Original Article

Prevalence of Metabolic Syndrome by the Adult Treatment Panel III, International Diabetes Federation, and World Health Organization Definitions and their Association with Coronary Heart Disease in an Elderly Iranian Population

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Abstract

Introduction: To determine the prevalence of the metabolic syndrome (MS) in an Iranian elderly population and show its association with coronary heart disease (CHD). Materials and Methods: This is a cross-sectional study on 720 Iranian men and women aged ≥65 years who participated in the Tehran Lipid and Glucose Study (TLGS). Logistic regression analysis was used to estimate the odds ratio (OR) of developing CHD in model 1, an age-adjusted model; model 2, adjusted for age, smoking status, premature history of CHD and low-density lipoprotein (LDL) cholesterol; and model 3, adjusted for mentioned variables plus the MS components. Results: The prevalence of MS was 50.8%, 41.8% and 41.9% based on the Adult Treatment Panel (ATPIII), the World Health Organisation (WHO), and the International Diabetes Federation (IDF) definitions, respectively. The IDF definition showed high agreement with the ATPIII definition. Age-adjusted OR (95% CI) of the MS for CHD was 1.6 (1.2 to 2.2) by both the ATPIII and WHO definitions and 1.4 (1.0 to 1.9) by the IDF definition. IDF-defined MS lost its association with CHD in model 2. In model 3, obesity (WHO definition) and high blood pressure (ATPIII and WHO definitions) were associated with CHD. Conclusions: In an elderly Iranian population MS is highly prevalent. ATPIII and WHO definitions seem to be more pertinent than IDF for screening CHD risk. None of these definitions showed association with CHD when considering their components.

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Key words: Ageing, Cardiovascular disease, Epidemiology, Insulin resistance

Introduction

Coronary heart disease (CHD) is one of the most common causes of morbidity and mortality in different communities.[1,2] Despite the lack of accurate data, there is evidence to indicate that CHD is increasing in magnitude in Iran.[3] While age-adjusted mortality from CHD is gradually decreasing in developed countries,[2,4] this rate has increased by 20% to 45% in Iran.[5] The overall prevalence of CHD in Tehran was reported to be 21.8%.[3] The metabolic syndrome (MS) is characterised by a clustering of cardiovascular risk factors, including abdominal obesity, high blood pressure (BP), increased glucose concentration and dyslipidaemia. The syndrome is associated with the development of diabetes and CHD.[6,7] Two definitions of MS have been proposed by the National Cholesterol Education Programme Adult Treatment Panel III (NCEP ATPIII) and the World Health Organization (WHO).[8,9] In April 2005, the International Diabetes Federation (IDF) proposed a new definition of MS that includes central obesity, measured by waist circumference (WC), as an essential component of the MS which must be determined by ethnicity- and sex-specific cutoff values.[10]

Recently we reported the prevalence of the MS in the adult Iranian population.[11] To the best of our knowledge, no study has compared the prevalence defined by all the 3 definitions in an older group. In addition, data on the relationship between the MS and CHD on developing countries are limited.[12] This study aimed to establish the prevalence of MS as defined by the ATPIII, IDF and the WHO definitions and to examine the relationship between MS and CHD in a population-based survey of an elderly Iranian population in Tehran.

Materials and Methods

Subjects

This study was conducted within the framework of the

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Tehran Lipid and Glucose Study (TLGS), a prospective study performed on a representative sample of residents of district-13 of Tehran with the aim of determining the prevalence of non-communicable disease risk factors and developing a healthy lifestyle to improve these risk factors.[13] In the TLGS, 15,005 people aged 3 years and over, living in district-13 of Tehran, were selected by a multi-stage cluster random sampling method. Of 1071 individuals, aged ≥65 years who participated in the first phase of the TLGS (1998 to 2001), 720 subjects had complete data on electrocardiogram (ECG), history of CHD and Rose angina, and were thus enrolled for the current study with full relevant data. Informed written consent was obtained from each subject.

Methods

Demographic and lifestyle information were obtained by the use of a standard and validated questionnaire for all invited participants. All subjects were questioned about their past history of CHD, which reflected any prior diagnosis by a physician and was defined as a positive answer to the relevant question at the time of the interview. Familial history of premature CHD reflected any prior diagnosis of CHD by a physician in any female first-degree relative under 65 years of age and male first-degree relative aged below 55 years and was defined as a positive answer to the relevant question at the time of the interview. Smoking was categorised into 3 groups; those with daily or occasionally smoking, those who used to smoke in the past called ex-smokers, and those who never smoked. Details of the TLGS protocol and all laboratory procedures are published elsewhere.[13]

