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Prevalence and predictors of metabolic syndrome among type 2 diabetes patients: A cross-sectional study in Eastern Cape, South Africa

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Background: Metabolic syndrome is a burgeoning global concern that predisposes individuals to cardiovascular diseases and shares a complex bidirectional relationship with type 2 diabetes mellitus (T2DM). Its prevalence and associated risk factors among T2DM patients vary across populations depending on diagnostic criteria.

Aim: This study aimed to determine the prevalence, components and predictors of metabolic syndrome among T2DM patients.

Setting: The medical outpatient department of Nelson Mandela Academic Hospital, Mthatha, Eastern Cape province, South Africa.

Methods: A cross-sectional study was conducted among 142 patients with T2DM. Data on demographic, anthropometric, haemodynamic and biochemical parameters were collected using a structured questionnaire. Metabolic syndrome was defined according to the International Diabetes Federation (IDF) criteria. Variable-specific standardised descriptive and inferential statistics were computed using SPSS 29.

Results: The prevalence of metabolic syndrome was 83.8%, with high rates among females (90.3%). Among males, hypertension (84.2%) and low high-density lipoprotein cholesterol (88.6%) were the most common components, whereas females exhibited higher rates of abdominal obesity (98.1%), hypertriglyceridaemia (83.3%) and dyslipidaemia (84.2%). Abdominal obesity was the predominant risk component (129 [90.8%]). Poor glycaemic control was evident with 111 (83.5%) participants having a glycosylated haemoglobin of 7% or higher. Predictors of metabolic syndrome were obesity in males (odds ratio [OR]: 28.34, 95% confidence interval [CI]: 2.23–359.80, $p = 0.010$) and dyslipidaemia in females (OR: 59.06, 95% CI: 3.46–1007.16, $p = 0.005$).

Conclusion: Metabolic syndrome was highly prevalent, with abdominal obesity as the predominant risk component. Obesity and dyslipidaemia were significant predictors, and diabetes remained poorly controlled in a large proportion of patients.

Contribution: This study is the first to report on the prevalence, main risk components and predictors of metabolic syndrome among T2DM patients in a typical rural South African population.

Keywords: metabolic syndrome; type 2 diabetes mellitus; Eastern Cape; South Africa; predictors.

Introduction

Diabetes mellitus is a metabolic disorder characterised by hyperglycaemia resulting from the absence, inadequate production or deficiency of the hormone insulin or functional resistance to its action.[1] The long-term persistence of these physiological abnormalities contributes to vascular morbidities and progressive functional deterioration.[2,3] Globally, an estimated 589 million individuals are currently living with one of the different types of diabetes, with projections suggesting an increase to 853 million by 2050.[4] The most significant relative increase is anticipated to occur in low- and middle-income countries, which already account for the majority (81%) of diabetic cases.[4] In South Africa, the burden is substantial, with 400 000 new diagnoses among adults 20–79 years between 2011 and 2024, of which 90% were type 2 diabetes mellitus (T2DM).[4,5] The Eastern Cape province, particularly rural districts such as OR Tambo, has witnessed a marked increase in both prevalence and incidence of type 2 diabetes.[6,7]

The rising prevalence of diabetes in South Africa reflects both avoidable and unavoidable determinants. These include changing population demographics associated with increased life expectancy, facilitated by improved healthcare access and successful antiretroviral therapy[8,9,10,11,12], familial predisposition[12,13], rural-urban migration, which is often accompanied by the adoption of sedentary lifestyles and an unhealthy diet[7,14,15], and escalating rates of obesity and psychological distress.[12,16,17] Evidence indicates that individuals with T2DM often develop additional risk factors encompassed within metabolic syndrome,[18,19,20] a condition defined by the co-occurrence of insulin resistance, obesity, atherogenic dyslipidaemia and hypertension.[21,22] These interrelated abnormalities share common mediators, mechanisms and pathways,[23] and their cumulative effect causes microvascular dysfunction, amplifies insulin resistance and exacerbates hypertension.[24]

Globally, metabolic syndrome is increasingly prevalent, affecting 20% to 25% of the general adult population and 70% to 80% of individuals with T2DM.[25] In sub-Saharan Africa, prevalence estimates among T2DM patients vary depending on diagnostic criteria, ranging from 60.8% with the International Diabetes Federation (IDF) to 63.1% with the National Cholesterol Education Program-Adult Treatment Panel (NCEP-ATP) III 2004.[25] Country-specific studies also demonstrate considerable heterogeneity: in the Gwalior Chambal region of central India, prevalence rates were 28% with WHO definitions, 45.8% with IDF and 57.7% with NCEP-ATPIII;[26] in Ghana, prevalence was 58% using NCEP-ATPIII[27] and 59.90% using harmonised criteria;[28] while rates of 52.38% in Ethiopia,[29] 63.6% in Nigeria[30] and 80.5% in Nepal[31] have also been reported. Importantly, individuals with metabolic syndrome are at substantially greater risk of myocardial infarction and other cardiovascular diseases, particularly when coexisting with T2DM.[25] Although a bidirectional relationship exists between metabolic syndrome and T2DM, with each increasing the likelihood of the other, not all patients with one condition necessarily develop the other. Risk factors include demographic variables such as gender and body mass index (BMI),[27,28,29] lifestyle factors such as physical inactivity,[32] clinical factors including elevated blood pressure and elevated triglycerides[32] and genetic predisposition to diabetes.[28] In developing countries, lifestyle-related risk factors predominate, compounded by demographic and Western lifestyle influences.[33]

