Gender Differences in Metabolic Disorder Prevalence Among North China Residents: A Cross-sectional Study

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Abstract

Background: Numerous studies have found sex disparity in the prevalence of metabolic disorders.

However, information is lacking on gender difference among residents of north China and little epidemiological data is available on metabolic disorders in North China.

Methods: This cross-sectional study involved 2650 randomly selected adult residents of Hebei province, North China. Demographic, biochemical, and physical examination parameters were collected and compared between men and women. Metabolic disorder prevalence was estimated and their associations with baseline characteristics was analyzed by multivariate logistic regression.

Results: Our data suggest that the prevalence of metabolic disorders including metabolic syndrome (MetS), diabetes, prediabetes, hypertension, central obesity, and hypertriglyceridemia are significantly higher in men than in women. We find that aging people, overweight or obese people, urban residents, smokers, people with lower education, manual workers, and people with family history of diabetes are at higher risk of metabolic disorders. However, these associations differ between men and women.

Conclusions: Our findings suggest that metabolic disorders are an important public health concern and highlights an urgent need for intervention in middle-aged and elderly populations in North China. There are sex-specific associations between multiple risk factors and metabolic disorders.

Introduction

Metabolic disorders are the most common human disorders. With the rapid development of China's economy, people's lifestyles have changed markedly. The prevalence of lifestyle-associated metabolic disorders like metabolic syndrome (MetS), central obesity, hypertension, diabetes, and dyslipidemia continue to rise globally[1–3]. Such disorders are of great socioeconomic importance as they cause higher all-cause mortality[4].

National epidemiological surveys of Chinese adults estimated that in 2010, the prevalence of MetS and dyslipidemia was 33.9% and 34.0%, respectively[2]. In 2013, the prevalence of prediabetes and diabetes was estimated to be 35.7% and 10.9%, respectively[5]. In 2017, hypertension prevalence was estimated at 37.2%[6]. Currently, few studies have assessed the prevalence of adult metabolic disorders in North China. This study is based on data from an epidemiological cross-sectional survey of natural populations living in Hebei province, a developing North China province that surrounds Beijing, China's capital. Here, we examined the factors influencing adult metabolic disorders in Hebei Province. Our findings may guide prevention and control metabolic disorders in Hebei.

Methods

Study population

This 2016 epidemiological study used a multistage, stratified sampling method and was conducted in Hebei province, North China (Supplementary Figure 1). First, a representative urban setting (Shijiazhuang city) and a representative rural setting (Renqiu city) in Hebei province were randomly selected. Next, 2 residential districts were randomly selected from each area. Qualified participants were then randomly selected from the residential districts based on the inclusion criteria. The ratio of age, sex, urban or rural participants in each district (Supplementary Table 1) were based on the latest national census data[7].

The study recruited 2650 participants. The inclusion criteria were: age≥18 years, having resided locally for at least five years, non-pregnant women. The exclusion criteria were as follows: missing demographic or metabolism information; the presence or history of severe chronic diseases, such as cancer, cardiovascular or cerebrovascular diseases. Finally, 2638 adults were included in the analysis upon excluding 12 participants with missing information. Ethical approval for the study was granted by the medical ethics committee of The Second Hospital of Hebei Medical University. All participants provided with written informed consent following a thorough explanation of the research procedures.

Laboratory Test

Venous blood samples were collected and serum samples were stored at -20°C. After fasting for 12 hours, total cholesterol (TC), triglycerides (TG), high density lipoprotein-cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) were measured using automatic biochemical analyzer (Mindray BS-180 Analyzer). The oral glucose tolerance test (OGTT) was performed on all subjects except those diagnosed with diabetes. Hexokinase enzymatic method were used to measure fasting plasma glucose (FPG) and two hour plasma glucose levels after carrying out an oral 75g glucose tolerance test (OGTT-2h PG) (Au400 automatic analyzer, Olympus company, Japan, reagent purchased from Daiichi Pharmaceutical Co. Ltd). Glycosylated hemoglobin (HbA1c) measurement were tested by BioRad reagents. All experiments were performed in accordance with relevant guidelines and regulations.

