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Association of Obesity and Metabolic Abnormalities with Metabolic Syndrome Among Adults: A Hospital-Based Cross-Sectional Study

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Abstract

Background: Metabolic syndrome is a cluster of interrelated cardiometabolic abnormalities associated with increased risk of diabetes and cardiovascular disease. Obesity, particularly central obesity, is an important determinant of metabolic syndrome, while abnormalities in blood pressure and lipid and glucose metabolism may further increase risk.

Objective: To assess the association of obesity and selected metabolic abnormalities with metabolic syndrome among adults attending a hospital-based clinical setting.

Methods: A hospital-based cross-sectional study was conducted among 280 adults from January to December 2025. Participants were assessed for demographic characteristics, body mass index (BMI), waist circumference, blood pressure, random/fasting glucose, total cholesterol, triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C). Metabolic syndrome was defined using internationally accepted harmonized criteria. Descriptive statistics and comparative analyses were performed, and $p<0.05$ was considered statistically significant.

Results: Among 280 participants, 72 (25.7%) had metabolic syndrome. Participants with metabolic syndrome had significantly higher BMI, waist circumference, systolic blood pressure, glucose, and triglyceride levels, and lower HDL-C levels than those without metabolic syndrome (all $p<0.001$). Metabolic syndrome was more prevalent among obese participants than non-obese participants (39.8% vs. 15.7%, $p<0.001$). Central obesity, elevated triglycerides, low HDL-C, elevated blood pressure, and elevated glucose were significantly more frequent among participants with metabolic syndrome. BMI showed a strong positive correlation with waist circumference ($r=0.68$, $p<0.001$) and significant associations with several adverse cardiometabolic parameters. In multivariable analysis, central obesity (aOR 2.87, 95% CI: 1.61–5.12) and elevated triglycerides (aOR 2.76, 95% CI: 1.59–4.78) showed strong associations with metabolic syndrome.

Conclusion: Metabolic syndrome was common among the studied adults and was strongly associated with obesity, central adiposity, elevated blood pressure, hypertriglyceridemia, low HDL-C, and impaired glucose metabolism. Routine assessment of anthropometric and metabolic risk factors may facilitate early identification of adults at increased cardiometabolic risk.

Keywords: Metabolic syndrome; Obesity; Central obesity; Dyslipidemia; Hypertension; Glucose metabolism

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Introduction

Metabolic syndrome (MetS) is a complex and increasingly recognized cardiometabolic condition characterized by the clustering of multiple interrelated metabolic abnormalities, including central obesity, elevated blood pressure, impaired glucose regulation, and atherogenic lipid abnormalities [1]. The coexistence of these risk factors substantially increases an individual's susceptibility to type 2 diabetes mellitus, cardiovascular disease, and other long-term metabolic complications, making MetS an important public health and clinical concern. The global burden of MetS has increased alongside the rising prevalence of obesity, physical inactivity, unhealthy dietary patterns, and other lifestyle-related risk factors [2,3]. Consequently, early recognition of individuals with clustered cardiometabolic abnormalities has become increasingly important for disease prevention and risk reduction. Obesity, particularly excess visceral and central adiposity, plays a central role in the development and progression of metabolic syndrome. Excess adipose tissue is associated with metabolic disturbances that may promote insulin resistance, impaired glucose regulation, dyslipidemia, inflammation, and elevated blood pressure [4]. Although body mass index (BMI) is widely used to assess general obesity, it does not adequately reflect the distribution of body fat. Waist circumference provides additional information regarding abdominal and central adiposity and may therefore offer clinically relevant information when assessing cardiometabolic risk [5]. This distinction is particularly important because central adiposity may be associated with metabolic abnormalities even among individuals who do not have marked overall obesity. Assessment of both BMI and waist circumference can therefore provide a more comprehensive evaluation of obesity-related metabolic risk [6].