Despite the growing burden, uncertainty persists regarding the prevalence and predictors of metabolic syndrome in a typical South African population, as context-specific evidence remains limited. Accordingly, the present study was undertaken to determine the prevalence, components and predictors of metabolic syndrome among type 2 diabetic patients attending a rural tertiary hospital in the Eastern Cape. By identifying individuals at heightened risk of severe metabolic crisis and macrovascular and microvascular events,[34,35] the study is expected to furnish robust evidence to support routine screening, integrated multimorbidity management and epidemiological investigations aimed at identifying root causes in clinical settings.

Aim and objectives

This study was designed to investigate the prevalence and predictors of metabolic syndrome among individuals with type 2 diabetes attending the medical outpatient department of Nelson Mandela Academic Hospital, Mthatha. Specifically, the objectives were to characterise the demographic, anthropometric, haemodynamic and biochemical profiles of participants, to ascertain the proportion of patients with type 2 diabetes exhibiting the various components of metabolic syndrome (high waist circumference, hypertension, increased triglycerides and low high-density lipoprotein cholesterol [HDL-C]) and to determine the overall prevalence of metabolic syndrome within this cohort. The study additionally examined the association between demographic, anthropometric, haemodynamic and biochemical parameters and the presence of metabolic syndrome, thereby elucidating its predictors within this patient population.

Research methods and design

Study design and setting

This facility-based cross-sectional study was conducted between January and December 2021 at the diabetic clinic of the medical outpatient department of Nelson Mandela Academic Hospital, Mthatha, Eastern Cape, South Africa. Mthatha, the administrative capital of the former Transkei region in the Eastern Cape province, has an estimated population of approximately one million. Nelson Mandela Academic Hospital is a tertiary referral institution with a capacity of roughly 600 beds, rendering specialist services to district hospitals and clinics across the region. The hospital employs a large team of medical practitioners, ranging from interns to consultants in various specialties, and provides allied health services, including physiotherapy, nutrition therapy and occupational therapy.

Study population and sampling technique

The study selected a sample of patients with type 2 diabetes who were under clinical management at the study site, using a convenience sampling technique. Eligibility criteria comprised confirmed type 2 diabetes, age ≥18 years, either sex and consent to participate in the study. Exclusion criteria were age younger than 18 years and diabetes other than type 2 diabetes.

Sample size

Using the Epidemiologic Analysis of Tabulated Data Software (EPIDAT) sample size calculator, the required sample size was determined based on a 95% confidence interval (CI), a 5% margin of error, a population of 400 patients with type 2 diabetes who received routine care at the diabetic clinic and an estimated prevalence rate of 60.8%.[25] The calculated sample size was 192, with a 10% contingency range (minimum 173 and a maximum 211). However, because of coronavirus disease 2019 (COVID-19) restrictions that markedly reduced clinic attendance, only 142 participants were ultimately recruited.

Data collection

Data were collected using a study-specific questionnaire designed to capture clinical and epidemiological variables relevant to the prevalence of metabolic syndrome and its associated factors. The research-made tool consisted of 12 items, with modest internal consistency (Cronbach's alpha = 0.528), indicating that it measured distinct constructs. The research tool was piloted with 10 patients to improve clarity, logistics and layout. Questionnaires were administered in person, while laboratory tests were performed by National Health Laboratory Service (NHLS) technicians blinded to the study's objectives.

The collected data included biodemographic variables (age, sex and race) and cardiovascular risk factors (medical history of hypertension, ischaemic heart disease, stroke, preeclampsia and polycystic ovarian syndrome, as well as medication use, including antihypertensives, lipid-lowering agents, nitrates and oral contraceptives).

Anthropometric data were obtained using standardised instruments: body weight was measured with a weighing scale calibrated to a precision of 0.5 kg, height was assessed with a calibrated vertical board to the nearest centimetre, and waist circumference was determined using a flexible measuring tape positioned at the midpoint between the superior border of the iliac crest and the inferior margin of the last rib. Body mass index was calculated as weight in kilograms (kg) divided by the square of height in metres (m^2).

Haemodynamic data (systolic and diastolic blood pressure) were recorded as the mean of two measurements taken 10 min apart using a digital sphygmomanometer, following a 10-min rest period.

