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Prevalence of Metabolic Syndrome in a Large Health Check-up Population in Taiwan

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Background. Metabolic syndrome is a major risk factor for cardiovascular disease and the development of type 2 diabetes. The purpose of the present study was to investigate the prevalence of metabolic syndrome in a large health check-up population in Taiwan.

Methods. During the period of 2000-2001, about 120,000 adults aged 20 years and above received health check-ups at the MJ Health Screening Centers. Among these, 24,329 participants with complete data on waist circumference, blood pressure, fasting levels of glucose, triglyceride, and high-density-lipoprotein cholesterol were randomly selected for analysis. The prevalence of metabolic syndrome was estimated according to the criteria proposed by the National Cholesterol Education Program (NCEP III), with adoption of the Asian criteria for abdominal obesity.

Results. Based on the strict NCEP III criteria, the prevalence of metabolic syndrome was 9.5% (10.6% in men and 8.1% in women, respectively); with Asian criteria for waist circumference, 12.9% (15.5% in men and 10.5% in women, respectively). The prevalence of metabolic syndrome increased with age. Prevalences of all components of metabolic syndrome increased sharply with age in women. In contrast, the prevalences of high triglyceride and low high-density-lipoprotein cholesterol flattened and declined after the age of 50 years in men. Therefore, the gender difference resulted in a cross-over of the prevalence of metabolic syndrome between men and women at the age of 60 years.

Conclusions. The prevalence of metabolic syndrome in a physical check-up population is significantly affected by age and gender. Age- and gender-specific strategies may be useful in the control of the syndrome.

Obesity, dyslipidemia, diabetes, and hypertension are well-documented risk factors for atherosclerosis and cardiovascular disease, and most individuals who develop cardiovascular disease have multiple risk factors.[1] The frequent clustering of these risk factors was first recognized in the late 1960s and was thought to be related to insulin resistance.[2] Both the World Health Organization[3] and the Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (NCEP III)[4] used the term "metabolic syndrome" and provided criteria for the diagnosis of this syndrome. It appears that the metabolic syndrome, insulin resistance syndrome,[5] and syndrome X[6] all refer to the same clustering of risk factors associated with atherosclerosis and cardiovascular disease.[1]

Metabolic syndrome is a major risk factor for the development of type 2 diabetes mellitus and is responsible for the epidemics of cardiovascular disease in most of the world.[7,8] Estimation of the prevalence of the metabolic syndrome is essential for the prediction of the future burdens of type 2 diabetes and cardiovascular disease. We've reported the prevalence of metabolic syndrome in Kinmen.[9] However, the prevalence of the metabolic syndrome may vary greatly in different regions and also in different ethnicities in the same region. Therefore, the primary objective of this study was to examine the prevalence of metabolic syndrome in a sample from a large health screening

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population in Taiwan.

METHODS

Study population

MJ Health Screening Center is a private membership chain clinic with 4 health screening centers (in Taipei, Taoyuan, Taichung, and Kaohsiung, respectively) around the Taiwan island, which provides periodic health examination to its members. During the period of 2000-2001, about 120,000 members received health examination in the 4 centers. According to the policy of the MJ Corporation, no more than one-quarter of the records from the database can be open for academic researchers on request. Therefore, 30,909 records during the period were selected from the database by simple randomization for the purpose of the present study. Subjects in the random sample population were excluded for analysis when (1) they were younger than 20 years old, or (2) their data for any one of the components of the metabolic syndrome were missing. Finally, a total of 24,329 subjects were eligible for analysis. Characteristics of the subjects selected and not selected for the study are presented in Table 1. The unselected subjects were slightly younger, had slightly greater waist circumference and body mass index, higher levels of triglyceride and systolic blood pressure, lower level of high-density-lipoprotein cholesterol, and higher prevalence of hypertension and diabetes when compared to the selected subjects.

Health screening

The health screening procedures at the MJ Health Screening Center are carried out in a highly efficient way. In 4 hours, every subject attends 18 stations for 28 major examinations. Subjects are advised to fast for at least 8 hours before participating in the health check-up. Fasting venous blood samples are collected for a battery of biochemistry analyses. Levels of glucose, triglycerides, and high-density-lipoprotein cholesterol are measured enzymatically on a Hitachi 7150 autoanalyzer (Hitachi, Tokyo, Japan). A structured questionnaire incorporating information on educational level, uses of cigarette and alcohol, physical activities, and previous history of stroke and heart disease is self-administered under the assistance of a nurse.