Using the Persian translated version of the Rose questionnaire, the history of any chest pain was assessed during the interview. Rose angina was considered for participants who had chest pain during exertion. This pain forces the person to stop and then goes away in less than 10 minutes after he/she stops. If present, the pain is situated over the anterior or left lateral sternum or radiates to the left arm.[14] A 12-lead rest ECG was recorded by 2 trained and qualified technicians using a PC-ECG 1200 machine for each individual. Two trained physicians coded the ECGs independently according to the Minnesota codes;[15] to assure the quality, a third trained physician recorded 10% of ECGs and all the data were doubly entered and rechecked. The population under the examination was categorised into 3 groups of probable CHD, possible CHD and non-CHD on the basis of ECG findings and Whitehall criteria.[16]

For collecting clinical data, weight was then measured while they were minimally clothed without shoes, using digital scales and recorded to the nearest 100 g. Height was measured in a standing position without shoes, using a tape meter while the shoulders were in a normal state. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. WC was measured at the narrowest level and that of the hip at the maximal level over light clothing, using an outstretched tape meter, without any pressure to the body surface, and was recorded to the nearest 0.1 cm. Waist-to-hip ratio (WHR) was calculated as WC divided by hip circumference. To avoid inter-subjective error, all measurements were taken by the same person. Other details of clinical data collection including systolic and diastolic BP have already been described.[17]

A blood sample was taken after 12 to 14 hours overnight fasting for biochemical measurements. Blood samples were taken in a sitting position according to the standard protocol and centrifuged within 30 to 45 minutes of collection. Biochemical analysis was conducted on fasting plasma samples; all blood analyses being done at the TLGS research laboratory on the day of blood collection. For oral glucose tolerance test (OGTT), 75 g glucose was administered orally to subjects and plasma glucose was measured 2 hours after. Fasting plasma glucose (FPG) and 2-hour post-load glucose (2hPG) were measured on the day of blood collection by the enzymatic colorimetric method using a glucose oxidation kit. For lipid measurements, total cholesterol (TC) and triglycerides (TG) kits (Pars Azmoon Inc., Iran) were used. TC and TG were assayed using enzymatic colorimetric tests with cholesterol esterase and cholesterol oxidise, and glycerol phosphate oxidise, respectively. High-density lipoprotein cholesterol (HDL-C) was measured after precipitation of the apolipoprotein B containing lipoproteins with phosphotungistic acid. Low-density lipoprotein cholesterol (LDL-C) was calculated from serum TC, TG and HDL-C;[18] it was not calculated when serum TG concentration was greater than 4.52 mmoL/L. Lipid standard (C.f.a.s., Boehringer Mannheim, Germany; Cat. No. 759350) was used to calibrate the selectra 2 auto-analyser for each day of laboratory analyses. All samples were analysed when internal quality control met the acceptable criteria. Inter- and intra-assay co-efficients of variation were 2% and 0.5% for TC and 1.6% and 0.6% for TG, respectively.

Definition of Terms

The MS was defined according to each of the IDF and ATPIII definitions as described in Table 1.[8,10] The WHO definition of MS[9] has been modified for use in epidemiological studies[19] as proposed, in part, by the European Group for the Study of Insulin Resistance,[20] which excluded microalbuminuria from the definition. The modified version of the WHO definition used in the present study differs from the proposed WHO definition[9] in that the

Table 1. Metabolic Syndrome Defined by the IDF, ATPIII and Modified WHO Definitions

The IDF definition	The ATPIII definition	The Modified WHO definition
Central obesity: defined as waist circumference ≥94 cm for Middle East men and ≥80 cm for Middle East women, with ethnicity specific values for other groups	Three or more of the following	Diabetes or impaired glucose tolerance (2-h post-load plasma glucose ≥7.8 mmol/L)
Plus any two of the following four factors:	Central obesity: defined as waist circumference >102 cm for men and >88 cm for women	Plus two or more of the following:
Raised TG level: ≥1.7 mmol/L, or specific treatment for this lipid abnormality	Raised TG level: ≥1.7 mmol/L	Obesity: BMI >30 kg/m^2, or WHR >0.9 in male and >0.85 in female
Reduced HDL cholesterol: <1.03 mmol/L in males and <1.29 mmol/L in females, or specific treatment for lipid abnormality	Reduced HDL cholesterol: <1.03 mmol/L in males and <1.29 mmol/L in females	Dyslipidaemia: TG level ≥1.7 mmol/L, or HDL-C <0.9 mmol/L in male and <1 mmol/L in female
Raised BP: systolic BP ≥130 or diastolic BP ≥85 mm Hg, or treatment of previously diagnosed hypertension	Raised BP: systolic BP ≥130 or diastolic BP ≥85 mm Hg	Raised blood pressure: systolic BP ≥140 or diastolic BP ≥90 mm Hg, or treatment of previously diagnosed hypertension
Raised FPG: ≥5.6 mmol/L, or previously diagnosed type 2 diabetes	Raised FPG: ≥6.1 mmol/L	