Clinical measurements

Questionnaires were used by trained professionals to collect participant information, including age, gender, education, profession, income, and lifestyle factors. Body mass index (BMI) (kg/m^2) was calculated and classified as normal (<24 kg/m^2), overweight (≥24 & <28 kg/m^2) and obese (≥28 kg/m^2)[8]. Waist circumference (WC) was measured midway between the lower border of the rib margin and the iliac crest at the end of normal expiration. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured twice with a corrected automated electronic device and average readings recorded.

Clinical diagnosis

Metabolic disorders were diagnosed as detailed in Supplemental Table 2[9-12].

Statistical analysis

Statistical analyses were done on SPSS version 22.0 (IBM). Continuous variables were presented as mean±95% confidence intervals (CIs). Between-group comparisons were done using z test or non-parametric statistical hypothesis tests. Categorical variables were expressed as number (percentages) and compared by Chi-square test. To estimate the age-specific prevalence of metabolic disorders and the linear relationship between age and prevalence, linear-by-linear chi-square tests were used to detect emerging trends in both men and women. To evaluate confounding factors, multivariable logistic regression models were adjusted for age group, BMI, location, smoking status, education, income, occupation, and family history of diabetes in men and women, separately. Odds ratio (OR) and 95% CIs were used to determine risk factors for metabolic disorders. $P<0.05$ indicates statistical significance.

Results

Of the 2650 participants, 2638 were eligible for analysis and their features (grouped by sex) are shown in Table 1. There was a significant difference between the 2 groups with regards to smoking, family history of diabetes, income level, and occupation. Relative to women, men were more likely to be overweight, with higher BMI, WC, blood pressure, FPG, HbA1c, TG, and LDL, and lower levels of HDL-C.

Table 1
Baseline characteristics of the study by demographic data and clinical variables in men and women. CI: confidence interval; MetS, Metabolic Syndrome; BMI, Body Mass Index; WC, Waist Circumference; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; FBG, Fasting Blood Glucose; TG, Triglycerides; TC, Total Cholesterol; HDL-C, High Density Lipoprotein-Cholesterol; LDL-C, Low Density Lipoprotein-Cholesterol.

Characteristics, n(%)	Men (n = 1352)	Women (n = 1286)	*P*-value
Age group			1.000
18 ~ 29	348(51.7)	325(48.3)	
30 ~ 39	275(50.7)	267(49.3)	
40 ~ 49	295(51.2)	281(48.8)	
50 ~ 59	208(51.4)	197(48.6)	
≥ 60	226(51.1)	216(48.9)	
Location			0.992
Urban area	712(51.3)	677(48.7)	
Rural area	640(51.2)	609(48.8)	
Smoking			< 0.001
Yes	679(94.3)	41(5.7)	
Family history of diabetes			0.006
Yes	276(46.3)	320(53.7)	
BMI			< 0.001
Normal	433(41.2)	619(58.8)	
Overweight	539(54.9)	442(45.1)	
Obesity	380(62.8)	225(37.2)	
Individual variables			
Education, n (%)			0.708
Senior high school or lower	935(51.0)	898(49.0)	
College or higher level	417(51.8)	388(48.2)	
Family income per year, n (%)			< 0.001
Less than 50000 yuan	898(48.5)	953(51.5)	
More than 50000 yuan	454(57.7)	333(42.3)	
Occupation, n (%)			< 0.001
Non-qualified/homemaker	399(44.6)	496(55.4)	
Manual work	692(57.5)	512(42.5)	
Clerical work or other	261(48.4)	278(51.2)	
Clinical variables,mean (95%CI)			
Age (years)	42.52 (41.65–43.39)	42.57 (41.70–43.44)	0.939
BMI (kg/m^2)	25.82 (25.60–26.03)	24.45 (24.23–24.66)	< 0.001
Waist circumference (cm)	89.46 (88.91–90.01)	80.37 (79.82–80.93)	< 0.001
SBP (mmHg)	131.45 (130.46–132.44)	122.93 (121.87–123.99)	< 0.001
DBP (mmHg)	81.87 (81.21–82.52)	77.01 (76.41–77.61)	< 0.001
FPG (mmol/L)	5.80 (5.71–5.90)	5.43 (5.37–5.49)	< 0.001
HbA1c (%)	5.88 (5.82–5.93)	5.70 (5.66–5.75)	< 0.001
TG (mmol/L)	1.82 (1.73–1.91)	1.43 (1.37–1.49)	< 0.001
TC (mmol/L)	4.62 (4.56–4.67)	4.63 (4.57–4.70)	0.658
HDL-C (mmol/L)	1.28 (1.26–1.30)	1.50 (1.48–1.52)	< 0.001

