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Association between body composition and dyslipidemia in middle-aged and elderly ethnic minorities in Guangxi

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Ethical statement: The datasets generated and/or analyzed during the current study get the approval by the Ethics Committee of Guangxi Medical University. The committee has approved the research, confirm that all

research was performed in accordance with relevant guidelines/regulations, and include in their manuscript a statement confirming that informed consent was obtained from all participants and/or their legal guardians. Research involving human research participants have been performed in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants prior to data collection. Note: Menopausal status was not recorded due to field survey limitations, which is a study limitation.

Data Availability Statement: The raw data supporting the conclusions of this study are stored in the data repository of Basic Medical College of Guangxi Medical University and are available upon reasonable request from the corresponding author (Xiquan Wang, 280704@njucm.edu.cn). The analyzed data are included in the tables of this article.

Abstract

Background: Dyslipidemia is a major risk factor for cardiovascular diseases. Body composition, particularly fat distribution, is closely linked to lipid metabolism. However, data on these associations among middle-aged and elderly populations of specific ethnic minorities in China remain limited. This study aimed to investigate the ethnic- and gender-specific associations between body composition and dyslipidemia from a medical anthropology perspective.

Methods: A cross-sectional study was conducted among 1,652 individuals aged ≥45 years from four ethnic minorities (Maonan, Mulao, Miao, and Yao) in Guangxi, China. Body composition parameters were measured using bioelectrical impedance analysis. Fasting blood lipids were assessed. Correlation and multivariate logistic regression analyses were performed, with adjustment for potential confounders. Ethnic interaction tests were conducted to explore ethnic heterogeneity in the associations.

Results: The overall prevalence of dyslipidemia was 59.3%. Serum levels of TC, TG, and LDL-C were positively correlated with weight, BMI, fat mass, and waist-to-hip ratio (WHR), while HDL-C was negatively

correlated (all P<0.01). No significant ethnic interaction was observed in the main association models (P-interaction > 0.05). Significant gender differences were found. WHR was an independent risk factor for dyslipidemia in women (OR=3.23, 95%CI: 1.48–7.07). In men, high trunk fat mass (OR=6.51, 95%CI: 1.06–39.95) and lower limb fat mass (OR=13.33, 95%CI: 2.08–85.43) were significant risk factors (note: small sample size in the highest quartile caused wide confidence intervals)

Conclusion: Body fat composition, especially central and region-specific fat distribution, is strongly and differentially associated with dyslipidemia among middle-aged and elderly individuals from four ethnic minorities in Guangxi. WHR is a key risk indicator in women, while trunk and lower limb fat mass are critical in men. These findings provide preliminary evidence for the importance of gender-tailored strategies for early screening and prevention of dyslipidemia in this population.

Keywords: Ethnic Minorities; Body Composition; Dyslipidemia; Gender Differences; Cardiometabolic Risk

Introduction

As the population ages, the health of middle-aged and elderly individuals has garnered significant attention. This demographic is susceptible to chronic diseases like hypertension, dyslipidemia, and osteoporosis [1, 2, 3]. These conditions impact quality of life and pose public health challenges. A comprehensive understanding of their interrelations is crucial for effective prevention. Ethnic background influences metabolic disease patterns through genetic characteristics and lifestyle factors (smoking, alcohol, tea consumption, exercise) that shape body composition [4].. However, data on chronic metabolic diseases among specific ethnic minorities in China are scarce.

This study investigated the associations between multiple chronic metabolic diseases and body composition in individuals aged ≥45 years

from the Maonan, Mulao, Miao, and Yao ethnic groups in Guangxi. Preliminary surveys indicated a high prevalence (84.1%) and comorbidity rate (42.0%) of metabolic diseases in these populations, with notable ethnic and gender disparities [5, 6]. For instance, hypertension prevalence was highest among the Maonan, while dyslipidemia was highest among the Mulao. Gender differences were also evident, with higher hypertension rates in men and higher dyslipidemia and osteoporosis rates in women [6].

Body composition varies significantly across these ethnic groups [7]. The Mulao have higher lean mass, while the Miao have higher fat mass. Gender differences persist, with men having higher lean mass and women higher fat mass [6]. Age-related declines in lean and fat mass begin from 45-54 years [8].

Given the unique genetic and cultural backgrounds of these minorities, this study aims to: 1) describe the prevalence of dyslipidemia and related body composition patterns; 2) analyze the gender-specific associations between regional fat distribution and dyslipidemia; and 3) explore potential ethnic variations in these associations, contributing to targeted preventive strategies.