ATPIII: Adult Treatment Panel III; BP: blood pressure; FPG: fasting plasma glucose; IDF: International Diabetes Federation; TG: triglycerides; WHO: World Health Organization; WHR: waist-to-hip ratio

measurement of serum insulin and urine albumin excretion is disregarded (Table 1). CHD was defined as "positive history of CHD, Rose angina, or ECG-based CHD". The ECG-based CHD was considered as both the probable CHD and possible CHD.

Statistical Analysis

Statistical analyses were done using the SPSS 9.05 statistical software package (SPSS Inc., Chicago, IL). Prevalence rates were standardised using WHO standard world population.[21] All means are presented as mean ± SD. Since the TG distribution was highly skewed, its log transformed was used in all analysis. Significant differences in general characteristics were searched using chi-square and Student's *t*-test. Logistic regression analysis with enter method was used to examine the association of CHD with the MS and each of its components according to the ATPIII, IDF and the WHO definitions in 3 models as follows; model 1 is an age-adjusted model, model 2 shows the odds ratios (OR) of MS and its components in predicting CHD adjusted for age, smoking status, premature history of CHD and LDL-C and model 3 is a full model adjusted for mentioned variables in model 2 plus the components of the MS according to each definition. CHD was considered as dependent variable, while the MS and each of its components were independent variables.

Results

From a total of 1071 elderly participants from phase 1 TLGS, 720 subjects enrolled in the current study. There

Table 2. Baseline Characteristics of the TLGS Elderly Population Based on Their Coronary Heart Disease Status

	Without CHD (n = 437)	With CHD (n = 283)	*P*
Age (y)*	68.8 ± 3.9	69.9 ± 4.7	0.001
Sex male†	58.1	56.5	0.7
WC (cm)	92.2 ± 11.0	94.0 ± 10.7	0.02
BMI (kg/m^2)	26.6 ± 4.2	27.0 ± 4.3	0.1
FPG (mmol/L)	6.2 ± 2.6	6.3 ± 2.3	0.4
TG (mmol/L)	2.0 ± 1.2	2.2 ± 1.6	0.2
SBP (mmHg)	137.1 ± 21.4	141.7 ± 25.5	0.01
DBP (mmHg)	78.7 ± 11.7	81.2 ± 13.1	0.007
HDL-C (mmol/L)	1.11 ± 0.28	1.09 ± 0.029	0.3
LDL-C (mmol/L)	3.78 ± 0.99	3.94 ± 1.23	0.07
Positive family history† of premature CHD	11.7	17.3	0.02
Positive smoking†			
Daily or occasionally	9.4	10.8	0.7
Ex-smoker	17.6	16.2	0.7

BMI: body mass index; CHD: coronary heart disease; DBP: diastolic blood pressure; FPG: fasting plasma glucose; SBP: systolic blood pressure; TG: triglycerides; TLGS: Tehran Lipid and Glucose Study; WC: waist circumference

* Data are means ± SD

† Numbers are presented as % in column

CHD was defined as positive history of CHD, Rose angina, or ECG-based CHD.

Positive family history of premature CHD: Any prior diagnosis of CHD in a female first-degree relative under 65 years old and male first-degree relative under the 55 years old.

Smoking was categorised to three groups; those with daily or occasionally smoking, ex-smoker, never smoked.

Table 3. Sex-specific Prevalences of Central Risk Factors of the Metabolic Syndrome in the TLGS Elderly Population (n = 720)

Definition of the metabolic syndrome*	Total	Male	Female	*P*
The ATPIII definition				
Central obesity	282 (39.2)	57 (13.8)	225 (73.5)	<0.001
Triglycerides domain	376 (52.2)	186 (44.9)	190 (62.1)	<0.001
Serum HDL domain	444 (61.7)	226 (54.6)	218 (71.2)	<0.001
Glucose domain	217 (30.2)	124 (30.1)	93 (30.4)	0.9
BP domain	510 (70.9)	284 (68.6)	226 (74.1)	0.1
ATPIII-defined metabolic syndrome	364 (50.8)	153 (37.1)	211 (69.2)	<0.001
The Modified WHO definition				
Glucose domain	357 (52.2)	203 (51.1)	154 (53.7)	0.5
Lipid domain	426 (59.2)	224 (54.1)	202 (66.0)	0.002
Obesity	583 (81.0)	315 (76.1)	268 (87.6)	<0.001
BP domain	406 (56.7)	214 (52.1)	192 (63.0)	0.004
Modified WHO-defined metabolic syndrome	286 (41.8)	152 (38.3)	134 (46.7)	0.03
The IDF definition				
Central obesity	458 (63.6)	178 (43.0)	280 (91.5)	<0.001
Triglycerides domain	389 (54.3)	194 (47.2)	195 (63.9)	<0.001
HDL domain	456 (63.5)	232 (56.3)	224 (73.2)	<0.001
Glucose domain	316 (44.0)	179 (43.3)	137 (44.9)	0.7
BP domain	474 (65.8)	268 (64.7)	206 (67.3)	0.4
IDF-defined metabolic syndrome	301 (41.9)	108 (26.2)	193 (63.3)	<0.001

