Predictors of cardiovascular events in elderly with metabolic syndrome from rural Northeast China

Shasha Yu
First hospital of China Medical University
Xiaofan Guo
First hospital of China Medical University
GuangXiao Li
First hospital of China Medical University
Hongmei Yang
First hospital of China Medical University
Liqiang Zheng
Shengjing Hospital of China Medical University
Yingxian Sun (sunyingxiancmu1h@163.com)
the first hospital of China Medical university https://orcid.org/0000-0003-0592-2058

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Abstract

Background

Metabolic syndrome (MetS) had close relationship with cardiovascular events (CVEs). In the present study, among elderly with MetS, we intend to estimate the possible predictors of CVEs in order to prevent cardiovascular complications; among elderly without MetS, we aim to evaluate the possible risk factors for developing MetS in order to control it more effectively.

Methods

In total 2869 elderly from rural China were enrolled. They took part in a physical examination and completed a questionnaire during 2012–2013 and were followed up during 2015–2017. Cox proportional hazards analysis was conducted to assess the possible predictors of CVEs and multivariate analysis was used to estimate the risk factors of newly diagnosed MetS.

Results

Over a median follow-up of 4.66 years, 128 nonfatal or fatal cardiovascular events were documented and the cumulative incidence of MetS was 28.7% (36.3% for female; 24.3% for male). Cox proportional hazards analysis showed that family history of hypertension [Hazard ratio (HR): 1.694], current smoking (HR: 1.518), per 1 unit increase of systolic blood pressure (SBP) (HR: 1.016), and HDL-C (HR: 0.365) were strong predictors of newly onset CVEs among elderly with MetS at baseline. As for newly diagnosed MetS, male [Odd ratio (OR): 0.390] and proper sleep duration (8–9 hours/day) (OR: 0.580) served as protective factors. Furthermore, SBP (OR: 1.013), body mass index (OR: 1.178) and all lipid profiles were also associated factors of newly diagnosed MetS among elderly.

Conclusions

Current smoking and relatively higher value of SBP, and HDL-C at baseline were correlated with higher possibility to have CVEs among elderly with MetS. In order not to develop MetS, elderly should pay more attention to metabolic parameters and have proper sleep duration.

Background

During the past decades, with the rapid development of economic growth, changes in lifestyle and longer life expectancy, geriatric population increase worldwide. Together with the aging population, is that age-related metabolic disorders, like hypertension, diabetes, obesity and dyslipidemia which gradually became more prevalent. Korean survey of cardiometabolic syndrome reported that there was an increasing trend of metabolic syndrome with elevating ages and with the highest rate among subjects older than 60 years (37.9%) [1]. Similarly, results from the SABE survey claimed that the prevalence of MetS was 66.0% in elderly women and 47.1% in elderly men which was closed to many previous studies [2–4]. Previous studies already confirmed that MetS were relatively more prevalent among urban residents when compared with rural residents [5, 6]. However, our previous study found that 39.0% of rural Northeast residents suffered from MetS which was higher than other rural areas in China, such as Hanzhong (15.1%), Nantong (23.3%), and XinJiang (14.43%) [7–9]. Therefore, it is necessary to evaluate the epidemiologic situation of MetS among elderly and figure out the possible risk factors of MetS in order to have a more comprehensive understanding of cardiometabolic diseases and make a more suitable strategies to reduce MetS among elderly from rural areas.

In recent years, many studies reported that MetS was correlated with cardiovascular events (CVEs), Cancer, Psoriasis, Erectile Dysfunction, Osteoporosis and many other kinds of non-communicable diseases [10–12]. Among all this possible association, the major one was that MetS increased incidence of cardiovascular disease, coronary heart disease, and stroke [12–14]. CVD mortality had become the major mortality cause among elderly in recent years. With the improvement of preventing, diagnosis and treatment of cardiovascular risk factors, the CVD mortality began to fall in developed countries [15, 16]. Nevertheless, as metabolic disorder like obesity, hypertension, diabetes, and dyslipidemia became prevalent in rural China, the CVD mortality increased synchronously [17, 18]. With the increasing trend of both MetS and CVEs among elderly subjects. It is necessary to evaluate the possible predictors of CVEs among elderly with MetS in order to decrease the incidence of CVEs among MetS.

