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**Research Article**

# Central Obesity as a Predictor of Renal Stress in Metabolic Syndrome: Biochemical and Urinary Evidence

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**Abstract**

**Background:**

Central obesity is a defining feature of metabolic syndrome (MetS) and is increasingly implicated in early renal dysfunction [1,2]. However, biochemical and urinary markers linking central obesity to renal stress in MetS are underexplored in Indian populations.

**Objectives:**

To evaluate the association of central obesity, assessed by waist circumference and waist-hip ratio (WHR), with metabolic abnormalities and early renal stress markers in individuals with metabolic syndrome.

**Methods:**

In this cross-sectional study, 1000 individuals were screened for metabolic syndrome using NCEP ATP-III criteria. Participants with MetS were categorised into Group A (3 criteria), Group B (4 criteria), and Group C (5 criteria). Anthropometric measurements, glycaemic parameters, lipid profile, renal function tests, urinary markers, and estimated glomerular filtration rate (eGFR) were assessed. Pearson's correlation was used to study associations between central obesity and metabolic and renal parameters.

**Results:**

Metabolic syndrome was present in 35% of the study population. Waist circumference and waist-hip ratio increased significantly with increasing MetS severity. WHR showed significant associations with fasting glucose, HDL cholesterol, serum creatinine, serum uric acid, eGFR, urine albumin, and urine creatinine. Renal biochemical and urinary markers demonstrated significant alterations despite the absence of overt chronic kidney disease, indicating early renal stress associated with central obesity.

**Conclusion:**

Central obesity is a strong predictor of early renal stress in metabolic syndrome. Waist-hip ratio shows consistent associations with biochemical and urinary markers of renal involvement, underscoring its value as a simple screening tool for early renal risk in MetS.

**Keywords:** Central obesity, metabolic syndrome, renal stress, waist-hip ratio, eGFR, microalbuminuria.

## Introduction

Metabolic syndrome (MetS) is a constellation of interrelated metabolic abnormalities, including central obesity, insulin resistance, dyslipidaemia, and hypertension, which collectively increase the risk of cardiovascular disease, type 2 diabetes mellitus, and chronic kidney disease [1–4]. Among these components, central obesity plays a pivotal role in driving metabolic and vascular dysfunction [5].

Emerging evidence suggests that renal involvement in metabolic syndrome begins early and often remains clinically silent [6,7]. Subtle alterations in renal haemodynamics, glomerular hyperfiltration, and low-grade albuminuria may precede overt chronic kidney disease [6–8]. Central obesity, through mechanisms including insulin resistance, chronic inflammation, oxidative stress, and endothelial dysfunction, may directly contribute to renal stress [9–11].

This study examined the role of central obesity—measured by waist circumference and waist-to-hip ratio—as a predictor of early renal stress in individuals with metabolic syndrome, using biochemical and urinary markers.

## Materials and Methods

### Study Design and Population

A cross-sectional study was conducted on 1000 individuals. Metabolic syndrome was diagnosed using the National Cholesterol Education Program Adult Treatment Panel-III (NCEP ATP-III) criteria [1].

### Grouping

Participants with metabolic syndrome were categorised as:

- **Group A:** Three MetS criteria
- **Group B:** Four MetS criteria
- **Group C:** Five MetS criteria

### Data Collection

The following parameters were assessed:

- **Anthropometry:** Waist circumference, waist-hip ratio
- **Blood pressure:** Systolic and diastolic
- **Biochemical parameters:** Fasting blood glucose, lipid profile
- **Renal parameters:** Blood urea nitrogen, serum urea, creatinine, uric acid
- **Urinary parameters:** Urine albumin, urine creatinine, urine albumin-creatinine ratio

- **Renal function:** Estimated glomerular filtration rate (eGFR)

