Prevalence and associated factors of metabolic syndrome in adults and construction of nomogram model: a cross-sectional analysis

XIE Si-si[1], LIU Huang-yao[1], LIU Yan-hong[1], ZHENG Chuan-lei[1], XU Cong[1], ZHANG Ting[1], WANG Qi[1], LI Jian[2], HUANG Zheng-chun[2], LI Si-si[1], HAO Ming[1], DONG Ming-hua[1], LUO Xiao-ting[3], WU Qing-feng[1]

(1. School of Public Health and Health Management, Gannan Medical University; 2. School of Basic Medicine, Gannan Medical University; 3. School of General Medicine, Gannan Medical University, Ganzhou, Jiangxi 341000)

Abstract: Objective: This study aimed to investigate the prevalence and determinants of metabolic syndrome (MetS) among the population in Gannan (Southern Jiangxi), and to develop a nomogram for MetS prediction. **Methods:** In 2022, a multi-stage stratified random sampling method was used to select permanent residents aged 35 years and above in southern Jiangxi as study participants. MetS was defined according to the International Diabetes Federation (IDF) criteria. Participants' demographics, medical history, blood biochemistry data, and anthropometric variables were collected to screen for significant variables for the prediction model of MetS. Multivariable logistic regression was employed to explore the factors associated with MetS. Subsequently, the data were divided into a training set and a validation set, and a nomogram was developed to create the predictive model for MetS. The training set was utilized for nomogram model construction and preliminary validation, while the validation set was used for internal validation. The performance of the nomogram was assessed based on receiver operating characteristic curve (ROC), calibration curves, and decision curve analysis (DCA). **Results:** A total of 1 581 participants were enrolled in the study, revealing a prevalence of MetS of 27.39% (95%*CI*: 25.19%-29.59%). The age-standardized prevalence was calculated to be 27.81%. Nine variables were identified as influencing factors for MetS: age, residence, occupation, history of hyperlipidemia, history of hyperuricemia, hip circumference, glycated hemoglobin A1c (HbA1c), resting heart rate (RHR), and body mass index (BMI). The participants were randomly divided into a training set (n=1 107, 70%) and a validation set (n=474, 30%). The nomogram was validated through preliminary validation area under curve (AUC: 0.844) and internal validation (AUC: 0.825). Calibration plots demonstrated good agreement in the training sets. **Conclusion:** The prevalence of MetS is notably high in Ganzhou, Jiangxi. The nomogram, which is based on age, residence, occupation, history of hyperlipidemia, history of hyperuricemia, hip circumference, HbA1c, RHR and BMI variables, exhibits strong predictive efficacy and can be utilized to assess the risk of MetS in middle-aged and elderly populations.

Key words: Gannan; Metabolic syndrome; Prevalence; Influencing factors; Nomogram

CLC Number: R589 **Document code:** A **Article ID:** 1001-5779(2025)09-0837-10

DOI: 10.3969/j.issn.1001-5779.2025.09.003

代谢综合征的影响因素分析及列线图模型构建:横断面研究

谢思思[1],刘煌尧[1],刘艳红[1],郑传雷[1],徐 聪[1],张 婷[1],王 琦[1],李 剑[2],黄争春[2],李思思[1],郝 明[1],董明华[1],罗晓婷[3],吴清锋[1]

(1. 赣南医科大学公共卫生与健康管理学院;2. 赣南医科大学基础医学院;
3. 赣南医科大学全科医学院,江西 赣州 341000)

摘 要:目的:探讨赣南地区人群代谢综合征(Metabolic syndrome,MetS)的患病情况及其相关影响因素,并构建

Corresponding author: WU Qingfeng, male, doctor, associate professor, research direction: epidemiology of chronic diseases. E-mail: wuqf0920@163.com

代谢综合征的患病风险列线图预测模型。**方法**:选取2022年赣南地区35岁以上常住居民作为调查对象,通过多阶段分层随机抽样获取样本人群。收集参与者的人口统计学特征、病史、血液生化数据和体格检查等数据。依据国际糖尿病联合会(International Diabetes Federation,IDF)的标准对患者进行MetS诊断。本研究以单因素分析,对MetS患病风险因素进行筛选,用多变量Logistic回归分析探讨风险因素与MetS患病的相关系数。随后,将数据分为训练集和验证集,并以Nomogram来建立MetS患病的预测模型。训练集用于Nomogram模型的构建和初步验证,验证集用于预测模型的内部验证。根据受试者工作特征曲线(Receiver operating characteristic curve,ROC)、校准曲线和决策曲线评估Nomogram预测模型的效能。**结果**:本次研究共纳入赣州常住居民1 581人,MetS患病率为27.39%(95%*CI*:25.19%~29.59%),年龄标准化患病率为27.81%。Logistic回归分析结果表明年龄、居住地、职业、高脂血症史、高尿酸血症史、臀围、糖化血红蛋白(Glycated hemoglobin A1c,HbA1c)、静息心率(Resting heart rate,RHR)和体重指数(Body mass index,BMI)等9个因素是赣南地区MetS患病的独立影响因素。参与者被随机划分为训练集(n=1 107,70%)和验证集(n=474,30%)。模型初步验证曲线下面积(Area under curve,AUC)为0.844,内部验证AUC为0.825,说明模型有较高的区分度,校准曲线说明模型有较高的校准度。**结论**:赣南地区中老年人MetS患病率较高,以年龄、居住地、职业、高脂血症病史、高尿酸血症病史、臀围、HbA1c、RHR、BMI等因素构建预测模型有较好的预测效能,可用于中老年人MetS患病预测。

