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ORIGINAL RESEARCH

Visceral Fat Thickness and Abdominal Girth as an Independent Determinant of Metabolic Syndrome: A Cross Sectional, Single-Centre Study

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Abstract

Background: Metabolic syndrome (MetS) is a health condition marked by abdominal obesity, insulin resistance, elevated blood pressure, and dyslipidaemia, with various diagnostic criteria proposed by international organizations. MetS affects 25% of adults globally and around 30% in India, with significant risk factors including age, physical inactivity, diet, and tobacco use. Visceral Ft Thickness (VFT) is a crucial indicator of MetS, with ultrasonography (USG) being a reliable, cost-effective tool for its assessment, offering potential for early MetS detection and management.

Methods and material: The cross-sectional study, conducted from January 2023 to January 2024 at a Mumbai tertiary care centre, included 223 participants aged 18-65 years. Participants underwent clinical exams, including medical history, fasting/postprandial blood sugar, cholesterol, triglycerides, blood pressure, BMI, and abdominal circumference. VFT was measured with USG technique. Metabolic syndrome was diagnosed per International Diabetes Federation (IDF) criteria. Data were summarized using descriptive statistics, and a p-value < 0.05 was considered significant.

Results: Statistically significant positive correlations were found between BMI (P = 0.028), postprandial blood sugar (P = 0.057), abdominal girth (P = 0.024), and metabolic syndrome. Abdominal girth significantly correlated with diabetes (P = 0.003) and hypertension (P = 0.028). Hypertension was strongly correlated with visceral fat thickness (P < 0.0001). BMI, abdominal girth, and visceral fat significantly correlated with metabolic syndrome (P < 0.0001).

Conclusion: This study reaffirms the significant role of VFT and abdominal obesity as risk factors for MetS. The findings emphasize the importance of monitoring abdominal obesity and VFT as key indicators of metabolic health risks.

Keywords

Visceral fat thickness, Metabolic syndrome, Abdominal girth, BMI

Introduction

Metabolic syndrome (MetS) is a condition characterized by a complex combination of physiological, biochemical, and metabolic factors. The MetS encompasses abdominal obesity, insulin resistance, elevated blood pressure, and dyslipidaemia, which is marked by high triglycerides and low levels of high-density lipoprotein cholesterol [1]. Various international organizations and expert groups have proposed different criteria for defining MetS, with the modified National

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Cholesterol Education Program Adult Treatment Panel III (ATP III) and the International Diabetes Federation (IDF) being among the most widely used and compared [2,3]. While both ATP III and IDF recognize abdominal girth (assessed by waist circumference with ethnicity- and gender-specific cutoff values) as a criterion, the IDF mandates central obesity as a prerequisite for diagnosis, whereas ATP III considers it as one of several possible diagnostic components [4,5]. The prevalence of MetS is rising globally, affecting about 25% of the adult population and posing a major public health challenge [6]. In India, a systematic review found that the overall prevalence of metabolic syndrome was approximately 30% [7]. In 2020, approximately 25.8 million children and 35.5 million adolescents worldwide were affected by MetS [8]. In people less than 45 years of age, lack of regular and adequate physical exercise, non-vegetarian diet, and use of tobacco were identified as strong and statistically significant risk factors for MetS [9].