Biochemical data comprised glycosylated haemoglobin (HbA1c) and fasting lipid profiles (total cholesterol, triglycerides, HDL-C and low-density lipoprotein cholesterol) derived from venous blood samples collected after an overnight fast of approximately 12 h. Fasting lipid profiles were analysed at the NHLS using the Cobas 6000 analyser with low-density lipoprotein cholesterol estimated using the Friedewald equation. Optimal lipid values were defined as total cholesterol < 200 mg/dL (5.172 mmol/L), triglycerides < 150 mg/dL (1.694 mmol/L), HDL-C > 50 mg/dL (1.293 mmol/L) in men and > 60 mg/dL (1.552 mmol/L) in women and low-density lipoprotein cholesterol < 100 mg/dL (2.586 mmol/L).[36]

Criteria for the diagnosis of metabolic syndrome

The IDF criteria, currently applied in South Africa, were adopted to define metabolic syndrome. Diagnosis required the presence of central obesity (waist circumference ≥ 94 cm in males and ≥ 80 cm in females) plus any two of the following: raised triglycerides (≥ 150 mg/dL or 1.7 mmol/L) or treatment for this abnormality; reduced HDL-C (< 40 mg/dL or 1.03 mmol/L in males and < 50 mg/dL or 1.29 mmol/L in females) or treatment for this abnormality; elevated blood pressure (systolic ≥ 130 mm Hg or diastolic ≥ 85 mm Hg or on antihypertensive therapy) and raised fasting plasma glucose (≥ 100 mg/dL or 5.551 mmol/L) or previously diagnosed T2DM.

Statistical analysis

Data were captured in Microsoft Excel 365, cleaned and then exported into the International Business Machines Statistical Package for the Social Sciences (IBM SPSS) software version 29 for statistical analysis. Normality tests were performed on all continuous variables, qualifying their summarisation as medians with interquartile ranges. Categorical variables were presented as counts and corresponding percentages. Group comparisons for continuous variables were performed using the non-parametric Mann–Whitney U-test, while associations between categorical variables were assessed with Pearson's chi-square test. Binary logistic regression was used to examine the associations between baseline variables and metabolic syndrome, with results reported as crude relative risks and adjusted odds ratios. Statistical significance was set at less than 0.05 with a 95% CI.

Ethical considerations

Ethical approval was obtained from the Walter Sisulu University Faculty of Medicine and Health Sciences Research Ethics Committee, which approved the protocol, with protocol number 085/2019. Permission was obtained from the Eastern Cape Department of Health and the management of Nelson Mandela Academic Hospital. The study was explained to the participants in the language they understood, and written informed consent was obtained. Data were collected anonymously, ensuring confidentiality throughout the research process. All data documents and study materials were securely stored in a password-protected locker.

Results

Demographic, anthropometric, haemodynamic, and biochemical profiles of study participants stratified by gender

A total of 142 participants were recruited, of whom 103 (72.5%) were females. The median age was 63 years (interquartile range = 53–67), with males slightly older (65 [54–69] years) than females (60 [52–67] years) ($p = 0.080$). Female participants had a significantly higher BMI than males, and their waist circumference was also higher; however, the difference was not statistically significant. Systolic blood pressure was higher in females and diastolic blood pressure in males, though neither difference reached statistical significance. Biochemically, females exhibited significantly higher HDL-C, whereas males had higher but non-significant triglyceride (TG) levels. Median haemoglobin A1c (HbA1c) was 9.1% across the cohort, with no significant sex-based difference ($p = 0.684$) (Table 1).

TABLE 1: Demographic, anthropometric, haemodynamic and biochemical parameters of the study participants.

Characteristics	All (*n* = 142)		Male (*n* = 39)		Female (*n* = 103)		*p*-value
	Median	IQR	Median	IQR	Median	IQR	
Demographic							
Age (years)	63.00	53–67	65.00	54–69	60.00	52–67	0.080
Anthropometric							
Waist circumference (cm)	105.00	93–117	97.00	91–112	107.00	93–117	0.117
Body mass index (kg/m^2)	32.30	28–35.38	30.00	26.45–32.91	32.00	28.60–37	0.006
Haemodynamic							
Systolic blood pressure (mmHg) (*n* = 133)	146.00	128–165.5	143.00	128.5–156.5	146.50	128–171	0.900
Diastolic blood pressure (mmHg) (*n* = 133)	78.00	67–88	78.00	70.5–87.5	77.00	66.25–88	0.393
Biochemical							
High-density lipoprotein (mmol/L) (*n* = 122)	1.12	0.99–1.30	1.03	0.89–1.22	1.14	1.03–1.35	0.013
Triglyceride (mmol/L) (*n* = 125)	1.46	1.04–2.42	1.48	0.92–2.70	1.46	1.10–2.38	0.889
Haemoglobin A1c (%) (*n* = 133)	9.10	7.45–11.25	9.00	7.50–11.10	9.15	7.33–11.40	0.684

IQR, interquartile range.