ATPIII: Adult Treatment Panel III; BP: blood pressure; HDL: high-density lipoprotein; IDF: International Diabetes Federation; TLGS: Tehran Lipid and Glucose Study; WHO: World Health Organization

*Numbers in parenthesis are percents.

The prevalences were standardised using WHO standard world population

Details of the IDF, ATPIII and the modified WHO criteria for defining metabolic syndrome are described in Table 1

was no difference between the participated and non-participated groups regarding their baseline variables such as sex (male; 57.7% vs 52.4%), age (69.3 vs 71.2 years), WC (92.9 vs 93.1 cm), BMI (26.8 vs 26.5 kg/m^2), FPG (6.3 vs 6.1 mmoL/L) and LDL-C level (3.83 vs 3.84 mmoL/L), respectively. Of the 720 study subjects (414 males, 306 females; average age, 69 years), 283 subjects were positive according to their CHD status.

The baseline characteristic of the study subjects regarding their CHD status is shown in Table 2. There was no difference between men and women with regard to having CHD. Subjects with CHD were older, had higher WC, systolic and diastolic BP and were more likely to have positive family history of premature CHD.

Table 3 shows the proportion of the components of MS in both genders according to each of the 3 definitions. The overall prevalence of MS according to the ATPIII, WHO and IDF definitions were 50.8%, 41.8% and 41.9%, respectively and the MS prevalence was higher in women according to each of these definitions. In addition, ATPIII had good agreement with the IDF definition with the *k* statistics of 63.4 ± 0.02 (*P* <0.001), sensitivity of 80.7%, and specificity of 82.8%, while modified WHO showed low agreement by IDF definition with the *k* statistics of 38.3 ± 0.03(*P* <0.001), sensitivity and specificity of 60.1% and 78.8%, respectively (data not shown). Of all components, high BP showed the highest prevalence according to both the ATPIII and the IDF definitions, while by the WHO definition, obesity was the most prevalent factor. Also the glucose domain showed the lowest prevalence of all components in the 3 definitions. According to both the IDF and ATPIII definitions, central obesity, high triglyceride level and low HDL-C level, and considering the WHO definition, obesity, high lipid domain and high BP were more prevalent in women.

Prevalence of the MS and its components in subjects according to their CHD status is shown in Table 4. According to the ATPIII and WHO definitions, prevalence of MS was higher in those with positive CHD. High BP was significantly more common in those with CHD compared to those without CHD when considering all 3 definitions. Also high FPG was more prevalent in subjects with CHD

Table 4. Prevalence of the Metabolic Syndrome and its Components in the TLGS Elderly Population Based on their Coronary Heart Disease Status

	Without CHD (n = 437)	With CHD (n = 283)	*P*
Alternations by the ATPIII criteria*			
High WC	162 (37.1)	120 (42.4)	0.1
High TG	223 (51.0)	153 (54.1)	0.4
Low HDL-C	268 (61.3)	176 (62.2)	0.8
High BP	285 (65.4)	225 (79.5)	<0.001
High FPG	119 (27.3)	98 (34.8)	0.3
Metabolic syndrome	204 (46.9)	160 (56.7)	0.01
One or more components	392 (90.1)	272 (96.5)	0.001
Two or more components	314 (72.2)	228 (80.9)	0.01
Alternations by Modified WHO criteria*			
High glucose	200 (47.7)	157 (59.2)	0.004
Obesity	340 (77.8)	243 (85.9)	0.009
High lipid	250 (57.2)	176 (62.2)	0.1
High BP	216 (49.8)	190 (67.4)	<0.001
Metabolic syndrome	157 (37.5)	129 (48.7)	0.004
One or more components	381 (91.4)	258 (96.7)	0.001
Two or more components	311 (74.6)	229 (86.7)	<0.001
Alternations by the IDF criteria*			
High WC	269 (61.6)	189 (66.8)	0.1
High TG	229 (52.5)	160 (57.1)	0.2
Low HDL-C	274 (63.0)	182 (64.3)	0.7
High BP	275 (62.9)	199 (70.3)	0.04
High FPG	177 (40.7)	139 (49.1)	0.03
Metabolic syndrome	171 (39.3)	130 (45.9)	0.08
One or more components	406 (93.5)	272 (97.1)	0.03
Two or more components	351 (80.9)	245 (87.5)	0.02

