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Prevalence and Determinants of Metabolic Syndrome According to Three Definitions in Middle-Aged Chinese Men

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Abstract

Background: The prevalence of metabolic syndrome has varied markedly between different studies because of the lack of internationally agreed-upon criteria to define the condition. We estimated the prevalence and lifestyle risk factors of metabolic syndrome according to three definitions of metabolic syndrome in urban Chinese men participating in the Shanghai Men's Health Study (SMHS).
Methods: In this cross-sectional study, 3988 middle-aged, urban Chinese men 40–74 years of age who were free of type 2 diabetes at baseline provided fasting blood samples, anthropometric measurements, and information on lifestyle factors and disease history.
Results: The three definitions of metabolic syndrome used in this report are from the International Diabetes Federation (IDF), the U.S. Third Report of the National Cholesterol Education Program, Adult Treatment Panel (ATP III), and a modified version of the ATP III criteria for Asian populations (ATP III–modified criteria). The prevalence of metabolic syndrome was 18.63%, 18.36%, and 29.34% according to IDF, ATP III, and ATP III–modified criteria, respectively. Agreement between the IDF and ATP III criteria was moderate ($\kappa = 0.43$), whereas agreement between ATP III–modified and the IDF and ATP III criteria was good ($\kappa = 0.71$ and 0.70, respectively). Physical activity was associated with a lower prevalence of metabolic syndrome, whereas drinking more than three drinks per day was associated with a higher risk of metabolic syndrome, regardless of the criteria employed. The association between smoking and the prevalence of metabolic syndrome in this population failed to reach significance.
Conclusions: Results from this representative sample of middle-aged, urban Chinese men show that metabolic syndrome is highly prevalent in this population. Our data support the hypothesis that physical activity decreases the risk of developing metabolic syndrome and that high alcohol consumption increases risk.

Introduction

Metabolic syndrome is characterized by a cluster of conditions, including hyperglycemia, abdominal obesity, dyslipidemia, and high blood pressure.[1] The prevalence of this syndrome has varied markedly between different studies because of the lack of internationally agreed-upon criteria for its definition. Definitions of the syndrome have been proposed by the World Health Organization (WHO) in 1999,[2] the U.S. Third Report of the National Cholesterol Education Program, Adult Treatment Panel (ATP III) in 2001,[3] and the International Diabetes Federation in 2005 (IDF).[4] The ATP III criteria were revised using a cut point for central obesity that is ethnicity specific and a lower cut point for glucose intolerance (ATP III–modified).[5] Despite the lack of agreement on a definition of metabolic syndrome, the health

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risks associated with it, including an increased risk of developing type 2 diabetes, cardiovascular disease (CVD), and probably some cancers, is well recognized.

In 2002, we launched a population-based cohort study of 61,582 men aged 40–74 years in Shanghai, China, the Shanghai Men's Health Study (SMHS). In this report, we estimate the prevalence of metabolic syndrome according to each of the three definitions in middle-aged Chinese men living in urban Shanghai who had provided fasting blood samples. We also evaluated associations of alcohol intake, physical activity, and smoking with the prevalence of metabolic syndrome.

Methods

The Shanghai Men's Health Study

Recruitment for the SMHS began in April 2002 and was completed in June 2006. A total of 83,125 male residents of eight communities of urban Shanghai between the ages of 40 and 74, were invited to participate by trained interviewers through in-person contact. A total of 61,582 participants were enrolled in the study with a response rate of 74.1%. Reasons for nonparticipation were refusal (21.1%), out of area during enrollment (3.1%), and other miscellaneous reasons, including poor health or hearing problems (1.7%). The study protocols were approved by the Institutional Review Boards of all participating institutes, and all participants provided written informed consent. An in-person interview was conducted by trained interviewers, and information was collected on demographic characteristics, disease history, and lifestyle factors, including dietary intake and physical activity. Participants were measured for weight and waist and hip circumferences according to a standard protocol.