Characteristics, n(%)	Men (n = 1352)	Women (n = 1286)	*P*-value
LDL (mmol/L)	2.67 (2.63–2.71)	2.60 (2.55–2.64)	0.014

The total population was assessed based on age group and gender. The prevalence of metabolic disorders and related components are shown in Table 2 and Fig. 1. The metabolic disorders prevalence was 89.3% in men and 80.0% in women. Low HDL-C and TC were more prevalent in women (29.8% and 27.8%, respectively) than men (16.1% and 26.4%, respectively). Men had a higher prevalence of central obesity (52.1%), prediabetes (44.8%), MetS (43.6%), hypertriglyceridemia (38.6%), hypertension (38.2%), diabetes (17.3%), and high LDL-C (15.8%) relative to women (31.3%, 39.2%, 29.7%, 26.0%, 24.5%, 11.0% and 14.3%, respectively). Low HDL-C prevalence was not significantly different in men vs women ($p > 0.05$).

Table 2
The prevalence of metabolic disorders and related diseases according to age groups. MetS, Metabolic Syndrome; BMI, Body Mass Index; WC, Waist Circumference; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; FBG, Fasting Blood Glucose; TG, Triglycerides; TC, Total Cholesterol; HDL-C, High Density Lipoprotein-Cholesterol; LDL-C, Low Density Lipoprotein-Cholesterol.

Diagnosis, n(%)	Total n(%)	18 ~ 29 (n = 673)	30 ~ 39 (n = 542)	40 ~ 49 (n = 576)	50 ~ 59 (n = 405)	≥ 60 (n = 442)	*P*-value	*P*-trend
Metabolic disorders	2236(84.8)	457(67.9)	442(81.5)	508(88.2)	393(97.0)	436(98.6)	< 0.001	< 0.001
Men	1207(89.3)	254(73.0)	246(89.5)	278(94.2)	206(99.0)	223(98.7)	< 0.001	< 0.001
Women	1029(80.0)	203(62.5)	196(73.4)	230(81.9)	187(94.9)	213(98.6)	< 0.001	< 0.001
MetS	971(36.8)	89(13.2)	177(32.7)	209(36.3)	232(57.3)	264(59.7)	< 0.001	< 0.001
Men	589(43.6)	69(19.8)	125(45.5)	140(47.5)	129(62.0)	126(55.8)	< 0.001	< 0.001
Women	382(29.7)	20(5.2)	52(13.6)	69(18.1)	103(27.0)	138(36.1)	< 0.001	< 0.001
Diabetes	375(14.2)	22(3.3)	44(8.1)	85(14.8)	94(23.2)	130(29.4)	< 0.001	< 0.001*
Men	234(17.3)	10(2.9)	29(10.5)	65(22.0)	63(30.3)	67(29.6)	< 0.001	< 0.001
Women	141(11.0)	12(3.7)	15(5.6)	20(7.1)	31(15.7)	63(29.2)	< 0.001	< 0.001
Prediabetes	1120(42.5)	207(30.8)	204(37.6)	244(42.4)	222(54.8)	243(55.0)	< 0.001	< 0.001
Men	606(44.8)	118(33.9)	117(42.5)	134(45.4)	111(53.4)	126(55.8)	< 0.001	< 0.001*
Women	504(39.2)	89(27.4)	87(32.6)	110(39.1)	111(56.3)	117(54.2)	< 0.001	< 0.001
Hypertention	831(31.5)	77(11.4)	121(22.3)	184(31.9)	201(49.6)	248(56.1)	< 0.001	< 0.001
Men	516(38.2)	55(15.8)	88(32.0)	118(40.0)	118(56.7)	137(60.6)	< 0.001	< 0.001
Women	315(24.5)	22(6.8)	33(12.4)	66(23.5)	83(42.1)	111(51.4)	< 0.001	< 0.001
Central obesity	1106(41.9)	139(20.7)	224(41.3)	235(40.8)	248(61.2)	260(58.8)	< 0.001	< 0.001
Men	704(52.1)	110(31.6)	162(58.9)	176(59.7)	132(63.5)	124(54.9)	< 0.001	< 0.001
Women	402(31.3)	29(8.9)	62(23.2)	59(21.0)	116(58.9)	136(63.0)	< 0.001	< 0.001
Hypertriglyceridemia	856(32.4)	118(17.5)	199(36.7)	220(38.2)	168(41.5)	151(34.2)	< 0.001	< 0.001
Men	522(38.6)	87(25.0)	130(47.3)	128(43.4)	106(51.0)	71(31.4)	< 0.001	0.011
Women	334(26.0)	31(9.5)	69(25.8)	92(32.7)	62(31.5)	80(37.0)	< 0.001	< 0.001
Hypercholesterolemia	715(27.1)	80(11.9)	116(21.4)	169(29.3)	178(44.0)	172(38.9)	< 0.001	< 0.001
Men	357(26.4)	38(10.9)	77(28.0)	101(34.2)	74(35.6)	67(29.6)	< 0.001	< 0.001
Women	358(27.8)	42(12.9)	39(14.6)	68(24.2)	104(52.8)	105(48.6)	< 0.001	< 0.001
High LDL-C	397(15.0)	34(5.1)	66(12.2)	99(17.2)	95(23.5)	103(23.3)	< 0.001	< 0.001
Men	213(15.8)	21(6.0)	51(18.5)	57(19.3)	44(21.2)	40(17.7)	< 0.001	< 0.001
Women	184(14.3)	13(4.0)	15(5.6)	42(14.9)	51(25.9)	63(29.2)	< 0.001	< 0.001
Low HDL-C	601(22.8)	135(20.1)	141(26.0)	128(22.2)	96(23.7)	101(22.9)	0.174	0.441
Men	218(16.1)	48(13.8)	58(21.1)	49(16.6)	35(16.8)	28(12.4)	0.064	0.502
Women	383(29.8)	87(26.8)	83(31.1)	79(28.1)	61(31.0)	73(33.8)	0.434	0.122