In addition to obesity, abnormalities in glucose, lipid, and blood pressure regulation represent important components of the metabolic syndrome. Elevated triglyceride concentrations and reduced high-density lipoprotein cholesterol (HDL-C) are frequently associated with an adverse metabolic profile, while elevated blood pressure and impaired glucose regulation further contribute to cardiometabolic risk [7]. The simultaneous presence of these abnormalities reflects a broader pattern of metabolic dysfunction rather than isolated abnormalities. Their clustering may therefore help identify individuals who are at increased risk of developing diabetes and cardiovascular complications and who may benefit from early clinical assessment and preventive intervention [8]. The relationship between obesity and metabolic syndrome may also vary according to population characteristics, demographic factors, and clinical setting. Differences in body composition, dietary patterns, physical activity, socioeconomic conditions, and healthcare access can influence the distribution of metabolic risk factors across populations. In South Asian populations, cardiometabolic risk may occur at comparatively lower levels of BMI, highlighting the importance of assessing central adiposity and metabolic abnormalities alongside conventional measures of general obesity [9]. Therefore, population-specific assessment of obesity and metabolic abnormalities remains important for understanding the burden and pattern of metabolic syndrome. Hospital-based populations provide an important setting for evaluating these relationships because adults attending clinical services may represent a heterogeneous group with varying levels of cardiometabolic risk. Assessment of anthropometric measures, blood pressure, and biochemical parameters in such populations may help identify individuals with previously unrecognized metabolic abnormalities and provide evidence for appropriate screening and preventive strategies [10]. The present study was designed to assess the association of obesity and selected metabolic abnormalities with metabolic syndrome among adults attending a hospital-based clinical setting.

Methods and Materials

A hospital-based cross-sectional study was conducted among 280 adults attending a clinical setting during the period from January to December 2025. The study aimed to evaluate the association between obesity and selected metabolic abnormalities and the presence of metabolic syndrome. Relevant demographic, anthropometric, clinical, and biochemical information was obtained from the study participants for assessment of their overall cardiometabolic profile. Anthropometric measurements included body mass index (BMI) and waist circumference, which were assessed to characterize general and central adiposity, respectively. Clinical assessment included measurement of blood pressure. Biochemical evaluation comprised random or fasting blood glucose, total cholesterol, triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C). These anthropometric, clinical, and biochemical parameters were evaluated individually and in relation to the presence of metabolic syndrome.

Metabolic syndrome was defined according to internationally accepted harmonized criteria. The assessment incorporated the relevant anthropometric, blood pressure, glucose, and lipid components specified within the harmonized definition11. Based on these criteria, participants were classified according to the presence or absence of metabolic syndrome, allowing comparison of demographic, anthropometric, clinical, and biochemical characteristics between the two groups. Statistical analysis was performed using appropriate descriptive and comparative statistical approaches. Continuous variables were summarized using measures of central tendency and dispersion, whereas categorical variables were expressed as frequencies and percentages. Differences in demographic, anthropometric,

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clinical, and biochemical characteristics between participants with and without metabolic syndrome were assessed using appropriate statistical tests based on the nature and distribution of the variables. The relationship between BMI and waist circumference was further evaluated using correlation analysis. Statistical significance was considered at a p-value of less than 0.05.

Results

A total of 280 adults were included in the present study. Among the participants, 112 (40.0%) were male and 168 (60.0%) were female. Metabolic syndrome (MetS) was identified in 72 participants, corresponding to an overall prevalence of 25.7%. The remaining 208 participants (74.3%) did not meet the criteria for metabolic syndrome.

Table 1: Demographic, anthropometric, and clinical characteristics of the study participants.

Characteristics	Total (n=280)	MetS (n=72)	Non-MetS (n=208)	p-value
Sex, n (%)				
Male	112 (40.0)	28 (38.9)	84 (40.4)	0.832
Female	168 (60.0)	44 (61.1)	124 (59.6)	
BMI, kg/m²	27.1 ± 4.8	30.2 ± 4.6	26.0 ± 4.2	<0.001
Waist circumference, cm	90.6 ± 12.4	101.4 ± 11.8	86.9 ± 10.7	<0.001
Systolic BP, mmHg	128.3 ± 15.9	138.6 ± 16.4	124.7 ± 14.1	<0.001
Diastolic BP, mmHg	81.4 ± 9.8	86.1 ± 9.5	79.8 ± 9.5	<0.001

Values are presented as mean ± SD or n (%).

Participants with metabolic syndrome demonstrated a less favorable anthropometric and clinical profile than those without metabolic syndrome. Mean BMI was higher among participants with MetS than among those without MetS (30.2±4.6 vs. 26.0±4.2 kg/m², p<0.001). Similarly, mean waist circumference was substantially greater in the MetS group (101.4±11.8 vs. 86.9±10.7 cm, p<0.001). Systolic blood pressure was also significantly higher among participants with MetS than among those without MetS (138.6±16.4 vs. 124.7±14.1 mmHg, p<0.001). Female participants represented 61.1% of the MetS group compared with 59.6% of the non-MetS group, although the difference in sex distribution was not statistically significant (Figure 1).

