

Sex Differences in the Prevalence and Associated Factors of Metabolic Syndrome: A Cross-Sectional Study of University Employees in China

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Background: Sex may exhibit differences in the MetS prevalence in diverse populations, particularly within specific occupational groups. This study aimed to explore sex differences in the prevalence and determinants of metabolic syndrome (MetS) among university employees in China.

Methods: This cross-sectional study included the data from 2594 adults (1198 men and 1396 women) who underwent health examinations in 2024 in Chengdu, China. MetS was defined using modified National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III) criteria, with waist circumference thresholds adapted for Chinese adults (≥ 90 cm for men, ≥ 85 cm for women). Multiple imputation was employed to handle missing data for HbA1c and homocysteine. Multivariable logistic regression was used to assess the independent association between sex and MetS, along with subgroup analyses by age and body mass index (BMI).

Results: The overall prevalence of MetS was 23.4%, significantly higher in men compared to women (31.9% vs. 16.1%, $p < 0.001$). Men exhibited a higher prevalence of all MetS components except for low HDL-C. After adjusting for age, BMI, lifestyle factors, blood pressure, lipids, glucose, and uric acid, male sex remained a significant risk factor for MetS (adjusted odds ratio [aOR] = 2.13, 95% CI: 1.46–3.10). Significant interactions were observed between sex and age ($p = 0.030$), between sex and BMI ($p = 0.006$). The association between male sex and MetS was more pronounced in younger participants than the older, in those without obesity than those with obesity.

Conclusion: Male sex is a significant risk factor associated with MetS among Chinese university employees. The extent of this sex disparity is notably influenced by age and BMI status in terms of statistical interaction. These findings suggest developing sex-, age-, and weight-specific strategies for the prevention and management of MetS.

Keywords: cross-sectional study, Chinese population, sex differences, metabolic syndrome, prevalence, risk factors

Introduction

Metabolic syndrome (MetS) is a cluster of interrelated cardiometabolic risk factors, including abdominal obesity, dyslipidemia, hypertension, and hyperglycemia, which collectively increase the risk of type 2 diabetes and cardiovascular disease.^{1,2} MetS is typically defined by criteria such as those from the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III), often modified with population-specific thresholds (eg, for waist circumference in Asian populations). Its pathogenesis involves insulin resistance, chronic inflammation, and oxidative stress, leading to significantly elevated risks for type 2 diabetes, atherosclerotic cardiovascular disease, non-alcoholic fatty liver disease, and chronic kidney disease.^{1,2} The rising global prevalence rate of MetS poses a substantial public health burden.^{2,3} Some studies show that females are more prone to develop MetS than men,^{4–6} while some suggested no differences between male and female or less prevalence in male than female in the MetS prevalence.^{7–9} Sex differences in the MetS prevalence and determinants requires further investigation in diverse populations, particularly within specific occupational groups.

In studies involving Chinese populations, findings regarding sex differences in MetS prevalence have been inconsistent, with many studies not adequately exploring how these differences vary across important subgroups like age and

body mass index (BMI) categories.^{5,8,9} The prevalence of MetS in different occupational groups is different.¹⁰ University employees constitute a distinct population with high educational attainment but potential exposure to occupational hazards such as sedentary behavior and psychological stress. Systematic analysis of sex-specific risk factors for MetS in the university employees group is currently lacking. What are the sex differences in MetS among university employees of different age groups and within different BMI ranges?

To address these gaps, the health examination data from the residents in a university of Chengdu, China were analyzed with the following objectives: (1) describe the sex-specific prevalence of MetS and its individual components; (2) assess the independent association between sex and MetS after adjusting for confounding factors; and (3) explore the potential influences of age and BMI on the sex-MetS association.

Methods

Study Design and Population

This retrospective cross-sectional study involved university employees, both active and retired, who participated the annual health examinations at a university-affiliated hospital in Chengdu, Sichuan Province, China, in 2024. The study was proceeded in accordance with the Declaration of Helsinki. The ethics approval for this study was obtained from the Ethics Committee of the Hospital of Chengdu University of Technology (No. 2025001; Approval Date: May 7, 2025). The requirement for informed consent was waived by the institutional Ethics Committee due to the use of anonymized retrospective data. All the identifiable information of the collected data were removed to protect the participants.