Prevalence of metabolic syndrome and its components stratified by gender

According to the IDF criteria, metabolic syndrome was identified in 119 (83.8%) participants, with a higher prevalence among females (90.3%, *n* = 93) compared to males (33.3%, *n* = 26). Hypertension and low HDL-C levels were proportionally higher among males, whereas abdominal obesity, hypertriglyceridaemia and dyslipidaemia were more prevalent among females. Most of the participants exhibited uncontrolled diabetes (HbA1c ≥ 7%; [83.5%, *n* = 111]). Abdominal obesity was the predominant risk component (129 [90.8%]), followed by low HDL-C (105 [86.1%]), dyslipidaemia (108 [82.4%]) and hypertriglyceridaemia (103 [81.7%]) (Table 2).

TABLE 2: Prevalence of metabolic syndrome and its components according to gender.

Symptoms of metabolic syndromes	All (*n* = 142)		Male (*n* = 39)		Female (*n* = 103)	
	n	%	*n*	%	*n*	%
Metabolic syndrome						
Yes	119	83.8	26	66.7	93	90.3
No	23	16.2	13	33.3	10	9.7
Hypertension (*n* = 137)						
Yes	107	78.1	32	84.2	75	75.8
No	30	21.9	6	15.8	24	24.2
Dyslipidaemia (*n* = 131)						
Yes	108	82.4	28	77.8	80	84.2
No	23	17.6	8	22.2	15	15.8
Hypertriglyceridaemia (*n* = 126)						
Yes	103	81.7	28	77.8	75	83.3
No	23	18.3	8	22.2	15	16.7
High-density lipoprotein cholesterol (*n* = 122)						
Low	105	86.1	31	88.6	74	85.1
Normal	17	13.9	4	11.4	13	14.9
Abdominal obesity						
Yes	129	90.8	28	71.8	101	98.1
No	13	9.2	11	28.2	2	1.9
Haemoglobin A1c groups (*n* = 133) (%)						
< 7.0	22	16.5	6	16.2	16	16.7
≥ 7	111	83.5	31	83.8	80	83.3

Association of metabolic syndrome with demographic, anthropometric, haemodynamic and biochemical parameters of study participants

Bivariate analysis revealed significant associations between metabolic syndrome and sex, age, BMI, hypertension, dyslipidaemia, HDL-C, and hypertriglyceridaemia. In contrast, HbA1c was not significantly associated with metabolic syndrome (Table 3).

Gender subgroup analysis demonstrated comparable association of dyslipidaemia and hypertriglyceridaemia with metabolic syndrome, suggesting their predictive power irrespective of gender. However, the effect of BMI was more pronounced among males (Table 4), whereas age, hypertension and HDL-C were more pronounced among females (Table 5), suggesting potential gender-specific mechanisms. No gender differences were observed for HbA1c.

Factors predicting metabolic syndrome among study participants

Binary logistic regression analysis indicated that females were significantly more likely to have metabolic syndrome than males (odds ratio [OR] = 12.26; 95% CI: 2.69–55.96, *p* = 0.001). Participants with hypertension had increased odds of metabolic syndrome (OR = 5.90; 95% CI: 1.30–26.79, *p* = 0.022), while dyslipidaemia was also a strong predictor (OR = 9.57; 95% CI: 2.20–41.60, 0.003) (Table 6).

Gender-specific subgroup analysis identified obesity as the only predictor of metabolic syndrome among males, whereas dyslipidaemia was the sole predictor among females. Obese males were 28.34 times more likely to develop metabolic syndrome (OR = 28.34; 95% CI: 2.23–359.80, *p* = 0.010), while females with dyslipidaemia had markedly increased odds (OR = 59.06; 95% CI: 3.46–1007.16, *p* = 0.005) of developing metabolic syndrome (Table 7).

Discussion

Metabolic syndrome encompasses multiple risk factors arising from insulin resistance, accompanied by abnormal adipose tissue deposition and function.[24] Patients with metabolic syndrome have a twofold increased risk of

TABLE 3: Association of metabolic syndrome with demographic, anthropometric, haemodynamic and biochemical parameters of study participants.

