 71-80 years, 1.6% belonged to 81-90 years and 0.4% belonged to 91-100 years. The mean age of the study participants was 56.36±10.93 as shown in Table 1.

Among the study participants, 125 were hypertensive and the rest were normal with respect to blood pressure. The mean systolic blood pressure was 133.68±22.22 and mean diastolic blood pressure was 83.73±12.62 as shown in Table 1.

With regards to the nutritional status of the study participants according to BMI, 14.8% were underweight, 58.8% were normal, 17.6% were pre-obese and 8.8% were obese as seen in Table 2. The mean BMI of the study participants was 23.09±4.97 as seen in Table 1; 80% of the total males studied and 86% of the total females studied were obese with respect to WHR as seen in Table 2. The mean WHR was 0.93±0.08 as seen in Table 1.

Variable	Total Mean± SD N=250	Male Mean± SD N=180	Female Mean± SD N=70	t Value	P Value
Age (years)	56.36± 10.93	55.53± 10.82	58.49± 11.0	1.9331	0.0544
Height (cms)	162.86± 8.96	166.13± 7.57	154.44± 6.47	11.3988	0.0001*
Weight (kgs)	61.20± 13.50	63.12± 13.10	56.27± 13.35	3.6925	0.0003*
BMI (Kg/m2)	23.09± 4.97	22.89± 4.77	23.60± 5.47	1.0132	0.3119
Waist circumference (cms)	84.06± 12.77	84.58± 12.50	82.74± 13.42	1.0235	0.3071
Hip Circumference (cms)	90.69± 10.69	89.93± 9.87	92.65± 12.43	1.8141	0.0709
Neck circumference (NC)	35.76±3.60	36.15± 3.56	34.76± 3.53	2.7784	0.0059*
Sagittal Abdominal diameter (cms)	22.0± 4.58	22.34± 4.74	25.16± 4.08	4.3846	0.0001*
Waist Hip Ratio	0.93± 0.08	0.94± 0.08	0.89± 0.07	4.5892	0.0001*
Systolic Blood Pressure (mm Hg)	133.68± 22.22	132.62± 21.02	136.4± 25.02	1.2085	0.2280
Diastolic Blood Pressure (mm Hg)	83.73± 12.62	83.36± 12.71	84.69± 12.41	0.7478	0.4553

Table 1: Demographic, Anthropometric and Blood Pressure Characteristics of the Study Participants by Sex

*Statistically significant

With regards to the neck circumference, 46.7% of the males had a neck circumference ≥37 cms and 62.9% of the females had a neck circumference ≥34 cms as seen in Table 2. The mean neck circumference was 35.76±3.60 as seen in Table 1.

47.77% of the males had sagittal abdominal diameter ≥22 cms and 35.71% of females had SAD ≥20 cms as seen in Table 2.

It was noted that hypertension was not solely restricted to the overweight and obese individuals, but also seen in study subjects who had a normal BMI, waist circumference, waist-hip ratio, neck circumference and sagittal abdominal diameter as seen in Table 2 and 3.

Variables	Males		Chi square
	Hypertensives No. (%)	Normotensives No. (%)	
BMI			
< 18.50	10 (5.56)	20 (11.11)	df=1 p=0.003*
18.50-24.99	45 (25)	60 (33.33)	
25.00-29.99	19 (10.56)	12 (6.67)	
≥ 30	12 (6.67)	2 (1.11)	
Waist Circumference			
< 85 cms	35 (19.44)	62 (34.44)	df=1 p=0.001*
≥ 85 cms	51 (28.33)	32 (17.78)	
Waist Hip Ratio			
< 0.88	15 (8.33)	21 (11.67)	df=1 p=0.412
≥ 0.88	71 (39.44)	73 (40.56)	
Neck Circumference			
< 37 cms	34 (18.89)	62 (34.44)	df=1 p=0.000*
≥ 37 cms	52 (28.89)	32 (17.78)	
Sagittal Abdominal Diameter			
< 22 cms	31 (17.22)	63 (35)	df=1 p=0.000*
≥22 cms	55 (30.56)	31 (17.22)	