We found that except for low HDL-C, the prevalence of other metabolic disorders positively correlated with advancing age in men and women. In men, metabolic disorder prevalence was highest in age group 50–59, where the prevalence of central obesity, MetS, hypertriglyceridemia, hypercholesterolemia, diabetes, and high LDL-C was 63.5%, 62%, 51%, 35.6%, 30.3%, and 21.2%, respectively. In women, metabolic disorder prevalence was higher at ≥ 60 years of

age, where the prevalence of central obesity, hypertension, hypertriglyceridemia, MetS, diabetes, and high LDL-C was 63%, 51.4%, 37%, 36.1%, 29.2%, and 29.2% respectively. Moreover, the prevalence of diabetes and prediabetes in the overall population increased linearly with age.

The prevalence of metabolic disorders and related diseases differed significantly in men vs women. However, whether risk factors differ for men vs women warrants investigation. In men, upon adjusting for confounding factors, the prevalence of metabolic disorders and related diseases positively correlated with age, except for low HDL-C (Table 3). Relative to normal participants, overweight or obese men had gradually higher ORs for developing metabolic disorders ($p < 0.05$), except for hypercholesterolemia. Men living in rural areas had lower ORs for prediabetes, hypertriglyceridemia, and hypercholesterolemia, and higher ORs for central obesity and low HDL-C. The prevalence of hypertriglyceridemia and hypercholesterolemia was higher in smoking men (OR = 1.427 and 1.307 respectively) relative to nonsmokers. The prevalence of MetS and hypertension was relatively lower in men with higher education (OR = 0.711 and 0.636, respectively) relative to normal men. Manual work was a risk factor for prediabetes and high LDL-C (OR = 1.848,1.729 and 1.764 respectively). Diabetes and prediabetes were more prevalent in those with family histories of diabetes in men (OR = 1.916 and 1.912 respectively).

Table 3

Association of independent variables with metabolic disorders and related diseases in multivariable logistic regression in men. BMI, Body Mass Index; MetS, Cholesterol. *Statistically significant.