Variables of interest	All (*n* = 142)		Metabolic syndrome (*n* = 119)		Non-metabolic syndrome (*n* = 23)		Crude		x^2 *p*-value
	n	%	*n*	%	*n*	%	OR	95%CI	
Sex	-	-	-	-	-	-	4.7	1.8–11.8	0.0020
Male	39	27.5	26	66.7	13	33.3	-	-	-
Female	103	72.5	93	90.3	10	9.7	-	-	-
Age group (years)	-	-	-	-	-	-	5.8	2.0–17.0	0.0020*
≥ 40	124	87.3	109	87.9	15	12.1	-	-	-
< 40	18	12.7	10	55.6	8	44.4	-	-	-
Body mass index (kg/m²)	-	-	-	-	-	-	5.3	2.0–13.9	0.0010
≥ 30	90	63.4	83	92.2	7	7.8	-	-	-
< 30	52	36.6	36	69.2	16	30.8	-	-	-
Hypertension (*n* = 137)	-	-	-	-	-	-	4.9	1.8–13.2	0.0020*
Yes	107	78.1	97	90.7	10	9.3	-	-	-
No	30	21.9	20	66.7	10	33.3	-	-	-
Dyslipidaemia (*n* = 131)	-	-	-	-	-	-	11.1	3.6–34.2	< 0.0001*
Yes	108	82.4	101	93.5	7	6.5	-	-	-
No	23	17.6	13	56.5	10	43.5	-	-	-
High-density lipoprotein cholesterol (*n* = 122)	-	-	-	-	-	-	6.7	2.1–21.3	0.0020*
Low	105	86.1	95	90.5	10	9.5	-	-	-
Normal	17	13.9	10	58.8	7	41.2	-	-	-
Hypertriglyceridaemia (*n* = 126)	-	-	-	-	-	-	10.5	3.4–32.5	< 0.0001*
Yes	103	81.7	96	93.2	7	6.8	-	-	-
No	23	18.3	13	56.5	10	43.5	-	-	-
Haemoglobin A1c groups (*n* = 133) (%)	-	-	-	-	-	-	-	-	0.6420*
< 7.0	23	17.3	19	82.6	4	17.4	0.9	0.3–3.1	1.0000*
7 – 10	60	45.1	52	86.7	8	13.3	1.5	0.6–4.0	0.5040
> 10	50	37.6	40	80.0	10	20.0	0.7	0.3–1.7	0.5540

OR, odds ratio; CI, confidence interval.

*, signifies statistical significance based on Fisher's exact test *p*-value.

TABLE 4: Association of metabolic syndrome with demographic, anthropometric, haemodynamic and biochemical parameters in males.

Variables of interest	Male (*n* = 39)				Crude		x^2 *p*-value
	Metabolic syndrome (*n* = 26)		Non-metabolic syndrome (*n* = 13)				
	n	%	*n*	%	OR	95% CI	
Age group (years)	-	-	-	-	7.5	0.7–81.0	0.099*
≥ 40	25	71.4	10	28.6	-	-	-
< 40	1	25.0	3	75.0	-	-	-
Body mass index group (kg/m²)	-	-	-	-	12.4	2.2–69.2	0.005
≥ 30	18	90.0	2	10.0	-	-	-
< 30	8	42.1	11	57.9	-	-	-
Hypertension	-	-	-	-	2.6	0.4–15.1	0.357*
Yes	23	71.9	9	28.1	-	-	-
No	3	50.0	3	50.0	-	-	-
Dyslipidaemia	-	-	-	-	6.1	1.1–33.2	0.040*
Yes	22	78.6	6	21.4	-	-	-
No	3	37.5	5	62.5	-	-	-
High-density lipoprotein cholesterol level	-	-	-	-	2.4	0.3–20.1	0.575*
Low	22	71.0	9	29.0	-	-	-
Normal	2	50.0	2	50.0	-	-	-
Hypertriglyceridaemia	-	-	-	-	6.1	1.1–33.2	0.040*
Yes	22	78.6	6	21.4	-	-	-
No	3	37.5	5	62.5	-	-	-
Haemoglobin A1c groups (%)	-	-	-	-	-	-	0.737*
< 7.0	4	57.1	3	42.9	0.7	0.1–3.6	0.636*
7 – 10	12	70.6	5	29.4	1.6	0.4–6.3	0.503
> 10	8	61.5	5	38.5	0.8	0.2–3.3	0.755

OR, odds ratio; CI, confidence interval.

*, signifies statistical significance based on Fisher's exact test *p*-value.

cardiovascular disease within 5 years to 10 years and a fivefold increased risk for T2DM.[37] Low- and middle-income countries already bear a disproportionate burden of T2DM (4 in 5 persons) compared to the global ratio of 1 in 9.[4] By 2050, diabetes prevalence is projected to rise by 45% globally, with increases of 10% in Europe (72.4 million) and 142% in Africa (59.5 million).[4] In general, metabolic health rates show no evidence of decline across high-, middle-

TABLE 5: Association of metabolic syndrome with demographic, anthropometric, haemodynamic and biochemical parameters in females.