Blood glucose and lipid measurements

At the time of the in-person interview, a 10-mL blood sample was drawn into an EDTA vacutainer tube. The samples were kept in a portable Styrofoam box with ice packs (0–4°C) and were processed within 6 hours. All samples were stored at −70°C immediately after processing. One set of samples was shipped to the United States on dry ice, and these samples are currently stored at Vanderbilt University. Among those subjects who donated a blood sample at baseline (n = 46,169), 12.5% reported having had their last meal at least 8 hours prior to the blood draw. In this study we include the first 3988 participants who were free of diabetes at baseline and had provided a fasting blood sample. Blood glucose and lipid profiles were measured by the Vanderbilt Clinical Nutrition Center using an ACE clinical chemistry system.

Physical activity

Detailed assessment of physical activity was obtained using a validated physical activity questionnaire (PAQ).[6] The questionnaire evaluated regular exercise and sports participation during the 5 years preceding the interview, daily activities such as walking, stair climbing, cycling, and household activities, and the daily commuting journey to/from work. Summary energy expenditure values (metabolic equivalent task [MET], hours/day) for these activities were estimated using a compendium of physical activity values.[7] We calculated leisure time physical activity (LPA), daily living physical activity (DPA), commuting physical activity (CPA), and total nonoccupational physical activity (total METs) by combining LPA, DPA, and CPA.

Smoking status

Never smokers were defined as participants who had never smoked at least one cigarette per day for more than 6 months. Ex-smokers were defined as participants that had smoked at least one cigarette per day for more than 6 months but were not currently smoking. All other participants were defined as current smokers. Current smokers were asked how many cigarettes they smoked per day. Participants were then classified according to their current smoking status into one of six categories: never smoker (n = 728; 18.25%), ex-smoker (n = 243; 6.09%); smoke less than 10 cigarettes per day (n = 860; 21.56%); smoke between 10 and 20 cigarettes per day (n = 1720 43.13%); and smoke more than 20 cigarettes per day (n = 437; 10.96%). Participants also provided information on the age they started smoking. We evaluated the association between years of exposure to tobacco smoke and the number of pack years (years of smoking multiplied by packs of 20 cigarettes) with the prevalence of metabolic syndrome.

Alcohol intake

We asked each participant whether he had ever drunk alcoholic beverages at least once a week for 6 months or more. If the answer was yes, he was asked to provide the usual amount of consumption of rice wine, grape wine, beer, or liquor separately. Participants that had given up drinking were coded as ex-drinkers (n = 149) and were not included in the analysis. One drink was defined as 360 grams of beer (12.6 grams of ethanol), 103 grams of grape wine (12.3 grams of ethanol), 30 grams of liquor (12.9 grams of ethanol), or 103 grams of rice wine (12.3 grams of ethanol). Participants were then classified into five categories according to their alcohol intake: nondrinkers (n = 2340; 60.95%), occasional drinkers (less than 0.5 units/day; n = 65; 1.69%), light drinkers (0.5–0.99 units per day; n = 178; 4.64%), moderate drinkers (1.0–2.99 units per day; n = 743; 19.43%), and heavy drinkers (more than 3 units per day; n = 510; 13.28%). Because occasional drinkers were a small group, we combined them with light drinkers.

Body size and weight history

Anthropometric measurements of weight, height, and waist and hip circumferences were taken twice, according to a standard protocol. If the difference between the first two measurements was larger than 1 cm for circumferences or 1 kg for weight, a third measurement was taken. The average of the two closest measurements was applied in the present study. From these measurements, the following variables were created: body mass index (BMI), weight in kg divided by the square of height in meters, and waist-to-hip ratio (WHR), waist circumference divided by hip circumference.

Other confounding factors

Usual dietary intake was assessed through an in-person interview using a validated food frequency questionnaire.[8] The Chinese Food Composition Tables[9] were used to estimate intake of nutrients and total energy intake (kcals/day). Sociodemographic factors such as age, level of education (none, elementary school, middle/high school, college), income in yuan/year (<500, 500–999, 1000–1999, >1999), occupation (professional, clerical, manual), and a history of CVD at baseline (yes/no) were included in the analyses as potential confounders.