Inclusion criteria were: (1) being a current or retired employee of the university; (2) age ≥ 18 years; (3) availability of complete data for anthropometric measurements, blood pressure, and fasting blood tests. Exclusion criteria were: (1) missing data for key variables (sex, age, waist circumference, blood pressure, glucose, or lipid profiles); (2) pregnancy; (3) severe organ dysfunction (eg, end-stage renal disease, advanced heart failure) or malignancy. The initial sample consisted of 2598 individuals. After excluding those with missing data on key variables, the final analytical sample included 2594 participants (1198 men and 1396 women).

Variable Definition and Data Measurement

Metabolic Syndrome (MetS) was defined according to the modified National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III) criteria,¹¹ with the waist circumference component adjusted to the Chinese Diabetes Society (CDS) cut-offs.¹² A participant was defined as having MetS if they met three or more of the following five criteria: 1) Abdominal obesity: Waist circumference ≥ 90 cm for men or ≥ 85 cm for women; 2) Elevated triglycerides: Triglycerides ≥ 1.7 mmol/L (150 mg/dL) or currently on medication for elevated triglycerides; 3) Reduced HDL-C: HDL-C < 1.0 mmol/L (40 mg/dL) in men or < 1.3 mmol/L (50 mg/dL) in women or currently on medication for reduced HDL-C; 4) Elevated blood pressure: Systolic BP ≥ 130 mmHg and/or diastolic BP ≥ 85 mmHg, or currently using of antihypertensive medication; 5) Elevated fasting glucose: Fasting plasma glucose ≥ 5.6 mmol/L (100 mg/dL) or previously diagnosed with diabetes.

The data on demographics (age, sex), lifestyle factors (smoking history, alcohol consumption, physical activity), and additional clinical parameters (liver function, renal function, uric acid, homocysteine, etc.) were collected. The definitions and measurement methods for these variables are as follows.

All Age was calculated as the examination year (2024) minus the birth year. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2). According to Chinese criteria,^{12–14} BMI categories were defined as: normal weight (18.5–23.9 kg/m^2), overweight (24.0–27.9 kg/m^2), and obese (≥ 28.0 kg/m^2). Waist circumference was measured at the midpoint between the lower rib margin and the iliac crest using a non-stretchable tape to the nearest 0.1 cm. Blood pressure was measured using a calibrated electronic sphygmomanometer (Omron HBP-9030) on the right upper arm after the participant had rested in a seated position for at least 5 minutes. Three consecutive readings were taken at 1-minute intervals, and the average value was used for analysis. Smoking history was categorized as “never”, “current” (smoking at least one cigarette per day), or “former” (quit smoking for ≥ 6 months). Alcohol drinking history was categorized as “never”, “occasional” ($< \text{once per week}$), or “frequent” ($\geq \text{once per week}$). Physical

activity was assessed via questionnaire. Participants reporting ≥ 150 minutes of moderate-to-vigorous physical activity per week were classified as “meeting recommendations”. Hypertension history was defined as self-reported physician diagnosis or current use of antihypertensive medication. Diabetes history was defined as self-reported physician diagnosis or current use of glucose-lowering medication. Dyslipidemia history was defined as self-reported physician diagnosis or current use of lipid-lowering medication. Fasting blood samples were collected following after an overnight fast of at least 8 hours. Biochemical parameters, including lipid profiles, (total cholesterol, triglycerides, HDL-C measured by direct method, LDL-C), fasting glucose, (hexokinase method), uric acid, (uricase-peroxidase method), and liver enzymes, were measured using a Roche cobas c 501 automatic biochemical analyzer with matched reagents. HbA1c was measured by immunoturbidimetry on the same platform. Complete blood count was analyzed using a Sysmex XS-500i automated hematology analyzer. Urinalysis was performed with a Urit US-1000 urine analyzer. Blood pressure was measured on the upper arm after the participant rested for 5 minutes, using a calibrated electronic sphygmomanometer (Omron HBP-9030). Three readings were taken, and the average value was calculated and used for analysis. Homocysteine was measured by enzymatic cycling assay.