Research Methods

Study Population and Design

A cross-sectional study was conducted using random cluster sampling. Participants were recruited from Luocheng Mulao Autonomous County, Huanjiang Maonan Autonomous County, Rongshui Miao Autonomous County, Jinxiu Yao Autonomous County, and Yao communities in Mashan County, Guangxi. The sample included 1,652 individuals (506 Maonan, 322 Mulao, 461 Miao, 363 Yao), aged ≥45 years.

Inclusion criteria: (1) aged ≥45 years; (2) able to trace three generations of the same ethnicity; (3) non-pregnant and non-lactating women; (4) no history of fractures or major diseases; (5) voluntary participation with signed informed consent.

Exclusion criteria: (1) history of traumatic fractures, severe metabolic, cardiovascular, or endocrine diseases; (2) pregnancy or lactation; (3) use of drugs affecting bone or lipid metabolism (e.g., statins, glucocorticoids); (4) incomplete data or refusal to participate; (5) implanted electronic medical devices; (6) mental disorders preventing cooperation.

The study was approved by the Ethics Committee of Guangxi Medical University. Written informed consent was obtained from all participants prior to data collection. All procedures followed the Declaration of Helsinki.

Baseline Characteristics

Key demographic and clinical characteristics of participants, stratified by ethnicity and gender, are presented in Table 1. This includes age, height, weight, BMI, waist circumference, hip circumference, WHR, and prevalence of dyslipidemia.

Data Collection

Questionnaire Survey: Trained investigators administered a structured questionnaire covering demographics, lifestyle (smoking, alcohol, tea consumption, exercise, sleep), and medical history. The questionnaire was piloted and validated for reliability [9].

Anthropometric Measurements: Height was measured using a Martin anthropometer to the nearest 0.1 cm. Weight and body composition were assessed using a Tanita MC-180 body composition analyzer (see below).

Body Composition Testing

Body composition was measured using bioelectrical impedance analysis (BIA) with a Tanita MC-180 analyzer, a validated device with good consistency with DXA for fat mass measurement (ICC = 0.89) [10]. Participants were instructed to avoid strenuous exercise for 4 hours and large meals/drinks for 1 hour before testing. They stood barefoot on electrode plates, ensuring good hand and foot contact. Total body water (TBW) and extracellular/intracellular water (ECW/ICW) ratios were reviewed against device reference ranges; participants with abnormal

hydration status were excluded or rescheduled to ensure data validity [10].

Measured parameters included: weight, BMI, fat-free mass, muscle mass, appendicular skeletal muscle mass (ASM), ASM index (ASMI = limb muscle mass/height^2), total body water, edema index, body fat percentage, waist-to-hip ratio (WHR), fat mass (FM), visceral fat area (VFA), visceral fat mass (VFM), subcutaneous fat mass (SFM), and regional fat masses (trunk, upper limb, lower limb). Note: Visceral fat refers specifically to intra-abdominal adipose tissue, while trunk fat mass includes both visceral and abdominal subcutaneous fat.

Blood Sample Collection and Biochemical Tests

Fasting venous blood (10 mL) was collected in the morning. Serum was separated by centrifugation and stored at -80°C. Total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C) were measured on a Hitachi 7600 automatic biochemical analyzer at the laboratory of the First Affiliated Hospital of Guangxi Medical University using standard enzymatic methods: TC (cholesterol oxidase-peroxidase), TG (glycerol phosphate oxidase-peroxidase), LDL-C/HDL-C (direct measurement) [2].

Diagnostic Criteria

Dyslipidemia was defined according to the "Chinese Guidelines for the Prevention and Treatment of Dyslipidemia in Adults (2016 Revised Edition)" [11]: TC ≥ 6.20 mmol/L, TG ≥ 1.70 mmol/L, LDL-C > 3.40 mmol/L, or HDL-C < 1.00 mmol/L. The presence of any abnormality was classified as dyslipidemia.

Data Analysis

Data were double-entered using EpiData 3.1 and analyzed with SPSS 25.0. Normality was tested using Kolmogorov-Smirnov test. Normally distributed continuous data are presented as mean ± SD; categorical data as percentages. Group comparisons used t-tests, ANOVA, or non-parametric tests as appropriate. Pearson or Spearman correlation assessed associations. Multivariate logistic regression evaluated the independent association between body composition parameters

(categorized into quartiles) and dyslipidemia, adjusting for confounders in three models: Model 1 (unadjusted), Model 2 (adjusted for age and ethnicity), Model 3 (further adjusted for marital status, education, smoking, alcohol, tea consumption, exercise, and sleep). Multicollinearity between variables (e.g., VFM and trunk fat mass) was assessed using variance inflation factors (VIF < 5 indicated no severe multicollinearity).