Definitions of metabolic syndrome used in this study

ATPIII criteria: Participants were classified as having metabolic syndrome if they had three or more of the following abnormalities: waist circumference $\geq$ 102 cm; serum triglyceride levels $>$ 1.70 mmol/L; high-density lipoprotein cholesterol (HDL-C) <1.04 mmol/L; blood pressure ≥85/130 mmHg and/or taking hypertension medication; serum glucose level ≥6.1 mmol/L.[3]

ATP III-modified criteria: Participants were classified as having metabolic syndrome if they had three or more of the above abnormalities, but waist circumference cut points that are ethnicity specific for Chinese men (≥90 cm instead of 102 cm) were used and the fasting glucose cut point was set at ≥5.6 mmol/L.[5]

IDF criteria (as defined in 2005): Participants were classified as having metabolic syndrome if they had central obesity (waist circumference ≥90 cm for Chinese men), plus at least two of the following risk factors: hypertension (blood pressure ≥85/130 mmHg and/or taking hypertension medication), fasting HDL <1.04 mmol/L, fasting triglycerides >1.70 mmol/L, or fasting glucose ≥5.6 mmol/L.[4]

Statistical analysis

We calculated the prevalence of metabolic syndrome according to the three sets of criteria, and we compared the results using Cohen's κ statistic. Associations between metabolic syndrome and smoking, physical inactivity, and alcohol intake were investigated by using unconditional logistic regression analysis. The analyses were adjusted for age, other environmental factors, and pre-existing CVD. We performed the analyses with and without adjustment for BMI. Tests for linear trends were performed by entering the ordinal physical activity and alcohol intake categories as continuous parameters in the models. All analyses were performed using SAS (version 9.1) and all tests of statistical significance were based on two-sided probability.

We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this research.

Results

A total of 743 (18.63%), 732 (18.36%), and 1170 (29.34%) participants met the IDF, ATP III, and ATP III–modified criteria for metabolic syndrome, respectively (Table 1). The level of agreement between the IDF and ATP III criteria was only moderate (κ statistic = 0.43). The agreement of IDF and ATP III criteria with the ATP-III modified criteria was good, κ statistic = 0.71 and 0.70, respectively. A total of 26.05% participants had low HDL-C (<1.04 mmol/L), whereas 40.92% had high triglycerides (>1.70 mmol/L), 48.60% had hypertension (≥85/130 mmHg and/or were taking hypertension medication), 39.07% had a fasting glucose level of at least 5.6 mmol/L, and 976 (24.47%) had a fasting glucose level of 6.1 mmol/L or higher. Whereas 1025 (25.70%) had a high waist circumference according to the ethnicity specific cut point (90 cm for Chinese men), only 112 participants (2.81%) met the ATP III criteria for high waist circumference.

The prevalence of metabolic syndrome increased with age. Using the IDF criteria, 16.4% of those 40–45 years of age had metabolic syndrome versus 21.2% of those 66–74 years old. Using the ATP III criteria, 14.6% of those 40–45 years of age had metabolic syndrome versus 18.4% of those 66–74 years old. Using the ATP III–modified criteria, 25.1% of those 40–45 years of age had metabolic syndrome versus 30.6% of those 66–74 years (Table 1). Participants with metabolic syndrome had higher daily energy intake and were less likely to participate in exercise (Table 2).

Among participants with BMI $<$ 23 kg/m^2, the prevalence of metabolic syndrome using the IDF, ATP III, and ATP III–modified criteria was 0.92%, 6.9%, and 9.5%, respectively. Among participants with BMI $\geq$ 23 kg/m^2, the prevalence of metabolic syndrome using the IDF, ATP III, and ATP III–modified criteria was 33.0%, 28.3%, and 46.6%, respectively, whereas the prevalence of metabolic syndrome among participants with BMI $>$ 25 kg/m^2 was 50.0%, 37.8%, and 60.8%, respectively (data not shown in tables).