In the present study, we first aimed to estimate the epidemiologic characters of MetS among elderly and then figure out the possible risk factors for better prevention. Secondly, we intended to evaluate the predictors of CVEs among elderly with MetS in order to reduce the risk of getting CVEs among elderly.

Methods

Participants

The Northeast China Rural Cardiovascular Health Study (NCRCHS) is a community-based prospective cohort study carried out in rural areas of Northeast China. The specific sampling methods and the criteria for admission were described previously in detail [19]. The study was approved by the Ethics Committee of China Medical University (Shenyang, China AF-SDP-07-1, 0-01). During 2012-2013 year, a total of 3479 participants aged ≥ 60 years were recruited and all of them signed the informed consent. They finished the physical examination including anthrometric parameters, blood pressure (BP), and regular blood test. Besides, they completed a questionnaire which used to collect all the relevant data, such as personal details, medical history, and socioeconomic situation. The questionnaire used in our study has previously been published before [19]. All the participants were invited to follow-up during 2015-2017. In the end, 2869 consented to take the follow-up physical examination and completed the questionnaire again. Among them, 435 participants were diagnosed cardiovascular events previously and were excluded in the analysis of predictors for newly onset CVEs.

Baseline data

History of stroke, CHD and heart failure at baseline was defined as self-reported and confirmed by medical records. Weight and height were measured with participants in light weight clothing and without shoes. Waist circumference was measured at the umbilicus using a non-elastic tape. Body mass index (BMI) was computed as weight in kilograms divided by the square of height in meters. BP was assessed three times with participants seated after at least 5 min of rest using a standardized automatic electronic sphygmomanometer (HEM-907; Omron, Tokyo, Japan). Fasting blood samples were collected in the morning from participants who had fasted at least 12h. Fasting plasma glucose (FPG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglyceride (TG), and other routine blood biochemical indexes were analyzed enzymatically. Physical activity contained occupational and leisure-time physical activity. We have detailed descripted it previously [20]. It is divided into three classes, low, moderate and heavy. MetS was diagnosed follow the unify criteria from the meeting between several major organizations in 2009 [21]: The presence of any 3 of 5 risk factors constitutes a diagnosis of metabolic syndrome. 1. Elevated waist circumference (population- and country-specific definitions): ≥90cm for men; ≥80cm for women (Asians; Japanese; South and Central Americans); 2. Elevated triglycerides (drug treatment for elevated triglycerides is an alternate indicator): ≥150 mg/dL (1.7 mmol/L); 3. Reduced HDL-C (drug treatment for reduced HDL-C is an alternate indicator) : <40 mg/dL (1.0 mmol/L) in men; <50 mg/dL (1.3mmol/L) in women; 4. Elevated blood pressure (antihypertensive drug treatment in a patient with a history of hypertension is an alternate indicator): Systolic ≥130 and/or diastolic ≥85 mm Hg; 5. Elevated fasting glucose (drug treatment of elevated glucose is an alternate indicator): ≥100 mg/dL;

Follow-up

The median follow-up was 4.66 years. An incident CVEs was defined as a composite of new onset stroke or CHD during follow-up period. The specific incidences of stroke and CHD were also determined. For all participants reporting possible diagnoses or death, all available clinical information was collected including medical records and death certificates. All materials were independently reviewed and adjudicated by the end-point assessment committee. Stroke was defined according to the WHO Multinational Monitoring of Trends and Determinants in Cardiovascular Disease (MONICA) criteria [22, 23], as rapidly developing signs of focal or global disturbance of cerebral function, lasting more than 24 hours (unless interrupted by surgery or death) with no apparent non-vascular causes. Hemorrhagic stroke was defined as stroke cases with diagnosis of subarachnoid hemorrhage or intracerebral hemorrhage and ischemic stroke was defined as stroke cases with diagnosis of thrombosis or embolism. Transient ischemic attack and chronic cerebral vascular disease were excluded. CHD was defined as a diagnosis of hospitalized angina, hospitalized myocardial infarction, CHD death or any revascularization procedure [24].

