



METABOLIC SYNDROME AND EARLY RENAL DYSFUNCTION: A CROSS-SECTIONAL ANALYSIS IN AN URBAN INDIAN POPULATION

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Abstract

Metabolic syndrome (MetS) is an escalating public health problem and is increasingly recognised as a contributor to early renal dysfunction. This study evaluated the association between MetS severity and renal function markers in an urban Indian population. Among 1000 screened individuals, 350 met the NCEP-ATP III criteria for MetS. Participants were stratified into three groups based on the number of MetS components present. Anthropometric, biochemical, and renal parameters were analysed. Progressive worsening of fasting glucose, lipid abnormalities, serum urea, uric acid, estimated glomerular filtration rate (eGFR), and urinary markers was observed with increasing MetS components. Central obesity showed significant correlations with multiple renal indices. These findings emphasise the importance of routine renal monitoring in individuals with MetS to enable early detection of kidney involvement.

Key Words: Metabolic Syndrome, Early renal dysfunction, Chronic Kidney disease, Obesity

Introduction

Metabolic syndrome represents a cluster of metabolic abnormalities characterised by central obesity, insulin resistance, dyslipidaemia, and hypertension, which together increase the risk of cardiovascular disease, type 2 diabetes mellitus, and chronic kidney disease (CKD) [1,2]. In recent years, renal dysfunction has emerged as an important but under-recognised complication of MetS [3,4].

India has witnessed a rapid rise in MetS prevalence due to urbanisation, sedentary lifestyles, and dietary transitions, with reported prevalence ranging from 30–50% in urban populations [5,6]. Shared pathophysiological mechanisms such as chronic inflammation, oxidative stress, endothelial dysfunction, and altered renal haemodynamics link MetS to kidney injury [7,8]. Early identification of renal impairment in MetS is therefore essential.

Materials and Methods

This observational descriptive study was conducted at a tertiary care centre in central India after institutional ethical approval. Adults aged 30–65 years were screened, and those fulfilling NCEP-ATP III criteria for metabolic syndrome were included. Participants were categorised according to the presence of 3, 4, or 5 MetS components.

Anthropometric indices, blood pressure, fasting blood glucose, lipid profile, serum urea, creatinine, uric acid, eGFR, urine albumin, urine creatinine, and urine albumin-to-creatinine ratio were assessed. Statistical analysis was performed using SPSS, with $p < 0.05$ considered statistically significant.

Results

A total of 1000 individuals were screened, and 350 were identified as having metabolic syndrome according to the National Cholesterol Education Program Adult Treatment Panel-III (NCEP ATP-III), yielding a prevalence of 35%. (Table 1)

Table 1: Prevalence of Metabolic Syndrome		
Group	Number	Percentage
Normal Participant	650	65%
MetS-Group A	254	25.4%
Mets-Group B	77	7.7%
Mets-Group C	19	1.9%

Age and Gender Distribution

No statistically significant association was observed between MetS severity and age or sex. Male predominance was noted across all groups, but the difference was not significant ($p > 0.05$). (Table 2)

Table 2: Gender wise distribution among Metabolic Syndrome Groups.				P-value
Sex	MetS-Group A	MetS-Group B	MetS-Group C	0.8350
Male	166	53	13	
Female	88	24	6	

Comparison of Anthropometric Measurements among Groups

Waist circumference and waist-hip ratio differed significantly among the groups, increasing with the number of MetS criteria satisfied. Blood pressure parameters did not show statistically significant intergroup differences. (Table 2)

Table 2: 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	0.8350
Female	88	24	6	
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

Glycemic and Lipid Profile

Fasting blood glucose showed a highly significant increase across Groups A, B, and C ($p < 0.001$). Total cholesterol and HDL levels differed significantly among groups, whereas triglycerides and LDL did not. VLDL levels were significantly different. (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 Function Parameters

Serum creatinine, urea, and uric acid showed statistically significant differences among MetS groups, whereas blood urea nitrogen did not. These findings suggest early renal involvement 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	0.01
Uric acid	4.85±0.86	5.23±1.05	5.54±1.05	0.01

Urinary Parameters and eGFR

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

Waist circumference showed a significant weak positive correlation with serum creatinine ($r=0.273$, $p<0.001$) and serum uric acid ($r=0.201$, $p<0.001$). But no relation with BUN and Blood urea. Serum creatinine alone showed a significantly weak positive correlation with waist-to-hip ratio ($r=0.231$, $p<0.001$). Waist-hip ratio was not significantly correlated with blood urea nitrogen ($r=0.017$, $p=0.546$), serum urea ($r=0.027$, $p=0.657$), and serum uric acid ($r=0.051$, $p=0.171$). (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
BUN	0.103	0.034	0.017	0.546
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

Discussion

The present cross-sectional study highlights a high burden of metabolic syndrome (35%) in an urban Indian population and demonstrates a progressive association between metabolic syndrome severity, central obesity, and early renal dysfunction.