关键词:赣南地区;代谢综合征;流行现状;影响因素;列线图预测模型

Metabolic syndrome (MetS), also known as syndrome X, is a cluster of metabolic dysregulations characterized by abdominal obesity, insulin resistance, impaired glucose tolerance, elevated blood pressure, atherogenic dyslipidemia (high triglyceride and low high-density lipoprotein), a proinflammatory state, and thrombosis[1]. In the United States, the prevalence of MetS was reported at 19.5% among individuals aged 20 to 39 years old, increasing to 48.6% among those aged 60 years old and older, based on data collected from 2011 to 2016[2]. Additionally, the prevalence of MetS has been reported as 37.4% in Iran[3] and 32.4% in Africa[4]. Notably, a comprehensive national survey spanning 31 provinces and cities in China from 2015 to 2017 revealed a standardized prevalence of 31.1% for MetS, with the lowest prevalence observed among participants aged 20 to 44 years old(23.3%)[5]. These studies indicate a higher prevalence of MetS in individuals over 39 years old, prompting this study to focus on individuals aged 35 years old and older.

In Xinjiang, 12.8% of individuals aged 60-74 years old were diagnosed with MetS. Risk factors identified for MetS included a history of diabetes, previous hypertension, fatty liver, smoking, and elevated systolic and diastolic blood pressure[6]. In 2015, the prevalence of MetS in Jiangxi was reported at 21.1%. Factors such as low education levels and menopausal status were recognized as independently associated with MetS[7]. Among the indigenous population of Taiwan, the prevalence of MetS was found to be 42.9%, with older age, lower education levels and high levels of uric acid, alanine transaminase (ALT), gamma-glutamyl transferase (γ-GT) and creatinine identified as influential factors[8]. Research has shown that the occurrence of MetS and its contributing factors are different in different regions. The present study aims to investigate the prevalence of MetS and its contributing factors specifically in Gannan, thereby addressing the existing data gap in this region.

MetS significantly increases the risk of type 2 diabetes mellitus (T2DM) and cardiovascular disease (CVD). Research indicates that patients with MetS experience a twofold increase in the risk of CVD within 5 to 10 years, a fivefold increase in the likelihood of developing T2DM[9] and a 1.5-fold increase in all-cause mortality rates[10]. The rising prevalence of MetS presents a substantial burden on healthcare systems and economic development across various countries[11]. Evidence suggests that early screening, lifestyle interventions, and exercise can effectively mitigate cardiovascular risks in the MetS population[12]. Most existing prediction models for MetS rely on single indicators derived from physical examinations or laboratory screenings, with few models integrating demographic factors along with physical examination and laboratory tests[13-14]. Consequently, we undertook this study to assess the epidemiological characteristics and develop a predictive model for MetS, thereby providing a foundation for its

prevention and treatment.

1 Methods

1.1 **Subjects** Data for this study were collected during one of the follow-up visits of the Gannan Medical University cohort study, conducted from June to August 2022[15]. Multi-stage random sampling was adopted to divide 18 counties and urban areas in Ganzhou into 3 grades according to the level of economic development. From each level of area, 2 to 3 counties or urban areas were randomly selected, and a total of 7 counties or urban areas were selected. Then, 21 community, township or town districts were selected from these 7 counties or urban areas. Inclusion criteria: (1) men or women aged ≥35 years old; (2) permanent residents who had lived in the selected survey sites for more than one year. Exclusion criteria: (1) pregnant women; (2) individuals with serious physical disabilities that hinder normal communication; (3) participants whose questionnaire completion rate was less than 70%. A total of 1 647 individuals participated in the study. After excluding those with a questionnaire completeness of less than 70%, a valid sample of 1 581 cases was retained, resulting in a validity rate of 96%. The study protocol was reviewed and approved by the Scientific Research Ethics Review Committee of Gannan Medical University (Ethics committee number: NO. 2019129) and adhered to the principles outlined in the Helsinki Declaration. All participants voluntarily agreed to participate in the study and provided informed consent.

1.2 **Data collection** Data on demographic characteristics, disease histories, and anthropometric indicators were collected through physical examinations and face-to-face questionnaires. Fasting blood samples were collected between 7 a. m. and 10 a. m. and analyzed uniformly at the same laboratory. Serum levels of triglycerides (TG, mmol·L^{-1}), uric acid (UA), high-density lipoprotein cholesterol (HDL-C, mmol·L^{-1}), low-density lipoprotein cholesterol (LDL-C, mmol·L^{-1}), glycated hemoglobin (HbA1c), and fasting plasma glucose (FPG) were measured by using a fully automatic biochemical analyzer (Beckman Coulter AU5800). The latex particle-enhanced turbidimetric immunoassay, hexokinase method, glycerol-3-phosphate oxidase-peroxidase (GPO-PAP) method, peroxide scavenging, and surfactant removal method were used to detect HbA1c, FPG, TG, HDL-C, and LDL-C respectively. All assays utilized reagent kits from Medical System company. Uniformly trained investigators conducted questionnaires and physical examinations, while laboratory analyses were performed by professional medical staff.