Statistical analysis

Descriptive statistics were calculated for all the variables, including continuous variables (reported as mean values and standard deviations) and categorical variables (reported as numbers and percentages). Differences among categories were evaluated using t-test, ANOVA, non-parameter test or the χ^2-test as appropriate. Hazard ratio of CVEs was calculated by Cox's proportional-hazard model. Hazard ratio was calculated for each unit increment of metabolic parameters and other possible confounders. Logistic regression analyses was used to estimate odds ratio (ORs) and 95% confidence intervals (CIs) for the possible risk factors of newly diagnosed MetS after adjusting for possible confounders. All the statistical analyses were performed using SPSS version 17.0 software, and P values less than 0.05 were considered to be statistically significant.

Results

Baseline characteristics of elderly by MetS status

Demographic data for the 2869 elderly at baseline in 2012–2013 were presented in Table 1. Elderly with MetS had significantly higher rate of female (66.6% vs. 38.3%), light physical activity (63.9% vs. 55.2%), family history of hypertension (24.2% vs. 16.1%), CHD (14.1% vs. 10.2%) and Stroke (20.9% vs. 15.9%) compared with those without MetS. As for biochemical parameters, elderly with MetS had significantly higher value of SBP, DBP, BMI, WC, TG, LDL-C, HDL-C, and FPG.

Table 1
Baseline characteristics of rural Northeast Chinese elderly by MetS status.

Variables	Total (n = 2869)	Non-MetS (n = 1565)	MetS (n = 1304)	P-value
Man	1401(48.8)	965(61.7)	436(33.4)	< 0.001
Age (years)	66.91 ± 5.72	67.01 ± 5.86	66.79 ± 5.56	0.308
Ethnicity				0.279
Han	2742(95.6)	1492(95.3)	1250(95.9)	
Others [a]	127(4.4)	73(4.7)	54(4.1)	
Education status				0.052
Primary school or below	2161(75.3)	1152(73.6)	1009(77.4)	
Middle school	582(20.3)	343(21.9)	239(18.3)	
High school or above	126(4.4)	70(4.5)	56(4.3)	
Physical activity				< 0.001
Light	1679(59.2)	856(55.2)	823(63.9)	
Moderate	455(16.0)	247(15.9)	208(16.2)	
Severe	703(24.8)	447(28.8)	256(19.9)	
Annual income (CNY/year)				0.099
≤ 5000	677(23.6)	389(24.9)	288(22.1)	
5000–20000	1614(56.3)	878(56.2)	736(56.5)	
> 20000	574(20.0)	295(18.9)	279(21.4)	
Current smoking status (Yes)	1019(35.5)	673(43.0)	346(26.5)	< 0.001
Current drinking status (Yes)	580(20.2)	419(26.8)	161(12.3)	< 0.001
Family history of hypertension	567(19.8)	252(16.1)	315(24.2)	< 0.001
Family history of CHD	344(12.0)	160(10.2)	184(14.1)	0.001
Family history of Stroke	522(18.2)	249(15.9)	273(20.9)	< 0.001
SBP (mmHg)	152.66 ± 24.54	148.03 ± 24.09	158.21 ± 23.91	< 0.001
DBP (mmHg)	82.27 ± 11.71	80.41 ± 11.40	84.49 ± 11.71	< 0.001
BMI (kg/m^2)	24.46 ± 3.72	22.92 ± 3.24	26.30 ± 3.40	< 0.001

Variables	Total (n = 2869)	Non-MetS (n = 1565)	MetS (n = 1304)	P-value
WC (cm)	82.89 ± 10.06	78.22 ± 8.61	88.48 ± 8.74	< 0.001
TG (mmol/L)	1.64 ± 1.35	1.12 ± 0.60	2.26 ± 1.70	< 0.001
LDL-C(mmol/L)	3.11 ± 0.87	2.96 ± 0.80	3.30 ± 0.92	< 0.001
HDL-C (mmol/L)	1.43 ± 0.40	1.57 ± 0.41	1.26 ± 0.31	< 0.001
FPG (mmol/L)	6.10 ± 1.81	5.65 ± 1.25	6.64 ± 2.19	< 0.001

