Original Article

Metabolic Disorders Increase the Risk to Incident Cardiovascular Disease in Middle-aged and Elderly Chinese*

ZHANG Ming Liang[1], HOU Xu Hong[1], ZHU Yun Xia[1], LU Jun Xi[1], PENG Liang Pu[2], GU Hui Lin[3], and JIA Wei Ping[1,#]

1. Department of Endocrinology and Metabolism, Sixth People's Hospital Affiliated to Shanghai Jiao Tong University; Shanghai Diabetes Institute; Shanghai Clinical Center of Diabetes; Shanghai Key Laboratory of Diabetes Mellitus, Sixth People's Hospital Affiliated to Shanghai Jiao Tong University , Shanghai 200233, China; 2. Shanghai Caoyang Community Health Care Center, Shanghai 200062, China; 3. Shanghai Huayang Community Health Care Center, Shanghai 200042, China

Abstract

Objective The association of metabolic syndrome (MetS) with cardiovascular diseases (CVD) has not been adequately explored in middle-aged and elderly Chinese. This study aimed to investigate MetS' prevalence and its impact on the CVD incidence in this specific population group.

Methods A data set of a community-based prospective cohort study was analyzed. A total of 2300 subjects aged 40-94 years were followed up for the CVD events. MetS defined according to the JCDCG criteria was assessed at baseline, and the middle-aged and elderly groups were classified by the WHO definition.

Results As compared with the middle-aged group, the prevalence of MetS increased by 0.6 times (34.6% vs. 21.3%) and the incidence density of CVD increased by 4.9 times in the elderly group (52.3/1000 person-year vs. 8.9/1000 person-year). Furthermore, the multivariate Cox regression revealed that the risk to CVD incidence was independently related to increased waist circumference in the middle-aged group (HR=2.23, $P<0.01$) and to elevated blood glucose in the elderly group (HR=1.39, $P<0.01$).

Conclusion MetS was highly prevalent in middle-aged and elderly Chinese. MetS significantly increased the risk to CVD incidence in the elderly. All individuals with metabolic disorders should receive active clinical care to reduce the incidence of CVD.

Key words: Metabolic syndrome; Cardiovascular disease; The middle-aged; The elderly

Biomed Environ Sci, 2012; 25(1):38-45 doi: 10.3967/0895-3988.2012.01.006 ISSN:0895-3988

www.besjournal.com(full text) CN: 11-2816/Q

INTRODUCTION

Due to rapid economic growth and increase of the ageing population in the past two decades in China, the epidemic of overweight and sedentary lifestyles has raised the prevalence of metabolic syndrome (MetS), which in turn predicts an increased risk to cardiovascular diseases (CVD)[1]. MetS, also known as insulin resistance syndrome, has long been characterized with a cluster of risk factors, including obesity, glucose intolerance, dyslipidemia and elevated blood

*This research was supported by the Major Program of Shanghai Municipality for Basic Research (08dj1400601), Shanghai Key Laboratory of Diabetes Mellitus (08DZ2230200), by the Key Project of Science and Technology of Shanghai (09DZ1950202).

#Correspondence should be addressed to JIA Wei Ping. Tel: 86-21-64369181-8922. Fax: 86-21-64368031. E-mail: wpjia@sjtu.edu.cn

Biographical note of the first author: ZHANG Ming Liang, male, born in 1982, Ph.D candidate, majoring in endocrinology and metabolism.

Received: February 24, 2011; Accepted: August 1, 2011

pressure (BP)[2]. In 2005, the American Heart Association/National Heart, Lung and Blood Institute (AHA/NHLBI) recommended that to reduce risk to cardiovascular disease, all individuals who were affected with MetS should receive long-term care and follow-up in a clinical setting[3]. Thus, information about the prevalence of MetS is most important for estimating the health burdens caused by MetS, including CVD, that is, all individuals with MetS should receive long-term follow-up care and full cardiovascular risk assessment. CVD has the highest growth and recurrence rate in China. It is the major cause of death for both men and women, in which stroke contributes to over 40% of deaths[4]. Our previous papers have reported that females with MetS are 1.5 to 2 times more likely to be faced with the risk to CVD than those without MetS[5]. However, the prevalence of MetS in elderly individuals has not been well documented. Hence, an understanding of the prevalence of the MetS in this population group is essential for the rational allocation of health care and research resources. Also, there has been little data regarding the prevalence of MetS and the relationship of MetS with CVD in middle-aged and elderly Chinese[6]. As MetS becomes more prevalent among the middle-aged and the elderly people, the issues are becoming more crucial with worldwide progressively growing of aged populations. The present paper aimed: (1) to investigate the prevalence of MetS, (2) to compare the incidence of CVD, and (3) to assess the association between MetS and CVD, which were all oriented towards the middle-aged and the elderly of China.