Variables	Metabolic disorders	MetS	Diabetes	Prediabetes	Hypertention	Central obesity
Age						
30 ~ 39	1.708 (0.981, 2.976)	2.073(1.350,3.184)*	3.281(1.520,7.084)*	1.273(0.864,1.875)	1.713(1.126,2.604)*	1.962(1.23
40 ~ 49	3.069(1.646,5.724)*	2.403(1.580,3.654)*	8.405(4.012,17.220)*	2.061(1.394,3.049)*	2.458(1.641,3.681)*	2.133(1.35
50 ~ 59	19.724(4.605,84.481)*	5.240(3.294,8.336)*	13.417(6.442,27.942)*	4.893(2.993,7.998)*	4.833(3.133,7.455)*	2.803(1.71
≥ 60	19.086(5.760,,63.245)*	6.414(4.071,10.106)*	15.796(7.635,32.681)*	6.973(4.306,11.294)*	6.589(4.320,10.052)*	2.792(1.75
BMI						
Overweight	3.687(2.327,5.842)*	4.504(3.195,6.349)*	0.982(0.657,1.469)	1.386(1.013,1.896)*	2.093(1.532,2.859)*	7.147(5.06
Obesity	35.191(10.930,113.304)*	20.929(14.125,31.011)*	1.999(1.315,3.020)*	2.125(1.498,3.015)*	4.164(2.968,5.842)*	107.924(6
Area						
Rural	0.477(0.302, 0.755)*	0.879(0.665,1.163)	0.510(0.358,0.725)	0.416(0.313,0.552)*	1.002(0.769,1.305)	2.200(1.60
Smoking						
Yes	0.772(0.514,1.160)	1.130(0.870,1.469)	0.840(0.617,1.142)	1.044(0.800,1.361)	0.961(0.752,1.229)	0.924(0.69
Education						
College or higher level	0.762(0.462,1.257)	0.711(0.506,0.999)*	0.806(0.527,1.234)	0.727(0.521,1.014)	0.636(0.459,0.880)*	0.726(0.48
Family income per year						
More than 50000 yuan	1.147(0.731,1.800)	1.116(0.825, 1.509)	1.169(0.816,1.676)	1.114(0.822,1.509)	0.989(0.743,1.316)	1.137(0.81
Occupation						
Manual work	1.848(1.101,3.103)*	1.383(0.977,1.958)	1.294(0.841,1.991)	1.729(1.221,2.447)*	1.487(1.071,2.063)	1.356(0.93
Clerical work or other	1.233(0.682,2.229)	2.111(1.381,3.227)	1.133(0.662,1.941)	1.361(0.903,2.051)	1.450(0.965,2.178)	1.537(0.97
Family history of diabetes						
Yes	1.060(0.635,1.771)	1.333(0.961,1.849)	1.916(1.332,2.756)*	1.912(1.355, 2.698)*	0.772(0.564,1.057)	0.940(0.65

Associations between independent variables and metabolic disorders with related diseases in women are shown in Table 4. Our data show that metabolic disorders and most associated diseases positively correlated with age. However, in women in age group 40–49, low HDL-C was a protective factor (OR = 0.654, $p < 0.05$). Relative to normal BMI, ORs gradually rose from overweight to obesity in women with metabolic disorders and their associated diseases. In women, living in rural areas emerged as an underlying protective factor for the prevalence of prediabetes, hypertriglyceridemia, hypercholesterolemia, and high LDL-C, but was an underlying risk factor for diabetes, hypertension, and low HDL-C. The prevalence of hypercholesterolemia was higher in smoking women (OR = 2.072, $p < 0.05$) than normal women. The prevalence of MetS, prediabetes, and hypertriglyceridemia, negatively correlated with higher education level in women (OR = 0.546, 0.681, and 0.636, respectively). Women with clerical work had higher ORs for diabetes (OR = 2.41) and prediabetes (OR = 1.474) prevalence relative to other occupations. Family history of diabetes was also a risk factor for diabetes in women (OR = 1.969, $p < 0.05$).

Table 4
Association of independent variables with metabolic disorders and related diseases in multivariable logistic regression in women. BMI, Body Mass Index; Lipoprotein-Cholesterol. *Statistically significant.