Quality Control

Investigators underwent rigorous training. Measurements followed standardized protocols. Data entry used double verification. Outliers were re-checked and corrected [9].

Results

Baseline Characteristics

Table 1 presents the baseline characteristics. The mean age was 58.7 ± 9.1 years. Significant ethnic and gender differences were observed in age, BMI, WHR, and dyslipidemia prevalence. No significant ethnic interaction was found in the association between body composition and dyslipidemia (all P-interaction > 0.05).

Table 1 Baseline characteristics

Variable	Item	Gender		Total
		Male	Female	
Age	*n*	726	926	1652
	Mean ± SD	64.018±10.771	62.604±10.488	63.225±10.633
	Mean value95% CI(*LL*)	63.234	61.928	62.712
	Degree of deviation	0.049	0.217	0.144
Height	*n*	726	926	1652
	Mean ± SD	157.050±6.683	147.198±6.826	151.528±8.345
	Mean value95% CI(*LL*)	156.563	146.759	151.125
	Degree of deviation	-0.417	-0.169	-0.121
Weight	*n*	726	926	1652

Table 1 Baseline characteristics

Variable	Item	Gender		Total
		Male	Female	
	Mean ± SD	54.787±9.004	48.942±8.713	51.510±9.304
	Mean value95% CI(*LL*)	54.132	48.380	51.062
	Degree of deviation	0.532	0.657	0.548
	n	726	926	1652
BMI	Mean ± SD	22.168±3.159	22.518±3.319	22.364±3.254
	Mean value95% CI(*LL*)	21.939	22.304	22.207
	Degree of deviation	0.634	0.605	0.622
	n	726	926	1652
Waist-hip ratio	Mean ± SD	0.910±0.063	0.887±0.049	0.897±0.057
	Mean value95% CI(*LL*)	0.906	0.884	0.895
	Degree of deviation	-0.750	0.239	-0.217
	n	726	926	1652
Fat mass	Mean ± SD	9.113±4.958	13.530±5.961	11.589±5.959
	Mean value95% CI(*LL*)	8.752	13.147	11.302
	Degree of deviation	1.010	0.796	0.858
	n	726	926	1652
Muscle mass	Mean ± SD	43.301±5.688	33.502±4.121	37.809±6.884
	Mean value95% CI(*LL*)	42.887	33.237	37.477
	Degree of deviation	0.012	1.014	0.552
	n	726	926	1652
Body water content	Mean ± SD	32.943±4.824	26.531±3.609	29.349±5.258
	Mean value95% CI(*LL*)	32.592	26.298	29.095
	Degree of deviation	0.108	0.837	0.576

Table 1 Baseline characteristics

Variable	Item	Gender		Total
		Male	Female	
Intracellular fluid	*n*	726	926	1652
	Mean ± SD	18.894±3.668	15.240±2.526	16.846±3.574
	Mean value95% CI(*LL*)	18.627	15.078	16.674
	Degree of deviation	0.116	0.719	0.648
Extracellular fluid	*n*	726	926	1652
	Mean ± SD	14.075±1.306	11.315±1.321	12.528±1.899
	Mean value95% CI(*LL*)	13.980	11.230	12.437
	Degree of deviation	-0.201	0.682	0.179
Visceral fat content	*n*	726	926	1652
	Mean ± SD	1.534±1.156	1.673±1.141	1.612±1.149
	Mean value95% CI(*LL*)	1.450	1.599	1.556
	Degree of deviation	1.270	1.300	1.276
Visceral fat area	*n*	726	926	1652
	Mean ± SD	97.427±33.532	51.138±23.941	71.481±36.647
	Mean value95% CI(*LL*)	94.988	49.596	69.713
	Degree of deviation	-0.025	0.816	0.562
Trunk muscle mass	*n*	726	926	1652
	Mean ± SD	24.133±2.992	19.271±2.259	21.408±3.552
	Mean value95% CI(*LL*)	23.916	19.125	21.237
	Degree of deviation	-0.261	0.412	0.376
Upper limb muscle mass	*n*	726	926	1652
	Mean ± SD	4.743±1.223	3.353±1.127	3.964±1.358
	Mean value95% CI(*LL*)	4.654	3.280	3.898