Table 2: Biochemical characteristics of participants according to metabolic syndrome status.

Biochemical parameter	Total (n=280)	MetS (n=72)	Non-MetS (n=208)	p-value
Glucose, mg/dL	108.5 ± 32.8	128.4 ± 38.7	101.6 ± 27.4	<0.001
Total cholesterol, mg/dL	188.7 ± 42.5	197.6 ± 45.1	185.6 ± 41.2	0.041
Triglycerides, mg/dL	153.2 ± 68.4	198.3 ± 72.6	137.5 ± 58.9	<0.001
HDL-C, mg/dL	43.8 ± 10.6	39.1 ± 8.7	45.4 ± 10.7	<0.001
LDL-C, mg/dL	112.4 ± 34.8	117.6 ± 37.2	110.6 ± 33.8	0.146

Values are presented as mean ± SD.

The biochemical profile differed substantially between the two groups. Mean glucose concentration was significantly higher among participants with MetS than among those without MetS (128.4±38.7 vs. 101.6±27.4 mg/dL, p<0.001). Similarly, triglyceride concentration was considerably higher in the MetS group (198.3±72.6 vs. 137.5±58.9 mg/dL, p<0.001). Mean HDL-C was lower among participants with MetS (39.1±8.7 vs. 45.4±10.7 mg/dL, p<0.001). Total cholesterol was modestly higher in the MetS group, whereas the difference in LDL-C was not statistically significant (Figure 2).

Table 3: Distribution of individual metabolic abnormalities among participants.

Metabolic abnormality	MetS (n=72), n (%)	Non-MetS (n=208), n (%)	p-value
Central obesity	39 (54.2)	42 (20.3)	<0.001
Elevated triglycerides	42 (58.3)	44 (21.2)	<0.001
Low HDL-C	44 (61.1)	57 (27.4)	<0.001
Elevated blood pressure	43 (59.7)	53 (25.5)	<0.001
Elevated glucose	35 (48.6)	39 (18.8)	<0.001

Low HDL-C was the most frequently observed metabolic abnormality among participants with metabolic syndrome, occurring in 44 (61.1%) participants. Elevated triglycerides were observed in 42 (58.3%) participants, while central obesity was present in 39 (54.2%). In comparison, these abnormalities were less frequent among participants without metabolic syndrome, with low HDL-C present in 27.4%, elevated triglycerides in 21.2%, and central obesity in 20.3%. The differences between the two groups were statistically significant (Figure 3).

The prevalence of metabolic syndrome was significantly higher among participants with obesity than among those without obesity. Metabolic syndrome was present in 39.8% of obese participants compared with 15.7% of non-obese participants (p<0.001). This finding indicates a strong association between obesity and the occurrence of metabolic syndrome in the study population. Central adiposity showed a similar pattern. Central obesity was identified in 54.2% of participants with metabolic syndrome compared with 20.3% of those without metabolic syndrome (p<0.001). Mean waist circumference was also substantially higher in the MetS group (101.4±11.8 cm) than in the non-MetS group (86.9±10.7 cm), further demonstrating the relationship between abdominal adiposity and metabolic syndrome.

Table 4: Association between obesity and metabolic syndrome.

Obesity status	Prevalence of MetS	p-value
Obese	39.80%	<0.001
Non-obese	15.70%	

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Correlation analysis demonstrated a significant positive relationship between BMI and waist circumference (r=0.68, p<0.001). This was the strongest correlation observed among the evaluated anthropometric relationships, indicating that increasing general adiposity was closely associated with greater central adiposity. BMI also showed significant positive correlations with systolic blood pressure (r=0.31, p<0.001), glucose (r=0.27, p<0.001), and triglycerides (r=0.29, p<0.001). In contrast, BMI was inversely correlated with HDL-C (r=−0.22, p<0.001). Similar associations were observed for waist circumference, which was positively correlated with systolic blood pressure (r=0.35, p<0.001), glucose (r=0.32, p<0.001), and triglycerides (r=0.34, p<0.001), while demonstrating an inverse relationship with HDL-C (r=−0.26, p<0.001) (Figure 5).