Variables	Metabolic disorders	MetS	Diabetes	Prediabetes	Hypertention	Central obesity
Age						
30 ~ 39	1.169(0.788,1.735)	2.048(1.117,3.756)*	1.224(0.549,2.729)	1.114(0.765,1.621)	1.218(0.666,2.227)*	1.481(0.807,2.7
40 ~ 49	1.623(1.049,2.512)*	2.631(1.443,4.797)*	1.367(0.624,2.994)	1.414(0.963,2.079)	2.639(1.492,4.666)*	1.199(0.648,2.2
50 ~ 59	5.857(2.881,11.905)*	8.714(4.763,15.941)*	3.087(1.461,6.522)*	3.543(2.292,5.476)*	5.605(3.156,9.954)*	9.841(5.343,18.
≥ 60	20.197(6.137,66.467)*	12.884(7.004,23.704)*	7.297(3.535,15.060)*	5.763(3.530,9.323)*	7.650(4.333,13.506)*	9.483(5.129,17.
BMI						
Overweight	3.633(2.440,5.409)*	4.495(3.084,6.552)*	1.501(0927,2.432)	1.616(1.205,2.166)*	2.386(1.662,3.426)*	6.543(4.358,9.8
Obesity	12.306(5.262,28.782)*	22.956(14.605,36.081)*	2.931(1.763,4.874)*	2.349(1.596,3.548)*	6.054(4.031,9.093)*	83.042(48.571,
Area						
Rural	0.503(0.358,0.706)*	0.850(0.561,1.286)	1.969(1.283,3.022)*	0.629(0.467,0.847)*	1.788(1.208,2.646)*	0.960(0.618,1.4
Smoking						
Yes	3.481(0.774,15.653)	1.225(0.526,2.853)	1.199(0.497,2.894)	1.262(0.577,2.761)	0.931(0.407,2.128)	0.631(0.256,1.5
Education						
College or higher level	0.958(0.663,1.384)	0.546(0.333,0.895)*	0.512(0.254,1.030)	0.681(0.487,0.953)*	0.951(0.580,1.557)	0.823(0.493,1.3
Family income per year						
More than 50000 yuan	0.753(0.520,1.089)	0.961(0.635,1.454)	0.500(0.277,0.903)	0.955(0.695,1.311)	0.849(0.558,1.293)	1.013(0.649,1.5
Occupation						
Manual work	1.445(0.967,2.188)	1.327(0.856,2.058)	1.554(0.873,2.764)	1.185(0.853,1.647)	1.371(0.905,2.075)	1.282(0.806,2.0
Clerical work or other	1.069(0.710,1.609)	1.305(0.740,2.301)	2.410(1.141,5.092)*	1.474(1.005,2.160)*	0.922(0.514,1.655)	0.977(0.537,1.7
Family history of diabetes						
Yes	1.247(0.859,1.812)	1.026(0.716,1.470)	1.969(1.283,3.022)*	1.001(0.742,1.352)	0.800(0.558,1.149)	1.088(0.739,1.6

Discussion

With rapid economic growth, the prevalence of metabolic diseases like central obesity, diabetes, and hyperlipidemia is rising rapidly, worldwide. This is attributable to aging populations, urbanization, lack of physical activity, and unhealthy diets[3,13–14]. Metabolic disorder may progress into disorders like atherosclerosis, coronary heart disease, and kidney diseases, which negatively impact physical and mental health, and social development. Thus, metabolic disorders are a major public health challenge in China. Data from the TIDE (Thyroid Disorders, Iodine Status and Diabetes, a national epidemiological cross-sectional study) program[15], which involved 51795 adult participants in 31 provinces in 2015–2017 identified prediabetes (39.4%), central obesity (34.5%), hypertension (29.3%), MetS (28.6%), hypertriglyceridemia (28.5%), hypercholesterolemia (28.2%), high LDL-C (21.1%), low HDL-C (19.5%), and diabetes (8.7%) as the most prevalent metabolic disorders. The overall prevalence of metabolic disorders was 81.2%. In men and women, it was 85% and 76.7%, respectively.

Here, we investigated the association between sex and metabolic disorders in Hebei province, North China. Our data show that the overall prevalence of metabolic disorders in this region was 84.8% and that in men and women, it was 89.3 and 80%, respectively. The most prevalent metabolic disorders were prediabetes, central obesity, MetS, hypertriglyceridemia, hypertension, hypercholesterolemia, low HDL-C, high LDL-C, and diabetes at 42.5%, 41.9%, 36.8%, 32.4%, 31.5%, 27.1%, 22.8%, 15%, and 14.2%, respectively.