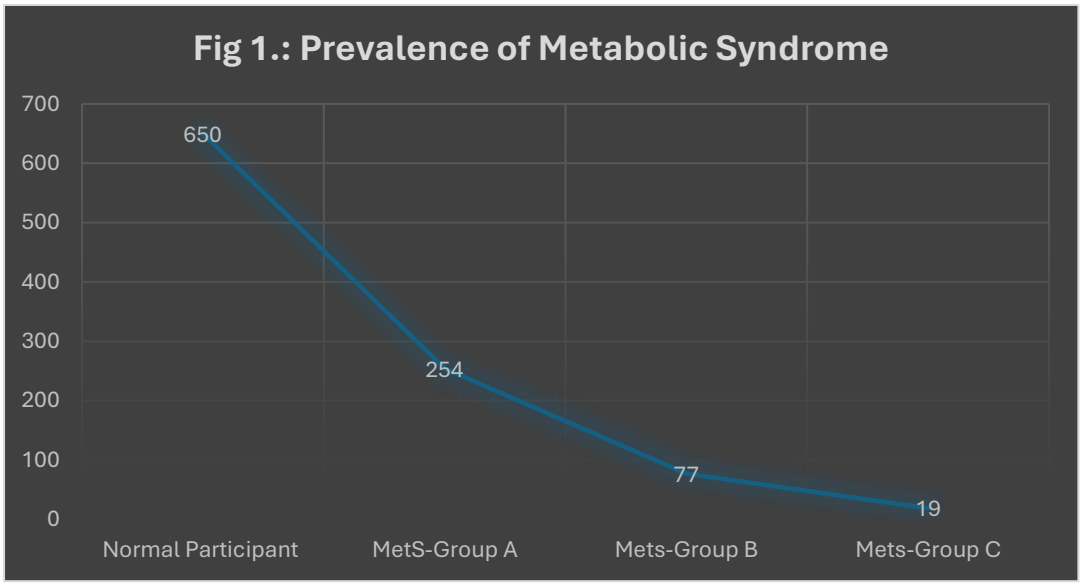
**Statistical Analysis**

Data were expressed as mean ± standard deviation. Intergroup comparisons were performed using one-way ANOVA. Pearson's correlation coefficient was used to evaluate associations between central obesity indices and metabolic and renal parameters. A p-value <0.05 was considered statistically significant.

**Results**

**Prevalence of Metabolic Syndrome**

Out of 1000 individuals screened, 350 were diagnosed with metabolic syndrome, yielding a prevalence of **35%**. Among them, 254 (25.4%) were classified as Group A, 77 (7.7%) as Group B, and 19 (1.9%) as Group C. (Figure 1)




**Age and Gender Distribution**

There was no statistically significant difference in age or gender distribution across the metabolic syndrome groups. Male predominance was observed numerically, but the association between sex and MetS severity was not significant ($p > 0.05$). (Table 1)

| Table 1: Gender wise distribution among Metabolic Syndrome Groups. | P-value |
|---|---|

| Sex | MetS-Group A | MetS-Group B | MetS-Group C | |
|---|---|---|---|---|
| Male | 166 | 53 | 13 | 0.8350 |
| Female | 88 | 24 | 6 | |

**Comparison of Anthropometric Measurement among Groups**.

The results indicated a significant difference in waist circumference among groups A, B, and C ($p < 0.05$), with Group A at 102.32±6.57 cm, Group B at 104.51±6.58 cm, and Group C at 103.27±9.85 cm (Table 4 & Fig. 4). Waist-hip ratios were also significant: Group A 0.77±0.07, Group B 0.79±0.06, and Group C 0.85±0.07 (Table 2). However, ANOVA revealed no significant differences in systolic and diastolic blood pressure among the groups

.

Table 4: Demographic and Anthropometric Profiles of Groups A, B, and C

| Parameters | Group A Mean± SD N=254 | Group B Mean± SD N=77 | Group C Mean± SD N=19 | P-value |
|---|---|---|---|---|
| Age | 56.11±7.49 | 55.52± 8.60 | 53.95± 9.20 | 0.4661 |
| Male | 166 | 53 | 13 | |
| Female | 88 | 24 | 6 | 0.8350 |
| Waist circumference (cm) | 102.32±6.57 | 104.51±6.58 | 103.27±9.85 | 0.0454 |
| Waist-Hip Ratio | 0.77±0.07 | 0.79±0.06 | 0.85±0.07 | <0.001 |
| Systolic Blood Pressure (mm Hg) | 148.5± 6.87 | 149± 5.75 | 150± 7.58 | 0.577 |
| Diastolic Blood Pressure (mm Hg) | 85.73± 5.37 | 86.32± 5.32 | 83.53± 4.76 | 0.1252 |

**Glycaemic and Lipid Profile**

Fasting blood glucose demonstrated a highly significant stepwise increase from Group A to Group C ($p < 0.001$). Total cholesterol and HDL cholesterol differed significantly across groups, whereas

triglycerides and LDL cholesterol did not. VLDL levels were significantly higher with increasing MetS severity. (Table 3)