Abdominal obesity and Visceral Fat Thickness is identified as a precursor to MetS, which encompasses a range of risk factors that can lead to type 2 diabetes and cardiovascular disease [10]. Changes in VF over time, such as increases and decreases during weight loss, are linked to insulin resistance, hypertension, and dyslipidaemia [11]. Metabolic syndrome (MetS) was defined based on the International Diabetes Federation (IDF) criteria, requiring at least three of the following factors: (i) Central obesity (abdominal circumference > 90 cm in men and > 80 cm in women, with ethnicity-specific thresholds), (ii) Elevated triglyceride levels > 150 mg/dl (1.7 mmol/L) or treatment for this lipid abnormality, (iii) Reduced HDL-c levels < 40 mg/dl (1.0 mmol/L) in men and < 50 mg/dl (1.3 mmol/L) in women, or treatment for this lipid abnormality including fibrates (PPAR alpha agonists) or statins, (iv) Increased blood pressure (systolic ≥ 130 mmHg or diastolic ≥ 85 mmHg) or treatment for hypertension, and (v) Elevated fasting glucose levels (≥ 100 mg/dl) [5,12,13]. Prevalence of MetS has varied from 10% to 84% worldwide, depending on both the criteria used for diagnosis and differences in the geographic distribution, ethnicity, age, and sex of the population studied [14]. Studies indicate that Asian Indians are at a greater risk for MetS compared to populations in Western countries, even with a lower BMI, primarily due to higher levels of visceral fat [15,16]. According to the analysis of India's National Family Health Survey 5 of the year 2019 to 2021 the prevalence of abdominal obesity in the country was found to be 40% in women and 12% in men. The findings show that 5-6 out of 10 women between the ages of 30-49 are abdominally obese. The association of abdominal obesity in women is stronger with older age groups, urban residents, wealthier sections, and non-vegetarians. Abdominal obesity is also on the rise in rural areas and is penetrating lower and middle socioeconomic sections of society [17]. Therefore, the ability to predict the onset of metabolic syndrome years in advance is considered to be one of the most useful tools for preventing the development of MetS.

Measuring visceral fat might offer more valuable insights than just assessing waist circumference (WC). While Computerized Tomography (CT) is considered the gold standard for quantifying visceral fat volume, it is costly, exposes patients to radiation, and may not be accessible everywhere. Magnetic Resonance Imaging (MRI) is another effective method but is even more expensive, tends to overestimate fat deposits, and also has limited availability, making both CT and MRI unsuitable for routine use [18,19]. Ultrasonography is relatively inexpensive, readily available equally reliable and involves no radiation and is a method with established validity [20]. A 2018 study demonstrated that ultrasonography is a more reliable and accurate tool compared to traditional anthropometric indices for assessing abdominal visceral fat thickness, which is a crucial predictor of metabolic diseases [21].

Therefore, this study aimed to investigate whether visceral fat thickness (VFT) and abdominal girth measured by ultrasonography can adequately assess visceral fat and abdominal girth accumulation and predict presence of metabolic diseases.

Methods and Materials

The study was a cross-sectional, single-centre study conducted from January 2023 to January 2024 at the department of Radiology of a tertiary care centre of Mumbai Suburban Region. The study was approved by the Institutional Ethics committee.

In the study, 223 participants between the ages of 18 to 65 years who visited the OPD for a routine check-up were included. Participants who were pregnant, who had history of liver or kidney diseases, malignancy, chronic inflammatory diseases, which used steroids or hormone replacement therapy were excluded from the study.

After obtaining informed consent, participants underwent a comprehensive clinical examination. This included recording demographic information, medical history, smoking status, current medication use and lab values of fasting and postprandial blood sugar level, total cholesterol, triglyceride. Additionally, blood pressure, BMI of individual participants was also noted. Abdominal circumference was assessed at the midpoint between the lower rib margin and the iliac crest with a non-stretchable tape measure. Visceral fat thickness was evaluated using standard sonographic techniques. The diagnosis of metabolic syndrome was made according to the International Diabetes Federation (IDF) criteria. The BMI values were divided as healthy weight (18.5 to 24.9 kg/m^2), overweight (25 to 29.9 kg/m^2) obese 30 kg/m^2 or higher. The diabetes was classified based on diagnostic values of postprandial blood sugar level as normal (below 140 mg/dL), prediabetic (140 and 199 mg/dL) and diabetic (Above 200 mg/dL). The cholesterol levels were interpretated as normal (less than 200 mg/dL), borderline high (200 to 239 mg/dL) and as high (greater than 240 mg/dL). The triglyceride values were interpretated as healthy (below 150 mg/dL), borderline high (150 to 199 mg/dL), and high (200 to 499 mg/dL). As per the standard guidelines of IDF, if the VFT value is less than 7 mm there is no risk of MetS, there is borderline risk of developing MetS if the VFT value ranges from 7.1 to 9 mm, there is a high risk of metabolic syndrome if the VFT value is more than 9.1 mm. The abdominal girth value varies gender wise, for males the healthy abdominal girth value is less than 102 cm whereas for females it is 88 cm.

