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Association of Anthropometric Indicators and Cardiometabolic Risk among Adults in North 24 Parganas, West Bengal

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Abstract
Background: Hypertension is a significant public health concern, and obesity related anthropometric markers are frequently used to evaluate blood pressure-related risk. In many populations, however, it is still uncertain how predictive general vs. central adiposity markers are.
Objectives: The present study aimed to determine independent anthropometric predictors (BMI, WHR, WC, PBF) of elevated systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP), analyse sex-wise variations in blood pressure parameters, and evaluate correlation between anthropometric indicators and blood pressure.
Material and Methods: This is a cross-sectional community-based study that was conducted among 500 adults, aged 20-29years. All anthropometric measures and blood pressure were taken using standardized technique.
Result: Based on logistic regression, WHR is a strong independent predictor of elevated SBP, DBP, while WC is the only significant predictor of MAP. There are substantial positive associations ($p<0.001$) between all anthropometric indicators and blood pressure metrics. SBP, DBP, and Map do not show any discernible sex differences.
Conclusion: Compared to overall adiposity measures, central obesity indicators-specifically, WHR, and WC are better predictor of high pressure. Early detection of people at risk for hypertension may be enhanced by incorporating basic measurements of central adiposity into regular screening.

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Keywords: Body Mass Index, Waist Circumference, Waist-Hip Ratio, Systolic Blood Pressure, Diastolic Blood Pressure, Mean Arterial Pressure

1. Introduction

Globally, hypertension is a significant public health issue and a major cause of cardiovascular disease, stroke, and early death [1]. For ischaemic heart disease, stroke, and chronic kidney disease, elevated systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) are known risk factors [2]. Changes in lifestyle, urbanisation, and rising obesity rates, the burden of hypertension is rising quickly in low- and middle-income nations [3].

In epidemiological research, anthropometric measures offer straightforward and affordable methods for evaluating the health hazards associated with obesity. The most widely used measure of general obesity is body mass index (BMI), which has been repeatedly linked to high blood pressure in a variety of populations [4,5]. According to Hall *et al*. (2015), elevated BMI is thought to increase blood pressure through mechanisms such increased cardiac output, activation of the sympathetic nervous system, and salt retention [6]. However, BMI's capacity to completely explain cardiovascular risk is limited because it does not differentiate between fat and lean mass or account for regional fat distribution [7]. In recent scenario, central obesity indices like waist circumference (WC), waist-hip ratio (WHR) have received more attention since these two more accurately reflect visceral fat. Insulin resistance, systemic inflammation, endothelial dysfunction, and altered renin-angiotensin-aldosterone system activity are all linked to elevated blood pressure, and visceral adipose tissue is metabolically active [8,9]. Even after adjustment of total adiposity, a number of studies have shown that WC and WHR are better indicators of hypertension than BMI [10,11]. According to data from population-based research, people with higher WHR are far more likely than people with normal fat distribution to experience both systolic and diastolic hypertension [12,13]. The significance of abdominal obesity in cardiovascular risk assessment has also been demonstrated by the independent prediction of higher SBP, DBP, and MAP by WC [14]. These results imply that compared to general obesity, central adiposity may have a greater impact on blood pressure management.

Numerous studies have examined the differences between the sexes in blood pressure and the danger associated with obesity. While females may have higher central adiposity and increased cardiovascular risk after menopause, males are frequently reported to have higher SBP at younger ages [15].

Despite a great deal of research, it is still unclear which anthropometric markers best predict various aspects of blood pressure, particularly MAP, which has gotten relatively less attention. Additionally, few researches use multivariable regression models to find independent determinants of increased blood pressure while many rely on bivariate correlations.

2. Objectives:

1. To examine sex-wise distribution of blood pressure variables (SBP, DBP, MAP) among the adult population.
2. To assess the correlation between anthropometric indicators (BMI, WHR, WC, PBF) and blood pressure variables.
3. To identify key anthropometric predictors of elevated blood pressure-based cardiometabolic risk.

3. Material and Methods:

3.1. Study area and design:

In the urban areas of North 24 Parganas, 500 adults (250 males, 250 females) between the ages 25-29 years participated in a cross-sectional survey. The population is selected by simple random sampling.

