

Analysis of the Association of Obesity Indicators with Diabetes and Hypertension

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ABSTRACT

Background: The global burden of diabetes and hypertension has grown substantially in recent decades, making them leading causes of illness and death worldwide. Central obesity indicators such as waist circumference (WC) and waist-to-hip ratio (WHR) have shown a strong association with increased risk of these conditions. Although body mass index (BMI) is widely used to measure obesity, evidence suggests that WC and WHR may serve as more reliable predictors for the development of diabetes and hypertension. A clearer understanding of these relationships can enhance risk assessment and support the design of targeted public health interventions.

Aim and objectives: This study was aimed to assess the association between diabetes mellitus, hypertension, and various anthropometric measures in adults aged 25–70 years. The specific objectives were to measure obesity indicators such as BMI, WC, and WHR among adults with diabetes and/or hypertension and assess the individual risk association of these indices with diabetes and hypertension.

Materials and methods: A cross-sectional study was conducted in the Medicine Outpatient Department (OPD) of Government Cuddalore Medical College and Hospital, involving 100 participants aged 25–70 years from both genders. The participants were divided into four groups of 25 each: normotensive diabetics, hypertensive nondiabetics, hypertensive diabetics, and normotensive nondiabetics. Anthropometric measurements such as weight, height, BMI, WC, and WHR were recorded, along with random blood sugar (RBS) and blood pressure levels. Data were analyzed using analysis of variance (ANOVA) in SPSS software.

Results: Most participants were aged between 41 and 50 years, with a female preponderance. The mean BMI was significantly higher ($p < 0.05$) in the groups with diabetes, hypertension, and both conditions, compared with the group without either condition. Additionally, the mean WC and WHR were significantly higher ($p < 0.05$) in the group with both diabetes and hypertension than in the group without these conditions.

Conclusion: Central obesity measures such as BMI, WC, and WHR are strongly associated with diabetes and hypertension, underscoring their significance in risk assessment and targeted public health interventions.

Keywords: Anthropometric measures, Central obesity, Diabetes mellitus, Hypertension, Waist circumference, Waist-to-hip ratio.

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INTRODUCTION

Diabetes mellitus and hypertension are major contributors to global morbidity and mortality, with their prevalence rising steadily due to lifestyle changes, aging populations, and increasing rates of obesity. Recent estimates suggest that over 537 million adults are living with diabetes, a significant portion of whom remain undiagnosed, leading to escalating healthcare costs and a growing burden on health systems. Central obesity, characterized by the accumulation of visceral fat, has been identified as a key risk factor for both diabetes and hypertension. Anthropometric indices such as body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), and waist-adjusted BMI (wBMI) serve as practical, low-cost tools for assessing obesity and associated health risks. While BMI is the most widely used indicator, it does not differentiate between fat types or distribution, making central obesity markers potentially more accurate predictors of cardiometabolic conditions.¹ Despite several studies highlighting the association between these indices and the risk of type 2 diabetes and hypertension, uncertainty remains about which measure offers the best predictive value and what threshold values are most appropriate for screening.

This study was undertaken to explore the association between various anthropometric measures and the prevalence of diabetes and hypertension in adults aged 25–70 years.

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Aim and Objectives

This study was aimed to assess the association between diabetes mellitus and hypertension with various anthropometric measures in adults aged 25–70 years. The specific objectives were to measure obesity indicators like BMI, WC, and WHR among adults with diabetes and/or hypertension and normal controls, and assess the individual risk association of these indices with diabetes and hypertension.

By analyzing these relationships, the study seeks to contribute to the development of more effective screening strategies and preventive interventions for these widespread noncommunicable diseases.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Medicine Outpatient Department (OPD) of Government Cuddalore Medical College and Hospital, Tamil Nadu, India, following approval from the Institutional Ethics Committee.