BP: blood pressure; FPG: fasting plasma glucose; HDL-C: high-density lipoprotein; TG: triglycerides; WC: waist circumference
* Numbers represent % in column
Details of the IDF, ATPIII and the Modified WHO criteria for defining metabolic syndrome were described in Table 1
Coronary heart disease (CHD) was defined as positive history of CHD, Rose angina, or ECG-based CHD

considering the IDF definition; based on the WHO definition, all the components except the high lipid domain were more prevalent in subjects with CHD.

Table 5 shows the association of ATPIII-defined MS and its components with CHD in the 3 models previously described; considering this definition, MS was found to be associated with CHD in models 1 and 2. Only high BP was associated with CHD in all the 3 models, while high WC, low HDL-C and high triglycerides were not associated with CHD in any of the 3 models. High FPG was a CHD predictor in models 1 and 2. The same analysis was done using the WHO MS definition; results are shown in Table 6. MS predicted CHD in models 1 and 2. Obesity and high BP were good predictors of CHD in all the 3 models. High glucose associated with CHD only in models 1 and 2. Table 7 shows results according to the IDF definition. MS predicted CHD only in model 1. High FPG was associated with CHD in models 1 and 2, while other components were not predictors of CHD in any of the 3 models.

Discussion

This study of MS focused on elderly Iranian population 65 years or older, a group that is at higher risk of developing CHD and makes it easier to analyse the relationship between MS and the risk of CHD. A higher association of the definition with CHD may be considered as a more important precursor of the disease. In this respect, we examined which definition of the MS may be closely related to the

Table 5. Association of ATPIII-defined Metabolic Syndrome and its Components with Coronary Heart Disease in 3 Models*

Alternations by ATPIII criteria	Model 1		Model 2		Model 3	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Metabolic syndrome	1.6 (1.2-2.2)	0.002	1.6 (1.1- 2.2)	0.007	1.2 (0.6-2.3)	0.5
High WC	1.3 (1.0-1.8)	0.06	1.3 (0.9-1.8)	0.1	1.1 (0.7-1.7)	0.6
Low HDL-C	1.1 (0.8-1.5)	0.5	1.2 (0.8-1.6)	0.3	1.0 (0.7-1.5)	0.9
High BP	2.0 (1.4- 2.8)	0.0001	2.1 (1.4-3.0)	0.0002	1.8 (1.2-2.8)	0.005
High TG	1.2 (0.9-1.6)	0.2	1.0 (0.7-1.5)	0.7	0. 8 (0.5-1.3)	0.3
High FPG	1.4 (1.0-2.0)	0.02	1.6 (1.1-2.2)	0.01	1.4 (0.9-2.0)	0.1

95% CI: 95% confidence interval; BP: blood pressure; CHD: coronary heart disease; FPG: fasting plasma glucose; OR: odds ratio; TG: triglycerides; WC: waist circumference
*Model 1: Model adjusted for age; Model 2: Multivariate model adjusted for age, smoking status, premature history of CHD and LDL-C;
Model 3: Full model adjusted for mentioned variables in model 2 plus metabolic syndrome and its other components
Details of the ATPIII criteria for defining metabolic syndrome were described in Table 1
CHD was defined as positive history of CHD, Rose angina, or ECG-based CHD

Table 6. Association of Modified WHO-defined Metabolic Syndrome and its Components with Coronary Heart Disease in 3 Models*

Alternations by modified WHO criteria	Model 1		Model 2		Model 3	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Metabolic syndrome	1.6 (1.2-2.2)	0.003	1.7 (1.2-2.4)	0.003	0.8 (0.4-1.7)	0.5
Obesity	1.8 (1.2-2.7)	0.004	1.9 (1.2-2.9)	0.004	1.7 (1.0- 2.8)	0.03
High lipid	1.3 (1.0-1.8)	0.07	1.2 (0.8-1.7)	0.3	1.0 (0.7-1.5)	0.9
High BP	2 (1.5-2.8)	<0.001	2.1 (1.5-2.9)	<0.001	1.8 (1.2-2.7)	<0.001
High glucose	1.6 (1.2-2.2)	0.003	1.6 (1.1-2.2)	0.008	1.6 (0.9-3.0)	0.1