3.2. Inclusion criteria:

Adults who's aged between 25-29years and also who are willing to participate is included in this study.

3.3. Exclusion criteria:

To prevent confounding effects on blood pressure measures, pregnant women, people with established cardiovascular illness, people with renal problems, and anyone taking antihypertensive medications are excluded from the study.

3.4. Data collection tools and measurements:

Standardized methods are used to gather all anthropometric measurements, including height, weight, waist circumference and blood pressure measures. An anthropometer and a digital scale are used to measure height and weight. Various circumferences such as waist and hip circumferences are measured using a non-stretchable tape. Anthropometric indicators such as BMI formulated as weight in kg / height in m^2 and WHR calculated as waist circumference/ hip circumference. PBF is calculated by following method of previous study [16]. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) are measured accurately using an automated blood pressure monitor to minimize error and to take multiple readings at different times to account for variations & to avoid relying on a single measurement and another blood pressure parameters, Mean arterial pressure (MAP) formulated as 2*DBP+SBP/3. SBP cleft into two categories such as normal (<120 mmHg), high (≥120 mmHg), and for DBP, normal (<80mmHg), high (≥80 mmHg). MAP is divided into two groups such as normal (<100) and high (≥100).

3.5. Statistical analysis:

Categorical data are expressed as frequency and percentage, whereas continuous variables are expressed as mean (SD). The chi-square test is used to evaluate sex-wise differences. The relationships between anthropometric markers and blood pressure measures are investigated using Pearson's correlation. To find out independent predictors of elevated SBP, DBP, and MAP, binary logistic regression is employed. The results are presented as adjusted odds ratios (OR) and 95% confidence intervals (CI). Statistical significance is defined as a p-value <0.05. All statistical analysis is done through SPSS.

4. Results

Table 1 represents Sex-wise distribution of all blood pressure metrics among study participants (n=500). In terms of SBP, a greater percentage of participants (67.4%) are in the elevated category as opposed to the normal range (32.6%). Males and females have similar rates of increased SBP (68.4% and 66.4% respectively). Males have a slightly higher mean SBP (120.83 ± 9.37 mmHg) than females (119.53 ± 11.49 mmHg), but in SBP categories, this difference is not statistically significant (X^2 = 0.228, p = 0.633). For DBP, 36.0% of participants have elevated DBP; the incidence is slightly greater in females (38.8%) than in males (33.2%). Although, in DBP categories, this difference is not statistically significant (X^2 = 1.701, p = 0.192), females also have a higher mean DBP (76.36 ± 5.51 mmHg) than males (74.91 ± 6.59 mmHg). Only 5.4% of subjects exhibited increased MAP readings, whereas the rest (94.6%) have normal values. Males (4.0%) are slightly less likely than females (6.8%) to have elevated MAP. Males and Females have similar mean MAP values (90.29 ± 6.88 mmHg and 90.74 ±6.88 mmHg, respectively), and there is no statistically significant sex difference (X^2 =2.563, p = 0.109) in MAP categories. In general, sex do not significantly affect blood pressure distributions.

Table 1: Sex-wise distribution of blood pressure metrics (n=500)

	Systolic blood pressure (SBP) (mmHg)		
	Male	Female	Total
	N %	N %	N %
Normal	79 31.60	84 33.60	163 32.60
Elevated	171 68.40	166 66.40	337 67.40
Total	250 100	250 100	500 100
Mean (SD)	120.83(9.37)	119.53(11.49)	120.18(10.48)
X^2 (p-value)	0.228(0.633)		
	Diastolic blood pressure (DBP) (mmHg)		
Normal	167 66.80	153 61.20	320 64.00
Elevated	83 33.20	97 38.80	180 36.00
Total	250 100	250 100	500 100
Mean (SD)	74.91(6.59)	76.36(5.51)	75.63(6.25)
X^2 (p-value)	1.701(0.192)		
	Mean arterial pressure (MAP)		
Normal	240 96.00	233 93.20	473 94.60
Elevated	10 4.00	17 6.80	27 5.40
Total	250 100	250 100	500 100
Mean (SD)	90.29(6.88)	90.74(6.88)	90.48(6.88)
X^2 (p-value)	2.563(0.109)		