Numerical and categorical data were summarized using descriptive statistics, including counts, means, frequencies, and percentages. A normality test was performed prior to applying any statistical tests, and a p-value of less than 0.05 was considered statistically significant.

Results

In the present study, 223 participants were included with 136 (60.99%) males and 87 (39.01%) females (36.32%). Most of the participants were under the age group of 39 to 48 years. Analysis of body mass index (BMI) revealed that nearly half of the participants were classified as obese (47.98%), and 80 participants (35.87%) were categorized as overweight. Additionally, more than half of the participants (55.16%) were pre-diabetic. 48.43% participants had borderline high triglyceride levels. While 54.41% of males had a healthy abdominal girth, a significant 93.10% of females had an unhealthy abdominal girth. Furthermore, 80.72% of the participants were found to have a high risk of visceral fat thickness (Table 1). 201 participants were diagnosed with at least one metabolic syndrome (Table 2).

The mean BMI (31.28 ± 5.97), Fasting blood sugar level (151.16 ± 32.99), postprandial blood sugar level (190.09 ± 45.01), total cholesterol (173.11 ± 31.53), triglyceride (155.42 ± 44.11), abdominal girth (107.09 ± 14.98), and visceral fat thickness (10.28 ± 1.48) was higher in females in comparison to males. Additionally,

Table 1: Demographic and baseline characteristics distribution.

Parameters	Variables	n (%)
Gender Wise Distribution	Male	136 (60.99%)
	Female	87 (39.01%)
Age wise distribution	Less than 29 years	13 (5.83%)
	29 to 38 years	34 (15.25%)
	39 to 48 years	81 (36.32%)
	49 to 58 years	45 (20.18%)
	59 to 68 years	32 (14.35%)
	More than 69 years	18 (8.07%)
Body Mass Index	Healthy Weight	36 (16.14%)
	Obese	107 (47.98%)
	Overweight	80 (35.87%)
Classification of Diabetes	Normal	46 (20.63%)
	Pre Diabetic	123 (55.16%)
	Diabetic	54 (24.22%)
Classification of Cholesterol	Normal	174 (78.03%)
	Borderline High	42 (18.83%)
	High	7 (3.14%)
Classification of Triglyceride	Healthy	97 (43.50%)
	High	18 (8.07%)
	Borderline High	108 (48.43%)
Abdominal Girth in Male (n = 136)	Healthy	74 (54.41%)
	Unhealthy	62 (45.59%)
Abdominal Girth in female (n = 87)	Healthy	6 (6.90%)
	Unhealthy	81 (93.10%)
Classification of Visceral Fat Thickness	No risk	2 (0.90%)
	Borderline Risk	41 (18.39%)
	High Risk	180 (80.72%)

Table 2: Correlation of metabolic syndrome with BMI, abdominal girth and visceral fat thickness.

Parameter	Metabolic syndrome: Yes (n = 201)	Metabolic syndrome: No (n = 22)	Z Value	P Value
	Mean ± SD	Mean ± SD		
BMI	30.56 ± 5.42	27.64 ± 5.21	2.41	0.017
Abdominal girth	106.92 ± 12.57	81.36 ± 5.68	9.41	< 0.0001
Visceral fat thickness	6.36 ± 1.0	4.55 ± 0.59	8.32	< 0.0001

Table 3: Comparison of baseline characteristics in male and female group.