MATERIALS AND METHODS

Study Population

This paper was based on a data set of a community-based prospective cohort study in Shanghai communities, i.e. Shanghai Diabetes Study (SHDS)[7]. The cohort subjects were selected from the two urban communities with the multi-stage sampling method starting from 1998 in the Huayang community and from 2001 in the Caoyang community. A total of 5 994 subjects aged from 15 to 94 years were recruited and examined at baseline.

Subsequently, only 2 919 participants aged over 30 were followed up from December 2003 to November 2004 for the occurrences of CVD. Of them 123 subjects had CVD events at baseline, and the causes of death for other 8 subjects during the follow-up period were uncertain. Therefore, these 131 subjects were excluded from this study. Among the remaining CVD-free 2 788 subjects at baseline, 2 300 subjects aged over 40 years were included in this analysis. The population of the study has been described elsewhere[5,7].

Informed consent was obtained from each participant. The protocol was in accordance with the Helsinki Declaration and approved by the local ethical committee.

Data Collection

Participants were invited to the local hospital at 6:00-7:00 AM following an overnight fast. After a fasting venous blood sample was collected, each participant received a 75-g OGTT, except for those with a validated history of diabetes mellitus. Plasma glucose levels were measured by using the glucose oxidase method. Serum true insulin was assayed with a bio-antibody technique (Linco, St Louis, MO, USA). Serum lipid profiles were measured with an automated biochemical instrument by RIA based on the double-antibody technique (DPC, Los Angeles, CA, USA).

The methods of the anthropometric measurement, including height and weight, waist circumference and hip circumferences, had been previously described in details[7]. Blood pressure measurements were taken three times by using a sphygmomanometer and then averaged.

At the same time, a standardized health questionnaire was completed by trained nurses. It covered demography, medical histories, smoking habits and family history of diseases, etc.

Definition

(1) ***The Middle-aged Group and the Elderly Group*** According to the WHO definition[8], the middle-aged group is defined as 40-65 years, while the elderly group is defined as more than 65 years.

(2) ***MetS Definition*** According to the JCDCG-MetS definition[9], if a Chinese is to be classified as having MetS，he/she must have at least 3 of the following components: 1. Increased WC: waist circumference >90 cm for men and >85 cm for women; 2. Elevated TG: Triglycerides (TG) ≥1.70 mmol/L; 3. Reduced HDL-C: HDL cholesterol (HDL-C)<1.04 mmol/L; 4. Elevated BP: Blood pressure≥130/85 mmHg or known treatment for hypertension; 5. Elevated BG: Fasting plasma glucose (FPG) ≥6.1 mmol/L and/or 2 h plasma glucose (2 h-PG) ≥ 7.8 mmol/L and/or diabetes mellitus having been diagnosed and currently receiving therapy.

Ascertainment of CVD Events

CVD events were mainly validated through two sources: hospital records and death certificates.

(1) ***Diagnostic Categories of CVD for Survivors*** We defined incident CVD events as the first occurrence of CHD or stroke. According to the diagnostic criteria of Monitoring of Trends and Determinants in Cardiovascular Disease (MONICA), CHD includes physician-diagnosed stable angina pectoris, prinzmetal's variant angina, acute myocardial infarction (unstable angina pectoris, ST segment elevation myocardial infarction and non ST segment elevation myocardial infarction)[10]. According to the diagnostic criteria of US National Institute of Neurological and Communicative Diseases and Stroke (NINCDS), stroke was defined as physician-diagnosed cerebrum hemorrhage and cerebral infarction, which includes cerebral thrombosis, cerebral embolism, lacunar cerebral infarction and hemorrhagic infarction[11]. All diagnoses were verified by the hospital records.