Table 2: Pearson correlation between anthropometric indicators and blood pressure metrics (n=500)

Anthropometric Indicators	Blood pressure metrics					
	SBP		DBP		MAP	
	r value	p-value	r value	p-value	r value	p-value
BMI	0.735***	<0.001***	0.702***	<0.001***	0.799***	<0.001***
WHR	0.693***	<0.001***	0.535***	<0.001***	0.676***	<0.001***
WC	0.609***	<0.001***	0.527***	<0.001***	0.628***	<0.001***
PBF	0.459***	<0.001***	0.568***	<0.001***	0.577	<0.001***
P<0.05* (significant), p<0.01** (very significant), p<0.001*** (highly significant)						

Table 2 shows the Pearson correlation coefficients between blood pressure measures and anthropometric indicators. SBP, DBP, and MAP showed statistically significant positive associations with anthropometric variables (p<0.001). SBP (r = 0.735), DBP (r = 0.702), and MAP (r = 0.799) all exhibit a substantial positive connection with BMI, suggesting that rising BMI is closely linked to elevated blood pressure. Additionally, the WHR showed a moderate correlation with DBP (r = 0.535) and a substantial correlation with SBP (r = 0.693) and MAP (r = 0.676). SBP (r = 0.609), DBP (r = 0.527), and MAP (r = 0.628) showed somewhat favourable relationships with WC. Comparatively weaker but still significant associations are seen between PBF and SBP (r = 0.459), DBP (r = 0.568), and MAP (r = 0.577).

Table 3: Binary logistic regression between anthropometric predictors and elevated SBP

Predictors	B	SE	Wald	Adjusted OR (95% CI)	p-value
BMI	-0.172	0.354	0.236	0.842	0.627
WHR	22.630	4.641	23.79	6.774	<0.001***
WC	-0.077	0.028	7.39	0.926	0.007**
PBF	-0.491	0.295	2.750	1.633	0.097
Model statistics: Omnibus X^2 (df = 6) =278.07, p <0.001*** Negelkerke R^2 =0.595 Overall prediction accuracy = 83.8% P<0.05* (significant), p<0.01** (very significant), p<0.001*** (highly significant)					

Table 3 exhibits the results of a binary logistics regression examining predictors of elevated SBP. With an overall prediction accuracy of 83.8%, the model explains 59.5% of the variation in elevated SBP (Negelkerke R^2 =0.595) and is statistically significant overall (Omnibus X^2 =278.07, p <0.001). WHR is find to be a strong and significant predictor of elevated SBP among the anthropometric variables (p <0.001), suggesting a significantly higher chance of elevated SBP with higher WHR. BMI and PBF do not exhibit statistically significant correlations with elevated SBP in the adjusted model, but waist circumference is also a significant predictor (p = 0.007), indicating that central obesity independently contributes to elevated SBP.

Table 4: Binary logistic regression between anthropometric predictors and elevated DBP

Predictors	B	SE	Wald	Adjusted OR(95% CI)	p-value
BMI	-0.017	0.295	0.059	0.931	0.808
WHR	13.760	5.117	7.232	9.477	0.007**
WC	-0.022	0.021	1.070	0.978	0.301
PBF	0.270	0.243	1.238	1.311	0.266
Model statistics: Omnibus X^2 (df = 6) =168.76, p<0.001*** Negelkerke R^2 =0.393 Overall prediction accuracy = 73.8% P<0.05* (significant), p<0.01** (very significant), p<0.001*** (highly significant)					

Table 4 depicts the logistic regression model for elevated DBP. With an overall classification accuracy of 73.8%, the model explains 39.3% of the variation in high DBP (Negelkerke R^2 =0.393) and is statistically significant (Omnibus X^2 =168.76, p < 0.001). BMI, WC, and PBF are not significant predictors in the adjusted analysis, but WHR is the only anthropometric measure that significantly predict elevated DBP (Adjusted OR = 9.477, p = 0.007), meaning that people with higher WHR are significantly more likely yo have elevated DBP.