95% CI: 95% confidence interval; BP: blood pressure; CHD: coronary heart disease
* Model 1: Model adjusted for age; Model 2: Multivariate model adjusted for age, smoking status, premature history of CHD and LDL-C
Model 3: Full model adjusted for mentioned variables in model 2 plus metabolic syndrome and its other components
Details of the WHO criteria for defining metabolic syndrome were described in Table 1
CHD was defined as positive history of CHD, Rose angina, or ECG-based CHD

Table 7. Association of IDF-defined Metabolic Syndrome and its Components with Coronary Heart Disease in 3 Models*

Alternations by IDF criteria	Model 1		Model 2		Model 3	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Metabolic syndrome	1.4 (1.0-1.9)	0.03	1.2 (0.9-1.7)	0.2	0.7 (0.4-1.4)	0.3
High WC	1.4 (1.0-1.9)	0.06	1.3 (0.9-1.8)	0.1	1.4 (0.9-1.8)	0.4
Low HDL-C	1.1 (0.8-1.6)	0.4	1.2 (0.8-1.6)	0.3	1.2 (0.8-1.7)	0.4
High BP	1.3 (1.0-1.8)	0.08	1.4 (1.0-1.9)	0.08	1.3 (0.9-1.9)	0.1
High TG	1.3 (0.9-1.8)	0.09	1.1 (0.8-1.6)	0.4	1.1 (0.7-1.7)	0.6
High FPG	0.7 (0.5-0.9)	.01	1.4 (1.0-2.0)	0.03	1.4 (1.0-2.0)	0.07

95% CI: 95% confidence interval; BP: blood pressure; FPG: fasting plasma glucose; HDL-C: high-density lipoprotein cholesterol; TG: triglycerides; WC: waist circumference
*Model 1: Model adjusted for age; Model 2: Multivariate model adjusted for age, smoking status, premature history of CHD and LDL-C
Model 3: Full model adjusted for mentioned variables in model 2 plus metabolic syndrome and its other components
Details of the IDF criteria for defining metabolic syndrome were described in Table 1
CHD was defined as positive history of CHD, Rose angina, or ECG-based CHD

risk for CHD by comparing the ORs of MS for CHD. According to all of the 3 definitions, MS was not an independent predictor of CHD over and above its individual components.

In this study, the prevalence of MS ranged between 42% and 51% depending on different definitions. Furthermore, ATPIII had a concordance rate of 63% with the IDF definition. This high concordance of the 2 definitions is perhaps not surprising given that these definitions use almost identical variables except for the central obesity criteria.[22] In our study, the prevalence of MS was much higher in women than in men (with the highest prevalence

defined by the ATPIII), a finding also shown by other studies.[23-25] The sex difference is mainly attributable to the higher prevalence of abdominal obesity, high lipid domain and low HDL-C in women as compared to men. However, the association between the MS and prevalence of CHD was similar between men and women (data not shown).

In an elderly Turkish population, the prevalence of MS was higher in females than males (70.9% vs. 29.1% and 25.1% vs. 20.2% for the WHO and the ATPIII definitions, respectively).[26] In the Cardiovascular Health Study, the prevalence of MS in Caucasian men and women ≥65 years was 27.6% and 20.8% according to the ATPIII and the WHO definitions, respectively.[12] The prevalence of IDF-defined MS in our study was similar to the prevalence of ATPIII-defined MS in the Ford study of a US population aged ≥70 years; Ford et al[22] showed that the prevalence of the MS differed little among men and women, but after 70 years of age women had a higher prevalence.

We showed that an association exists between CHD and cardiovascular risks even in subjects with 1 or 2 risk factors while they were not qualified for the MS definition. This indicates the importance of having risk factors irrespective of the presence or absence of MS and suggests that all risk factors should be managed aggressively.

In the present study, like others,[27,28] the MS defined by both the ATPIII and WHO definitions continue to be an independent predictor of CHD after further adjustments of the conventional risk factors, while the IDF-defined MS lost its association in this model. The IDF definition also showed the least age-adjusted OR compared to the 2 other definitions; however, their confidence intervals overlapped considerably. None of the 3 defined MS had significant associations with CHD after further adjustment for their components. We found that considering the ATPIII and the WHO definitions, hypertension showed significant association with CHD in model 3. In the Cardiovascular Health Study, high BP was the component most strongly associated with incident CHD considering the ATPIII definition.[29]