1.3 **Diagnostic criteria** According to the IDF diagnostic criteria for MetS[16], MetS is diagnosed when an individual meets at least three of the following five criteria: (1) Abdominal obesity (waist circumference ≥ 90 cm in men or ≥85 cm in women); (2) Hyperglycemia [indicated by a fasting plasma glucose (FPG) level of ≥ 6.1 mmol·L^{-1} or a prior diagnosis of T2DM]; (3) Hypertension [characterized by a blood pressure of ≥ 130/85 mmHg (where 1 mmHg=0.133 kPa) or a previous diagnosis of hypertension]; (4) Hypertriglyceridemia (TG≥1.70 mmol·L^{-1}); (5) Low HDL-C (＜1.04 mmol·L^{-1}). BMI was categorized as follows: thin (＜18.5 kg·m^{-2}), normal (18.5-23.9 kg·m^{-2}), overweight (24.0-27.9 kg·m^{-2}), or obese (≥28.0 kg·m^{-2})[5]. Hypertension was defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg[17]. Hyperuricemia: UA＞420 μmol·L^{-1}[18]. The diagnosis of hyperlipidemia is determined based on hospital criteria.

1.4 **Statistical analysis** Data analysis was conducted using SPSS (version 22.0) and R (version 4.1.2). Continuous data were reported as mean±standard deviation, while categorical data were presented as counts and percentages. Comparisons between two independent sample groups were performed using either the *t*-test or chi-square test. Normality tests were conducted on the data, with the *t*-test applied for univariate analysis of data meeting the normality criteria, and the chi-square test utilized for univariate analysis of data not meeting these

criteria. Logistic regression with a stepwise strategy was applied to select variables for inclusion in the nomogram. Through logistic regression analysis, independent risk factors for MetS were identified. A nomogram model was then developed to visualize these influencing factors. By scoring individual risk factors, this model can predict the probability of an individual developing MetS. The patient cohort was divided into training and validation sets in a 7∶3 ratio using the R functions 'car' and 'survival', ensuring that outcome events were randomly distributed between the two sets. The training set was utilized to construct the model, while the validation set was employed to assess the results obtained from the training set. Consequently, a nomogram was constructed using the 'rms' package. The model's discrimination performance was evaluated using the receiver operating characteristic curve (ROC). Calibration curves were plotted to evaluate the calibration of the nomogram, accompanied by the Hosmer-Lemeshow test. The clinical utility of the model was assessed through decision curve analysis (DCA). Internal validation was performed using the bootstrap method (200 bootstrap resamples to calculate a relatively corrected C-index) with the 'caret' package, and a calibration curve was subsequently plotted. Significance level ($\alpha = 0.05$).

2 Results

2.1 Patient Characteristics This study included a total of 1 581 permanent residents aged ≥35 years old from Ganzhou. Participants comprised 504 males (31.88%) and 1 077 females (68.12%), with a mean age of (55.81±8.26) years old. The prevalence of MetS was 27.39% (95%*CI*: 25.19%-29.59%), and the age-standardized prevalence was 27.81%. Statistically significant differences were observed between the MetS and non-MetS groups ($P<0.05$) for the following variables: age, gender, residence, hyperlipidemia, hyperuricemia, family history of hypertension, family history of hyperlipidemia, smoking, alcohol consumption, hip circumference, body fat percentage, HbA1c, LDL-C, resting heart rate (RHR), and BMI (Table 1).

Table 1 Comparison of baseline characteristics between MetS and non-MetS

Variable	Total (n=1 581)	MetS (n=433)	non-MetS (n=1 148)	Z/χ^2	P
Age/years, $\bar{x}\pm s$	55.81±8.26	57.26±7.95	55.26±8.31	−4.311	<0.001
Gender/n(%)				27.037	<0.001
Male	504(31.88)	181(41.80)	323(28.14)		
Female	1 077(68.12)	252(58.20)	825(71.86)		
Marital status/n(%)				0.055	0.815
Married	1 501(94.94)	412(95.15)	1 089(94.86)		
Other status	80(5.06)	21(4.85)	59(5.14)		
Education/n(%)				5.080	0.079
Primary or below	595(37.63)	159(36.72)	436(37.97)		
Junior high	534(33.77)	133(30.72)	401(34.93)		
Senior high or above	452(28.60)	141(32.56)	311(27.10)		
Residence/n(%)				7.694	0.021
Urban	1 164(73.63)	340(78.52)	824(71.78)		
Rural	336(21.25)	77(17.78)	259(22.56)		
Urban village	81(5.12)	16(3.70)	65(5.66)		
Length of residence/n(%)				2.778	0.249
Less than 10 years	282(17.84)	87(20.00)	195(17.00)		
10–20 years	243(15.37)	70(16.20)	173(15.07)		
More than 20 years	1 056(66.79)	276(64.00)	780(67.93)		