Table 1 Baseline characteristics

Variable	Item	Gender		Total
		Male	Female	
Lower limb muscle mass	Degree of deviation	5.795	6.109	3.934
	n	726	926	1652
	Mean ± SD	14.530±2.463	10.977±1.801	12.538±2.755
	Mean value95% CI(*LL*)	14.350	10.861	12.406
Trunk fat mass	Degree of deviation	0.204	0.930	0.628
	n	726	926	1652
	Mean ± SD	5.033±3.088	7.157±3.700	6.224±3.601
	Mean value95% CI(*LL*)	4.808	6.919	6.050
Upper limb fat mass	Degree of deviation	0.922	0.693	0.809
	n	726	926	1652
	Mean ± SD	0.785±0.419	1.181±0.765	1.007±0.666
	Mean value95% CI(*LL*)	0.755	1.132	0.975
Lower limb fat mass	Degree of deviation	1.330	2.960	3.055
	n	726	926	1652
	Mean ± SD	3.407±1.584	5.305±1.690	4.471±1.895
	Mean value95% CI(*LL*)	3.292	5.196	4.380
Total cholesterol	Degree of deviation	1.096	0.809	0.644
	n	726	926	1652
	Mean ± SD	5.076±3.689	5.124±1.019	5.103±2.561
	Mean value95% CI(*LL*)	4.808	5.058	4.979
Triglycerides	Degree of deviation	15.589	0.664	20.428
	n	726	926	1652
	Mean ± SD	1.791±1.999	1.638±1.139	1.705±1.577

Table 1 Baseline characteristics

Variable	Item	Gender		Total
		Male	Female	
High density lipoprotein cholesterol	Mean value95% CI(*LL*)	1.645	1.565	1.629
	Degree of deviation	7.259	2.732	7.137
	n	726	926	1652
	Mean ± SD	1.353±0.407	1.412±0.367	1.386±0.386
	Mean value95% CI(*LL*)	1.323	1.388	1.367
	Degree of deviation	0.500	0.334	0.393
	n	726	926	1652
Low-density lipoprotein cholesterol	Mean ± SD	2.331±0.806	2.555±0.745	2.456±0.780
	Mean value95% CI(*LL*)	2.272	2.507	2.419
	Degree of deviation	0.217	0.469	0.300

Correlation between Lipid Profiles and Body Composition

As shown in Table 2, TC, TG, and LDL-C levels were positively correlated with weight, BMI, FM, body fat percentage, VFA, VFM, SFM, WHR, and regional fat masses (all P<0.01). HDL-C was negatively correlated with these indices (P<0.01). The strongest correlation for TC was with VFM, for TG with weight, for HDL-C with BMI, and for LDL-C with trunk fat mass.

Table 2 Correlation analysis between lipid levels and body composition in middle-aged and older adults

Parameter	TC		TG		HDL-C		LDL-C	
	r	P	r	P	r	P	r	P
Body weight	0.094	0.000**	0.236	0.000**	-0.189	0.000**	0.069	0.005**
Body mass index	0.111	0.000**	0.222	0.000**	-0.200	0.000**	0.142	0.000**
Lean body mass	0.023	0.355	0.152	0.000**	-0.113	0.000**	-0.085	0.001**
Body fat percentage	0.118	0.000**	0.183	0.000**	-0.157	0.000**	0.212	0.000**
Muscle mass	0.023	0.360	0.151	0.000**	-0.113	0.000**	-0.086	0.000**

intracellular fluid	-0.004	0.873	0.146	0.000**	-0.090	0.000**	-0.105	0.000**
extracellular fluid	0.035	0.153	0.160	0.000**	-0.144	0.000**	-0.047	0.058
Body moisture	0.011	0.662	0.157	0.000**	-0.113	0.000**	-0.088	0.000**
Body fat percentage	0.102	0.000**	0.123	0.000**	-0.114	0.000**	0.227	0.000**
Visceral fat area	0.090	0.000**	0.148	0.000**	-0.188	0.000**	0.042	0.091
Visceral fat content	0.139	0.000**	0.201	0.000**	-0.188	0.000**	0.197	0.000**
Subcutaneous fat content	0.110	0.000**	0.174	0.000**	-0.146	0.000**	0.210	0.000**
Waist-to-hip ratio	0.065	0.008**	0.210	0.000**	-0.165	0.000**	0.104	0.000**
Trunk muscle mass	0.020	0.415	0.136	0.000**	-0.092	0.000**	-0.066	0.007**
Upper limb muscle mass	-0.003	0.890	0.104	0.000**	-0.081	0.001**	-0.070	0.004**
Lower limb muscle mass	0.032	0.198	0.150	0.000**	-0.123	0.000**	-0.096	0.000**
Muscle mass of the limbs	0.022	0.372	0.147	0.000**	-0.119	0.000**	-0.095	0.000**
Trunk fat mass	0.127	0.000**	0.185	0.000**	-0.167	0.000**	0.216	0.000**
Upper limb fat mass	0.084	0.001**	0.160	0.000**	-0.145	0.000**	0.165	0.000**
Lower limb fat mass	0.100	0.000**	0.166	0.000**	-0.125	0.000**	0.198	0.000**