Table 3 shows the associations between the prevalence of metabolic syndrome as defined by the ATP III–modified criteria and physical activity (PA) categories. We found an inverse dose–response association between all types of PA (LPA, DPA, and CPA and combined PA) and the prevalence of metabolic syndrome when using the ATP III criteria. Every three MET/day increase of each type of PA or combined PA was associated with a corresponding decrease in the odds ratio (OR) of metabolic syndrome. ORs for quartiles of total nonoccupational METs were 1.00, 0.73, 0.71, and 0.56 (p = 0.03), data not shown in tables). Further adjustment for BMI attenuated the association slightly and, in the case of CPA, the association with metabolic syndrome failed to reach significance.

The association between smoking and the prevalence of metabolic syndrome was defined by the ATP-modified criteria is shown in Table 4. Before adjustment for BMI, smoking less than 20 cigarettes per day was associated with a lower prevalence of metabolic syndrome. After inclusion of BMI in the analysis, the association was no longer significant, whereas smoking more than 20 cigarettes per day was associated with a higher prevalence of metabolic syndrome (the association was only of marginal significance). We did not find pack years to be associated with a higher prevalence of metabolic syndrome.

A total of 37.05% participants were current alcohol drinkers. Among drinkers, more than half reported consuming beer (58.24%), 70.71% rice wine, 27.95% liquor, and only 5.14% reported consuming grape wine. Drinking three or more drinks per day was associated with a higher prevalence of metabolic syndrome using the ATP III–modified criteria (Table 5, OR = 1.54; 95% confidence interval [CI], 1.19–2.06). Wine consumption (primarily rice wine) of more than one drink per day was associated with higher prevalence of metabolic syndrome. Drinking liquor or beer was not significantly associated with the prevalence of

TABLE 1. PREVALENCE OF METABOLIC SYNDROME ACCORDING TO THREE DEFINITIONS

	IDF criteria[a]		*ATPIII criteria*[b]		*ATP III–modified criteria*[c]	
	n	%	n	%	n	%
Overall prevalence						
No	3245	81.37	3256	81.64	2818	70.66
Yes	743	18.63	732	18.36	1170	29.34
By age group						
40–45	192	16.4	171	14.6	293	25.1
46–50	205	16.2	220	17.4	347	27.4
51–55	168	23.4	168	23.4	262	36.4
56–60	71	20.5	74	21.3	111	32.0
61–65	46	23.0	46	23.0	69	34.5
66–74	61	21.2	53	18.4	88	30.6

[a]IDF criteria (as defined in 2005): Participants were classified as having metabolic syndrome if they had central obesity (waist circumference ≥ 90 cm for Chinese men), plus at least two of the following risk factors: hypertension (blood pressure ≥85/130 mmHg and/or taking hypertension medication), fasting HDL < 1.04 mmol/L, fasting triglycerides > 1.70 mmol/L, or fasting glucose ≥ 5.6 mmol/L.
[b]ATP III criteria: Participants were classified as having metabolic syndrome if they had three or more of the following abnormalities: waist circumference ≥ 102 cm; serum triglyceride levels > 1.70 mmol/L; HDL-C < 1.04 mmol/L; blood pressure ≥ 85/130 mmHg and/or taking hypertension medication; serum glucose level ≥ 6.1 mmol/L.
[c]ATP III–modified criteria: Participants were classified as having metabolic syndrome if they had three or more of the above abnormalities, but waist circumference cut points that are ethnicity specific for Chinese men (≥ 90 cm instead of 102 cm) were used and the fasting glucose cut point was set at ≥ 5.6 mmol/L.
Note: IDF, International Diabetes Federation; ATP III, U.S. Third Report of the National Cholesterol Education Program, Adult Treatment Panel.

metabolic syndrome. However, these estimations were based on low frequency and low amounts of these alcoholic beverages.

Table 6 shows associations of metabolic syndrome as defined by the IDF and ATP III criteria with physical activity, smoking, and alcohol intake. Overall, we found trends similar to those found when using the ATP III–modified criteria.