Parameter	Male (n = 136)	Female (87)	Z Value	P Value
	Mean ± SD	Mean ± SD		
Systolic Blood Pressure	131.01 ± 17.04	134.01 ± 15.02	1.34	0.18
Diastolic Blood Pressure	81.67 ± 9.28	80.11 ± 8.51	1.26	0.21
BMI	29.63 ± 5.02	31.28 ± 5.97	2.21	0.028
Fasting blood sugar level	142.79 ± 37.59	151.16 ± 32.99	1.7	0.091
Post prandial blood sugar level	177.76 ± 48.06	190.09 ± 45.01	1.92	0.057
Total Cholesterol	172.4 ± 35.97	173.11 ± 31.53	0.15	0.88
Triglyceride	153.96 ± 34.46	155.42 ± 44.10	0.28	0.78
Abdominal girth	102.67 ± 13.58	107.09 ± 14.98	2.27	0.024
Visceral fat thickness	10.17 ± 1.55	10.28 ± 1.48	0.53	0.6

Table 4: Correlation of visceral fat thickness and abdominal girth with comorbid conditions.

Parameter	Visceral Fat Thickness			Abdominal Girth		
	Mean ± SD	Z Value	P Value	Mean ± SD	Z Value	P Value
Diabetes: Yes (n = 176)	10.28 ± 1.37	1.31	0.19	105.86 ±13.20	3.03	0.003
Diabetes: No (n = 47)	9.95 ± 2.0			98.89 ± 16.77		
Hypertension: Yes (n = 190)	10.36 ± 1.49	3.61	< 0.0001	105.27 ± 12.24	2.21	0.028
Hypertension: No (n = 33)	9.35 ± 1.47			99.36 ± 22.32		

when the parameters were compared between the two genders, there was a statistically positive correlation between BMI (P value = 0.028), fasting blood sugar level (P value = 0.091), postprandial blood sugar level (P value = 0.057), abdominal girth (P value = 0.024) (Table 3).

There was a statistically significant positive correlation between abdominal girth and the presence of diabetes in participants (p = 0.003), as well as between abdominal girth and hypertension (p = 0.028). Additionally, a positive correlation was observed between the diagnosis of hypertension and the presence of visceral fat thickness (p < 0.0001) (Table 4).

The BMI (p value = 0.017), abdominal girth (p < 0.0001), visceral fat thickness (p < 0.0001) had a statistically significant correlation with metabolic syndrome (Table 2).

Discussion

Visceral fat thickness and abdominal obesity are considered precursors to metabolic syndrome (MetS), a cluster of risk factors that can lead to type 2 diabetes and cardiovascular problems [10]. Many cross-sectional and longitudinal studies have demonstrated that VFT is a risk factor for MetS [11,22,23]. Longitudinal study, which includes the MERLOT (Multimedia Educational Resources for Learning and Online Teaching) study, has demonstrated a significant association between VFT and the incidence of metabolic syndrome [24]. Furthermore, the MESA (Multi-Ethnic Study of Atherosclerosis) study showed that both a single measurement and longitudinal changes in VFT predicted MetS [25]. Consistent with previous prospective studies, the current cross-sectional study demonstrates a highly significant positive correlation between metabolic syndrome and visceral fat thickness (p-value < 0.0001). Participants diagnosed with MetS had a mean visceral fat thickness (VFT) of 6.36 ± 1.0, whereas those not diagnosed with MetS had a significantly lower mean VFT of 4.55 ± 0.59 (Table 2).

Higher BMI has consistently been associated with an increased risk for type 2 diabetes [26]. The 2022 report from the Centers for Disease Control and Prevention indicates that obese adults are 4.74 times more likely to have metabolic syndrome compared to adults with a normal BMI [27]. According to a previous study, the mean BMI of the participants diagnosed with MetS was 32.9 ± 2.7 [28], which are in similar lines with the present study in which the mean BMI of participants with MetS was 30.56 ± 5.42 (Table 2). Also, another study stated that increasing BMI was statistically associated with presence of metabolic syndrome like diabetes, hypertension, dyslipidaemia [29] which is in line with the current study in which a statistically significant positive correlation was observed with BMI and presence of metabolic syndrome (p value = 0.017) (Table 2). According to a comparative analysis, it was concluded that there is considerable variation in the BMI amongst men and women. There were a higher proportion of women with high BMI as compared to men [30]. The current study also reveals a similar trend, with the mean BMI of females (31.28 ± 5.97) being significantly higher than that of males (29.63 ± 5.0) (p-value = 0.028) (Table 3).