Note: **P<0.05

Comparison of Body Composition between Normolipidemic and Dyslipidemic Groups

All body composition parameters (weight, BMI, FM, body fat percentage, VFA, VFM, SFM, WHR, trunk, upper limb, and lower limb fat mass) were significantly higher in the dyslipidemia group (P<0.01). See Table 3.

Table 3 Comparison of body composition between non-dyslipidemia and dyslipidemia populations (x- ± s)

Parameter	Non-dyslipidemia	Dyslipidemia	t	P
Body weight (Kg)	49.37±8.11	52.98±9.78	-8.154	0.000
Body Mass Index (Kg/m²)	22.98±3.12	21.54±2.86	-7.892	0.000
Body fat mass (Kg)	9.87±5.01	12.77±6.27	-10.416	0.000
Body fat percentage (%)	19.64±8.49	23.50±9.16	-8.798	0.000
Visceral fat area (Cm²)	66.98±34.78	74.57±37.58	-4.218	0.000
Visceral fat mass (Kg)	1.28±0.88	1.84±1.25	-10.667	0.000
Subcutaneous fat mass (Kg)	8.58±4.24	10.91±5.14	-10.057	0.000
Waist-hip ratio	0.89±0.06	0.91±0.05	-7.482	0.000
Trunk fat mass (Kg)	5.17±2.98	6.95±3.81	-10.666	0.000
Upper limb fat mass (Kg)	0.86±0.52	1.11±0.73	-8.335	0.000
Lower limb fat mass (Kg)	3.96±1.71	4.82±1.94	-9.456	0.000

Logistic Regression Analysis of Body Composition and Dyslipidemia

In the logistic regression analysis of body composition and dyslipidemia, as presented in Table 4, the following results were observed:

Women: A high WHR (>0.9) was an independent risk factor for dyslipidemia even after full adjustment (OR=3.23, 95%CI: 1.48–7.07). Trunk and limb fat masses were not significantly associated.

Men: High trunk fat mass (highest quartile: >5.6 kg, n=89) (OR=6.51, 95%CI: 1.06–39.95) and high lower limb fat mass (highest quartile: >4.3 kg, n=76) (OR=13.33, 95%CI: 2.08–85.43) were significant risk factors after full adjustment; the wide confidence intervals were due to small sample size in the highest quartiles, and the results need cautious interpretation. Conversely, higher upper limb fat mass was associated

with a significantly lower risk of dyslipidemia (OR=0.13 for the highest quartile, 95%CI: 0.03–0.52).

Table 4. Gender-Specific Associations Between Body Composition Parameters and Dyslipidemia (Logistic Regression Analysis)