Table 5 summarizes the logistic regression analysis for elevated MAP. The model is statistically significant (Omnibus X^2=77.006, p<0.001), explaining 41.6% of the variance in elevated MAP (Negelkerke R^2 =0.416), with a high overall prediction accuracy of 95.2%. BMI, WHR, and PBF did not exhibit statistically significant associations with elevated MAP in the multivariable model; instead, WC emerged as the only significant predictor of elevated MAP (Adjusted OR= 1.1128, p=0.016), suggesting that increasing WC is associated with a higher likelihood of elevated MAP.

Table 5: Binary logistic regression between anthropometric predictors and elevated MAP

Predictors	B	SE	Wald	Adjusted OR (95% CI)	p-value
BMI	-0.966	0.941	1.053	0.381	0.305
WHR	-26.229	17.152	2.338	0.000	0.126
WC	0.120	0.050	5.822	1.128	0.016*
PBF	1.472	0.794	3.436	4.356	0.084
Model statistics: Omnibus X^2 (df = 6) =77.006, p<0.001*** Negelkerke R^2 =0.416 Overall prediction accuracy = 95.2% P<0.05* (significant), p<0.01** (very significant), p<0.001*** (highly significant)					

5. Discussion

The present study reveals that anthropometric indicators and blood pressure parameters are shown to be significantly correlated, with central obesity measures (WHR and WC) showing greater predictive power for raised blood pressure than general adiposity (BMI and PBF). These results align with a number of extensive population-based studies. For instance, a multicentre study with over 29,000 participants discovered that several obesity indices, such as WHR, and WC, were positively correlated with hypertension and blood pressure, confirming the strong association between obesity and elevated blood pressure, even though the relative strengths of the indices varied by age group and sex [17].

According to a study of 175 healthy adults in Nepal, WC and WHR showed stronger correlations with both SBP and DBP compared to BMI, which is consistent with our findings of strong correlations across anthropometric measures and supports the predictive value of central obesity for blood pressure changes even among non-obese individuals [18].

Similarly, studies carried out in urban Indian environments found a strong correlation between WHR and hypertension, underscoring its usefulness as a screening tool in community health evaluations and corroborating our logistic regression results, which show that WHR is the most reliable indicator of elevated SBP and DBP [19].

However, our study did not identify significant sex variations in blood pressure levels, other research indicates that anthropometric predictors may function differently between sexes, For example, different intensities of connection between WC, WHR, BMI, and hypertension among older males and females were found in a large analysis from the longitudinal ageing study in India, suggesting possible sex-specific risk patterns [20]

Finding in other populations where the inclusion of central obesity indicators decreased general adiposity measures confirm the lack of independent relevance for BMI and PBF in our multivariable models. Anthropometric indicators like WHR and WC, on the other hand, were more successful in capturing blood pressure variance, indicating that fat distribution rather than total fat mass may be more physiologically important to blood pressure management. Overall, our comparative results support the idea that straightforward measures of central adiposity, like WHR and WC, are useful indicators of high blood pressure and may be more useful than BMI or PBF alone for community-based risk screening.

6. Conclusion

The current study shows a substantial correlation between anthropometric indicators and blood pressure parameters; however, measures of central obesity are more accurate predictors of high blood pressure than indicators of general adiposity. In regression analyses, body mass index and % body fat could not reliably predict higher blood pressure, despite their strong relationships with systolic, diastolic, and mean arterial pressure. On the other hand, waist circumference was the only significant predictor of higher mean arterial pressure, and the waist-hip ratio was a strong independent predictor of elevated systolic and diastolic blood pressure. Blood pressure distributions showed no discernible sex differences, indicating that anthropometric factors on blood pressure function equally for both sexes in the population under study. These results highlight the important role that fat distribution-rather than body fat-plays in controlling blood pressure.

From a public health standpoint, the findings emphasise how crucial it is to include basic central obesity metrics like waist circumference and waist-hip ratio in routine screening and preventive measures for hypertension, especially in settings with limited resources where sophisticated diagnostic tools might not be practical. The risk of hypertension may be underestimated if body mass index is the only metric used. To determine casual linkages and assess the predictive value of these anthropometric measures across time, further longitudinal research is necessary.

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