(2) ***Ascertainment and Classification of CVD Deaths*** Death certificates were provided by the Chinese Center for Disease Control and Prevention (China CDC). Classification of death was defined by using the 9th revision of the International Classification of Diseases (ICD-9) before 2001 and the 10th revision thereafter. Ninth Revision (ICD-9) codes coronary heart disease (CHD) as 410, 411 413 and 414, and stroke as 430-437, and in the 10 th revision CHD is coded as I20-I25 and stroke-as 160-168.

$$\text{Incidence density (ID)} = \frac{\text{No. of disease onsets}}{\text{Sum of person-time at risk}}.$$

It is to be noted that the total person-year of observation was obtained by addition of the years contributed by each eligible subject. Observation of each subject began at baseline and continued until the incident CVD occurred (complete data) or follow-up ceased (censored data). The associations of metabolic disorders with CVD were assessed by univariable or multivariable Cox proportional hazards regression analysis. (1) Univariate Cox proportional hazards regression analysis was carried out with CHD, stroke or CVD as dependent variables and MetS or its components as independent variables. (2) Multivariable Cox proportional hazards regression analysis was carried out with CHD, stroke or CVD as dependent variables and age , smoking status and MetS components simultaneously as independent variables, including Model I (only being adjusted for age and single component of MetS) and Model II (being adjusted for age, smoking status and all five components of MetS). Age was introduced as a continuous variable, and the other variables were used as binary variables.

The Kaplan-Meier Hazard Curves were given for the middle-aged and the elderly with vs. without MetS during the average 3.7-year (range, 0.083 to 5.3 years) follow-up in the middle-aged and the average 3.1-year (range, 0.083 to 5.1 years) follow-up in the elderly.

Quality control was required to reduce information bias, recall bias, interviewer bias, and measurement bias in our research, which was described as follows

(1) The medical staff was trained before the study.

(2) Data were duplicately inputted and checked.

(3) All quality control of our laboratory was in line with standards of the Shanghai Clinical Testing Center.

(4) Survivors of CVD events were verified by patient's medical records; CVD mortality was confirmed by death registration in China CDC.

The Statistical analysis was performed with the SPSS software for Windows (Version 11.0). A value of $P<0.05$ was considered to be statistically significant.

RESULTS

Baseline Characteristics of the Middle-aged Group and the Elderly Group

The respective baseline characteristics of the middle-aged group and the elderly group are presented in Table 1. Of the 2 300 participants included in this analysis, 1 286 fell into the middle-aged group, while the other 1 014 fell into the elderly group. Compared with the middle-aged group, the elderly group had significantly higher waist circumference, FPG, 2h-PG, systolic blood pressure (SBP), diastolic blood pressure (DBP), HDL-C, low-density lipoprotein cholesterol (LDL-C) and total cholesterol (TC), but significantly lower fasting insulin level and HOMA-B. There were no differences in body mass index (BMI) or TG between the two groups. It could be noted that the elderly group had higher HDL-C than the middle-aged group.

According to the JCDCG definition of MetS, the prevalence of MetS in the elderly individuals was roughly 1.6 times as high as that in the middle-aged individuals (34.6% vs. 21.3%), (odds ratio [OR] 1.89, 95% CI 1.58-2.29).

Table 1. Baseline Characteristics of Middle-aged and Elderly Chinese

Characteristics	Middle-aged (*n*=1286)	Elderly (*n*=1014)	*P* Value
Sex (male/female)	503/783	495/519	<0.001
Age (years)	49 (44-56)	73 (69-77)	<0.001
Waist Circumference (cm)	80.0 (73.5-86.0)	83.0 (76.0-90.0)	<0.001
BMI (kg/m^2)	24.1±3.3	24.2±3.6	0.308
SBP (mmHg)	120 (108-135)	135 (121-150)	<0.001
DBP (mmHg)	77 (72-90)	80 (75-90)	0.002
FPG (mmol/L)	5.00 (4.60-5.40)	5.20 (4.80-5.70)	<0.001
2h-PG (mmol/L)	5.50 (4.60-6.70)	6.60 (5.40-8.20)	<0.001
FINS (mU/L)	7.09 (4.67-10.26)	6.66 (4.14-10.23)	0.035
TG (mmol/L)	1.60 (1.10-2.22)	1.56 (1.13-2.12)	0.52
TC (mmol/L)	4.96 (4.31-5.72)	5.07 (4.43-5.85)	0.008
HDL-C (mmol/L)	1.30 (1.10-1.46)	1.36 (1.20-1.51)	<0.001
LDL-C (mmol/L)	3.38 (2.89-4.06)	3.46 (3.03-4.20)	0.012
HOMA-B	92.1 (60.3-142.3)	76.6 (48.4-122.6)	<0.001
HOMA-IR	1.6 (1.0-2.5)	1.6 (1.0-2.5)	0.707
Smoking Status Non-/Ex-/Current Smoker	839/49/266	701/47/172	0.044
JCDCG-MetS	272 (21.3)	348 (34.6)	<0.001