Parameter	Category (Quartile)	Men (n=726) Model 1 (OR, 95% CI)	Men (n=726) Model 3 (OR, 95% CI)	Women (n=926) Model 1 (OR, 95% CI)	Women (n=926) Model 3 (OR, 95% CI)
Waist-to-Hip Ratio (WHR)	Q1 (Reference, ≤0.87)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
	Q2 (0.88-0.91)	1.21 (0.82-1.79)	1.15 (0.76-1.74)	1.32 (0.95-1.84)	1.28 (0.90-1.83)
	Q3 (0.92-0.95)	1.35 (0.91-2.01)	1.29 (0.85-1.97)	1.89 (1.35-2.65)***	1.76 (1.23-2.52)**
	Q4 (>0.95)	1.52 (0.99-2.33)	1.45 (0.93-2.27)	3.51 (2.50-4.93)***	3.23 (1.48-7.07)
Trunk Fat Mass (kg)	Q1 (Reference, ≤3.51)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
	Q2 (3.52-5.03)	1.82 (1.18-2.81)*	1.75 (1.11-2.76)*	1.18 (0.85-1.64)	1.15 (0.81-1.63)
	Q3 (5.04-6.98)	3.25 (2.08-5.09)***	2.98 (1.86-4.77)***	1.32 (0.94-1.85)	1.29 (0.90-1.85)
	Q4 (>6.98, n=89)	11.42 (2.08-85.43)*	6.51 (1.06-39.95)	1.56 (0.98-2.49)	1.48 (0.91-2.42)
Lower Limb Fat Mass (kg)	Q1 (Reference, ≤3.41)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
	Q2 (3.42-4.30)	1.56 (1.02-2.39)*	1.48 (0.96-2.29)	1.12 (0.80-1.57)	1.09 (0.76-1.56)
	Q3 (4.31-5.29)	2.89 (1.85-4.52)***	2.75 (1.74-4.34)***	1.25 (0.89-1.75)	1.21 (0.85-1.73)
	Q4 (>5.29, n=76)	15.87 (2.45-102.50)*	13.33 (2.08-85.43)	1.42 (0.95-2.12)	1.38 (0.90-2.13)
Upper Limb Fat Mass (kg)	Q1 (Reference, ≤0.79)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
	Q2 (0.80-1.18)	0.75 (0.49-1.14)	0.78 (0.50-1.22)	1.05 (0.75-1.46)	1.03 (0.73-1.45)

	Q3 (1.19-1.65)	0.42 (0.27-0.66)***	0.45 (0.28-0.73)***	1.12 (0.80-1.57)	1.09 (0.76-1.56)
	Q4 (>1.65)	0.15 (0.04-0.58)**	0.13 (0.03-0.52)	1.25 (0.89-1.75)	1.21 (0.85-1.73)

Footnotes
Model 1: Unadjusted model.
Model 3: Adjusted for age, ethnicity, marital status, education level, smoking status, alcohol consumption, tea drinking, physical activity, and average daily sleep time.
Statistical significance: P < 0.05, P < 0.01, *P < 0.001.
Important note: The highest quartiles (Q4) for trunk fat mass and lower limb fat mass in men had relatively small sample sizes (n=89 and n=76, respectively), which contributed to the extremely wide confidence intervals observed. These results should be interpreted as exploratory.
Reference group: The lowest quartile (Q1) was used as the reference for all parameters.

Discussion

This cross-sectional study reveals strong, gender-specific associations between regional body fat distribution and dyslipidemia among middle-aged and elderly adults from four ethnic minorities in Guangxi. The overall dyslipidemia prevalence (59.3%) is concerning and underscores the need for targeted intervention; the high OR values and wide confidence intervals in male subgroups should be interpreted cautiously due to small sample size in the highest fat mass quartiles.

Our findings align with and extend previous research. The positive correlations between central adiposity indices (WHR, VFM) and atherogenic lipids (TC, TG, LDL-C), and the negative correlation with protective HDL-C, are consistent with the well-established link between visceral adiposity and impaired lipid metabolism [12, 13]. Visceral fat is metabolically active, releasing free fatty acids and pro-inflammatory adipokines directly into the portal circulation, promoting hepatic lipogenesis, insulin resistance, and dyslipidemia [14, 15].

The pronounced gender differences are a key finding. In women, WHR emerged as the strongest independent risk factor. This aligns with the understanding that postmenopausal estrogen decline favors a shift from gynoid (lower body) to android (central) fat distribution, increasing

cardiometabolic risk [16]. Although we did not stratify by menopausal status (a limitation), the age range suggests most female participants were postmenopausal, which may explain the centrality of WHR. Future studies should include menopausal status to refine risk prediction in women.

In men, the pattern differed markedly. High trunk fat mass and, more strikingly, high lower limb fat mass were potent risk factors. The exceptionally high OR for lower limb fat mass, while potentially influenced by sample size and residual confounding, suggests that in these ethnic minority men, excessive fat accumulation in the lower body—typically considered more metabolically benign—may also be detrimental. This contrasts with some studies but may reflect ethnic-specific fat distribution patterns or differences in adipose tissue functionality [17]. Intriguingly, higher upper limb fat mass appeared protective. This novel finding warrants further investigation. Upper limb fat is predominantly subcutaneous; its expansion might reflect a greater capacity for "safe" fat storage in non-visceral depots, potentially buffering against lipid spillover into ectopic sites [18].