Prevalence of Metabolic Syndrome

In this study, metabolic syndrome was identified in 35% of the screened population, which is comparable to prevalence rates reported in several Indian urban studies. Ramachandran et al. reported a prevalence of 25–34% among urban South Indians using modified ATP-III criteria, depending on age and sex distribution [9]. Similarly, the ICMR-INDIAB study by Anjana et al. reported an urban prevalence ranging from 30% to 40%, with higher rates in metropolitan regions [10]. The findings of the present study fall well within this reported range, reaffirming the rising metabolic risk associated with urbanisation and lifestyle transition in India.

The predominance of individuals in MetS Group A (three criteria) suggests that a substantial proportion of affected individuals are at an early and potentially reversible stage, a pattern also observed in the Chennai Urban Rural Epidemiology Study (CURES) by Deepa et al. [11].

Age and Gender Distribution

No statistically significant association was observed between metabolic syndrome severity and age or sex in the present study. Although males constituted a higher proportion numerically, the difference was not statistically significant. Similar observations have been reported by Gupta et al., who noted that while absolute prevalence may vary between men and women, clustering of metabolic abnormalities is not strongly sex-dependent in urban Indian adults [12]. This suggests that environmental and lifestyle factors may override biological sex differences in determining metabolic risk.

Central Obesity and Anthropometric Parameters

A key finding of this study is the significant increase in waist circumference and waist-hip ratio with increasing metabolic syndrome severity, whereas systolic and diastolic blood pressure did not show significant intergroup differences. This underscores the central role of abdominal obesity as the primary driver of metabolic syndrome in Asian Indians.

Misra and Shrivastava have emphasized that Asian Indians exhibit a characteristic phenotype marked by increased visceral adiposity at lower body mass indices, predisposing them to insulin resistance and metabolic complications [13]. The strong association of waist-hip ratio with MetS severity in the present study further supports the concept that central obesity is a more sensitive marker of metabolic risk than blood pressure alone in early disease stages.

Glycemic and Lipid Abnormalities

The present study demonstrated a stepwise and highly significant increase in fasting blood glucose levels from Group A to Group C, reflecting worsening insulin resistance with increasing metabolic burden. This finding is consistent with observations from Deepa et al. and Mohan et al., who reported progressive deterioration in glycemic parameters with an increasing number of MetS components [11].

Lipid profile analysis revealed significant differences in total cholesterol, HDL, and VLDL, while triglycerides and LDL did not differ significantly across groups. This lipid pattern aligns with Indian studies reporting low HDL and elevated VLDL as more consistent dyslipidemic features in metabolic syndrome than LDL cholesterol [12,13]. The absence of significant LDL variation supports the notion that traditional LDL-centric risk assessment may underestimate cardiometabolic risk in Indian populations.

Renal Function and Early Renal Dysfunction

An important observation in the present study is the presence of early renal involvement across metabolic syndrome groups, despite the absence of overt chronic kidney disease. Significant differences were noted in serum creatinine, urea, and uric acid, while blood urea nitrogen did not differ significantly.

Studies from India have increasingly recognized metabolic syndrome as a risk factor for early renal dysfunction. Vikram et al. demonstrated that metabolic syndrome is associated with subclinical reductions in renal function and increased renal risk, even in individuals without diagnosed kidney disease [14]. Elevated serum uric acid observed in Groups B and C in the present study further supports its role as a marker of metabolic and renal stress, as also described in Indian nephrology literature [14,15].

Urinary Parameters and Estimated Glomerular Filtration Rate

The present study found significant intergroup differences in eGFR, urine albumin, and urine creatinine, indicating early renal involvement with increasing MetS severity. Although the urine albumin-creatinine ratio did not differ significantly, elevated urinary albumin levels suggest early glomerular endothelial dysfunction.

Prasad et al. reported that metabolic syndrome is associated with early renal functional changes and low-grade albuminuria, even before clinically apparent chronic kidney disease develops [7]. The findings of the present study are concordant with these observations and reinforce the need for early renal screening in individuals with metabolic syndrome.

Association of Central Obesity with Renal Parameters

Correlation analysis revealed that waist circumference showed significant positive correlations with serum creatinine and serum uric acid, whereas waist-hip ratio was significantly correlated with serum creatinine alone. These findings suggest that central obesity contributes directly to early renal dysfunction, possibly through insulin resistance, inflammation, and altered renal hemodynamics.

Similar associations have been described by Misra et al. and Vikram et al., who proposed that visceral adiposity plays a central role in linking metabolic syndrome to renal impairment in Asian Indians [5,6]. The lack of strong correlation with blood urea nitrogen and serum urea supports the concept that structural and functional renal changes precede overt biochemical evidence of renal failure.

Conclusion

The present study adds to existing Indian literature by demonstrating that metabolic syndrome is highly prevalent in urban India and is associated with early renal dysfunction, even in the absence of overt chronic kidney disease. Central obesity emerges as the most consistent determinant of both metabolic and renal abnormalities, underscoring the importance of waist-based anthropometric measures in routine screening.

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