Note. Data represent means±SD, or median (interquartile range), or frequency. The differences between the two groups were tested with *t*-test, Mann-Whitney *U* test and Chi-square as appropriate. BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; TG: triglyceride; TC: total cholesterol; FPG: fasting plasma glucose; 2h-PG: 2 hour plasma glucose; FINS: fasting insulin.

Prospective Relationship of JCDCG-MetS with CVD Incidence

The prediction of CVD events based on each component of MetS is shown in Table 2. In the age-adjusted models, the ability of MetS' components to predict CVD events was evaluated with the Cox proportional hazard model. Although more associations between the components of MetS and CVD reached statistical significance in Model I, some statistical associations disappeared in Model II, in which the independent variables (age, the component variables of MetS and smoking status) were compulsively included. Results of the multivariate analyses (Model II) were as follows. (1) In the middle-aged group, only increased waist circumference was significantly associated with CVD (HR=2.23, *P*<0.01) and stroke (HR=3.57, *P*<0.05) (Table 2-3). (2) Reduced HDL-C was the only shared risk factor of CHD for both the middle-aged group (HR=5.08, *P*<0.05) and the elderly group (HR=2.28, *P*<0.05) (Table 2-2). (3) In the elderly group, only elevated blood glucose was significantly associated with CVD (HR=1.39, *P*<0.05), but no statistical association of any component of MetS with stroke was detected (Table 2-1).

Cumulative Hazard Curves of CVD

During the average 3.7-year (range, 0.083 to 5.3 year) follow-up, 42 individuals developed CVD (Stroke in 17 and CHD in 25) in the middle-aged group, while 164 developed CVD (Stroke in 102 and CHD in 62) in the elderly group during the average 3.1-year (range, 0.083 to 5.1 year) follow-up. The overall ID of CVD were 8.9/1000 person-year and 52.3/1000 person-year for the middle-aged and the elderly, respectively. Cumulative hazard curves of CVD showed that the risk of CVD incidence was significantly higher in the individuals with MetS than those without MetS both in the middle-aged (log rank test χ2=6.12, *P*=0.013, HR=2.3, 95% CI, 1.2-4.3) and in the elderly (log rank test χ2=5.10, *P*=0.024, HR=1.4, 95% CI, 1.0-1.9) (Figure 1).

Table 2-1. Risk of Stroke Incident by Components of MetS in Middle-aged and Elderly Subjects

Components	Stroke (Middle-aged)					Stroke (Elderly)				
	Person-year	Events	ID	HR (95% CI)		Person-year	Events	ID	HR (95% CI)	
				Model I	Model II				Model I	Model II
Waist Circumference										
Normal	3691.8	11	3.0	1.0 (referent)	1.0 (referent)	2074.4	62	29.9	1.0 (referent)	
Abdominal Obesity	1018.8	14	13.7	4.22 (1.90-9.38)**	3.57 (1.42-8.97)*	1068.2	40	37.4	1.34 (0.90-2.00)	
TG										
Normal	2414.8	11	4.6	1.0 (referent)		1705.0	55	32.3	1.0 (referent)	
High TG	2295.8	14	6.1	1.15 (0.52-2.56)		1437.6	47	32.7	1.15 (0.77-1.72)	

(Continued)