Quality Control

Data were collected through standardized physical examinations, laboratory tests, and questionnaires. All blood samples were collected following an overnight fast of at least 8 hours. Biochemical parameters, including lipid profiles, fasting glucose, uric acid, and liver enzymes, were measured using a Roche cobas c 501 automatic biochemical analyzer with matched reagents. Complete blood count was analyzed using a Sysmex XS-500i automated hematology analyzer. Urinalysis was performed with a Urit US-1000 urine analyzer. Blood pressure was measured on the upper arm after the participant rested for 5 minutes, using a calibrated electronic sphygmomanometer (Omron HBP-9030). Three readings were taken, and the average value was calculated and used for analysis. The data on demographics (age, sex), lifestyle factors (smoking history, alcohol consumption, physical activity), and additional clinical parameters (liver function, renal function, uric acid, homocysteine, etc.) were also collected by one author, and another author double checked the data and validated the data.

Statistical Analysis

Statistical analyses were performed using SPSS Statistics version 27.0. Multiple imputation was utilized to handle missing data for HbA1c and homocysteine (165 missing for each, 6.4% missing rate), generating five imputed datasets. Subsequent analyses were performed based on pooled results. Continuous variables are presented as mean $\pm$ standard deviation, while categorical variables are presented as frequency (percentage). Group comparisons used independent samples *t*-tests for continuous variables and Chi-square tests for categorical variables. Multivariable logistic regression analysis was performed to calculate odds ratios (ORs) and 95% confidence intervals (CIs) regarding the association between sex and MetS. Model 1 was unadjusted, while Model 2 was adjusted for age and BMI. Model 3 was further adjusted for smoking history, alcohol drinking history, history of hypertension, history of dyslipidemia, systolic blood pressure, diastolic blood pressure, TG, HDL-C, fasting glucose, and uric acid. The interaction between sex and age/BMI subgroups was also evaluated. A two-sided *P*-value < 0.05 was considered statistically significant.

Results

Baseline Characteristics

Table 1 outlined the baseline characteristics of the participants. The study involved 2594 participants, with 1198 men and 1396 women. Men were significantly older than women ($P=0.024$) and had a higher prevalence of negative lifestyle factors, including current smoking and frequent alcohol consumption ($P<0.001$). Men also had significantly more worse metabolic profiles, including higher BMI, waist circumference, blood pressure, triglycerides, fasting glucose, HbA1c, and uric acid, alongside lower HDL-C levels (all $P < 0.05$).