Data are expressed as the mean ± SD or as n (%). Abbreviations: BMI body mass index, WC waist circumference, CNY China Yuan (1CNY = 0.161 USD), SBP systolic blood pressure, DBP diastolic blood pressure, TC total cholesterol, TG triglyceride, LDL-C low-density lipoprotein cholesterol, HDL-C high-density lipoprotein cholesterol, FPG fasting plasma glucose. [a] Including some ethnic minorities in China, such as Mongol and Manchu.

Changes of biochemical parameters from baseline to follow-up in elderly with or without MetS

At baseline, 1304 elderly were diagnosed MetS. We intend to estimate the changes of metabolic parameters like SBP, DBP, WC, BMI and biochemical parameters in the past years among elderly with or without MetS. Data was shown in Fig. 1. From 2012–2013 to 2015–2017 year, SBP, DBP, BMI, FPG, and HDL-C significantly decreased among elderly with MetS whereas WC increased apparently. Similarly, among elderly without MetS at baseline, SBP, DBP, and HDL-C increased from 2012–2013 to 2015–2017 year. However, WC, FPG, TG and LDL-C increased as time passed among elderly without MetS. There were differences in the changes of biochemical parameters among participants with or without MetS.

The possible predictors of CVEs among elderly with MetS at baseline

In order to figure out the possible predictors of CVEs among elderly with MetS, we conducted the Cox's proportional-hazard analysis. In Table 2, we can see that family history of hypertension (HR = 1.694, 95%CI = 1.121, 2.560, $P = 0.012$), current smoking status at baseline (HR = 1.518, 95%CI = 1.020, 2.259, $P = 0.040$), per 1 mmHg increase of SBP (HR = 1.016, 95%CI = 1.006, 1.025, $P = 0.001$), and per 1 mmol/L increase of HDL-C (HR = 0.365, 95%CI = 0.164, 0.811, $P = 0.013$) were all correlated with CVEs among elderly with MetS.

Table 2
Cox proportional hazards model: Hazard ratio of newly onset cardiovascular events among elderly with MetS at baseline (n = 1059).

Variable	**Hazard ratio**	**HR lower CL**	**HR upper CL**	***P*-value**
Age at entry (per 1 year)	1.026	0.992	1.062	0.134
Gender (male as refer**)**	1.269	0.813	1.981	0.295
Race (minority as refer**)**	0.562	0.262	1.206	0.139
Family history of CHD (no as refer**)**	0.996	0.572	1.735	0.989
Family history of Stroke (no as refer**)**	1.268	0.815	1.973	0.292
Family history of Hypertension (no as refer**)**	**1.694**	**1.121**	**2.560**	**0.012**
SBP (per 1 mmHg**)**	**1.016**	**1.006**	**1.025**	**0.001**
DBP (per 1 mmHg**)**	0.999	0.980	1.019	0.945
BMI (per 1 kg/m^2**)**	1.012	0.957	1.070	0.681
FPG (per 1 mmol/L**)**	0.985	0.910	1.067	0.717
TG (per 1 mmol/L**)**	0.843	0.699	1.015	0.071
HDL-C (per 1 mmol/L**)**	**0.365**	**0.164**	**0.811**	**0.013**
LDL-C (per 1 mmol/L**)**	0.830	0.537	1.282	0.402
Sleep duration (≤ 7 hour/day as refer**)**				
7–8 hour/day	1.085	0.682	1.728	0.729
8–9 hour/day	1.108	0.639	1.921	0.714
>9 hour/day	1.412	0.754	2.645	0.281
Education status (Primary school or below as refer**)**				
Middle school	0.781	0.469	1.300	0.342
High school or above	0.810	0.315	2.085	0.662
Annual income (CNY/year)(≤ 5000 as refer**)**				
5000–20000	0.712	0.460	1.103	0.129
> 20000	0.667	0.388	1.148	0.144
Physical activity (Light as refer**)**				
Moderate	1.003	0.622	1.618	0.990