Sample size was calculated to be 100 for an analytical cross-sectional study. A convenience sampling technique was used to recruit participants who fulfilled the inclusion criteria, which included adults aged 25–70 years of both genders who were diabetic and/or hypertensive and also normal subjects without diabetes and hypertension.

Exclusion criteria included individuals with chronic kidney or liver disease, malignancy, secondary hypertension, pregnant or lactating women, or those with incomplete clinical or biochemical data.

Data were collected using a validated and standardized questionnaire, capturing demographic and clinical variables such as age, sex, physical activity, smoking, family history, and medication use. Anthropometric measurements such as weight, height, BMI, WC, and WHR were recorded using standard techniques. BMI was calculated as weight in kilograms divided by the square of height in meters (kg/m²), and values were classified based on World Health Organization (WHO) criteria for Southeast Asian populations. Central obesity was defined as WC >90 cm in men and >80 cm in women, or WHR >0.90 in men and >0.85 in women. Blood pressure was measured in a seated position using a standard mercury sphygmomanometer after a 5-minute rest, with two readings taken and averaged. High blood pressure was defined as systolic BP ≥130 mm Hg, diastolic BP ≥80 mm Hg, or the current use of antihypertensive medications, following JNC-8/ACC guidelines.

Random blood sugar (RBS) was assessed using a glucometer (Accu-Chek), and fasting blood samples were collected after a minimum of 10 hours without food to determine fasting blood glucose (FBG) using the glucose oxidase-peroxidase method. Diabetes was defined as FBG ≥126 mg/dL, RBS ≥200 mg/dL, or the use of antidiabetic medications, in accordance with WHO guidelines. Participants were categorized into four groups of 25 individuals each—group A (normotensive diabetics), group B (hypertensive nondiabetics), group C (hypertensive diabetics), and group D (normotensive nondiabetics).

Statistical analysis was carried out using SPSS software (version XX), with continuous variables expressed as mean ± standard deviation (SD) and categorical variables as frequencies and percentages. Differences between groups were evaluated using one-way analysis of variance (ANOVA), and where significant, *post hoc* Tukey’s test was employed to identify intergroup differences. A *p*-value of <0.05 was considered statistically significant.

RESULTS

A total of 100 participants aged between 25 and 70 years were included in the study. Each group—group A (normotensive diabetics), group B (hypertensive nondiabetics), group C (hypertensive diabetics), and group D (normotensive nondiabetics)—comprised 25 participants. The majority of participants (37%) fell within the 41–50 year age-group, followed by 22% in 51–60 years, 18% in 31–40 years, 13% in 61–70 years, and 10% in 25–30 years, with a mean age of 47.6 ± 11.2 years. The sample included 55 females and 45 males, with a slightly higher proportion of females in each group (Tables 1 and 2).

Table 1: Age and gender distribution of participants across study groups

Group (n = 25 each)	Gender	Age in years					Total
		25–30	31–40	41–50	51–60	61–70	n
Group A (normotensive diabetics)	Male	1	2	5	2	1	11
	Female	2	3	6	2	1	14
Group B (hypertensive nondiabetics)	Male	1	2	4	3	2	12
	Female	1	3	5	2	2	13
Group C (hypertensive diabetics)	Male	0	1	4	4	2	11
	Female	1	2	5	4	2	14
Group D (normotensive nondiabetics)	Male	2	3	3	2	1	11
	Female	3	2	5	3	1	14
Total (n = 100)	Male	4	8	16	11	6	45
	Female	7	10	21	11	6	55