Although it has been shown that both the presence of multiple risk factors and MS itself[30] confer an increased risk of CHD, it is unclear whether the adverse impact on health by the MS is greater than those related to the sum of its components.[31] In a large cross-sectional study conducted in the US population aged over 50 years (participants of the NHANES III survey), MS does not improve prediction of CHD events in the presence of its components considering the ATPIII definition.[32] On the contrary, in a prospective study on older individuals, the MS by the ATPIII definition but not by the WHO criteria, was an independent predictor of cardiovascular events after adjusting for its components and the traditional cardiovascular risk factors.[12] Finally, in a review of population-based prospective studies it has been shown that the MS defined by the ATPIII and WHO definitions only had the modest job of predicting cardiovascular disease (estimated summary relative risk of 1.7 to 1.9).[33]

Several limitations of this study, however, need to be considered. First, the cross-sectional nature of this study limits our casual inference. Although the relationships between individual components of the MS and CHD have been well-recognised, these results should be examined in prospective studies to demonstrate whether different definitions of MS increased the risk of CHD in this age group. Second, our estimates on the relationship between the MS and CHD may be underestimated since our participants were elderly survivors. Finally, since there is a rising prevalence of diabetes[34] and obesity[35,36] in our population, the reported prevalence of MS and CHD in this study may have been underestimated. Nevertheless, our study has its strong points. One, using a population sample, representative of Tehranian population, which enhances the validity of our findings. Furthermore, this study investigates the older population which is an important group of subjects who receive little attention in other epidemiological studies.

In conclusion, approximately half of the older Iranian population fulfills the MS criteria according to all the 3 mentioned definitions. We noted that the MS defined by both the ATPIII and WHO definitions were associated with CHD even after further adjustment for conventional risk factors, but none of the 3 MS definitions were associated with CHD when considering their components. In the elderly Iranian population, management of MS risk factors, especially obesity and hypertension, should be considered.

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REFERENCES

1. Castelli WP. Epidemiology of coronary heart disease: the Framingham study. Am J Med 1984;76:4-12.
2. Keil U. The Worldwide WHO MONICA Project: results and perspectives. Gesundheitswesen 2005;67(Suppl 1):S38-45.
3. Hadaegh F, Harati H, Ghanbarian A, Azizi F. Prevalence of coronary heart disease among Tehranian adults: Tehran Lipid and Glucose Study. East Mediterr Health J 2009 [In press].
4. Sytkowski PA, Agostino RB, Belanger A, Kannel WB. Sex and time trends in cardiovascular disease incidence and mortality: the Framingham heart study. Am J Epidemiol 1996;143:338-50.
5. Zali M, Kazem M, Masjedi MR. Health and disease in Iran. Deputy of

Research, Ministry of Health Bulletin No.10 (1993).