Variables of interest	Female (n = 103)				Crude		x^2 p-value
	Metabolic syndrome (n = 93)		Non-metabolic syndrome (n = 10)				
	n	%	n	%	OR	95% CI	
Age group (years)	-	-	-	-	9.3	2.3–38.5	0.0040*
≥ 40	84	94.4	5	5.6	-	-	-
< 40	9	64.3	5	35.7	-	-	-
Body mass index group (kg/m²)	-	-	-	-	2.3	0.6–8.7	0.2840*
≥ 30	65	92.9	5	7.1	-	-	-
< 30	28	84.8	5	15.2	-	-	-
Hypertension	-	-	-	-	30.5	3.5–264.4	< 0.0001
Yes	74	98.7	1	1.3	-	-	-
No	17	70.8	7	29.2	-	-	-
Dyslipidaemia	-	-	-	-	39.5	4.2–373.1	< 0.0001*
Yes	79	98.8	1	1.3	-	-	-
No	10	66.7	5	33.3	-	-	-
High-density lipoprotein cholesterol level	-	-	-	-	45.6	4.7–440.6	< 0.0001
Low	73	98.6	1	1.4	-	-	-
Normal	8	61.5	5	38.5	-	-	-
Hypertriglyceridaemia	-	-	-	-	37.0	3.9–349.7	< 0.0001*
Yes	74	98.7	1	1.3	-	-	-
No	10	66.7	5	33.3	-	-	-
Haemoglobin A1c groups (%)	-	-	-	-	-	-	0.6430*
< 7.0	15	93.8	1	6.3	1.7	0.2–14.3	0.6420
7 – 10	40	93.0	3	7.0	1.7	0.4–7.2	0.4720
> 10	32	86.5	5	13.5	0.5	0.1–1.9	0.2790

OR, odds ratio; CI, confidence interval.

*, signifies statistical significance based on Fisher's exact test p-value.

TABLE 6: Factors predicting metabolic syndrome among study participants.

Independent associates	Adjusted OR	95% CI	p-value
Body mass index (kg/m²)	1.000	0.900–1.290	0.942
Dyslipidaemia dyslipidaemia vs. non-dyslipidaemia	9.570	2.200–41.600	0.003
Sex female vs. male	12.260	2.690–55.960	0.001
Blood pressure groups hypertensive vs. non-hypertensive	5.900	1.300–26.790	0.022
Constant	0.006	0.006	0.029

OR, odds ratio; CI, confidence interval.

and low-income countries[38]; with disproportionately elevated prevalence observed among ageing, urbanised, non-African females and high-income level populations.[38,39] Pooled analyses estimate a global prevalence of 31.4% and higher rates in high-income countries (33.4% – 34.6%) compared to Africa (23.1%).[39] Among individuals with type 2 diabetes, prevalence is elevated in high-income countries such as Spain[40] and reaches 63.1% in sub-Saharan African countries,[41] with Southern African countries most affected.[42]

Metabolic syndrome is increasingly prevalent worldwide, primarily driven by rising obesity and sedentary lifestyles. Consequently, it represents both a public health challenge and a clinical issue. At the population level, a greater emphasis is required on lifestyle changes to reduce obesity and promote physical activity. At the clinical level, early identification of individuals affected is essential to mitigate multiple risk factors.[37] In South Africa, literature on the prevalence and predictors of metabolic syndrome remains limited, with no prior studies conducted among patients with T2DM in Mthatha, Eastern Cape.

In the present study, metabolic syndrome was identified in 83.8% of participants, exceeding prevalence estimates reported among type 2 diabetes patients in Ethiopia (52.38%), Nigeria (63.6%)[29,30] and Ghana (58%) using the NCEP-ATPIII and 59.90% using the harmonised criteria.[27,28] A systematic review of sub-Saharan African populations reported prevalence estimates of 60.8% by IDF criteria and 63.1% by NCEP-ATPIII.[25] Thus, the prevalence observed in the present setting falls within the reported range for sub-Saharan Africa but is notably higher. Comparable rates have been documented in Asia, with Nepal reporting 80.5%[31] and central India 57.7%.[26]

Among the 119 individuals with metabolic syndrome, prevalence was higher among females (90.3%) than males (66.7%). Comparable findings have been reported in Ghana, where the prevalence in females was approximately threefold that of males (77.01% vs. 22.99%),[27] and in Ethiopia, where females also exhibited higher rates.[29] A systematic review across sub-Saharan Africa similarly demonstrated a pooled prevalence of 71.6% (95% CI: 60.2–82.9) in females compared to 44.5% (95% CI: 34.2–54.8) in males.[25] In Asia, prevalence was higher among females in both central India (58.1% vs. 41%)[26] and Nepal.[31] Notably, the gender-stratified prevalence observed in the present study exceeds that reported in these settings. In contrast, findings from North Central Nigeria indicated a higher prevalence in males (74.5% vs. 64.9%; $p < 0.05$), attributed to the greater physical activity among women in that region.[30]

The higher prevalence of metabolic syndrome among females in the present study may be attributed to differences in

TABLE 7: Factors predicting metabolic syndrome in male and female participants.