Table 2: Comparison of mean values of variables among the study groups

Study groups (n = 25 each)	Age	BMI	WC	WHR	Systolic BP	Diastolic BP	FBS	RBS
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Group A (normotensive diabetics)	46.2 ± 6.1	28.3 ± 3.4	91.7 ± 8.9	0.93 ± 0.05	126.4 ± 11.6	82.1 ± 7.5	135.6 ± 44.7	189.3 ± 54.2
Group B (hypertensive nondiabetics)	47.5 ± 5.8	27.6 ± 3.9	90.4 ± 9.7	0.91 ± 0.06	144.2 ± 13.5	90.3 ± 8.4	102.5 ± 26.8	121.6 ± 30.7
Group C (hypertensive diabetics)	48.3 ± 6.4	29.1 ± 3.2	94.8 ± 8.6	0.94 ± 0.04	147.6 ± 14.3	93.2 ± 9.1	146.3 ± 52.4	211.7 ± 61.3
Group D (normotensive nondiabetics)	45.6 ± 6.9	25.8 ± 4.1	88.3 ± 9.2	0.89 ± 0.06	112.3 ± 10.2	75.5 ± 6.8	92.4 ± 12.6	112.8 ± 21.9

Table 3: Distribution of participants by anthropometric measures across study groups

Group	BMI (n)			WC (cm) (n)		WHR (n)	
	Healthy	Overweight	Obese	<90 (M)/<80 (F)	>90 (M)/>80 (F)	<0.90 (M)/<0.85 (F)	>0.90 (M)/>0.85 (F)
A (normotensive diabetics)	2	8	15	7	18	3	22
B (hypertensive nondiabetics)	3	9	13	5	20	4	21
C (hypertensive diabetics)	1	7	17	4	21	1	24
D (normotensive nondiabetics)	8	9	8	24	10	21	4

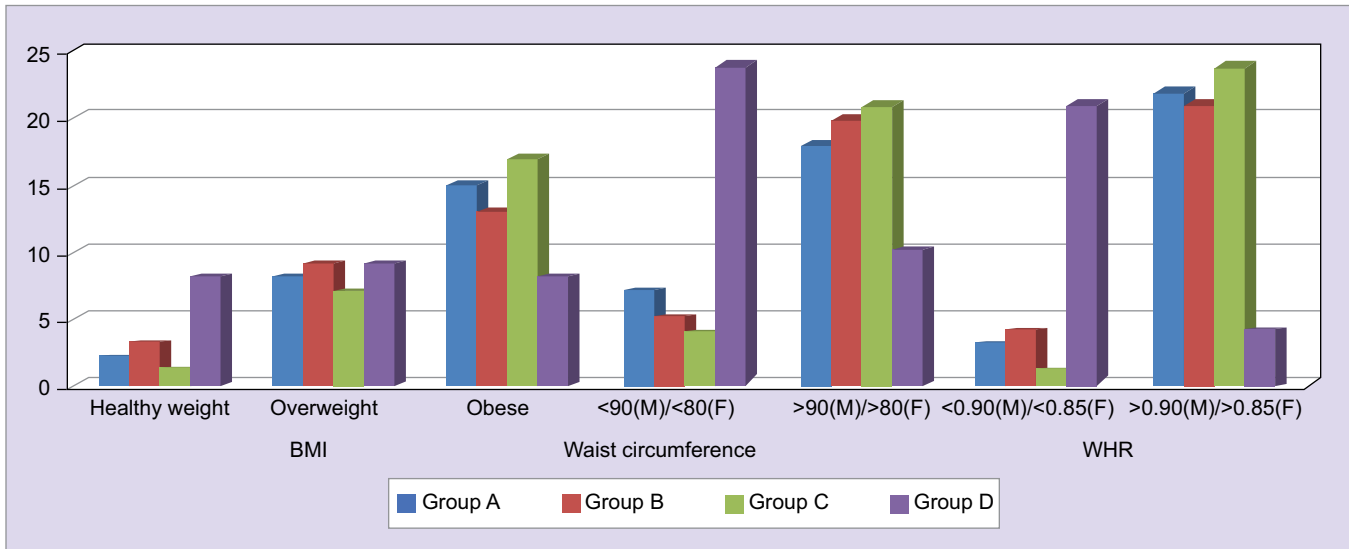


Fig. 1: Distribution of participants by anthropometric measures across study groups

The mean BMI across all participants was 27.9 ± 3.8 kg/m², indicating a general trend toward overweight and obesity. Group C (hypertensive diabetics) had the highest mean BMI of 29.1 ± 3.2 kg/m², while group D (normotensive nondiabetics) had the lowest mean BMI of 25.8 ± 4.1 kg/m². The average WC was 91.3 ± 9.5 cm, with group C showing the highest values (94.8 ± 8.6 cm). The mean WHR was 0.92 ± 0.06 , with elevated WHR values most prominent in groups A, B, and C (Table 2 and Fig. 1).