Continued Table 1　Comparison of baseline characteristics between MetS and non-MetS

Variable	Total (n=1 581)	MetS (n=433)	non-MetS (n=1 148)	Z/χ^2	P
Occupations/n(%)				11.958	0.063
Workers	246(15.56)	74(17.09)	172(14.98)		
Farmers	274(17.33)	79(18.25)	195(16.99)		
Professional technicians	129(8.16)	42(9.70)	87(7.58)		
Self-employed	190(12.02)	58(13.39)	132(11.50)		
Retirees	357(22.58)	97(22.40)	260(22.65)		
Housework	316(19.99)	64(14.78)	252(21.95)		
Others	69(4.36)	19(4.39)	50(4.35)		
Hyperlipidemia/n(%)				84.862	<0.001
No	1 290(81.59)	290(66.97)	1 000(87.11)		
Yes	291(18.41)	143(33.03)	148(12.89)		
Hyperuricemia/n(%)				55.235	<0.001
No	1 388(87.79)	337(77.83)	1 051(91.55)		
Yes	193(12.21)	96(22.17)	97(8.45)		
Family history of hypertension/n(%)				5.927	0.015
No	957(60.53)	241(55.66)	716(62.37)		
Yes	624(39.47)	192(44.34)	432(37.63)		
Family history of hyperlipidemia/n(%)				4.437	0.035
No	1 418(89.69)	377(87.07)	1 041(90.68)		
Yes	163(10.31)	56(12.93)	107(9.32)		
Family history of diabetes/n(%)				2.724	0.099
No	1 403(88.74)	375(86.61)	1 028(89.55)		
Yes	178(11.26)	58(13.39)	120(10.45)		
Smoking/n(%)				16.396	<0.001
Current	139(8.79)	50(11.55)	89(7.75)		
Never	1 353(85.58)	346(79.91)	1 007(87.72)		
Past	89(5.63)	37(8.54)	52(4.53)		
Alcohol consumption/n(%)				12.952	0.002
Current	1 175(74.32)	301(69.51)	874(76.13)		
Never	333(21.06)	100(23.09)	233(20.30)		
Past	73(4.62)	32(7.40)	41(3.57)		
Hip circumference/cm，$\bar{x}\pm s$	94.11±6.00	97.53±6.19	92.82±6.26	−13.373	<0.001
Body fat percentage/%，$\bar{x}\pm s$	30.00±6.38	31.22±5.67	29.55±6.58	−4.965	<0.001
FPG/mmol·L^{-1}，$\bar{x}\pm s$	5.33±1.50	6.09±2.24	5.05±0.95	9.392	<0.001
HbA1c/mmol·L^{-1}，$\bar{x}\pm s$	5.45±0.84	5.89±1.22	5.28±0.56	−10.047	<0.001
LDL-C/mmol·L^{-1}，$\bar{x}\pm s$	3.03±0.75	3.12±0.71	2.99±0.76	−3.100	0.002
HDL-C/mmol·L^{-1}，$\bar{x}\pm s$	1.30±0.28	1.08±0.22	1.38±0.26	−22.205	<0.001
Triglyceride/mmol·L^{-1}，$\bar{x}\pm s$	1.91±1.34	2.92±1.86	1.53±0.80	15.036	<0.001
Total cholesterol/mmol·L^{-1}，$\bar{x}\pm s$	5.00±0.93	5.05±0.93	4.98±0.92	−1.482	0.139
RHR/beats·min^{-1}，$\bar{x}\pm s$	77.88±10.85	80.40±11.23	76.93±10.55	−5.565	<0.001
BMI/n(%)				205.298	<0.001
Normal or thin	895(56.61)	124(28.63)	771(67.16)		
Overweight	549(34.72)	229(52.89)	320(27.87)		
Obesity	137(8.67)	80(18.48)	57(4.97)		

2.2 **Logistic regression analysis** The variables with $P<0.10$ in Table 1 were included in the logistic regression analysis as independent variables, with MetS designated as the dependent variable. The results indicated that age, residence, occupations, hyperlipidemia, hyperuricemia, family history of hypertension, hip circumference, HbA1c, RHR and BMI were significantly correlated with the prevalence of MetS ($P<0.05$). Among these factors, residing in rural areas (*OR*=0.599) and urban village (*OR*=0.406), as well as being retirees (*OR*=0.533) or housework (*OR*=0.443) were identified as protective factors against MetS. Conversely, age (*OR*=1.028), hyperlipidemia (*OR*=3.008), hyperuricemia (*OR*=1.937), hip circumference (*OR*=1.069), HbA1c (*OR*=2.406), RHR (*OR*=1.032), overweight (*OR*=3.424) and obesity (*OR*=3.836) were recognized as risk factors for MetS ($P<0.05$, Table 2).