Variable	Hazard ratio	HR lower CL	HR upper CL	*P*-value
Heavy	0.743	0.435	1.269	0.277
Current smoking (no as refer**)**	**1.518**	**1.020**	**2.259**	**0.040**
Current drinking (no as refer**)**	1.349	0.776	2.346	0.289
HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; TG: triglyceride; TC: total cholesterol;				

Cumulative incidence of newly diagnosed MetS among elderly

In the present study, 1565 elderly were without MetS at baseline. During 4.66 years of follow-up, the cumulative incidence of newly diagnosed MetS among this 1565 elderly was shown in Figure 2. Female had significantly higher rate of MetS compared to men (36.3% vs. 24.4%, P<0.001) (Figure 2A). As shown in Figure 2B, with the increase numbers of metabolic disorders, the rate of newly diagnosed MetS also increased (14.0%, 21.2% and 36.7%, P for trend<0.001). If elderly had metabolic disorders at baseline, they were more likely to develop MetS during follow-up (Figure 2C). Elderly with abdominal obesity (44.3% vs. 26.2%, P<0.001), elevated BP (30.5% vs. 22.9%, P=0.008), high TG (47.6% vs. 26.9%, P<0.001), and low HDL-C (39.0% vs. 28.0%, P<0.001) had significantly higher rate of newly diagnosed MetS compared with subjects without them. The highest rate of newly diagnosed MetS was among elderly with high TG (47.6%)

Possible associated factors of newly diagnosed MetS

In order to estimate the possible risk factors that might affect the incidence of MetS, we conducted the multivariable analysis (Table 3). Data showed that male gender (OR=0.390, 95%CI=0.272, 0.560, *P*<0.001), per 1 unit increase of SBP (OR=1.013, 95%CI=1.005, 1.022, *P*=0.002), BMI (OR=1.178, 95%CI=1.120, 1.239, *P*<0.001), FPG (OR=1.256, 95%CI=1.111, 1.420, *P*<0.001), TG (OR= 1.975, 95%CI=1.438, 2.712, *P*<0.001), HDL-C (OR=0.536, 95%CI=0.323, 0.890, *P*=0.016) and LDL-C (OR= 2.047, 95%CI=1.342, 3.124, *P*=0.001) at baseline and 8-9 hours/day sleep duration (OR=0.580, 95%CI=0.367, 0.917, *P*=0.020) were associated with incidence of MetS among elderly.

Table 3. Multivariable analysis of possible association between risk factors and cumulative incidence of MetS among elderly without MetS at baseline (n=1565).

Variable	Odd ratio	95%CI (lower)	95%CI (Upper)	*P*-value
Age at entry (per 1 year)	0.989	0.961	1.017	0.436
Gender (female as refer)	**0.390**	**0.272**	**0.560**	**<0.001**
Race (minority as refer)	1.088	0.552	2.145	0.807
SBP (per 1 mmHg)	**1.013**	**1.005**	**1.022**	**0.002**
DBP (per 1 mmHg)	1.000	0.983	1.016	0.959
BMI (per 1kg/m^2)	**1.178**	**1.120**	**1.239**	**<0.001**
FPG (per 1 mmol/L)	**1.256**	**1.111**	**1.420**	**<0.001**
TG (per 1 mmol/L)	**1.975**	**1.438**	**2.712**	**<0.001**
HDL-C (per 1 mmol/L)	**0.536**	**0.323**	**0.890**	**0.016**
LDL-C (per 1 mmol/L)	**2.047**	**1.342**	**3.124**	**0.001**
Sleep duration (≤7 hour/day)				
7-8 hour/day	0.859	0.613	1.204	0.378
8-9 hour/day	**0.580**	**0.367**	**0.917**	**0.020**
>9 hour/day	0.927	0.527	1.628	0.791
Education status (Primary school or below as refer)				
Middle school	1.215	0.863	1.711	0.265
High school or above	0.919	0.426	1.982	0.829
Annual income (CNY/year)(≤ 5000 as refer)				
5000-20000	0.809	0.572	1.145	0.232
> 20000	0.711	0.453	1.118	0.140
Physical activity (Light as refer)				
Moderate	0.857	0.573	1.280	0.450
Heavy	1.220	0.871	1.709	0.248
Family history of hypertension (no as refer)	1.101	0.749	1.619	0.625
Family history of CHD (no as refer)	0.786	0.491	1.257	0.315
Family history of Stroke (no as refer)	1.249	0.852	1.830	0.254
Current smoking (no as refer)	1.355	0.990	1.853	0.057
Current drinking (no as refer)	1.107	0.766	1.601	0.588

HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; TG: triglyceride; TC: total cholesterol;

Discussion

In the present study, the cumulative incidence of MetS was high among elderly from rural Northeast China. Proper sleep duration seemed decrease cumulative incidence of MetS among elderly. More attention should be paid on baseline SBP, BMI and lipid profiles in order to prevent developing MetS, especially among female elderly. As for elderly with MetS, except for some irreversible factors like family history of hypertension, smoking cessation should be suggested in order to prevent CVEs. Besides, elderly with elevated SBP and low HDL-C deserved more concern due to the relative higher risk of CVEs.

One study enrolled 6828 nonmetabolic syndromic adults, concluded that factors as being male, elderly, cigarette smoking, meat/food intake dietary pattern and metabolic components at the baseline showed significantly positive effects on the risk of developing MetS [25]. Hence, they suggested cigarette cessation and dietary pattern modification to be the major prevention strategies in controlling MetS. Other study reported that intermediate level of physical activity seemed to be a protected factor of MetS [26]. Therefore they claimed that there was need for prevention strategies involving promotion of physical activity. However, study enrolled specifically elderly, found that older adults with MetS presented the same level of physical activity as individuals without this diagnosis [27]. Similarly, data in our study exhibited no statistically significant relationship between physical activity and MetS among rural elderly. One possible reason might be the relative low rate of moderate and heavy physical activity among older subjects due to the aging. National Health and Nutrition Examination Survey (NHANES) aiming to assess the association between sleep duration and MetS figured out that there was a U-shape association between them. Both short and long sleep duration was correlated with higher risk of MetS and they suggested a proper sleep duration especially among men [28]. Consistent with this previous studies, only 8–9 hours/day sleep duration in our study showed significant protective effect on MetS [28, 29]. Among rural elderly, it might be more important to recommend a proper sleep duration in order to prevent MetS. Besides, we should pay more attention on female elderly since they had relatively higher risk of developing MetS compared to male. Furthermore, like many previous studies had already emphasized, the elderly should pay attention to their blood lipid profile, glucose, and blood pressure and monitor them frequently in order to discover the abnormal changes as early as possible.

Increasing evidence regarding the association between MetS and mortality confirmed that MetS was associated with a higher risk of all-cause mortality and CVD mortality among older subjects [30, 31]. Besides, more and more studies reported that elderly with MetS presented higher incidence of CVEs compared to those without MetS [32, 33]. Since elderly with MetS had higher risk of developing CVEs, there was a clear need to identify and manage individual risk factors of CVEs among metabolic syndromic elderly. There were many strategies that might be effective to decrease CVEs among metabolic syndromic subjects. First is the lifestyle changes. Evidence from clinical trials demonstrated that intensive lifestyle modification, such as increased physical activity and dietary changes can reduced the risk of CVEs [34]. Even though in our present study, we did not find significant predicting effect of physical activity intensity on CVEs among elderly with MetS. There were already many previous study clarified the protective effect of physical activity on CVEs [35–37]. The Mediterranean-style diet, as a recommended dietary pattern, was proved to be associated with reduced risk of CVEs [38]. A randomized trial reported that among patients with MetS following the Mediterranean-style diet got a significant reduction in body weight, WC, BP, plasma glucose, total cholesterol, TG as well as improvement in HDL-C concentration [39]. Meta-analysis also confirmed that increased vegetable and fruit intake was correlated with reduced risk of stroke and CHD [40]. The second effect strategies was smoking cessation. Smoking was proved to be relevant to atherosclerosis and CVD and also played an important role in the MetS [41]. Besides, in the Multiple Risk Factor Intervention Trial (MRFIT), smoking subjects did not receive beneficial effect from lifestyle intervention compared to non-smoking subjects [42]. As in our study shown, current smoking at baseline was associated with higher risk of CVEs which suggesting elderly should quit smoking to prevent CVEs.