The mean fasting blood sugar (FBS) across participants was 124.7 ± 48.5 mg/dL, with group C having the highest average (146.3 ± 52.4 mg/dL) and group D the lowest (92.4 ± 12.6 mg/dL). Systolic and diastolic blood pressures (DBPs) were also elevated in hypertensive groups. The mean systolic blood pressure (SBP) was 132.6 ± 14.8 mm Hg, and the mean DBP was 85.3 ± 9.7 mm Hg, with groups B and C recording significantly higher averages than groups A and D.

Descriptive statistics and intergroup comparisons using one-way ANOVA showed statistically significant differences ($p < 0.05$) in BMI, WC, WHR, FBS, SBP, and DBP across the groups, particularly between groups C and D. *Post hoc* analysis (Tukey's test) confirmed that group C had significantly higher metabolic and anthropometric risk indicators than other groups.

Our findings revealed that most participants fell within the 41–50-year age range, with a higher proportion of females than males. Group A (normotensive diabetics) had a majority of participants (15 out of 25) classified as obese based on BMI. Most individuals in this group also had WCs above the risk threshold (18 participants) and elevated WHR (22 participants), suggesting

a strong presence of central obesity. Group B (hypertensive nondiabetics) followed a similar pattern, with 13 participants classified as obese, 20 showing high WC, and 21 with elevated WHR.

Group C (hypertensive diabetics) exhibited the highest levels of obesity and central adiposity, with 17 participants in the obese category, 21 exceeding the WC threshold, and 24 having elevated WHR values. This group reflects the highest burden of combined hypertension and diabetes, aligning with the anthropometric risk indicators.

Group D (normotensive nondiabetics) shows a more balanced distribution across BMI categories, with eight participants in the healthy weight range. Nearly all participants in group D have WCs below the risk threshold (24 participants), although many (21) still show elevated WHR, indicating central adiposity. Overall, groups A, B, and C display higher obesity markers across all anthropometric measures, particularly in those with diabetes and/or hypertension, while group D presents a lower prevalence of central obesity markers, reflecting its association with the absence of these conditions (Table 3).

DISCUSSION

This study explored the relationship between anthropometric indicators and the presence of diabetes, hypertension, or both, among a study sample predominantly composed of middle-aged individuals, with females outnumbering males. This demographic pattern mirrors broader trends in which middle-aged women exhibit higher susceptibility to central obesity and metabolic disorders, influenced by hormonal changes and lifestyle transitions.

Adipose tissue in obesity undergoes hypertrophy and attracts proinflammatory M1 macrophages, leading to increased secretion of cytokines such as tumor necrosis factor alpha (TNF- α), interleukin-6 (IL-6), and monocyte chemoattractant protein-1 (MCP-1). This chronic low-grade inflammation disrupts insulin signaling via the c-Jun N-terminal kinase (JNK) and nuclear factor kappa-light-chain-enhancer of activated B cells (NF- κ B) pathways, contributing to insulin resistance.² Simultaneously, elevated free fatty acids promote oxidative stress and lipotoxicity in nonadipose tissues such as the liver and muscle. Adipokine imbalance—characterized by elevated leptin and reduced adiponectin—further impairs glucose uptake, β -cell function, and vascular homeostasis.³ Visceral adiposity activates the renin-angiotensin system and sympathetic pathways, contributing to increased vascular resistance and blood pressure.⁴ These mechanisms underpin the strong association between obesity, insulin resistance, and hypertension. Recent studies also highlight the role of MNK kinases in obesity-induced metabolic changes, offering potential therapeutic targets.⁵⁻⁷ The findings of this study—higher BMI, WC, WHR, blood glucose, and blood pressure in hypertensive and diabetic groups—are consistent with these pathophysiological processes, reinforcing the interconnected nature of metabolic syndrome (MetS), type 2 diabetes mellitus (T2DM), and hypertension.