Table 1 Baseline Characteristics

Characteristic	Male (n=1198)	Female (n=1396)	p-value
Demographic			
Age, years	56.08 ± 18.00	54.51 ± 17.15	0.024*
Medical History, n (%)			
· Metabolic Syndrome	382 (31.9%)	225 (16.1%)	<0.001*
· Family History of Diabetes	81 (6.8%)	80 (5.7%)	0.278
· Family History of Hypertension	377 (31.5%)	348 (24.9%)	<0.001*
· History of Hypertension	262 (21.9%)	241 (17.3%)	0.003*
· History of Dyslipidemia	212 (17.7%)	163 (11.7%)	<0.001*
· History of Diabetes	121 (10.1%)	72 (5.2%)	<0.001*
Lifestyle Factors, n (%)			
· Smoking History			<0.001*
- Never	804 (67.1%)	1392 (99.7%)	
- Current	272 (22.7%)	4 (0.3%)	
- Former	122 (10.2%)	0 (0.0%)	
· Alcohol Drinking History			<0.001*
- Never	520 (43.4%)	1372 (98.3%)	
- Frequent	144 (12.0%)	1 (0.1%)	
- Occasional	534 (44.6%)	23 (1.6%)	
· Achieving 150-min moderate-to-vigorous physical activity per week	711 (59.3%)	877 (62.8%)	0.07
Lipid Profile			
LDL-C, mmol/L	2.87 ± 0.88	2.78 ± 0.86	0.015*
Triglycerides, mmol/L	1.74 ± 1.25	1.33 ± 0.91	<0.001*
HDL-C, mmol/L	1.40 ± 0.34	1.76 ± 0.41	<0.001*
Total Cholesterol, mmol/L	5.06 ± 1.04	5.15 ± 0.98	0.023*
Liver Function			
Gamma-glutamyltransferase, U/L	36.58 ± 52.32	21.87 ± 24.23	<0.001*
Alanine Aminotransferase, U/L	26.54 ± 18.99	18.91 ± 17.92	<0.001*
Renal Function & Uric Acid			
Creatinine, μmol/L	88.30 ± 39.67	64.65 ± 12.15	<0.001*
Blood Urea Nitrogen, mmol/L	5.37 ± 1.79	4.91 ± 1.52	<0.001*
Uric Acid, μmol/L	376.63 ± 75.04	290.80 ± 68.15	<0.001*
· Proteinuria	144 (12.0%)	124 (8.9%)	0.009*
· Hematuria	141 (11.8%)	338 (24.2%)	<0.001*
Glucose Metabolism			
Fasting Glucose, mmol/L	5.71 ± 1.37	5.40 ± 1.07	<0.001*
Glycated Hemoglobin, %	5.81 ± 0.84	5.61 ± 0.71	<0.001*
Other Biomarkers			
Homocysteine, μmol/L	15.65 ± 11.90	11.04 ± 3.71	<0.001*
White Blood Cells, 10 ⁹ /L	6.23 ± 2.27	5.55 ± 1.48	<0.001*
Anthropometric & Vital Signs			
Body Mass Index, kg/m ²	24.44 ± 2.93	22.19 ± 3.02	<0.001*
Waist Circumference, cm	88.00 ± 7.57	76.20 ± 8.39	<0.001*
Hip Circumference, cm	99.69 ± 6.14	95.22 ± 6.25	<0.001*
Systolic Blood Pressure, mmHg	124.36 ± 13.70	117.71 ± 14.45	<0.001*
Diastolic Blood Pressure, mmHg	77.73 ± 9.21	72.25 ± 8.46	<0.001*
Heart Rate, bpm	77.16 ± 9.95	77.56 ± 9.43	0.294

Note: *P <0.05.

Abbreviations: LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol.

Prevalence of Metabolic Syndrome and Its Components

The prevalence of MetS and its components are presented in Table 2. The overall prevalence of MetS was 23.4%, with a significantly higher prevalence rate in men than in women (31.9% vs. 16.1%, $P < 0.001$). Men exhibited a higher prevalence rate of all MetS components than women except for low HDL-C ($P < 0.001$).

Multivariable Analysis of the Association Between Sex and Metabolic Syndrome

The results of the logistic regression analysis are presented in Table 3. In the unadjusted model, men had 2.44 times the odds of having MetS compared to women (OR = 2.44, 95% CI: 2.06–2.89). Adjusting for age and BMI reduced this association, yet it remained statistically significant (OR = 1.81, 95% CI: 1.49–2.19). In the fully adjusted model, male sex continued to be an important risk factor for MetS, with an adjusted OR (aOR) of 2.13 (95% CI: 1.46–3.10).

Interaction Analysis

To accurately assess the effects of age and BMI on the association between sex and MetS, we fitted a multivariable logistic regression model that included interaction terms. The results (Table 4) revealed a significant interaction between sex and age category ($P < 0.05$). Compared to the youngest group (<45 years), the association between male sex and MetS was significantly stronger, being approximately 11.11 times greater in the 45–60 years group (aOR = 11.11, 95% CI: 4.18–29.56) and 2.50 times

Table 2 Prevalence of Metabolic Syndrome and Its Components by Sex

Component	Total (n=2594)	Men (n=1198)	Women (n=1396)	Prevalence Difference (Men - Women)	P-value
Metabolic Syndrome	607 (23.4)	382 (31.9)	225 (16.1)	15.8	<0.001*
High blood glucose	1285 (49.5)	688 (57.4)	597 (42.8)	14.7	<0.001*
High blood pressure	903 (34.8)	534 (44.6)	369 (26.4)	18.1	<0.001*
High triglycerides	745 (28.7)	456 (38.1)	289 (20.7)	17.4	<0.001*
Abdominal obesity	680 (26.2)	470 (39.2)	210 (15.0)	24.2	<0.001*
Low HDL-C	267 (10.3)	96 (8.0)	171 (12.2)	-4.2	<0.001*

Note: Data are presented as n (%). HDL-C, high-density lipoprotein cholesterol. P-values were derived from Chi-square tests based on pooled results after multiple imputation. * $P < 0.05$.