Table 5: Correlation between anthropometric and selected metabolic parameters.

Variable pair	Correlation coefficient (r)	p-value
BMI vs. waist circumference	0.68	<0.001
BMI vs. systolic BP	0.31	<0.001
BMI vs. diastolic BP	0.24	<0.001
BMI vs. glucose	0.27	<0.001
BMI vs. triglycerides	0.29	<0.001
BMI vs. HDL-C	−0.22	<0.001
BMI vs. LDL-C	0.16	0.007
Waist circumference vs. systolic BP	0.35	<0.001
Waist circumference vs. diastolic BP	0.28	<0.001
Waist circumference vs. glucose	0.32	<0.001
Waist circumference vs. triglycerides	0.34	<0.001
Waist circumference vs. HDL-C	−0.26	<0.001

Multivariable logistic regression analysis demonstrated significant associations between metabolic syndrome and all evaluated metabolic risk factors. Central obesity showed a strong independent association with metabolic syndrome (adjusted OR [aOR]=2.87, 95% CI: 1.61–5.12, p<0.001). Elevated triglycerides were also strongly associated with metabolic syndrome (aOR=2.76, 95% CI: 1.59–4.78, p<0.001). Participants with obesity had approximately 2.4-fold higher odds of metabolic syndrome compared with those without obesity (aOR=2.41, 95% CI: 1.38–4.21, p=0.002). Significant associations were also observed for low HDL-C (aOR=2.34, 95% CI: 1.35–4.06, p=0.003), elevated blood pressure (aOR=2.18, 95% CI: 1.25–3.80, p=0.006), and elevated glucose (aOR=2.09, 95% CI: 1.20–3.65, p=0.010) (Figure 2).

Table 6: Multivariable logistic regression analysis of factors associated with metabolic syndrome.

Predictor	Adjusted OR	95% CI	p-value
Obesity	2.41	1.38–4.21	0.002
Central obesity	2.87	1.61–5.12	<0.001
Elevated blood pressure	2.18	1.25–3.80	0.006
Elevated triglycerides	2.76	1.59–4.78	<0.001
Low HDL-C	2.34	1.35–4.06	0.003
Elevated glucose	2.09	1.20–3.65	0.01

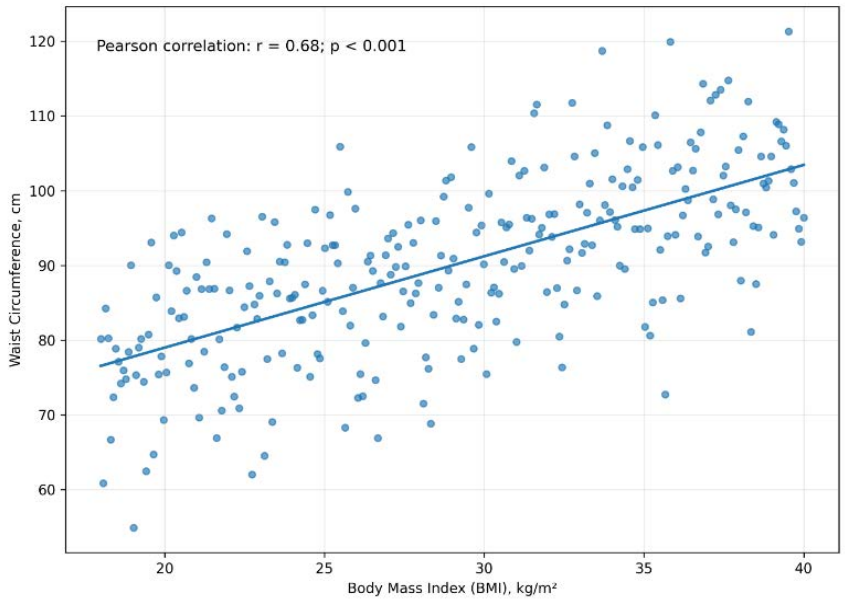

Figure 1: Correlation between Body Mass Index and Waist Circumference among Study Participants.