6. The DECODE Study Group, Qiao Q. Comparison of different definitions of the metabolic syndrome in relation to cardiovascular mortality in European men and women. Diabetologia 2006;49:2837-46.
7. Isomaa B, Almgren P, Tuomi T, Forsen B, Lahti K, Nissen M, et al. Cardiovascular morbidity and mortality associated with the metabolic syndrome. Diabetes Care 2001;24:683-9.
8. Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults. Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). JAMA 2001;285:2486-97.
9. Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. Diabet Med 1998;15:539-53.
10. Alberti KG, Zimmet P, Shaw J. IDF Epidemiology Task Force Consensus Group. The metabolic syndrome-a new worldwide definition. Lancet 2005;366:1059-62.
11. Zabetian A, Hadaegh F, Azizi F. Prevalence of metabolic syndrome in Iranian adult population, concordance between the IDF with the ATPIII and the WHO definitions. Diabetes Res Clin Pract 2007;77:251-7.
12. Scuteri A, Najjar SS, Morrell CH, Lakatta EG. Cardiovascular Health Study. The metabolic syndrome in older individuals: prevalence and prediction of cardiovascular events: the Cardiovascular Health Study. Diabetes Care 2005;28:882-7.
13. Azizi F, Rahmani M, Emami H, Madjid M. Tehran Lipid and Glucose Study: rationale and design. CVD prevention 2000;3:242-7.
14. Rose G, McCartney P, Reid DD. Self-administration of a questionnaire on chest pain and intermittent claudication, Br J Prev Soc Med 1997;31: 42-8.
15. Prineas RJ, Crow RS, Blackburn H. The Minnesota code manual of electrocardiographic findings: standards and procedures for measurements and classification. Boston: John Wright PCG, 1982.
16. Ford ES, Giles WH, Croft JB. Prevalence of nonfatal coronary heart disease among American adults. Am Heart J 2000;139:371-7.
17. Azizi F, Rahmani M, Emami H, Mirmiran P, Hajipour R, Madjid M, et al. Cardiovascular risk factors in an Iranian urban population: Tehran lipid and glucose study (phase 1). Soz Praventivmed 2002;47:408-26.
18. Friedwald WT, Levy RI, Fredridson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem 1972;18:499-502.
19. Laaksonen DE, Lakka HM, Niskanen LK, Kaplan GA, Salonen JT, Lakka TA. Metabolic syndrome and development of diabetes mellitus: application and validation of recently suggested definitions of the metabolic syndrome in a prospective cohort study. Am J Epidemiol 2002;156:1070-7.
20. Balkau B, Charles MA. Comment on the provisional report from the WHO consultation. European Group for the Study of Insulin Resistance (EGIR). Diabet Med 1999;16:442-3.
21. Ahmad O, Boschi-Pinto C, Lopez A, Murray CJL, Lozano R, Inoue M. Age Standardization of Rates: a New WHO Standard (GPE Discussion Paper Series No. 31), Geneva: World Health Organization, 2000.
22. Ford ES, Giles WH, Dietz WH. Prevalence of the metabolic syndrome among US adults: findings from the third National Health and Nutrition Examination Survey. JAMA 2002;287:356-9.
23. Gu D, Reynolds K, Wu X, Chen J, Duan X, Reynolds RF, et al. Inter ASIA Collaborative Group, Prevalence of the metabolic syndrome and overweight among adults in China. Lancet 2005;365:1398-405.
24. Thomas GN, Ho SY, Janus ED, Lam KS, Hedley AJ, Lam TH. Hong Kong Cardiovascular Risk Factor Prevalence Study Steering Committee, The US National Cholesterol Education Programme Adult Treatment Panel III (NCEP ATP III), prevalence of the metabolic syndrome in a Chinese population. Diabetes Res Clin Pract 2005;67:251-7.
25. He Y, Jiang B, Wang J, Feng K, Chang Q, Fan L, et al. Prevalence of the metabolic syndrome and its relation to cardiovascular disease in an elderly Chinese population. J Am Coll Cardiol 2006;47:1588-94.
26. Cankurtaran M, Halil M, Yavuz BB, Dagli N, Oyan B, Ariogul S. Prevalence and correlates of metabolic syndrome (MS) in older adults. Arch Gerontol Geriatr 2006;42:35-45.
27. Hunt KJ, Resendez RG, Williams K, Haffner SM, Stern MP. San Antonio Heart Study. National Cholesterol Education Program versus World Health Organization metabolic syndrome in relation to all-cause and cardiovascular mortality in the San Antonio Heart Study. Circulation 2004;110:1251-7.
28. Malik S, Wong ND, Franklin SS, Kamath TV, L'Italien GJ, Pio JR, et al. Impact of the metabolic syndrome on mortality from coronary heart disease, cardiovascular disease, and all causes in United States adults. Circulation 2004;110:1245-50.
29. McNeill AM, Katz R, Girman CJ, Rosamond WD, Wagenknecht LE, Barzilay JI, et al. Metabolic syndrome and cardiovascular disease in older people: The cardiovascular health study. J Am Geriatr Soc 2006;54:1317-24.
30. Gami AS, Witt BJ, Howard DE, Erwin PJ, Gami LA, Somers VK, et al. Metabolic syndrome and risk of incident cardiovascular events and death: a systematic review and meta-analysis of longitudinal studies. J Am Coll Cardiol 2007;49:403-14.
31. Grundy SM, Brewer HB Jr, Cleeman JI, Smith SC Jr, Lenfant C. American Heart Association; National Heart, Lung, and Blood Institute. Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. Circulation 2004;109:433-8.
32. Alexander CM, Landsman PB, Teutsch SM, Haffner SM. Third National Health and Nutrition Examination Survey (NHANES III); National Cholesterol Education Program (NCEP). NCEP-defined metabolic syndrome, diabetes, and prevalence of coronary heart disease among NHANES III participants age 50 years and older. Diabetes 2003;52:1210-4.
33. Ford ES. Risks for all-cause mortality, cardiovascular disease, and diabetes associated with the metabolic syndrome: a summary of the evidence. Diabetes Care 2005;28:1769-7.
34. Hadaegh F, Zabetian A, Harati H, Azizi F. The prospective association of general and central obesity variables with incident type 2 diabetes in adults, Tehran lipid and glucose study. Diabetes Res Clin Pract 2007;76:449-54.
35. Azadbakht L, Mirmiran P, Shiva N, Azizi F. General obesity and central adiposity in a representative sample of Tehranian adults: prevalence and determinants. Int J Vitam Nutr Res 2005;75:297-304.
36. Rashidi A, Mohammadpour-Ahranjani B, Vafa MR, Karandish M. Prevalence of obesity in Iran. Obes Rev 2005;6:191-2.