We find that prevalence of metabolic disorders is higher in Hebei province relative to national levels, except for hypercholesterolemia and high LDL-C. Additionally, the prevalence of all metabolic disorders were higher in men and women from Hebei province relative to national prevalence rates in men and women (Supplemental Table 3), indicating that without effective preventive measures, a large number of Hebei people are at risk of developing cardiovascular disorders.

Based on the 2017 national survey, diabetes and prediabetes rates rose with age in men and women and increased most sharply after 50 years of age[16]. Consistent with this, we found that metabolic disorder prevalence positively correlated with advancing age in men and women, except for low HDL-C. Men in age group 50–59 while women aged ≥ 60 had highest prevalence of one or more metabolic disorders (Table 2). Women's endocrine function changes at menopause, with estrogen level decreasing significantly. Estrogen deficiency is thought to cause central obesity[17–18]. Additionally, lipid deposits oxidation and resulting arterial walls stiffness and blockage aggravates development of metabolic diseases like hypertension and hyperglycemia[19–20].

According to World Health Organization (WHO), diabetes prevalence increased from 9.7% in 2010, to 10.4% in 2013, and 11.2% in 2017 in mainland China[16,21–22]. Although Hebei lacks reliable data on the incidence of diabetes in earlier years, the 14.2% prevalence reported in 2017 is markedly higher than reported for mainland China. Prediabetes is of critical health concern in Hebei (42.5%) and in mainland China (39.4%) due to lack of effective lifestyle changes or treatments.

MetS refers to a set of physiological and biochemical disorders characterized by various pathological features like abdominal obesity, impaired glucose metabolism, and elevated blood pressure[23]. MetS prevalence in Hebei residents aged ≥ 20 was 36.8%. In men and women it was 43.6% and 29.7%, respectively, which is markedly higher than the national prevalence based on the 2017 national survey that reported a standardized overall MetS prevalence of 28.6% and 32.5% and 24.1% in men and women, respectively[15]. The difference in MetS prevalence in Hebei vs mainland China is attributable to geographic, economic, and lifestyle differences.

our data also suggest that aging people, overweight or obese people, urban residents, smokers, those with low education, manual workers, and those with family history of diabetes, are at higher risk of metabolic disorders. However, associations between independent variables and metabolic disorders vary in men vs women (Tables 3 and 4). While there was no significant association between BMI and hypercholesterolemia in men, high BMI increased ORs in hypercholesterolemic women. Living in rural areas was a risk factor for diabetes and hypertension in women, but not in men. Higher education negatively correlated with MetS and hypertension prevalence in men. In women, it negatively associated with the prevalence of MetS, prediabetes, and hypertriglyceridemia.

Age, gender, regional distribution, and educational level influence metabolic risks. Regarding intervention strategies, our data emphasize early intervention in middle-aged and elderly Hebei populations, while considering gender and regional characteristics of metabolic risk factor distribution in the population.

Conclusion

The findings of the present study indicate that metabolic disorders are an important public health concern and highlights an urgent need for intervention in middle-aged and elderly populations in North China.

Limitations

This study has certain limitations. First of all, the diagnostic criteria for MetS in this study are the CDS criteria, which limits the horizontal comparison of MetS prevalence with related studies in other countries. Secondly, the design uses a cross-sectional study, which cannot determine the causal relationship between risk factors and disease. Finally, because the exposure information is obtained through questionnaires, the recall of some quantitative information does not rule out recall bias.

Abbreviations

MetS: Metabolic syndrome; TC: Total cholesterol; TG: Triglycerides; HDL-C: High density lipoprotein-cholesterol; LDL-C: Low-density lipoprotein cholesterol; OGTT: Oral glucose tolerance test; FPG: Fasting plasma glucose; HbA1c: Glycosylated hemoglobin; BMI: Body mass index; WC: Waist circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; OGTT-2h PG: Two hour plasma glucose levels after carrying out an oral 75g glucose tolerance test; CIs: Confidence intervals; OR: Odds ratio; TIDE: Thyroid Disorders, Iodine Status and Diabetes; WHO: World Health Organization; IDF: International Diabetes Federation.

Declarations

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Author contributions

Zhihua Hao, Mian Wang and Lihui Zhang: Conceptualization, Methodology, Software, Validation; Jie Li,Zibo Liu and Lingling Yuan: Data Curation, Writing-Original draft preparation; Yue Zhang and Zan Wang: Visualization, Investigation; Mian Wang and Lihui Zhang: Supervision; Zhihua Hao, Yanhong Ge and Qiuxiao Zhu: Writing- Reviewing and Editing.