Components	Stroke (Middle-aged)					Stroke (Elderly)				
	Person-year	Events	ID	HR (95% CI)		Person-year	Events	ID	HR (95% CI)	
				Model I	Model II				Model I	Model II
HDL										
Normal	3806.8	24	6.3	1.0 (referent)		2717.9	91	33.5		
Low HDL-C	903.8	1	1.1	0.22 (0.29-1.60)		424.7	11	25.9	0.85 (0.44-1.66)	
BP										
Normal	2622.4	6	2.3			764.3	15	19.6		
Hypertension	2088.2	19	9.1	2.90 (1.13-7.42)*		2378.3	87	36.6	1.78 (1.03-3.08)*	
BG										
Normal	3733.9	15	4.0			1948.1	51	26.2		
High BG	941.75	10	10.6	1.93 (0.85-4.36)		1180.3	51	43.2	1.57 (1.06-2.33)*	

Table 2-2. Risk of CHD Incident by Components of MetS in Middle-aged and Elderly Subjects

Components	CHD (Middle-aged)					CHD (Elderly)				
	Person-year	Events	ID	HR (95% CI)		Person-year	Events	ID	HR (95% CI)	
				Model I	Model II				Model I	Model II
Waist Circumference										
Normal	3691.8	13	3.5	1.0 (referent)		2074.4	42	20.2	1.0 (referent)	
Abdominal Obesity	1018.8	4	3.9	1.05 (0.34-3.24)		1068.2	20	18.7	0.77 (0.44-1.37)	
TG										
Normal	2414.8	7	2.9	1.0 (referent)		1705.0	31	18.2	1.0 (referent)	
High TG	2295.8	10	4.4	1.39 (0.52-3.71)		1437.6	31	21.6	1.22 (0.73-2.03)	
HDL										
Normal	3806.8	10	2.6	1.0 (referent)	1.0 (referent)	2717.9	45	16.6	1.0 (referent)	1.0 (referent)
Low HDL-C	903.8	7	7.7	3.63 (1.37-9.57)*	5.08 (1.74-14.89)*	424.7	17	40.0	2.63 (1.47-4.71)**	2.28 (1.19-4.35)*
BP										
Normal	2622.4	7	2.7	1.0 (referent)		764.3	14	18.3	1.0 (referent)	
Hypertension	2088.2	10	4.8	1.82 (0.69-4.79)		2378.3	48	20.2	1.07 (0.59-1.95)	
BG										
Normal	3733.9	12	3.2	1.0 (referent)		1948.1	33	16.9	1.0 (referent)	
High BG	941.8	5	5.3	1.38 (0.51-3.73)		1180.3	29	24.6	1.06 (0.58-1.92)	

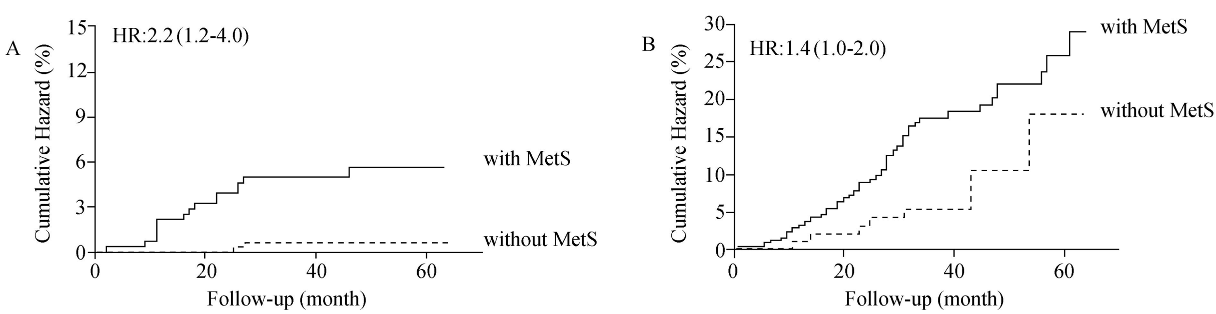
Table 2-3. Risk of CVD Incident by Components of MetS in Middle-aged and Elderly Subjects

Components	CVD (Middle-aged)					CVD (Elderly)				
	Person-year	Events	ID	HR (95% CI)		Person-year	Events	ID	HR (95% CI)	
				Model I	Model II				Model I	Model II
Waist Circumference										
Normal	3691.8	24	6.5	1.0 (referent)	1.0 (referent)	2074.4	60	28.9	1.0 (referent)	
Abdominal Obesity	1018.8	18	17.7	2.51 (1.36-4.66)*	2.23 (1.10-4.54)*	1068.2	104	97.4	1.11 (0.79-1.53)	
TG										
Normal	2414.8	28	11.6	1.0 (referent)		1705.0	120	70.4	1.0 (referent)	
High TG	2295.8	14	6.1	1.24 (0.67-2.31)		1437.6	44	30.6	1.18 (0.86-1.61)	