Table 2: Prevalence of Overweight/Obesity as per Different Anthropometric Indicators in Males

*Statistically significant

Variables	Females		
	Hypertensives No. (%)	Normotensives No. (%)	Chi-square
BMI			
< 18.50	3 (4.29)	4 (5.71)	df=1 p=1.000
18.50 - 24.99	24 (34.29)	18 (25.71)	
25.00 - 29.99	6 (8.57)	7 (10)	
≥ 30	6 (8.57)	2 (2.86)	
Waist Circumference			
< 80 cms	16 (22.86)	15 (21.42)	df=1 p=0.538
≥ 80 cms	23 (32.86)	16 (22.86)	
Waist Hip Ratio			
< 0.81	5 (7.14)	5 (7.14)	df=1 p=0.694
≥ 0.81	34 (48.58)	26 (37.14)	
Neck Circumference			
<34 cms	14 (20)	12 (17.14)	**df=1 p=0.809**
≥34 cms	25 (35.71)	19 (27.14)	
Sagittal Abdominal Diameter			
< 20 cms	17 (24.29)	28 (40)	df=1 p=0.000*
≥20 cms	22 (31.42)	3 (4.29)	

Table 3: Prevalence of Overweight/Obesity as per Different Anthropometric Indicators in Females

*Statistically significant

It was seen from Table 4 that the mean BMI, waist circumference, neck circumference, sagittal abdominal diameter and CRP was higher in hypertensive males than normotensives and it was statistically significant. But only CRP values were significantly higher when hypertensive females were compared with the normotensive females.

| Risk Factors | Male | | p value | Female | | p value |
	Normotensives Mean±SD	Hypertensives Mean±SD		Normotensives Mean±SD	Hypertensives Mean±SD	
BMI	21.57±3.57	24.33±5.46	<0.0001*	23.08±5.00	24.02±5.85	0.4793
WC	81.04±10.69	88.44±13.24	<0.0001*	81.62±13.18	83.62±13.71	0.5395
WHR	0.93±0.07	0.95±0.08	0.0754	0.89±0.08	0.89±0.07	1.0000
NC	35.13±3.06	37.28±3.73	<0.0001*	34.19±3.76	35.21±3.31	0.2321
SAD	20.99±3.89	23.81±5.15	<0.0001*	21±3.58	21.28±4.48	0.7778
CRP	1.69±1.54	2.77±1.93	<0.0001*	1.46±1.02	2.85±1.75	0.0002*
Table 4: Cardiovascular Risk Factors Stratified According to Gender and Hypertensive Status						

*Statistically significant

Karl Pearson correlation was used to measure and analyse the degree of relationship between the chosen cardiovascular risk factors with systolic and diastolic blood pressures. Among those risk factors which were considered in this study BMI, waist circumference, hip circumference, neck circumference, sagittal abdominal diameter, total cholesterol and CRP levels had a positive correlation with systolic and diastolic blood pressures and it was found to be statistically significant as seen in Table 5.

| Indicators | Systolic Blood Pressure | | Diastolic Blood Pressure | |
	r value	p value	r value	p value
AGE	0.101874	0.101874	0.026740	0.674395
BMI	0.144103	0.022672*	0.181996	0.003904*
WC	0.197988	0.001663*	0.177750	0.004831*
HC	0.203889	0.001194*	0.226913	0.000298*
WHR	0.082552	0.193560	0.014552	0.819547
NC	0.194056	0.002061*	0.176716	0.005079*
SAD	0.232101	0.000214*	0.217228	0.000543*
FBS	0.075585	0.234253	0.089748	0.157354
TC	0.125754	0.047099*	0.139442	0.027536*
LDL	0.022735	0.720968	0.039582	0.534164
HDL	-0.02384	0.717436	0.024674	0.698705
TGL	0.110723	0.080651	0.117398	0.064058
CRP	0.239175	0.000135*	0.240154	0.000126*
Table 5: Correlation of Systolic and Diastolic Blood Pressures with Different Anthropometric Indicators and CRP				