TABLE 2. AGE-STANDARDIZED PROPORTIONS[a] OF POPULATION CHARACTERISTICS BY METABOLIC SYNDROME PREVALENCE

	IDF criteria		*ATP criteria*		*ATP III–modified criteria*[c]	
	Non-cases	*Cases*	*Non-cases*	*Cases*	*Non-cases*	*Cases*
BMI[a]	22.5	26.9	22.8	25.7	22.3	25.7
WHR[a]	0.88	0.95	0.88	0.93	0.87	0.93
Waist circumference (cm)[a]	81.2	95.4	82.3	90.7	80.9	91.1
Kcal/day[a]	1908.3	2017.0	1921.3	1960.5	1908.9	1975.6
Education (%)						
None	3.1	3.1	3.2	3.3	3.4	2.9
Elementary	37.6	40.0	37.6	40.4	37.5	39.4
Middle/High	41.0	38.8	40.9	39.2	41.3	39.9
College	18.2	18.0	18.3	17.1	17.8	18.7
Income (%)						
<500	19.2	19.9	19.2	20.5	19.4	19.5
500–999	42.6	38.3	42.2	39.8	43.3	38.3
1000–1999	29.2	30.6	29.4	29.2	28.8	30.8
>1999	9.0	11.1	9.1	10.5	8.5	11.4
Occupation (%)						
Professional	19.7	22.5	20.3	19.7	20.1	20.6
Clerical	23.5	21.6	23.1	22.9	23.3	22.5
Manual laborers	56.8	55.9	56.5	57.4	56.6	56.9
Current smoker (%)	77.2	69.2	73.0	73.9	77.1	72.5
Current alcohol drinker (%)	37.5	38.2	37.5	38.1	37.1	39.1
Regular exerciser (%)	22.1	20.1	22.0	20.7	22.2	20.6

[a]For BMI, WHR, waist, and kcal/day age-adjusted means are presented.
Note: IDF, International Diabetes Federation; ATP III, U.S. Third Report of the National Cholesterol Education Program, Adult Treatment Panel; BMI, body mass index; WHR, waist-to-hip ratio.

TABLE 3. LOGISTIC REGRESSION ANALYSIS[a] WITH THE PREVALENCE OF METABOLIC SYNDROME AS DEFINED BY THE ATP III–MODIFIED CRITERIA AS THE DEPENDENT VARIABLE AND PHYSICAL ACTIVITY AS THE INDEPENDENT VARIABLE

	Cases	*OR*[a]	*(95% CI)*	*OR*[b]	*(95% CI)*
LPA METs[c]					
None	920	1.00		1.00	
≤3	192	0.88	0.72–1.07	0.83	0.67–1.04
>3	58	0.67	0.48–0.92	0.70	0.48–1.02
		p trend 0.01		*p* trend 0.02	
DPA METs[d]					
≤3	311	1.00		1.00	
3–6	413	0.75	0.62–0.90	0.80	0.65–0.99
>6–9	258	0.71	0.58–0.88	0.84	0.67–1.07
>9–12	112	0.59	0.45–0.77	0.75	0.55–1.02
>12	76	0.48	0.35–0.65	0.51	0.36–0.72
		p trend <0.001		*p* trend <0.001	
CPA METs[c]					
None	277	1.00		1.00	
≤3	448	0.82	0.68–0.98	0.92	0.74–1.14
>3	131	0.64	0.50–0.83	0.80	0.60–1.07
		p trend <0.01		*p* trend 0.14	
LPA + DPA METs					
≤3	282	1.00		1.00	
3–6	394	0.73	0.60–0.88	0.80	0.64–1.00
>6–9	248	0.66	0.54–0.82	0.78	0.61–1.00
>9–12	147	0.64	0.50–0.83	0.76	0.57–1.01
>12	99	0.43	0.32–0.57	0.51	0.36–0.70
		p trend <.0.001		*p* trend 0.001	
Total METs					
≤3	186	1.00		1.00	
3–6	340	0.77	0.61–0.97	0.84	0.65–1.10
>6–9	296	0.66	0.53–0.84	0.79	0.60–1.03
>9–12	199	0.64	0.50–0.83	0.75	0.56–1.01
>12	149	0.43	0.32–0.56	0.52	0.38–0.71
		p trend <.0.001		*p* trend <0.001	