Table 3: Comparison of Fasting Blood Sugar and Lipid Profile among Groups A, B, and C

| Parameters | Group A Mean± SD N=254 | Group B Mean± SD N=77 | Group C Mean± SD N=19 | P-value |
|---|---|---|---|---|
| BFS (mg/dl) | 121.24±38.42 | 144.76±48.75 | 183.21±13.21 | <0.001 |
| TC (mg/dl) | 195.27±33.13 | 207.54±39.43 | 186.57±7.85 | 0.01 |
| TG (mg/dl) | 204.15±83.21 | 207.02±37.56 | 241.72±65.58 | 0.108 |
| HDL (mg/dl) | 49.59±5.01 | 51.53±6.42 | 39.85±7.78 | <0.001 |
| LDL (mg/dl) | 103.45±33.52 | 105.76±5.89 | 94.37±18.04 | 0.234 |
| VLD (mg/dl) | 42.67±8.57 | 38.68±8.93 | 54.21±7.65 | <0.001 |

Note: – p-value 0.01 is significant, p-value < 0.001 is highly significant, and p-value>0.005 is not substantial.

**Renal Biochemical Parameters**

Serum creatinine, urea, and uric acid showed statistically significant differences across metabolic syndrome groups, while blood urea nitrogen did not. These findings indicate biochemical evidence of early renal stress with increasing MetS severity. (Table 4)

Table 4: **Comparison of Renal Function Test among Groups A, B, and C.**

| Parameters (mg/dl) | Group A Mean± SD N=254 | Group B Mean± SD N=77 | Group C Mean± SD N=19 | P-value |
|---|---|---|---|---|
| BUN | 11.73±1.24 | 12.01±1.21 | 11.59±1.53 | 0.180 |
| Creatinine | 1.02±0.11 | 1.03±0.12 | 0.97±0.21 | 0.001 |
| Urea | 28.69±2.58 | 27.43±2.94 | 27.57±3.25 | 0.001 |

| | | | | |
|---|---|---|---|---|
| Uric acid | 4.85±0.86 | 5.23±1.05 | 5.54±1.05 | 0.001 |

**Urinary Parameters and eGFR**

Estimated glomerular filtration rate differed significantly among groups ($p < 0.05$). Urine albumin and urine creatinine levels increased significantly with greater MetS severity, although the urine albumin-creatinine ratio did not differ significantly.

One-way ANOVA demonstrated a statistically significant difference in estimated glomerular filtration rate (eGFR) among the metabolic syndrome groups (Group A: 71.84 ± 10.24, Group B: 75.46 ± 11.85, Group C: 73.05 ± 9.54; $p < 0.05$) (Table 5).

Urinary creatinine levels differed significantly across groups (Group A: 1.53 ± 0.67, Group B: 2.42 ± 0.75, Group C: 2.35 ± 0.57; $p < 0.001$). Similarly, urine albumin levels showed a highly significant intergroup difference (Group A: 6.43 ± 3.23, Group B: 8.95 ± 3.57, Group C: 7.34 ± 4.32; $p < 0.001$).

In contrast, the urine albumin–creatinine ratio (UACR) did not differ significantly among the groups (Group A: 4.52 ± 2.43, Group B: 4.67 ± 2.51, Group C: 3.68 ± 1.74; $p > 0.05$) (Table 5).

Table 5: Comparison of Renal Function Test among Groups A, B, and C.

| Parameters (mg/dl) | Group A Mean± SD N=254 | Group B Mean± SD N=77 | Group C Mean± SD N=19 | P-value |
|---|---|---|---|---|
| Estimated Glomerular Filtration Rate (ml/min/1.73m$^2$) | 71.84±10.24 | 75.46±11.85 | 73.05±9.54 | 0.0322 |
| Urine Creatinine (mg/dl) | 1.53±0.67 | 2.42±0.75 | 2.35±0.57 | <0.001 |
| Urine Albumin (mg/dl) | 6.43±3.23 | 8.95±3.57 | 7.34±4.32 | <0.001 |
| Urine Albumin-Creatinine Ratio | 4.52±2.43 | 4.67±2.51 | 3.68±1.74 | 0.276 |