Across the four groups, central obesity was strongly associated with metabolic conditions. Group C (hypertensive diabetics) showed the most pronounced levels of adiposity, suggesting a cumulative effect of coexisting diabetes and hypertension on fat distribution. Elevated BMI, WC, and especially WHR in this group illustrate the metabolic clustering often observed in individuals with both conditions. Similar trends in groups A (normotensive diabetics) and B (hypertensive nondiabetics) imply that central adiposity may precede or contribute independently to the onset of these diseases. These findings are consistent with those of Kobayashi et al., who highlighted WHR as a reliable predictor of type 2 diabetes, and Kawasoe et al., who associated higher BMI and WC with increased hypertension risk, particularly in middle-aged men.^{8,9}

A particularly noteworthy finding was the elevated WHR in group D (normotensive nondiabetics), where 84% of participants had WHR values exceeding the defined threshold despite normal blood pressure and glucose levels. This observation introduces the possibility that WHR may detect subclinical metabolic dysfunction before overt disease manifests. The superiority of WHR in capturing central adiposity risk is echoed by Khader et al., who found WHR and WHR to be more predictive of diabetes and hypertension than BMI or WC, especially among women.¹⁰ Their proposed WHR cutoffs of 0.85 for women and 0.93 for men closely mirror the thresholds applied in our study, reinforcing the relevance of these measures across populations.

Further supporting these conclusions, Liu et al. demonstrated that central adiposity measures—specifically WC, WHtR, and the conicity index—were independently linked to higher diabetes risk, even after adjusting for other variables.¹¹ They emphasized the value of using these indices alongside BMI to better stratify individuals at risk, a strategy validated in our data where elevated WHR often revealed risk undetected by BMI alone. The fact that even individuals with a normal BMI in our study exhibited high WHR underscores this complementary diagnostic value.

While our findings add to the growing evidence on the predictive power of central obesity metrics, they must be

interpreted within the context of certain limitations. The sample size was relatively small and drawn from a single center, limiting the generalizability of the results. Moreover, the cross-sectional design prevents establishing causality or temporal progression. Despite these constraints, the data provide meaningful insights, especially regarding the underappreciated role of WHR in early detection.

These findings carry important clinical implications. WHR, due to its sensitivity and ease of measurement, may serve as a practical and effective screening tool in routine practice, particularly in primary care settings. Its predictive utility even among normotensive and nondiabetic individuals suggests that incorporating WHR into regular assessments could facilitate earlier intervention and possibly reduce the incidence of future cardiometabolic complications. In combination with BMI and WC, WHR could enhance the precision of risk stratification, allowing for more personalized preventive strategies.

CONCLUSION

In summary, this study highlights the significance of central obesity—measured by WC and WHR—as a more sensitive and reliable indicator of diabetes and hypertension risk compared to BMI alone. While BMI remains a useful general measure, it may overlook individuals with normal weight but excessive central fat accumulation. Our findings underscore the need to incorporate central adiposity assessments into routine clinical screening to better identify individuals at elevated cardiometabolic risk.

From a public health perspective, these results advocate for targeted interventions aimed at reducing central obesity through lifestyle modifications, including diet and physical activity. Implementing WHR and WC measurements in primary care settings and community health programs can enhance early detection and enable more precise, risk-based preventive strategies. These measures, when integrated into national screening guidelines and public health policies, have the potential to mitigate the growing burden of metabolic diseases in high-risk populations.

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