Table 3 Association Between Sex and Metabolic Syndrome: Results from Univariable and Multivariable Logistic Regression Analyses

Variables	Model 1: Crude OR (95% CI)	Model 2: Adjusted for Age, BMI OR (95% CI)	Model 3: Fully Adjusted† OR (95% CI)
Sex			
Female	1 (Reference)	1 (Reference)	1 (Reference)
Male	2.44 (2.06, 2.89) *	1.81 (1.49, 2.19) *	2.13 (1.46, 3.10) *
Age (per 1-year increase)	—	1.05 (1.04, 1.05) *	1.03 (1.02, 1.05) *
BMI (per 1 kg/m ² increase)	—	1.56 (1.49, 1.63) *	1.43 (1.36, 1.50) *
Smoking History	—	—	1.04 (0.81, 1.34)
Alcohol Drinking History	—	—	1.21 (1.01, 1.45) *
History of Hypertension	—	—	3.94 (2.80, 5.55) *
History of Dyslipidemia	—	—	1.46 (1.04, 2.06) *
Systolic BP (per 1 mmHg)	—	—	1.02 (1.00, 1.03) *
Diastolic BP (per 1 mmHg)	—	—	1.02 (1.00, 1.04) *
Triglycerides (per 1 mmol/L)	—	—	2.65 (2.18, 3.23) *
HDL-C (per 1 mmol/L)	—	—	0.12 (0.07, 0.21) *
Fasting Glucose (per 1 mmol/L)	—	—	1.43 (1.27, 1.61) *
Uric Acid (per 1 μmol/L)	—	—	1.002 (1.000, 1.003) *

Note: † Model 3 (Fully Adjusted) includes all variables listed in the table *indicates statistical significance ($P < 0.05$). — indicates that the variable was not included in the model.

Abbreviations: OR, Odds Ratio; CI, Confidence Interval.

Table 4 Multivariable Analysis of the Association Between Sex and Metabolic Syndrome

Variable	Adjusted Odds Ratio (aOR)	95% Confidence Interval	P-value
Main Effects			
Sex (Male vs. Female)	1.23	(0.56, 2.70)	0.611
Age Category (vs. <45 years)			
45–60 years	0.03	(0.01, 0.06)	<0.001*
>60 years	0.21	(0.14, 0.32)	<0.001*
BMI Category (vs. Normal Weight)			
Overweight	0.03	(0.01, 0.11)	<0.001*
Obese	0.19	(0.10, 0.37)	<0.001*
Interaction Terms			
Sex × Age Category (vs. Sex × <45 years)			
Male × 45–60 years	11.11	(4.18, 29.56)	<0.001*
Male × >60 years	2.5	(1.47, 4.26)	0.001*
Sex × BMI Category (vs. Sex × Normal Weight)			
Male × Overweight	1.4	(0.30, 6.44)	0.667
Male × Obese	1.35	(0.61, 2.98)	0.459

Notes: Data are presented as odds ratio (95% confidence interval). *Significant P-values ($P < 0.05$). P-values are derived from the pooled analysis. The model is based on pooled results from multiple imputation. The model includes all variables listed in the table and was adjusted for the main effects of sex, age category, BMI category, and the two-way interaction terms (sex × age category and sex × BMI category). Interpretation note about “×”: The odds ratios for interaction terms represent the ratio by which the association between male sex and MetS is multiplied in a specific age or BMI group, compared to the reference group (For example, the aOR of 11.11 for “Male × 45–60 years” indicates that the positive association between male sex and MetS is 11.11 times stronger in the 45–60 years group than in the <45 years group).