The findings of previous studies showed associations between VFT and insulin resistance and increased risk of type 2 diabetes [28,29]. However, in the current study there was no positive association of VFT with diabetes (Table 4). Similar to the results of the current study, a previous study conducted in 2019 stated that incidence of diabetes and was not associated with visceral fat [31]. According to a 2023 report, the prevalence of type 2 diabetes mellitus is rising in both sexes. However, men are more frequently diagnosed than women. Globally, it is estimated that 17.7 million more men than women have diabetes mellitus [32]. However the trends in the current study is opposite to that mentioned in the previous study in which the mean postprandial blood sugar level was higher in females (190.09 ± 45.01) than in males (177.76 ± 48.06) (Table 3), The trend can be explained by a review article that suggests women face a greater risk factor burden, particularly obesity, at the time of their type 2 diabetes diagnosis. Additionally, psychosocial stress appears to have a more significant impact on diabetes risk in women. Throughout their lives, women undergo more hormone fluctuations and body changes due to reproductive factors compared to men [32]. In the current study, there was a statistically significant difference in postprandial blood sugar level between genders (p value = 0.05) (Table 3), which is in similar lines with a previous study which shows a positive correlation in the glycemic value between both the genders (p value < 0.0001) [12].

According to the results of the previous study, there was not much significant difference in blood pressure in males and females [33]; however in the current study the systolic as well as diastolic blood pressure was higher in females as compared to males (Table 3). In the current study there was a positive correlation of visceral fat thickness with presence of hypertension (p < 0.0001) (Table 4), which is in similar lines with the study conducted previously in which there was a positive correlation of VFT with hypertension (p < 0.001) [33].

A previous year study showed a statistically significant positive correlation between abdominal girth and MetS (p-value < 0.001) [34]. This finding aligns with the current study, which also shows a strong statistical association between abdominal girth and the presence of metabolic syndrome (p < 0.0001) (Table 2). A previous study found a positive association between waist circumference and diabetes risk (p < 0.0001) [34], this finding is consistent with the current study, which also shows a positive correlation between waist circumference and diabetes risk (p = 0.003) (Table 4).

According to a systematic review, participants with substantially increased abdominal girth (> 88 cm) had a 5-fold increase for hypertension compared with participants with a normal waist circumference (< 80 cm) [35]. Furthermore, a population-based study identified abdominal girth as an independent risk factor for hypertension, with a significant association (P = 0.02) [34] similarly, a survey revealed a statistically significant correlation between increased abdominal girth and the diagnosis of hypertension (p < 0.001) [36]. Findings of previous study align with the present study, which also found a positive correlation between abdominal girth and hypertension (p = 0.028) as shown in Table 4.

The study has several limitations. First, there was a gender imbalance in the study population, with a higher number of males compared to females. Second, the study did not include dietary information, which could have confounded the relationship between BMI, visceral fat, abdominal girth, and metabolic syndrome. Third, the study was conducted among asymptomatic participants who had completed a comprehensive health check-up, which may limit the generalizability of the findings.

Limitations of the study

Study did not include dietary information, which could have confounded the relationship between BMI, visceral fat, abdominal girth, and metabolic syndrome. Nature of the study design couldn't permit comparison between symptomatic and asymptomatic patients, which may limit the generalizability of the findings.

Conclusion

The present study reaffirms the well-established role of visceral fat thickness (VFT) and abdominal obesity as significant risk factors for metabolic syndrome (MetS). It was observed that females had a higher postprandial blood sugar level and blood pressure compared to males, which may be attributed to factors such as hormonal fluctuations and psychosocial stressors that disproportionately affect women. Future research should explore the underlying mechanisms behind these associations and further investigate the observed gender disparities to enhance targeted interventions for metabolic syndrome.

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Conflict of Interest

None.

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