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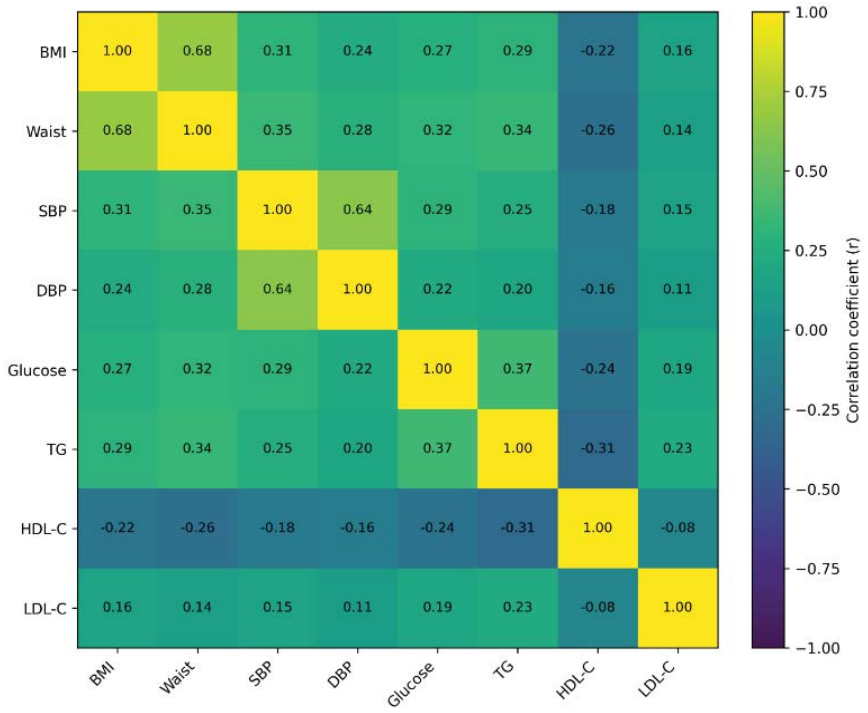

Figure 2: Correlation Heatmap of Anthropometric, Clinical, and Biochemical Parameters.

The scatter plot demonstrates a significant positive correlation between body mass index (BMI) and waist circumference among the study participants. As BMI increased, waist circumference also tended to increase. A correlation coefficient of $r = 0.68$ ($p < 0.001$) indicates a strong and statistically significant positive association, suggesting that higher general adiposity was closely related to greater central adiposity in the studied population. This finding supports the important relationship between overall obesity and abdominal fat accumulation in relation to cardiometabolic risk.

The heatmap illustrates the correlation patterns among anthropometric, clinical, and biochemical parameters. BMI and waist circumference demonstrated a strong positive correlation ($r=0.68$, $p<0.001$). BMI and waist circumference also showed positive relationships with systolic blood pressure, glucose, and triglycerides, whereas inverse relationships were observed with HDL-C. Overall, the correlation pattern indicates clustering of obesity-related anthropometric measures with adverse cardiometabolic parameters.

Discussion

The present study demonstrated that metabolic syndrome was common among the studied adult population, with 72 of 280 participants meeting the criteria for metabolic syndrome, corresponding to an overall prevalence of 25.7%. This finding indicates a substantial burden of clustered cardiometabolic risk in this hospital-based population. The observed prevalence is broadly consistent with the considerable burden reported in international studies, although direct comparison between studies should be made cautiously because metabolic syndrome prevalence varies according to population characteristics, age distribution, obesity burden, clinical setting, and diagnostic criteria [12]. Recent global evidence has reported substantial variation in metabolic syndrome prevalence, with South Asian populations generally showing a relatively high burden [13]. The most prominent finding of the present study was the strong relationship between obesity and metabolic syndrome. The prevalence of metabolic syndrome was substantially higher among obese participants than among non-obese participants (39.8% vs. 15.7%, $p<0.001$). This finding supports the established role of excess adiposity as an important driver of metabolic abnormalities. Obesity can contribute to insulin resistance, abnormal lipid metabolism, elevated blood pressure, and chronic metabolic dysfunction, thereby facilitating the clustering of multiple metabolic risk factors. Similar associations between BMI and metabolic syndrome have been reported in Bangladeshi adults, where BMI has been identified as an important factor associated with metabolic syndrome. Thus, the present findings reinforce the importance of obesity assessment when identifying adults at increased cardiometabolic risk [14]. Central obesity appeared to be particularly important in the present study. Central obesity was observed in 54.2% of participants with metabolic syndrome compared with only 20.3% of those without metabolic syndrome ($p<0.001$). In addition, mean waist circumference was markedly greater

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among participants with metabolic syndrome than among those without metabolic syndrome (101.4±11.8 vs. 86.9±10.7 cm, p<0.001). These findings suggest that abdominal adiposity may provide important information beyond overall body size. This is biologically plausible because visceral adipose tissue is metabolically active and is closely linked to insulin resistance, altered lipid metabolism, and other cardiometabolic disturbances. The high prevalence of central obesity observed in the present study is also consistent with evidence showing that central obesity is widespread globally and has increased substantially over recent decades [15].