[a]Adjusted for age, kcal/day, alcohol consumption, smoking, education level, income level, occupation and cardiovascular disease.
[b]All above plus body mass index.
[c]LPA METs, Leisure time physical activity, metabolic equivalent task.
[d]DPAMETs, Daily living physical activity, metabolic equivalent task.
[e]CPA, Commuting physical activity metabolic equivalent task; retired participants were excluded from the analysis.
Note: Modified version of ATP III, U.S. Third Report of the National Cholesterol Education Program, Adult Treatment Panel.

TABLE 4. LOGISTIC REGRESSION ANALYSIS WITH METABOLIC SYNDROME PREVALENCE AS DEFINED BY THE ATP III–MODIFIED CRITERIA AS THE DEPENDENT VARIABLE AND SMOKING AS THE INDEPENDENT VARIABLE

	Cases	*OR*[a]	*(95% CI)*	*OR*[b]	*(95% CI)*
Smoking status					
Never smoker	240	1.00		1.00	
Ex smoker	95	1.18	0.87–1.61	0.98	0.69–1.41
>0–10	214	0.71	0.56–0.89	0.86	0.66–1.12
>10–20	470	0.79	0.64–0.96	1.03	0.81–1.30
>20	151	1.06	0.81–1.39	1.35	0.99–1.85
Pack-years					
Never smoker	240	1.00		1.00	
Ex smoker	95	1.18	0.87–1.62	0.99	0.69–1.42
>0–13	169	0.74	0.58–0.95	0.88	0.66–1.17
>13–22	190	0.70	0.55–0.89	0.93	0.71–1.22
>22–30	220	0.82	0.65–1.04	1.06	0.81–1.40
>30	256	0.89	0.71–1.12	1.15	0.88–1.49

[a]Adjusted for age, kcal/day, alcohol consumption, physical activity, education level, income level, occupation and CVD.
[b]All above plus BMI.
Note: ATP III–modified, Modified version of U.S. Third Report of the National Cholesterol Education Program, Adult Treatment Panel.

Table 5. Logistic Regression Analysis with Metabolic Syndrome Prevalence as Defined by the ATP III–Modified Criteria as the Dependent Variable and Alcohol Intake as the Independent Variable

	Cases	*OR*[a]	*(95% CI)*	*OR*[b]	*(95% CI)*
Alcohol categories[a]					
Nondrinker	659	1.00		1.00	
Occasional/light	66	0.95	0.70–1.28	1.06	0.76–1.48
Moderate	216	1.06	0.88–1.28	1.11	0.90–1.38
Heavy	169	1.32	1.06–1.64	1.54	1.19–2.06
Wine[c]					
No	768	1.00		1.00	
<1 drink/day	127	1.00	0.79–1.25	1.04	0.80–1.34
>1–3 drink/day	147	1.21	0.97–1.51	1.43	1.11–1.85
≥3 drink/day	68	2.01	1.51–2.95	2.28	1.53–34.1
Beer					
No	864	1.00		1.00	
<1 drink/day	175	0.93	0.76–1.14	0.97	0.77–1.22
>1–3 drink/day	57	0.96	0.67–1.33	1.19	0.82–1.74
≥3 drink/day	14	0.91	0.49–1.71	1.13	0.54–2.36
Liquor					
No	979	1.00		1.00	
<1 drink/day	40	1.58	1.04–2.39	1.39	0.86–2.25
>1–3 drink/day	44	0.99	0.69–1.42	0.88	0.58–1.33
≥3 drink/day	47	1.12	0.78–1.61	0.88	0.57–1.36

[a]Adjusted for age, kcal/day, smoking, physical activity, education level, income level, occupation, and cardiovascular disease; analyses by type of individual drink were mutually adjusted for other types of alcoholic drinks.
[b]All above plus body mass index.
[c]Rice wine and grape wine combined.
Note: ATP III–Modified, U.S. Third Report of the National Cholesterol Education Program, Adult Treatment Panel.