Competing interests

The authors declare that they have no financial or non-financial competing interests.

Availability of data and materials

The data used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Ethical approval was obtained from the Medical Ethics Committee of The Second Hospital of Hebei Medical University. All participants have provided written informed consent prior to entering the study.

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Figures

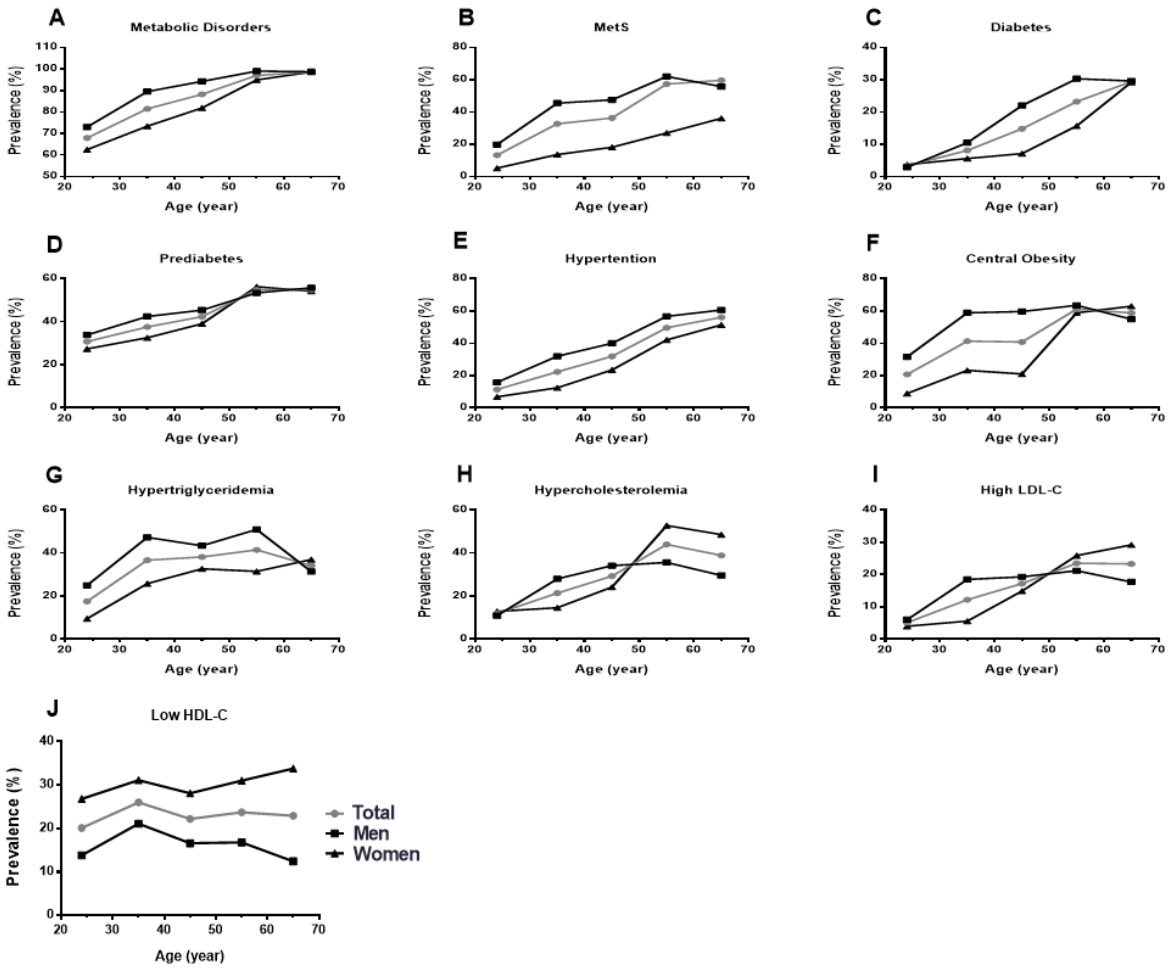

Figure 1

Association of the prevalence of metabolic disorders and related diseases with the increasing age.

Supplementary Files

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