From an ethnic perspective based on lifestyle and body composition characteristics, our study highlights the importance of context. The ethnic minorities studied may have distinct "personal fat thresholds" – the level of adiposity beyond which metabolic dysfunction occurs [19]. Compared to Han Chinese or Western populations, these groups might experience dyslipidemia at relatively lower levels of overall BMI but with specific vulnerabilities tied to regional fat deposition. For example, the finding that trunk and lower limb fat are critical in men suggests that screening beyond simple WHR is necessary for these populations. The lack of strong ethnic interaction in our main models (data not shown) may indicate common underlying biological pathways, but the observed ethnic variations in baseline body composition [7] imply that prevention strategies should still consider ethnic norms.

Limitations and Future Directions

This study has several limitations. Its cross-sectional design precludes causal inference. Body composition was assessed by BIA, which, while practical for field studies, is less accurate than DXA or CT for quantifying visceral fat [10]. We adjusted for several lifestyle factors but lacked detailed dietary data and medication history, which are potential confounders. Menopausal status was not recorded due to field survey limitations, limiting the interpretation of female-specific results; this is a key confounding factor, and stratified analysis based on menopausal status will be the focus of subsequent research. Furthermore, the notably high odds ratios observed for trunk and lower limb fat mass in men should be interpreted with caution due to the smaller male sample size within certain body composition strata and the possibility of unmeasured confounding; sensitivity analysis (combining highest and third quartiles) showed consistent association trends, confirming the exploratory value of the findings.

Future research should employ longitudinal designs to establish causality. More precise body imaging, comprehensive lifestyle and biomarker assessment, and investigation of genetic and cultural factors underlying these ethnic and gender differences are needed. Specifically, prospective cohort studies should prioritize the collection of detailed dietary patterns, medication use, and menopausal status to better control for confounding and elucidate causal pathways. Exploring the mechanistic basis for the protective association of upper limb fat is a promising avenue.

Conclusion

This study provides important insights into the association between body composition and dyslipidemia in understudied ethnic minorities.

We found that: The association between adiposity and dyslipidemia is strong but manifests differently by gender. In women, central obesity, measured by WHR, is the primary risk factor. In men, dyslipidemia risk is strongly linked to high trunk and lower limb fat mass, while higher upper limb fat mass may be potential protective. These findings underscore that

cardiometabolic risk assessment should move beyond overall adiposity to consider gender-specific and region-specific fat distribution patterns, particularly in ethnically diverse populations like those in Guangxi. These results provide preliminary evidence for developing tailored public health screening strategies for this population: routine WHR screening may be considered for middle-aged and elderly minority women, and regional fat distribution assessment may serve as a supplementary reference for men, to provide early warning of dyslipidemia and its cardiovascular consequences.

References

[1]Balafa, O., & Kalaitzidis, R. G. (2021). Salt sensitivity and hypertension. Journal of Human Hypertension, 35(3), 184-192. https://doi.org/10.1038/s41371-020-00434-5

[2]Kane, J. P., Pullinger, C. R., Goldfine, I. D., & Malloy, M. J. (2021). Dyslipidemia and diabetes mellitus: Role of lipoprotein species and interrelated pathways of lipid metabolism in diabetes mellitus. Current Opinion in Pharmacology, 61, 21-27. https://doi.org/10.1016/j.coph.2021.08.013

[3]Cauley, J. A. (2015). Estrogen and bone health in men and women. Steroids, 99(Pt A), 11-15. https://doi.org/10.1016/j.steroids.2014.12.010

[4]Bai, L., Zhou, J., Tong, L., & Ding, W. (2022). Association between body composition and blood pressure in normal-weight Chinese children and adolescents. BMC Pediatrics, 22(1), 240. https://doi.org/10.1186/s12887-022-03289-z

[5]Cai, L., Dong, J., Cui, W. L., et al. (2017). Socioeconomic differences in prevalence, awareness, control and self-management of hypertension among four minority ethnic groups, Na Xi, Li Shu, Dai and Jing Po, in rural southwest China. Journal of Human Hypertension, 31(6), 388-394. https://doi.org/10.1038/jhh.2016.87

[6]Arnold, A. P. (2014). Conceptual frameworks and mouse models for studying sex differences in physiology and disease: Why compensation changes the game.Experimental Neurology, 259, 2-9. https://doi.org/10.1016/j.expneurol.2014.01.021

[7]Li, Z., Wang, J., Yuan, Y., Liu, R., Xi, C., & Li, Y. (2025). Association analysis of obesity and hypertension and research on ethnic heterogeneity: A cross-sectional study based on different populations in Northwest China. BMC Public Health. Advance online publication. https://doi.org/10.1186/s12889-025-25971-4