The significant correlation between BMI and waist circumference further strengthens this observation. In the present study, BMI demonstrated a strong positive correlation with waist circumference (r=0.68, p<0.001), indicating that participants with greater overall adiposity tended to have greater abdominal adiposity. Importantly, this relationship suggests that BMI and waist circumference provide complementary information rather than completely interchangeable measures. BMI reflects overall body size, whereas waist circumference provides an indication of central adiposity. Therefore, incorporating both measures into routine cardiometabolic assessment may improve identification of individuals with an unfavorable metabolic phenotype [16]. The present study also demonstrated significant differences in blood pressure between participants with and without metabolic syndrome. Mean systolic blood pressure was substantially higher in the metabolic syndrome group than in the non-metabolic syndrome group (138.6±16.4 vs. 124.7±14.1 mmHg, p<0.001), while diastolic blood pressure showed a similar pattern. This finding is consistent with the established clustering of elevated blood pressure with obesity, insulin resistance, and dyslipidemia17. The association between adiposity and blood pressure may reflect several interacting mechanisms, including increased sympathetic activity, altered renal sodium handling, vascular dysfunction, and metabolic disturbances. Consequently, elevated blood pressure should not be considered in isolation but rather as part of the broader cardiometabolic risk profile [18,19].

Glucose metabolism also differed considerably between the two groups. Participants with metabolic syndrome had substantially higher mean glucose concentrations than those without metabolic syndrome (128.4±38.7 vs. 101.6±27.4 mg/dL, p<0.001). This finding is consistent with the central role of impaired glucose regulation and insulin resistance in the development of metabolic syndrome. Increased adiposity, particularly visceral adiposity, may contribute to impaired insulin action and subsequent disturbances in glucose homeostasis. The coexistence of elevated glucose with obesity, hypertension, and dyslipidemia in the present population highlights the importance of evaluating these abnormalities together rather than as isolated clinical findings [20]. The lipid profile showed a similarly unfavorable pattern among participants with metabolic syndrome. Mean triglyceride concentrations were substantially higher in the MetS group than in the non-MetS group (198.3±72.6 vs. 137.5±58.9 mg/dL, p<0.001), while HDL-C was lower among participants with metabolic syndrome. Elevated triglycerides were present in 58.3% of the MetS group compared with 21.2% of the non-MetS group, whereas low HDL-C was observed in 61.1% and 27.4%, respectively. These findings are consistent with the characteristic dyslipidemic pattern of metabolic syndrome, in which hypertriglyceridemia and reduced HDL-C commonly accompany central obesity and impaired glucose metabolism. Global evidence likewise identifies elevated triglycerides and low HDL-C among the most prevalent components of metabolic syndrome [21].

Conclusion

Metabolic syndrome was common among the adults included in this hospital-based study and was strongly associated with obesity, central adiposity, elevated blood pressure, hypertriglyceridemia, low HDL-C, and impaired glucose metabolism. The significant relationship between BMI and waist circumference further highlights the close link between general and central obesity. These findings emphasize the importance of routine assessment of anthropometric and metabolic parameters for early identification of adults at increased cardiometabolic risk. Integrated screening and timely preventive interventions targeting obesity and associated metabolic abnormalities may help reduce the future burden of diabetes and cardiovascular disease.

Limitations

This study has several limitations. First, the cross-sectional design does not allow temporal or causal relationships to be established between obesity, metabolic abnormalities, and metabolic syndrome. Second, the hospital-based setting and relatively modest sample size may limit the generalizability of the findings to the broader adult population. Third, the study may be subject to selection bias because participants attending a clinical setting may differ from the general community. Finally, information on potentially relevant lifestyle and behavioral factors, such as dietary patterns and physical activity, was not incorporated into the analysis, which may have limited a more comprehensive assessment of factors associated with metabolic syndrome.

Conflict of Interest: No

Author Contributions

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