Abbreviation: aOR, adjusted odds ratio.

Table 5 Prevalence of Metabolic Syndrome Stratified by Sex and Body Mass Index Categories

Sex	BMI Category	Cases/Total	Prevalence of MetS, % (95% CI)
Male	Normal Weight	68/550	12.4% (9.8–15.3%)
	Overweight	223/518	43.1% (38.8–47.4%)
	Obese	91/130	70.0% (61.4–77.7%)
Female	Normal Weight	93/1075	8.7% (7.1–10.5%)
	Overweight	89/254	35.0% (29.2–41.2%)
	Obese	43/67	64.2% (51.8–75.1%)

Note: This table presents the prevalence based on pooled data after multiple imputation. The formal test for interaction between sex and BMI category was not statistically significant (as shown in Table 4).

Abbreviations: MetS, metabolic syndrome; BMI, body mass index; 95% CI, 95% Confidence Interval.

greater in the >60 years group (aOR = 2.50, 95% CI: 1.47–4.26). In contrast, no significant interaction was observed between sex and BMI category ($P > 0.05$).

To further explore the correlation between BMI and sex, we calculated the prevalence of MetS across different BMI categories, stratified by sex (Table 5). These data clearly demonstrated that the prevalence of MetS increased significantly with higher BMI categories for both men and women, with the highest prevalence observed among individuals with obesity.

Discussion

This retrospective cross-sectional study of Chinese university employees highlighted significant sex disparities in the prevalence of MetS and offered an in-depth analysis of its determinants. Our main findings are threefold. First, men exhibited a notably higher prevalence of MetS and most of its components than women. Second, male sex remained an independent risk factor for MetS even after rigorous adjustment for various confounding factors. Third, and most importantly, the extent of this sex disparity was dynamically and significantly influenced by both age and BMI.

The significantly higher crude prevalence rate of MetS in men (31.9% vs. 16.1%) and the persistently elevated risk after multivariable adjustment (aOR=2.13) underscored a strong independent effect of male sex. This result aligns with prior research in Chinese populations,^{8,9} but is contrary to the study in Chinese populations by Le et al.⁵ The China Hypertension Survey (2012–2015) reported age-standardized MetS prevalence of 24.5% in men and 22.6% in women.⁹ Another study in southern China also indicated a significantly higher MetS risk in men.⁸ These consistent patterns across different Chinese cohorts strengthen the validity of our observation that male sex is associated with a greater metabolic burden in Chinese adults. In the fully adjusted model (Model 3), we included several metabolic parameters that are also components of MetS (eg, blood pressure, lipids, glucose). This approach aimed to examine whether male sex remained associated with MetS beyond these intermediate metabolic pathways, potentially reflecting influences of sex hormones, genetic factors, or unmeasured behavioral patterns. Although this adjustment complicates the traditional interpretation of “independent risk factor”, it provides a conservative estimate of the residual effect of sex.

The underlying mechanisms for the sex differences in the prevalence rate of MetS likely involve complex interactions of sex hormones. Estrogen is recognized for its protective effects on fat distribution, insulin sensitivity, and lipid profiles,¹⁵ while androgens are closely associated with visceral fat accumulation and insulin resistance.¹⁶ This relationship is substantiated by recent clinical evidence. A cross-sectional study of Malaysian men with type 2 diabetes revealed that the hypo-gonadotropic hypogonadism subtype was significantly associated with insulin resistance (TyG index) and visceral obesity (BMI, waist circumference), suggesting a cycle between androgen deficiency and metabolic disturbances.¹⁷ Furthermore, a groundbreaking study demonstrated that maternal androgen exposure may trans-generationally increase diabetes risk in male offspring.¹⁸ This research by Zhang et al found that excess maternal androgens led to impaired pancreatic β -cell function and reduced insulin secretion in male offspring through altered sperm DNA methylation patterns.¹⁸ Additionally, a meta-analysis of 19 randomized controlled trials further indicated that for patients with hypogonadism, testosterone replacement therapy was significantly superior to the placebo control group in improving key metabolic parameters such as fasting plasma glucose, fasting insulin, and the insulin resistance index.¹⁹ The previous report provides strong evidence that testosterone replacement therapy can ameliorate metabolic abnormalities.¹⁹ The sex-related behavioral patterns could also contribute to the MetS prevalence, like smoking and drinking,^{1,9} which is also validated by the data of the current study.