Table 2 Logistic regression analysis of factors associated with MetS prevalence

Variable	β	*S. E.*	Waldχ^2	*P*	*OR*	95%*CI*	
						Lower limit	Upper limit
Age	0.028	0.010	7.511	0.006	1.028	1.008	1.049
Residence (Urban)			12.414	0.002			
Rural	−0.512	0.190	7.263	0.007	0.599	0.413	0.870
Urban village	−0.901	0.347	6.724	0.010	0.406	0.206	0.803
Occupations (Workers)			17.502	0.008			
Farmers	−0.222	0.253	0.772	0.380	0.801	0.488	1.314
Professional technicians	−0.067	0.286	0.055	0.814	0.935	0.534	1.637
Self-employed	−0.046	0.255	0.033	0.857	0.955	0.580	1.573
Retirees	−0.629	0.249	6.375	0.012	0.533	0.327	0.869
Housework	−0.813	0.241	11.340	0.001	0.443	0.276	0.712
Others	−0.140	0.377	0.370	0.711	0.870	0.415	1.822
Hyperlipidemia	1.101	0.164	45.241	<0.001	3.008	2.182	4.147
Hyperuricemia	0.661	0.190	12.063	0.001	1.937	1.334	2.812
Hip circumference	0.067	0.014	21.426	<0.001	1.069	1.039	1.100
HbA1c	0.878	0.100	77.740	<0.001	2.406	1.979	2.924
RHR	0.031	0.006	23.488	<0.001	1.032	1.019	1.045
BMI (Normal or thin)			55.148	<0.001			
Overweight	1.231	0.167	54.352	<0.001	3.424	2.469	4.750
Obesity	1.344	0.286	22.096	<0.001	3.836	2.190	6.719

2.3 **Construction of nomogram model** The 'rms' package in R was utilized to construct a nomogram model based on the variables screened in Fig. 1, which include age, residence, occupations, hyperlipidemia, hyperuricemia, hip circumference, HbA1c, RHR and BMI. The C index of the nomogram was 0.845, indicating a strong discriminatory ability of the model. The nomogram comprised influencing factors, an individual score, the total score, and the associated risk of MetS. Figure 1 illustrates an example of using the nomogram to predict the probability of MetS. In this case, the patient was 49 years old, had a hip circumference of 100.0 cm, an HbA1c level of 5.1%, was classified as overweight, and had an RHR of 75 beats per minute, resulting in a MetS risk of 35.4%.

2.4 **Validation of nomogram model** The AUC of the nomogram was 0.844 (95%*CI*: 0.820-0.868) for the training set and 0.825 (95%*CI*: 0.785-0.865) for internal validation. The sensitivity, specificity, and Youden's index were 0.874, 0.659, and 0.533 for the training set, and 0.727, 0.816, and 0.543 for the validation set, respectively; the cutoff values were 0.185 and 0.290, respectively (Fig. 2). The Hosmer-Lemeshow test yielded a non-significant value ($P=0.640$), indicating that the model was well

calibrated. The calibration curve of the nomogram for the probability of MetS demonstrated good agreement between predictions and observations in the training set (Fig. 3). The decision curve analysis showed that using the nomogram to predict MetS provided greater benefit than either the treat-all-patients scheme or the treat-none scheme (Fig. 4). This suggests that the nomogram model predicts the occurrence of MetS with a strong correlation to influence factors, indicating its clinical value.

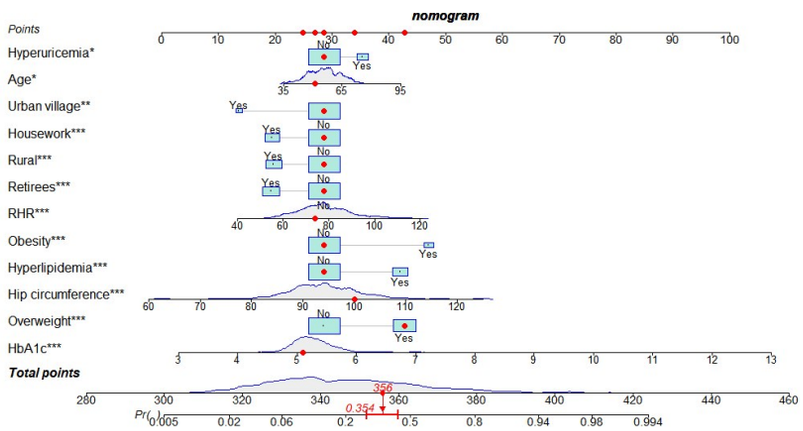
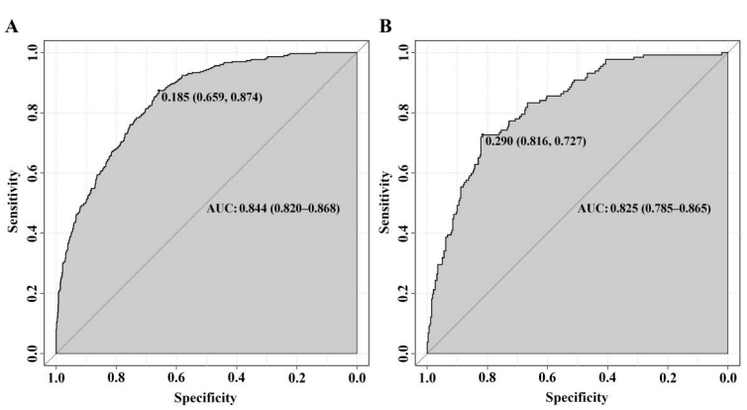