Discussion

In this representative sample of middle-aged urban Chinese men, almost 30% met current ATP III–modified criteria for metabolic syndrome, whereas around 18% met the IDF and ATP III criteria for metabolic syndrome. Physical activity was associated with a lower prevalence of metabolic syndrome, whereas drinking more than three drinks per day was associated with higher metabolic syndrome prevalence.

The prevalence of metabolic syndrome according to ATP III criteria in this population is higher than that reported in a large study of 27,739 participants conducted in 11 provinces in China, where the prevalence of metabolic syndrome for men according to ATP III criteria was 12.7%.[10] The prevalence of metabolic syndrome reported from a representative sample of 15,838 Chinese adults aged 35–74 years was 17.7% for IDF and 10% for ATP III–modified criteria.[11] The prevalence of metabolic syndrome in the elderly in China is higher, in particular when using the IDF criteria, and varies from 25.81 to 34.8%.[12,13] The prevalence of metabolic syndrome was lower among rural men compared to urban men living in China (1.7% vs. 12.7%, ATP III and 2.7 vs. 34.3%, ATP III–modified criteria).[14] Similar results were found among 14,327 Shanghai residents (15–74 years), using IDF criteria (10.72% and 13.71% for rural men and urban men, respectively).[15]

Reports on the prevalence of metabolic syndrome from other populations are sometimes in agreement with our results and sometimes not. Although the prevalence of metabolic syndrome in a Korean population was similar to ours (metabolic syndrome prevalence for men was 14.2% according to the IDF criteria and 25.7% according to ATP III–modified criteria),[16] in Taiwan the prevalence of metabolic syndrome defined by ATP III–modified criteria was much higher (35.32% for men aged 40–64 years and 43.23% for men aged 65 years and over). In Asian Indians metabolic syndrome prevalence was reported to be 23.2%, 25.8%, and 18.3% according to WHO, IDF, and ATP III criteria, respectively.[17] Using ATP III criteria, the prevalence of metabolic syndrome among Asian Indians was higher (28.8%) than that reported for Malays (24.2%) and Chinese (14.8%) living in Singapore.[18] In a report comparing the prevalence of metabolic syndrome using four criteria in four Asia–Pacific populations, age-adjusted prevalences for the four definitions ranged from 16% to 42% in Australia, 3% to 11% in Japan, 7% to 29% in Korea, and 17% to 60% in Samoa.[19] The prevalence of metabolic syndrome in the United States[20] is higher than that reported in European populations[1,21,22] and in our study population. Among U.S. men, the prevalence of metabolic syndrome according to ATP III criteria is lower (23.7%) than that for IDF criteria (39.9 %).

In our study PA was associated with a lower prevalence of metabolic syndrome. LPA has been associated with a lower risk of metabolic syndrome in other studies[23–26] and sedentary behaviours have also been linked to a higher risk of metabolic syndrome.[27] PA has been associated with lower risk for individual components of metabolic syndrome such as hypertension, obesity, glucose intolerance, and insulin resistance.[28]

Drinking more than three alcoholic beverages per day was associated with higher metabolic syndrome prevalence, and wine consumption (primarily rice wine) was associated with

TABLE 6. LOGISTIC REGRESSION ANALYSIS WITH THE PREVALENCE OF METABOLIC SYNDROME AS DEFINED BY THE IDF AND ATP III CRITERIA AS THE DEPENDENT VARIABLE AND PHYSICAL ACTIVITY, SMOKING, AND ALCOHOL CONSUMPTION AS THE INDEPENDENT VARIABLE