There were some limitations in the presents study. First, we did not evaluate the possible effect of diet on MetS and CVEs. Second, there are some participant loss contact in the follow-up which might cause bias in the predictive effect of MetS on CHD, stroke or CVD. Third, HDL-C, LDL-C, triglyceride, fasting plasma glucose were measured only once during the baseline and follow-up examination, which might be imprecise and resulted in random errors.

Conclusion

MetS was prevalent among rural Chinese elderly and the cumulative incidence was even relatively higher than many developed or urban areas in China. BP, BMI and lipid profiles at baseline was associated with incidence of MetS while proper sleep duration and male gender correlated with lower risk of MetS. Among metabolic syndromic elderly, smoking cessation should be recommended, SBP and HDL-C should be monitor in order to prevent CVEs.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of China Medical University (Shenyang, China AF-SDP-07-1, 0–01). All procedures were performed in accordance with ethical standards. Written consent was obtained from all participants after they had been informed of the objectives, benefits, medical items and confidentiality agreement regarding their personal information.

Consent for publication

All the participants gave consent for direct quotes from their interviews to be used in this manuscript.

Availability of data and materials

Enquiries regarding the availability of primary data should be directed to the principal investigator Professor Yingxian Sun (sunyingxiancmu1h@163.com).

Competing interests

The authors declare that they have no competing interests.

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No

Authors' Contributions

SSY contributed to the data collection, analysis and interpretation. XFG and HMY contributed to data collection. GXL and SSY contributed to data analysis. YXS contributed to the study conceptions and design. All authors read and approved the final version of the manuscript.