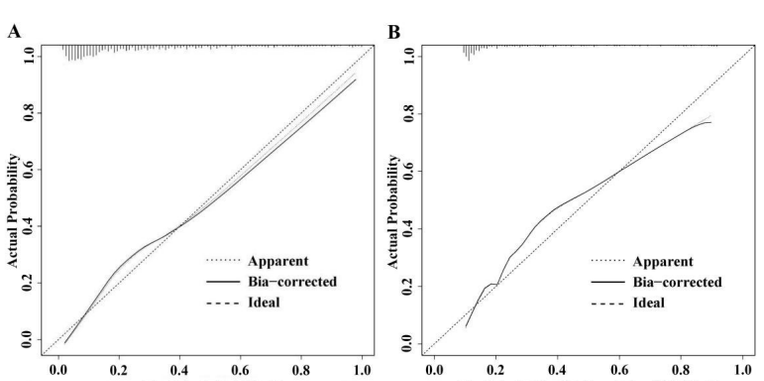
Fig. 1　Nomogram for predicting the risk of MetS

Note: To use the nomogram, first the variables were given a score on the first line of the scale, and then the scores of eight risk factors were added to get the total score; second, the risk of individual MetS was calculated by projecting the total score to the lowest line of the scale.



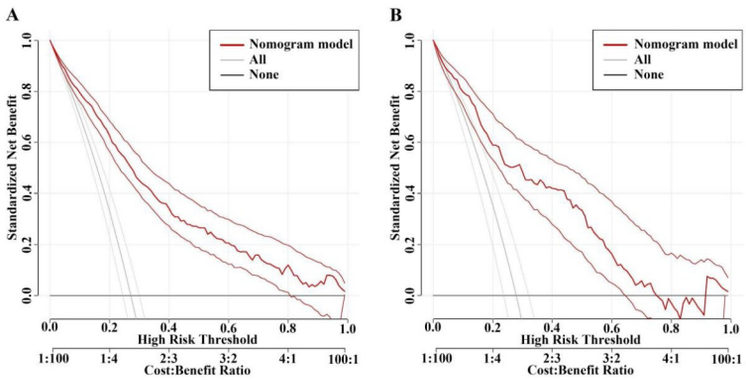
A: The discrimination of the training set; B: The discrimination of the internal validation.

Fig. 2　Receiver operating characteristic curve of the prediction model



A: The calibration curve of the training set; B: The calibration curve of the internal validation.

Fig. 3　Calibration curve of the prediction model



A: The decision curve analysis of the training set; B: The decision curve analysis of the internal validation.

Fig. 4 Decision curve analysis of the prediction model

3 Discussion

The residents of Ganzhou are primarily Hakka people, characterized by unique lifestyles and dietary practices. The prevalence of MetS among middle-aged and elderly individuals in Ganzhou is 27.81%. This rate is higher than the 21.1% prevalence reported in a 2015 study conducted in Jiangxi Province, which assessed adult residents aged ≥18 years old[7]. Furthermore, according to the standards set by the IDF, the prevalence of MetS in China has shown an increasing trend from 2011 to 2015, with higher rates observed among middle-aged and elderly populations[19]. In addition, MetS patients were at higher risk of cardiovascular events and all-cause mortality[10]. The population in this study is mainly aged ≥30 years old, which is higher than the rate of adult residents ≥18 years old in Jiangxi Province in 2017, indicating that the prevalence of MetS is higher among middle-aged and elderly individuals. Therefore, appropriate preventive measures should be implemented to mitigate the prevalence of MetS, thereby reducing the associated risks of cardiovascular events and mortality.

The results of this study indicated that factors such as age, residence, occupation, history of hyperlipidemia, history of hyperuricemia, hip circumference, HbA1c, RHR and BMI were related to MetS. A study conducted in Taiwan Province, China, found that residents aged 50-70 have a higher risk of MetS compared to those aged 30-50[20]. It is well established that MetS is closely linked to obesity, hyperglycemia, hypertension. The available studies suggest that the prevalence of obesity, hyperglycemia, and hypertension increase with age[21-23]. Compared with workers, retired residents had a lower risk of MetS, possibly due to reduced work-related stress and greater health awareness within this population. Residents in rural and urban valiage had lower risk of MetS than those living in cities, which was consistent with the results of other studies[5,24]. In addition, this study showed that patients with a history of hyperlipidemia, hyperuricemia and obesity had a higher prevalence of MetS. Evidences show that lipid accumulation products and triglyceride glucose index exhibit significant associations to the occurrence of MetS, and the sensitivity and specificity of identifying MetS are high, which can be used as simple biomarkers[25-26].

Fat factors play an important role in the process of insulin resistance and atherosclerosis[27-28], and the variation of apolipoprotein-B gene locus is also related to MetS and blood lipid level[29]. Elevated uric acid is a risk factor for MetS, as well as hypertension and cardiovascular diseases. The pathophysiological mechanisms involve the increased oxidative stress, inflammation, apoptosis[30], and insulin resistance mediated by insulin-dependent nitric oxide stimulation in endothelial cells[31]. As a result, these factors contribute to an increased risk of MetS.