	Cases	*OR*[a]	*(95% CI)*	*OR*[b]	*(95% CI)*
IDF					
Total METs					
≤3	120	1.00		1.00	
3–6	223	0.79	0.61–1.02	0.96	0.69–1.35
>6–9	174	0.59	0.45–0.78	0.76	0.53–1.07
>9–12	124	0.61	0.46–0.83	0.74	0.51–1.09
>12	102	0.46	0.34–0.68	0.66	0.45–0.99
		p trend <0.001		*p* trend <0.001	
Smoking status					
Never smoker	164	1.00		1.00	
Ex-smoker	77	1.40	1.00–1.96	1.17	0.76–1.78
>0–10	124	0.58	0.44–0.76	0.64	0.46–0.90
>10–20	282	0.65	0.51–0.82	0.83	0.62–1.11
>20	96	0.87	0.64–1.19	1.15	0.78–1.71
Alcohol categories					
Nondrinker	422	1.00		1.00	
Occasional/light	42	0.98	0.69–1.40	1.27	0.83–1.96
Moderate	142	1.13	0.91–1.40	1.30	0.99–1.71
Heavy	96	1.17	0.91–1.52	1.25	0.89–1.76
ATP III					
Total METs					
≤3	117	1.00		1.00	
3–6	217	0.83	0.64–1.07	0.93	0.70–1.23
>6–9	184	0.71	0.54–0.92	0.85	0.64–1.14
>9–12	120	0.66	0.49–0.89	0.77	0.56–1.06
>12	94	0.49	0.36–0.67	0.62	0.44–0.88
		p trend <0.01		*p* trend <0.01	
Smoking status					
Never smoker	142	1.00		1.00	
Ex-smoker	58	1.20	0.84–1.72	0.99	0.68–1.46
>0–10	130	0.787	0.59–1.02	0.91	0.68–1.23
>10–20	302	0.89	0.70–1.13	1.11	0.86–1.44
>20	100	1.16	0.85–1.59	1.39	0.99–1.95
Alcohol categories					
Nondrinker	416	1.00		1.00	
Occasional/light	42	0.96	0.67–1.36	1.06	0.73–1.54
Moderate	123	0.90	0.72–1.12	0.89	0.70–1.13
Heavy	109	1.26	0.98–1.62	1.30	1.05–1.74

[a]OR1 Analysis are adjusted for age, kcal/day, education level, income level, occupation, and CVD; in addition, each lifestyle factor is adjusted for the other two lifestyle factors.

[b]All above plus BMI.

Note: IDF, International Diabetes Federation; ATP III, U.S. Third Report of the National Cholesterol Education Program, Adult Treatment Panel; OR, Odds ratio; CI, confidence interval; MET, metabolic equivalent task.

higher prevalence of metabolic syndrome, whereas no significant association between smoking and metabolic syndrome was found. Although grape wine consumption has been associated with lower risk of metabolic syndrome in some studies,[29,30] data on the association of total alcohol intake and intake of individual alcoholic drinks with metabolic syndrome are limited and inconsistent.[26,29–31] The inconsistency could be explained by the favorable effect that alcohol has on HDL-C, insulin sensitivity, and glucose tolerance[32–35] and its detrimental effect on hypertension and triglycerides.[36,37] Smoking has been linked to higher risk of metabolic syndrome in some[31,38–40] but not all studies.[25,26] Smoking more than 20 cigarettes per day has been associated with higher risk of metabolic syndrome in European and Asian populations.[31,40] Smoking could increase the risk of metabolic syndrome via the development of abdominal obesity[40] and insulin resistance.[41]

The strengths of this study are: (1) it was performed in a representative sample of middle-aged Chinese men living in urban Shanghai; (2) there was extensive information on confounders; (3) it used a physical activity questionnaire that collected data on leisure time physical activity and other types of physical activity; and (4) it included a high prevalence of smokers, which allowed us to investigate associations between smoking and the prevalence of metabolic syndrome. The main limitation of the study is its cross-sectional design, which does not allow us to draw any causal inferences.

In summary, metabolic syndrome is common in this population, regardless of the set of criteria used to define it. We found that all types of physical activity were associated with a lower prevalence of the metabolic syndrome. Thus, promoting an active lifestyle should be one of the highest public health priorities.

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Author Disclosure Statement

The authors have no conflicts of interest to declare.

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