Independent associates	Male			Female		
	Adjusted OR	95% CI	*p*-value	Adjusted OR	95% CI	*p*-value
Age group ≥ 40 vs. < 40 years	N\M	-	N\M	1.870	0.078–46.720	0.702
Body mass index (kg/m^2)	28.330	2.23–359.81	0.010	N\M	-	N\M
Dyslipidaemia (dyslipidaemia vs. non-dyslipidaemia)	9.510	0.87–103.97	0.065	59.060	3.460–1007.160	0.005
Blood pressure groups (hypertensive vs. non-hypertensive)	N\M	-	N\M	21.750	0.990–477.850	0.051
Constant	0.139	-	0.090	0.199	-	0.290

OR, odds ratio; CI, confidence interval; N\M, not in the model.

health-seeking behaviour, as women are more likely than men to consult a healthcare practitioner at the early disease stages.[43] In South Africa, particularly among the black population, females generally have higher body weight than males,[44] which may reflect a combination of genetic predisposition and the influence of Western dietary patterns.[45] Furthermore, weight gained following multiple pregnancies often proves challenging to reverse.[46] Given that females comprised 72.5% of the study population, they contributed substantially to the overall obesity rate of 63.4%. The greater proportion of males in the non-metabolic group may be explained by the use of European-derived waist circumference cut-offs, which may be set too high for African males (≥94 cm) and too low for South African black females (≥80 cm) who are typically more obese.[47]

In the present study, increased waist circumference (indicative of abdominal obesity) was the most prevalent component, observed in 90.8% (*n* = 129) of participants. This was followed by low HDL-C (86.1%), dyslipidaemia (82.4%), hypertriglyceridaemia (81.7%), hypertension (78.1%) and obesity (63.4%). Comparative data from North Central Nigeria reported central obesity in 80% of patients, hypertension in 63%, hypertriglyceridaemia in 62% and low HDL-C in 70%,[30] all lower than the rates observed in the present setting. A systematic review of metabolic syndrome components in sub-Saharan Africa, based on IDF criteria, documented pooled prevalence rates of central obesity (61.6%), low HDL-C (49.9%) hypertriglyceridaemia (49.2%) and hypertension (56.1%).[25] In Nepal, central obesity (↑waist circumference) was the most prevalent component (99.9%), higher than the rate in the present study.[31] Similarly, an Indian study using NCEP-ATP criteria reported increased waist circumference in 64% of participants, with a lower prevalence of hypertension (45%), hypertriglyceridaemia (46%) and low HDL-C (30%), compared with the present findings. In Ghana, using NCEP-ATP III criteria, hypertension was the predominant component (60%), followed by high waist circumference,[27] which contrasts with the present study and other reports, where increased waist circumference was most common.

In developing countries, increasing urbanisation and lifestyle changes have led to a greater adoption of Western dietary patterns, characterised by refined carbohydrates, processed foods and unhealthy fats.[48,49] This trend has contributed to the rising prevalence of obesity and dyslipidaemia,[50] which may explain the high rate of dyslipidaemia (82.4%) in the present study. Hypertension is also increasing in these countries, likely because of factors such as inadequate sleep from demanding work schedules, insufficient physical activity and financial stress.[51] Accordingly, the high prevalence of hypertension (78.1%) in this population was not unexpected. Furthermore, a substantial proportion of participants had an HbA1c level greater than 7%, indicating poor glycaemic control among both the metabolic and non-metabolic groups. This may be attributed to limited financial resources, restricting patients' ability to attend regular clinical reviews or access treatment. Individuals from low socioeconomic backgrounds also face challenges in adhering to dietary recommendations, as financial constraints hinder their ability to purchase appropriate food.[52]

Among the study participants who met the IDF criteria for metabolic syndrome (83.8%), the prevalence of individual components was as follows: hypertension (82.9%), dyslipidaemia (88.6%), low HDL (90.5%) and hypertriglyceridaemia (88.1%). Obesity was present in 69.7% cases. No statistically significant gender differences were observed for these variables. This finding contrasts with results from Ghana, where central obesity and low HDL levels differed significantly between males and females under the NCEP-ATPIII criteria.[27] In North Central Nigeria, 79% of metabolic syndrome subjects had dyslipidaemia, and 41% were obese (↑BMI),[30] indicating a lower dyslipidaemia rate compared with the present setting (88.6%). Similarly, data from central India reported hypertension (69%), high triglyceride (44%) and low HDL (59%) among metabolic syndrome subjects,[26] all of which were lower than the rates observed in the cohort for the present study.

In the non-metabolic syndrome group, males predominated (56.5%) compared to females (43.5%), whereas the metabolic syndrome group showed a higher proportion of females (56.5%). Significant differences were observed between the metabolic and non-metabolic syndrome groups with respect to gender, obesity (92.2% vs. 7.8%), hypertension (90.7% vs. 9.3%), dyslipidaemia (93.5% vs. 6.5%), hypertriglycerides (93.2% vs. 6.8%) and low HDL-C (90.5% vs. 9.5%). These findings are consistent with the established association of metabolic syndrome with female gender, obesity and increased waist circumference. Comparable results were reported in India, where significant differences between metabolic syndrome and non-metabolic syndrome groups were noted for age, gender, weight, BMI, waist circumference (WC), systolic and diastolic blood pressure, TG and HDL-C.[32]