With rapid urbanization and an aging population, the prevalence of MetS has been increasing in recent years. Consequently, screening for MetS and implementing early interventions are essential to

alleviate the medical burden on society[19]. Some MetS prediction models have been preliminarily developed in different populations in recent years, such as in Korean, Chinese, and Nigeria. In these models, the risk factors of MetS varied significantly across studies. Age, BMI, and hip circumference were the most common independent factors in the studied population[32-34]. However, there remains a lack of consensus among researchers regarding what constitutes a major predictor of MetS. Therefore, we developed a nomogram model tailored to the characteristics of the population in southern Jiangxi to predict the prevalence of MetS.

The nomogram is a straightforward visual graph that illustrates the relative importance of predictors through segment length and can be utilized to assess a patient's risk of disease based on personal data. It aids in the initial screening and identification of patients[35]. In this study, the MetS risk prediction model was constructed based on demographic characteristics, laboratory tests, physical examination, and personal habits, with an AUC of 0.844 (95%*CI*: 0.820-0.868), which demonstrates the model's strong discriminatory power. Additionally, the absolute error was 0.028 in the study, indicating a good fit and predictive consistency[13].

Several limitations of this study should be noted: first, as this was a cross-sectional study, causal relationships could not be established; second, the sample size is relatively small, and only internal validation was conducted. Therefore, the extrapolation of the model requires further verification.

4 Conclusion

To the best of our knowledge, this was the latest study on MetS prevalence in Gannan. The prevalence of MetS in the middle-aged and elderly population in Gannan was high. In this study, a nomogram model for predicting MetS was constructed using nine indicators. The predictive efficacy of the model was evaluated and validated. The results showed that the model had good predictive performance and consistency. It can be used to predict the risk of MetS and provide evidence-based support for early detection, diagnosis, and treatment of MetS.

REFERENCES:

[1] RUS M, CRISAN S, ANDRONIE-CIOARA F L, et al. Prevalence and risk factors of metabolic syndrome: a prospective study on cardiovascular health [J]. Medicina (Kaunas), 2023,59(10):1711.

[2] HIRODE G, WONG R J. Trends in the prevalence of metabolic syndrome in the United States, 2011-2016 [J]. JAMA, 2020,323(24):2526-2528.

[3] JAMALI Z, AYOOBI F, JALALI Z, et al. Metabolic syndrome: a population-based study of prevalence and risk factors[J]. Sci Rep, 2024,14(1):3987.

[4] BOWO-NGANDJI A, KENMOE S, EBOGO-BELOBO J T, et al. Prevalence of the metabolic syndrome in African populations: a systematic review and meta-analysis[J]. PLoS One, 2023,18(7):e0289155.

[5] YAO F, BO Y, ZHAO L, et al. Prevalence and influencing factors of metabolic syndrome among adults in China from 2015 to 2017[J]. Nutrients, 2021,13(12):4475.

[6] ZHANG Y, RAZBEK J, LI D, et al. Construction of Xinjiang metabolic syndrome risk prediction model based on interpretable models[J]. BMC Public Health, 2022,22(1):251.

[7] WU L T, SHEN Y F, HU L, et al. Prevalence and associated factors of metabolic syndrome in adults: a population-based epidemiological survey in Jiangxi Province, China[J]. BMC Public Health, 2020,20(1):133.

[8] TSAO Y C, LI W C, YEH W C, et al. The association between metabolic syndrome and related factors among the community-dwelling indigenous population in Taiwan [J]. Int J Environ Res Public Health, 2020,17(23):8958.

[9] ASATO C B H, NELSON-HURWITZ D C, LEE T, et al. Comparative analysis of metabolic syndrome diagnostic criteria and its effects on prevalence in a multiethnic population[J]. Metab Syndr Relat Disord, 2021,19(6):347-351.

[10] MELONI A, CADEDDU C, CUGUSI L, et al. Gender differences and cardiometabolic risk: the importance of the risk factors[J]. Int J Mol Sci, 2023,24(2):1588.

[11] BOVOLINI A, GARCIA J, ANDRADE M A, et al. Metabolic syndrome pathophysiology and predisposing factors[J]. Int J Sports Med, 2021,42(3):199-214.

[12] ZHENG X, YU H, QIU X, et al. The effects of a nurse-led lifestyle intervention program on cardiovascular risk, self-efficacy and health promoting behaviours among patients with metabolic syndrome: Randomized controlled trial[J]. Int J Nurs Stud, 2020,109:103638.