*Statistically significant

DISCUSSION

Hypertension is a major risk factor for cerebrovascular and cardiovascular diseases. The importance of body mass index, waist circumference, waist hip ratio for estimating cardiovascular disease risk has been well established by various studies.[14,15,16,17,18,19] Ectopic fat accumulation in the viscera, mediastinum and epicardium might also be responsible for the concomitant increase in BP.[20] Thus, the present study includes in addition to the above-mentioned variables, sagittal abdominal diameter and neck circumference as risk factors. Only few studies in India have used these as risk factors of cardiovascular diseases in rural population.

In our study, waist circumference and sagittal abdominal diameter have also been considered as indicators of coronary risk since it had high correlation with abdominal fat as seen in some other studies.[21,22] Studies suggest that WC is the most widely used indicator of abdominal obesity and has also been used as a marker of increased BP.[15,16] SAD has been considered as more closely related to visceral fat mass than the other anthropometric measures, because it is measured in a supine position when subcutaneous fat is moved to the sides of the waist.[23]

Upper body subcutaneous fat as estimated by neck circumference may confer risk above and beyond visceral abdominal fat. Anatomically, upper body SC fat is a unique fat depot located in a separate compartment compared with visceral adipose tissue. Systemic free fatty acid concentrations are primarily determined by upper body SC fat, suggesting that this fat depot may play an important role in risk factor pathogenesis.[23] Studies have indicated that NC may be independent correlate of metabolic risk factors beyond BMI and waist circumference.[24] Besides, NC is considered an index of upper body obesity and correlates positively with changes in systolic and diastolic blood pressure and other components of the metabolic syndrome.[22,25]

The higher CRP levels are significantly correlated with higher grade of hypertension.[26] Epidemiological studies support a strong relationship between CRP levels and cardiovascular risk in individuals free of cardiovascular disease at baseline. Many of the epidemiological studies that associated CRP with future cardiovascular events included patients with hypertension.[27]

It is seen from Table 1 that the mean values of most of the anthropometric indicators in female were higher than the cut-off values for a female, which indicate a high trend of obesity/overweight in females than males in the study population. This corresponds to the global figures, which also indicate that obesity is more common in females than males.[28]

From Table 2 and 3, it is evident that the number of study subjects with BMI, WC, NC and SAD above the cut-off value were higher in hypertensive males than in normotensive males indicating that they might be risk factors for hypertension in the male population and these findings are similar to some studies.[29] But only SAD was significantly different in hypertensive and normotensive females. This might probably be because of a small sample of females recruited for the study.

In our study, the mean values of all the anthropometric indicators, except the waist hip ratio were significantly higher in hypertensive males than the normotensive males as seen in Table 4. This finding was similar to several studies.[30,31,32,33,34] thus indicating that the anthropometric indicators used in this study are indeed risk factors for hypertension and in turn cardiovascular diseases.

But only the CRP values were significantly different

among hypertensive and normotensive females. Rest of the variables was not significantly different in the studied female population. The probable reason might be a small sample of females who got randomly selected for the study. Further studies involving the female population would be needed before reaching a conclusion.

It is seen from Table 5 that a positive correlation between certain indicators like BMI, waist circumference, hip circumference, neck circumference, sagittal abdominal diameter, total cholesterol and CRP levels with systolic and diastolic blood pressure were found which was similar to several studies.[35,36,37,38] thus indicating that these indicators are related to hypertension.

CONCLUSION

In this study CRP, SAD, HC, WC and NC showed a positive correlation with both systolic and diastolic blood pressure. This suggests that WC and SAD can be used to get information about visceral obesity in an individual and Neck circumference can be used to measure upper body obesity. This also suggests that decrease in intra-abdominal fat could decrease the blood pressure.

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