(Continued)

Components	CVD (Middle-aged)					CVD (Elderly)				
	Person-year	Events	ID	HR (95% CI) Model I	HR (95% CI) Model II	Person-year	Events	ID	HR (95% CI) Model I	HR (95% CI) Model II
HDL										
Normal	3806.8	34	8.9	1.0 (referent)		2717.9	136	50	1.0 (referent)	
Low HDL-C	903.8	8	8.9	1.22 (0.56-2.64)		424.7	28	65.9	1.48 (0.97-2.26)	
BP										
Normal	2622.4	13	5.0	1.0 (referent)		764.3	29	37.9	1.0 (referent)	
Hypertension	2088.2	29	13.9	2.08 (1.06-4.09)*		2378.3	135	56.8	1.43 (0.96-2.14)	
BG										
Normal	3733.9	27	7.2	1.0 (referent)		1948.1	84	43.1	1.0 (referent)	1.0 (referent)
High BG	941.75	15	15.9	1.65 (0.87-3.15)		1180.3	80	67.8	1.55 (1.13-2.12)*	1.39 (1.10-4.54)*

Note. Hazard ratios were determined by Cox proportional hazards regression analysis. Model I: independent variables included age, smoking status, single component of JCDCG-MetS. Model II: Multivariate-adjusted: independent variables included age, smoking status and all five components of JCDCG-MetS. Abdominal obesity: waist circumference>90 cm for men and>85 cm for women; High TG: Triglycerides (TG) ≥1.70 mmol/L; Low HDL-C: HDL cholesterol (HDL-C)<1.04 mmol/L; Hypertension: Blood pressure≥130/85 mmHg or known treatment for hypertension; High BG : Fasting plasma glucose (FPG) ≥6.1 mmol/L and/or 2h plasma glucose (2 h-PG) ≥7.8 mmol/L and/or diabetes mellitus having been diagnosed and currently receiving therapy. ID: incidence density (per 1000 person-year); CHD: coronary heart disease; CVD: cardiovascular disease; CI: confidence interval. *P<0.05, **P<0.001.



Population	*N*	CVD Events	ID (Per 1000 Person-year)	Population	*N*	CVD Events	ID (Per 1000 Person-year)
Participants with MetS	285	16	14.80	Participants with MetS	354	72	64.2
Participants without MetS	1 001	26	7.20	Participants without MetS	660	92	45.7
Total Participants	1 286	42	8.94	Total Participants	1 014	164	52.4

Figure 1. Kaplan-Meier Hazard Curves of CVD incidence. ***Note.*** Kaplan-Meier hazard curves of CVD incidence were depicted for the middle-aged (A) and elderly group (B) with vs. without MetS. HR indicates hazard ratio; CI, confidence interval. HR was determined by Cox proportional hazards regression analysis. ID: incidence density.

DISCUSSION

Prevalence of MetS in the Middle-aged and in the Elderly

(1) ***Prevalence of MetS in the Middle-aged*** In our study, the prevalence of MetS in the middle-aged was 21.3% (25.7 in men and 18.5% in women) according to the JCDCG definition. On the basis of the definition of National Cholesterol Education Program Adult Treatment Panel III (NCEP), nearly 30% prevalence of MetS was reported for men aged 40-59 years in the National Health and Nutrition Examination Survey III in the United States between

1988 and 1994[12]. Another study demonstrated that the prevalence of MetS in the middle-aged population was 26.2% by the definition of the Adult Treatment Panel (ATP) III in Scotland[13]. Hildrum et al. reported that the prevalence of the International Diabetes Federation (IDF)-defined MetS reached 28% in the participants aged 40-59 years in Norway from 1995 to 1997[14]. Therefore, as reported by our scientists, the prevalence of MetS in the middle-aged Chinese was lower than that in other western countries during the same period.