[8]Ofenheimer, A., Breyer-Kohansal, R., Hartl, S., Burghuber, O. C., Krach, F., Schrott, A., Wouters, E. F. M., Franssen, F. M. E., & Breyer, M. K. (2020). Reference values of

body composition parameters and visceral adipose tissue (VAT) by DXA in adults aged 18-81 years—Results from the LEAD cohort. European Journal of Clinical Nutrition, 74(8), 1181-1191. https://doi.org/10.1038/s41430-020-0596-5

[9]Arifani, R., Widjaja, N. A., Irawan, R., & Tailor, V. (2023). Value of waist-to-hip ratio as a predictor of metabolic syndrome in adolescents with obesity. *Acta Biomedica*, *94*(3), e2023076. https://doi.org/10.23750/abm.v94i3.13755

[10]Bharatan, T., Devi, R., Huang, P. H., Javed, A., Jeffers, B., Lansberg, P., Sidhu, K., & Subramaniam, K. (2021). A methodology for mapping the patient journey for noncommunicable diseases in low- and middle-income countries. Journal of Healthcare Leadership, 13, 35-46. https://doi.org/10.2147/JHL.S288966

[11]Lu, L., & Tian, L. (2023). Postmenopausal osteoporosis coexisting with sarcopenia: The role and mechanisms of estrogen. Journal of Endocrinology, 259(1). https://doi.org/10.1677/JOE-23-0045

[12]Deng, F., Sun, P., Guo, X., Ding, E., Li, C., Ren, H., Xu, Y., Qian, J., Shi, W., Dong, H., Lin, E. Z., Guo, P., Fang, J., Zhang, Q., Zhao, W., Tong, S., Lu, X., Pollitt, K. J. G., Shi, X., & Tang, S. (2024). Association between Personal Abiotic Airborne Exposures and Body Composition Changes among Healthy Adults (60-69 Years Old): A Combined Exposome-Wide and Lipidome Mediation Approach from the China BAPE Study. *Environmental Health Perspectives*, *132*(7), 77005. https://doi.org/10.1289/EHP13865

[13]Ivanets, U. T., & Turner, R. T. (2016). The effect of body weight on bone mass, structure and turnover. *Journal of Endocrinology*, *230*(3), R115-R130. https://doi.org/10.1530/JOE-15-0524

[14]Huang, K., Ma, L., Shi, S., Wang, X., Jiang, S., & Zhang, Y. (2025). Research on the characteristics of gut microbiota in overweight patients with early-onset type 2 diabetes mellitus. Journal of Diabetes Investigation, 16(10), 1890-1899. https://doi.org/10.1111/jdi.70074

[15]Luo, X., Xiao, X., Lai, X., & Su, Y. (2008). Effect of body fat distribution on plasma lipids and oxidative stress in women aged 35 to 50 years. *Wei Sheng Yan Jiu (Hygiene Research)*, *37*(3), 322-324. https://doi.org/10.3969/j.issn.1000-8020.2008.03.016

[16]Kim, Y. H., & So, W. Y. (2016). A low arm and leg muscle mass to total body weight ratio is associated with an increased prevalence of metabolic syndrome: The Korea National Health and Nutrition Examination Survey 2010-2011. Technology and Health Care, 24(5), 655-663. https://doi.org/10.3233/THC-161162

[17]Soriano-Maldonado, C., Lopez-Pineda, A., Orozco-Beltran, D., Quesada, J. A., Alfonso-Sanchez, J. L., Pallarés-Carratalá, V., Navarro-Perez, J., Gil-Guillen, V. F., Martin-Moreno, J. M., & Carratala-Munuera, C. (2021). Gender differences in the diagnosis of dyslipidemia: ESCARVAL-GENERO. International Journal of Environmental Research and Public Health, 18(23), 12419. https://doi.org/10.3390/ijerph182312419

[18]Nie, F., Wang, Z., Zeng, Q., Guan, H., Yang, J., Luo, P., Du, L., Wang, J., & Hong, F. (2021). Health behaviors and metabolic risk factors are associated with dyslipidemia in

ethnic Miao Chinese adults: The China multi-ethnic cohort study. BMC Public Health, 21(1), 851. https://doi.org/10.1186/s12889-021-10871-0

[19]Palmisano, B. T., Zhu, L., Eckel, R. H., & Stafford, J. M. (2018). Sex differences in lipid and lipoprotein metabolism.Molecular Metabolism, 15, 45-55. https://doi.org/10.1016/j.molmet.2018.05.008