[13] WANG S, WANG S, JIANG S, et al. An anthropometry-based nomogram for predicting metabolic syndrome

in the working population[J]. Eur J Cardiovasc Nurs, 2020,19(3):223-229.
[14] SHIN M S, LEE J Y. Building a nomogram for metabolic syndrome using logistic regression with a complex sample-a study with 39, 991, 680 cases[J]. Healthcare (Basel), 2022,10(2):372.
[15] XIE S S, LUO X T, DONG M H, et al. Association between hemoglobin glycation index and metabolic syndrome in middle-aged and older people[J]. Diabetes Metab Syndr Obes, 2023,16:1471-1479.
[16] DIABETES SOCIRTY OF CHINESE MEDICAL ASSOCIATION. Chinese guidelines for the prevention and treatment of type 2 diabetes mellitus (2020 edition) (Part 2)[J]. Chinese Journal of Practical Internal Medicine, 2021,41(9):757-784.
[17] REVISION J C F G. 2018 Chinese guidelines for prevention and treatment of hypertension-a report of the revision committee of Chinese guidelines for prevention and treatment of hypertension[J]. J Geriatr Cardiol, 2019,16(3):182-241.
[18] LI Q, LI X, WANG J, et al. Diagnosis and treatment for hyperuricemia and gout: a systematic review of clinical practice guidelines and consensus statements[J]. BMJ Open, 2019,9(8):e026677.
[19] LIU B, CHEN G, ZHAO R, et al. Temporal trends in the prevalence of metabolic syndrome among middle-aged and elderly adults from 2011 to 2015 in China: the China health and retirement longitudinal study (CHARLS)[J]. BMC Public Health, 2021, 21(1): 1045.
[20] LIU P L, HSU M Y, HU C C, et al. Association of age and sex with metabolic syndrome in Taiwanese adults[J]. Int J Gen Med, 2021,14:1403-1411.
[21] BOUTARI C, MANTZOROS C S. A 2022 update on the epidemiology of obesity and a call to action: as its twin COVID-19 pandemic appears to be receding, the obesity and dysmetabolism pandemic continues to rage on[J]. Metabolism, 2022,133:155217.
[22] LI Y, GUO C, CAO Y. Secular incidence trends and effect of population aging on mortality due to type 1 and type 2 diabetes mellitus in China from 1990 to 2019: findings from the Global Burden of Disease Study 2019[J]. BMJ Open Diabetes Res Care, 2021, 9(2): e002529.
[23] ZHANG Z, ZHANG T, ZHAO E, et al. Interaction of sex, age, body mass index and race on hypertension risk in the American population: a cross-sectional study[J]. Eur J Public Health, 2021,31(5):1042-1047.
[24] NSABIMANA P, SOMBIÉ O O, PAUWELS N S, et al. Association between urbanization and metabolic syndrome in low- and middle-income countries: a systematic review and meta-analysis[J]. Nutr Metab Cardiovasc Dis, 2024,34(2):235-250.
[25] RAJENDRAN S, KIZHAKKAYIL PADIKKAL A K, MISHRA S, et al. Association of lipid accumulation product and triglyceride-glucose index with metabolic syndrome in young adults: a cross-sectional study[J]. Int J Endocrinol Metab, 2022,20(2):e115428.
[26] SHIN K A, KIM Y J. Usefulness of surrogate markers of body fat distribution for predicting metabolic syndrome in middle-aged and older Korean populations[J]. Diabetes Metab Syndr Obes, 2019,12:2251-2259.
[27] KIM J E, KIM J S, JO M J, et al. The roles and associated mechanisms of adipokines in development of metabolic syndrome[J]. Molecules, 2022,27(2):334.
[28] KUMARI R, KUMAR S, KANT R. An update on metabolic syndrome: metabolic risk markers and adipokines in the development of metabolic syndrome[J]. Diabetes Metab Syndr, 2019, 13(4): 2409-2417.
[29] JANG S J, TUAN W L, HSU L A, et al. Pleiotropic effects of *APOB* variants on lipid profiles, metabolic syndrome, and the risk of diabetes mellitus[J]. Int J Mol Sci, 2022,23(23):14963.
[30] COPUR S, DEMIRAY A, KANBAY M. Uric acid in metabolic syndrome: does uric acid have a definitive role?[J]. Eur J Intern Med, 2022,103:4-12.
[31] BAHADORAN Z, MIRMIRAN P, KASHFI K, et al. Vascular nitric oxide resistance in type 2 diabetes[J]. Cell Death Dis, 2023,14(7):410.
[32] SON D H, LEE H S, LEE Y J, et al. Comparison of triglyceride-glucose index and *HOMA*-IR for predicting prevalence and incidence of metabolic syndrome[J]. Nutr Metab Cardiovasc Dis, 2022,32(3):596-604.
[33] LI Y, GUI J, LIU H, et al. Predicting metabolic syndrome by obesity- and lipid-related indices in mid-aged and elderly Chinese: a population-based cross-sectional study[J]. Front Endocrinol (Lausanne), 2023,14:1201132.
[34] RAIMI T H, DELE-OJO B F, DADA S A, et al. Triglyceride-glucose index and related parameters predicted metabolic syndrome in nigerians[J]. Metab Syndr Relat Disord, 2021,19(2):76-82.
[35] DONG B R, GU X Q, CHEN H Y, et al. Development and validation of a nomogram to predict frailty progression in nonfrail Chinese community-living older adults[J]. J Am Med Dir Assoc, 2021,22(12):2571-2578. e4.

(收稿:2024-10-08)(修回:2024-12-20)
(责任编辑:肖载宇)