**Correlation of Central Obesity with Renal Stress Markers**

Waist circumference showed significant positive correlations with serum creatinine, serum uric acid, eGFR, urine albumin, and urine creatinine. Waist-hip ratio demonstrated significant positive correlations with serum creatinine and eGFR, as well as with urinary albumin and creatinine levels. These associations highlight the strong link between central obesity and early renal stress. (Table 6)

Table 6: Correlation of Waist Circumference and Waist-Hip Ratio with Renal Profile.

| Variable | Waist Circumference | | Waist-Hip Ratio | |
|---|---|---|---|---|
| | r-value | p-value | r-value | p-value |
| S. Urea | 0.105 | 0.023 | 0.027 | 0.657 |
| S. Creatinine | 0.273 | <0.001 | 0.231 | 0.001 |
| S. Uric Acid | 0.201 | <0.001 | 0.051 | 0.171 |
| Urine albumin | 0.167 | <0.001 | 0.163 | <0.001 |
| Urine creatinine | 0.121 | 0.02 | 0.136 | 0.012 |
| Estimate glomerular filtration (eGFR) | 0.251 | <0.001 | 0.341 | <0.001 |

**Discussion**

The present study demonstrates that individuals with increasing severity of metabolic syndrome (MetS) exhibit **early renal stress**, reflected by significant intergroup differences in estimated glomerular filtration rate (eGFR), urine albumin, and urine creatinine levels, despite the absence of overt chronic kidney disease. These findings support the concept that **renal involvement in MetS begins at a subclinical stage**.

A statistically significant difference in eGFR was observed across MetS groups, suggesting altered renal haemodynamics with increasing metabolic burden. Similar observations have been reported by **Chen et al.**, who demonstrated that metabolic syndrome is independently associated with reduced renal function, even in non-

diabetic populations [12]. Likewise, **Thomas et al.** reported in a systematic review and meta-analysis that MetS is associated with both reduced eGFR and an increased risk of chronic kidney disease, reinforcing the link between metabolic clustering and renal dysfunction [13].

In the present study, **urine albumin and urine creatinine levels increased significantly with MetS severity**, indicating early glomerular stress. This finding is consistent with the work of **Kurella et al.**, who reported that metabolic syndrome is associated with early renal injury manifested by albuminuria before the development of advanced kidney disease [14]. **Fox et al.** also demonstrated that low-grade albuminuria is an early predictor of future renal dysfunction in metabolically at-risk individuals [15].

Interestingly, despite significant changes in individual urinary parameters, the **urine albumin–creatinine ratio (UACR) did not differ significantly across groups** in the present study. This observation suggests that absolute increases in urinary albumin and creatinine may precede detectable changes in UACR. Similar findings have been reported by Prasad, who emphasised that early renal involvement in metabolic syndrome may manifest as subtle biochemical and urinary abnormalities that do not meet conventional thresholds for microalbuminuria [16].

The pattern of findings observed—significant alterations in eGFR and urinary markers with preserved UACR—supports the hypothesis of **early functional and haemodynamic renal changes rather than established structural damage**. Experimental and clinical studies by **Hall et al.** have shown that obesity-related renal stress is characterized initially by glomerular hyperfiltration and increased renal plasma flow, followed later by albuminuria and progressive nephron loss [17].

Overall, the results of the present study align with the existing literature in demonstrating that metabolic syndrome, particularly as it increases in severity, is associated with **early renal stress detectable through sensitive biochemical and urinary markers**. These findings underscore the importance of early renal assessment in individuals with metabolic syndrome, even in the absence of clinically overt kidney disease.

## Conclusion

This study shows that central obesity is linked to early renal stress in metabolic syndrome, even without evident chronic kidney disease. Larger waist circumference and waist–hip ratio correlate with changes

in renal biochemical parameters, estimated glomerular filtration rate (eGFR), and urinary markers, indicating early renal involvement with increased metabolic burden. Among measures of central adiposity, the waist–hip ratio is more strongly associated with renal stress markers, such as serum creatinine and uric acid. This suggests that visceral fat distribution significantly affects early renal function in patients with metabolic syndrome. The lack of differences in the urine albumin–creatinine ratio indicates that renal dysfunction occurs at a functional level before structural damage. Therefore, routine assessment of central obesity could help identify those at risk for renal complications. Early detection may allow for preventive measures to reduce the progression to chronic kidney disease, especially in populations with high central obesity.

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