In the present study, binary logistic regression analysis of gender, BMI, blood pressure and dyslipidaemia identified female gender, hypertension and dyslipidaemia as

independent predictors of metabolic syndrome. Given the predominance of females in the cohort, gender subgroup analysis was performed. Obesity emerged as the independent factor associated with metabolic syndrome in males, whereas dyslipidaemia was the independent factor in females. Similar findings have been reported elsewhere: in Ethiopia, female gender and BMI were associated with metabolic syndrome among patients with T2DM.[29] In Ghana, gender, BMI and educational status were identified as risk factors when NCEP-ATPIII criteria were applied.[27] In India, elevated TG, diastolic blood pressure, WC, sedentary behaviour (h/day) and lack of moderate activity (≥150 min/week) were significantly associated with metabolic syndrome among diabetes patients ($p < 0.05$).[32] In the present cohort, obesity was confirmed as an independent risk factor in males, reflecting increased WC alongside other components of metabolic syndrome. However, evaluation of factors associated with hypertension and dyslipidaemia did not yield significant associations, particularly with respect to age and hypertension. This is notable, as hypertension typically increases with age, making the absence of such an association unexpected.[53]

The identification of established components of metabolic syndrome as risk factors demonstrates their magnitude and independent contribution to the overall risk. Dyslipidaemia was confirmed as the principal driver among females. At the same time, obesity was the key determinant among males in this rural South African cohort, highlighting the relevance of gender-specific prevention strategies. The high prevalence of metabolic syndrome observed has important clinical implications. Firstly, adults with type 2 diabetes, especially women with dyslipidaemia and obese men, should be routinely screened for metabolic syndrome during outpatient visits to enable early intervention and reduce morbidity and mortality burdens for both patients and the healthcare system. Secondly, a systematic assessment to exclude metabolic syndrome in individuals with dyslipidaemia or high BMI should be integrated into the multimorbidity management models. Thirdly, multifactorial cardiovascular disease risk management should be reinforced in type 2 diabetes cohorts with metabolic syndrome.

Limitations

The present study's findings cannot be generalised to facilities within the district or province, as the study site manages only diabetic patients with complications or persistent uncontrolled blood sugar levels. The initially planned sample size of 192 could not be reached because of COVID-19 restrictions on facility access. Incomplete laboratory results also posed a limitation, as samples were occasionally unprocessed owing to NHLS gatekeeping rules or rejected for technical reasons. The sampled population was predominantly female, which may limit the applicability to males; however, subgroup analyses demonstrated consistent predictive effects of dyslipidaemia and hypertriglyceridaemia. Interpretation of dyslipidaemia in a male-dominated population and obesity in a female-dominated population should therefore be approached with caution. Another limitation was the omission of the ethnic background, despite evidence suggesting a higher predisposition to metabolic syndrome among women of African descent. The absence of ethnicity-specific data leaves a significant gap that future studies should address. Furthermore, reliance on IDF criteria, which mandate increased WC, may exclude individuals with normal WC who would otherwise meet diagnostic thresholds under the WHO, NCEP-ATPIII or harmonised criteria. Finally, the research-made tool demonstrated modest internal consistency, which may be attributed to the small sample size, the measurement of distinct but related constructs, and the omission of ethnicity data. This warrants future refinement and validation in larger samples. Despite these limitations, the study provides valuable data on the prevalence and putative risk factors of metabolic syndrome in a typical South African type 2 diabetes population. The identified predictors offer potential utility for risk stratification at the initiation of treatment and ongoing monitoring.

Recommendations

The high rate of metabolic syndrome among type 2 diabetes patients in this rural South African population calls for an aggressive root-cause management model to complement symptom-oriented management approaches in reducing cardiovascular risk. The integration of lifestyle, pharmacological and surgical interventions is particularly critical in low- and middle-income countries, where disparities and limited access to services often hinder the effectiveness of symptom-based models. Future prospective longitudinal studies are warranted to identify common complications associated with metabolic syndrome in the adult type 2 diabetes cohort, enabling targeted early intervention.

Conclusion

This study demonstrated a high prevalence of metabolic syndrome among T2DM patients managed at Nelson Mandela Academic Hospital in Mthatha, consistent with studies conducted both within and outside Africa. Metabolic syndrome was more prevalent among females, with abdominal obesity identified as the main risk component. Dyslipidaemia and obesity were independent factors associated with metabolic syndrome.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

CRediT authorship contribution

Oludayo O. Olubanwo: Conceptualisation, Methodology, Investigation, Writing – original draft, Visualisation, Project administration, Data curation, Resources, Writing – review & editing. Mirabel K. Nanjoh: Conceptualisation, Formal analysis, Writing – original draft, Software, Writing – review & editing. Chukwuma Ekpebegh: Conceptualisation, Methodology, Investigation, Writing – original draft, Visualisation, Data curation, Writing – review & editing, Supervision. All authors reviewed the article, contributed to the discussion of results, approved the final version for submission and publication and take responsibility for the integrity of its findings.

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Data availability

The data that support the findings of this study are available from the corresponding author, Mirabel K. Nanjoh, upon reasonable request.

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