(2) ***Prevalence of MetS in the Elderly*** Dariush et al. reported that ATPIII-defined MetS was common (38% of women, 31% of men) in a large population-based study of elderly Americans[15]. A research conducted in Beijing showed that the prevalence of MetS by the NCEP criteria was 30.5% (17.6% in men, 39.2% in women) in elderly Chinese (age ≥60 years old) from 2001 to 2002[6]. Our data showed that the prevalence of MetS in the elderly group was 34.6% (30.2% in men and 38.7% in women). Although MetS was defined by different criteria, that the prevalence of MetS in elderly Chinese was close to that in the United States.

Association between Metabolic Disorders and CVD

(1) ***Association between MetS and CVD*** MetS exerts its well-documented deleterious effects by adversely affecting the structural and functional properties of the vasculature, such as arterial wall stiffness and thickness[15]. Several prospective studies conducted in middle-aged and elderly populations have reported that significantly higher risks of CVD events occurred in the presence of MetS[13,17-19]. A 5-year prospective study of CHD in middle-aged Scottish men revealed that the HR regarding the relationship of MetS with CHD, adjusted for conventional risk factors, reached statistical significance (HR=1.30, *P*=0.045)[13]. Nillson et al. also reported that according to the IDF, NCEP-ATPIII and EGIR definitions, the HRs (95% CI) for CVD incidence in middle-aged adults were 1.11 (0.86-1.44), 1.59 (1.25-2.03) and 1.35 (1.05-1.74), respectively, after being adjusted for age, gender, LDL-C and lifestyle factors[17]. For elderly populations, Scuteri et al. pointed out that the ATP-III MetS was an independent predictor of fatal and nonfatal CVD (HR=1.38, *P*<0.01) after adjustment for traditional risk factors[18]. Another study also found that MetS significantly increased the risk of myocardial infarctions (HR=1.51, 95% CI, 1.12-2.05) in elderly adults[19].

In our study, cumulative hazard curves showed that MetS posed an increased risk of CVD incidence in middle-aged adults (ID: 14.8 per 1000 person-year in people with MetS vs. 7.2 per 1000 person-year in people without MetS, HR=2.15, *P*=0.009), and also in elderly adults (64.2 per 1000 person-year in people with MetS vs. 45.7 per 1000 person-year in people without MetS, HR=1.38, *P*=0.044).

(2) ***Association of the Components of JCDCG-MetS with CVD*** Obesity is a major underlying risk factor for CVD[20], and obese subjects experience CVD at a higher rate than non-obese individuals. Nevertheless, there has been a great debate on the association of obesity with CVD events. Knowler WC holds that obesity is always associated with T2DM, dyslipidaemia and hypertension, and it carries higher cardiovascular risks through these traditional risk factors[21]. However, there were studies regarding obesity as an independent factor for CVD events[22-23]. These were consistent with the result of our study ,which revealed that the increased waist circumference was an independent factor for predicting stroke after being adjusted for other confounding factors (HR=3.49, *P*<0.05) in the middle-aged group. This result was supported by other studies[24-25]. Tlwfighi et al. reported that waist circumference was an independent predicator of stroke in women aged 45 to 54 years (OR=1.54, *P*=0.049)[24]. Murphy et al. also found that obesity (BMI ≥30) independently increased the risk of stroke incidence (HR=1.41, *P*<0.05) in 15402 individuals aged 45-64 after 20-year follow-up[25]. Our study further strengthens the standpoint that excess weight is deleterious and appropriate interventions should be hence adopted.

The Framingham study found that HDL-C had an inverse association with coronary heart disease (CHD) in both men and women (*P*<0.001)[26]. Cooney et al. reported that a strong, dose-response independent, inverse relationship between HDL-C and both CVD and CHD mortality existed[27]. Our study found that reduced HDL-C was an independent risk factor of CHD for both middle-aged adults (HR= 5.1, *P*<0.01) and elderly adults (HR=2.3, *P*<0.01). Therefore, reducing HDL-C was of benefit to both middle-aged and elderly adults.

There were several strengths and weaknesses in our study. First, a multi-stage sampling method was used to obtain a representative population-based sample. Second, the components of MetS were well assessed at baseline and CVD was defined in details. But some associations may not have been detected in our research because of the short follow-up period and a higher proportion of participants who could not be followed up due to loss of contact.

In conclusion, metabolic syndrome was common in the middle-aged and elderly Chinese, and the syndrome or its components were associated with an increased risk of cardiovascular disease. This heightened the importance of interventions for metabolic disorders in clinical practices.

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