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Figures

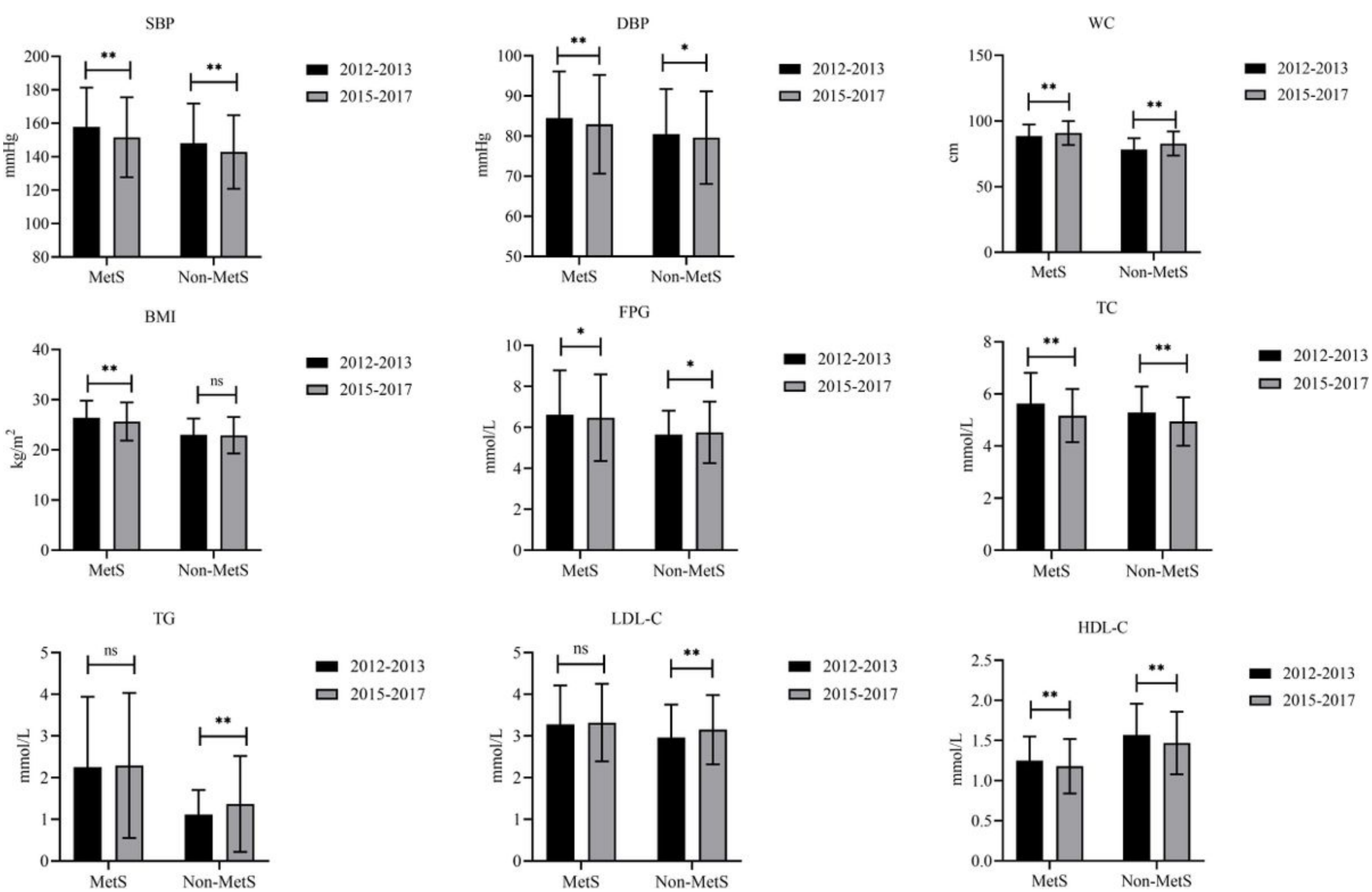

Figure 1

Changes of different metabolic parameters from 2012-2013 to 2015-2017 among rural elderly with or without metabolic syndrome. * means P<0.05; ** means P<0.001; ns means without significant difference; MetS: metabolic syndrome; SBP: systolic blood pressure; DBP: diastolic blood pressure; WC:

waist circumference; BMI: body mass index; FPG: fasting plasma glucose; TG: triglycerides; LDL-C: low density lipid cholesterol; HDL-C: high density lipid cholesterol;

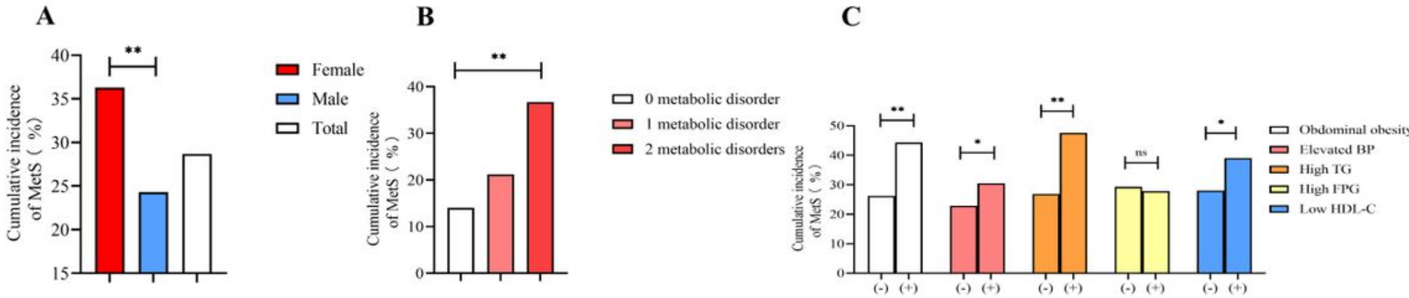

Figure 2

Cumulative incidence of metabolic syndrome among gender (A), different number of metabolic disorders at baseline (B) and different metabolic disorders (C). * means P<0.05; ** means P<0.001; ns means without significant difference; BP: blood pressure; TG: triglyceride; FPG: fasting plasma glucose; HDL-C: high density lipid cholesterol;