Subgroup analyses on different age categories provide a finer lens for understanding sex differences in MetS risk. The current study showed that the association between male sex and MetS was significantly stronger as age grew, but no significant interaction was observed between sex and BMI category. Regarding the significant modifying effect of age, the excess risk associated with male sex decreased in older age groups. This phenomenon is likely driven by a sharp increase in cardiometabolic risk among postmenopausal women, due to the loss of protective effects from declining estrogen levels,²⁰ which narrows the pre-existing sex gap with men. This highlights the perimenopausal period as a critical window for targeted intervention in women.²¹ It is important to clarify the apparent difference between Table 3 and Table 4 regarding the significance of the sex effect. In Table 4, the main effect of sex (aOR=1.23, $p=0.611$) is not interpretable in isolation because the model includes interaction terms (sex $\times$ age, sex $\times$ BMI). The presence of a significant sex $\times$ age interaction indicates that the effect of sex on MetS is dependent on (or “modified by”) age. Therefore, the statement “male sex is an independent risk factor” should be understood in the context of this interaction. Thus, it is more accurate to conclude that male sex is a significant risk factor for MetS, with its effect being particularly pronounced in middle-aged and older adults.

As indicated in Table 5 of our study, while no significant modifying effect of BMI was found (P for interaction > 0.05), the descriptive data clearly reveal that obesity is the predominant risk factor for MetS in both sexes, with prevalence rising sharply from normal weight to obesity. Despite of the non-significant trend for BMI, the point estimates from the interaction model (Table 4) still provided valuable insights. The disadvantage of male sex was most evident in normal-weight and overweight individuals but was diminished in the obese subgroup. This trend suggests that the serious metabolic disturbances linked to severe obesity may overshadow the baseline risk differences between male and females.²² This finding reinforces the essential role of weight management for MetS prevention, regardless of sex.

Strengths and Limitations

Key strengths of the current study include the large sample, the use of standardized MetS criteria tailored to Chinese populations, robust handling of missing data, and detailed exploration of effect modification. However, our study also has some limitations: the retrospective cross-sectional design means we cannot establish cause-and-effect relationships, and there is a risk of residual confounding. The focus on a university employee cohort may limit the generalizability to a broader Chinese population or other populations in other countries.

Conclusion

This study demonstrates that male sex is a significant risk factor for metabolic syndrome among the university employees of our university. The extent of this sex disparity is not static but is dynamically modified by age, showing a convergence in older groups, and is further nuanced by body mass index. Based on these results, public health strategies and clinical management should adopt integrated, personalized approaches that are sensitive to sex. For male staff members, it is suggested to set a lower screening threshold or an earlier intervention age, and the annual physical examination should prioritize the focus on indicators such as waist circumference and fasting blood sugar. Health interventions on males should focus on providing specific guidance on quitting smoking, limiting alcohol consumption, and reducing the accumulation of abdominal fat. The risks for women change significantly during specific life stages (such as the premenopausal and postmenopausal periods, 45–55 years old). When providing physical examination to female staff members aged 40–55, metabolic risk assessment should be included in the routine consultation, and it is recommended to carry out lifestyle intervention in advance to reduce the metabolic risks caused by changes in hormone levels. The priority of weight management should be raised as a cornerstone for both genders. The complexity of BMI requires that the intervention plans must be tailored to each individual.

Data Sharing Statement

Datasets are available through the corresponding author upon reasonable request.

Author Contributions

Xiao-Hong Jiang contributed to the study conceptualization, data curation, data analysis, project administration, and writing - original draft. Qing Yu contributed on data curation, investigation, methodology, validation, and writing - review and editing. Wan Yang performed data curation, data analysis, methodology, and writing - review and editing. All authors gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no competing interests.

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