All subjects are barefoot and wear light indoor clothing to measure body weight and height on an auto-anthropometer (KN-5000A, Nakamura, Tokyo, Japan). Body mass index is calculated by weight (kg) divided by the square of height (meter). Waist circumference is measured at the largest waist using a tape measure. Blood pressures over the right arm in a seated position are taken twice using a computerized automatic mercury-sphygmomanometer (CH-5000, Citizen, Tokyo, Japan). The mean of the two readings was used in the anal-

Table1. Characteristics of the subjects selected and not selected for the study

Characteristics	Selected (n = 24329)	Not selected (n = 6580)	*p* value
men (%)	48.2	48.2	0.9608
Age (yrs)	42.4 ± 13.4	40.3 ± 13.4	<.0001
Waist circumference (cm)	76.7 ± 10.2	77.0 ± 10.6	0.0189
Body mass index (kg/m^2)	23.0 ± 3.4	23.1 ± 3.6	0.0425
Triglycerides (mmol/L)	1.29 ± 0.73	1.92 ± 2.29	<.0001
High-density-lipoprotein cholesterol (mmol/L)	1.40 ± 0.39	1.35 ± 0.37	<.0001
Systolic blood pressure (mmHg)	118.8 ± 18.3	119.3 ± 18.5	0.0319
Diastolic blood pressure (mmHg)	71.5 ± 11.3	71.8 ± 11.8	0.1686
Fasting plasma glucose (mmol/L)	5.48 ± 1.19	5.51 ± 1.36	0.1772
Hypertension (%)	17.9 (17.4-18.4)	19.8 (19.3-20.3)	0.0009
Diabetes (%)	4.9 (4.6-5.2)	5.6 (5.3-5.9)	0.0176

Parentheses are 95% confidence intervals.

The conversion factors are as follow: triglycerides, mg/dL = 0.01129 mmol/L; high-density-lipoprotein cholesterol, mg/dL = 0.02586 mmol/L; fasting glucose, mg/dL = 0.05551 mmol/L.

ysis. Subjects with systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg or using regular antihypertensive medication were defined as hypertension.[10] Subjects with fasting glucose ≥ 6.99 mmol/L (126 mg/dL) or using regular antidiabetic medication were defined as diabetes.[11]

The definition of metabolic syndrome was based on the NCEP III recommendations[4] with some modification. The clinical components of metabolic syndrome include abdominal obesity, high triglycerides, low high-density-lipoprotein cholesterol, high blood pressure, and high fasting glucose.[4] According to NCEP III, the diagnosis of metabolic syndrome is made when 3 or more of the following risk determinants are present: abdominal obesity (waist circumference: men > 102 cm; women > 88 cm), high triglycerides (≥ 1.69 mmol/L [150 mg/dL]), low high-density-lipoprotein cholesterol (men < 1.03 mmol/L [40 mg/dL]; women < 1.29 mmol/L [50 mg/dL]), high blood pressure (systolic blood pressure ≥ 130 mmHg or diastolic blood pressure ≥ 85 mmHg), and high fasting glucose (≥ 6.11mmol/L [110 mg/dL]). Since the NCEP III criteria for abdominal obesity may not be appropriate for Chinese, we recalculated the prevalence of abdominal obesity and metabolic syndrome according to the cut-offs of waist circumferences > 90 cm in men and > 80 cm in women.[12] In this study, subjects who were regularly taking antihypertensive medications were counted as having high blood pressure, even if their blood pressure levels were < 130/85 mmHg (214 men and 165 women fulfilled this criteria). Similarly, subjects who were under regular treatment for diabetes mellitus were counted as having high fasting glucose, even if their fasting glucose levels were < 6.11mmol/L (110 mg/dL) (49 men and 55 women fulfilled this criteria). The status of the use of lipid-lowering drugs was not available in the records.

Statistical analysis

Data are presented as mean ± SD and 95% confidence interval. Student's *t*-test and *Chi-square* test were used for between-group comparisons where appropriate, and the 95% confidence intervals were provided. The trend associations between age and the prevalence of metabolic syndrome and its components were analyzed using the Cochran-Armitage test. Statistical significance was set at $p < 0.05$. The interaction effect of sex and age groups was tested using logistic regression. All statistical analyses were performed using the SAS statistical package (Statistical Analysis Software release 8.0, Cary, NC, USA).

RESULTS

Characteristics of the study population

The characteristics of the 24,329 eligible subjects are shown in Table 2. Men were slightly but significantly older than women. Men had significantly greater waist

Table 2. Characteristics of men and women in the study population

Characteristics	Men (n = 11731)	Women (n = 12598)	*p* values
Age (yrs)	42.7 ± 13.5	42.2 ± 13.4	<.0001
Waist circumference (cm)	82.3 ± 8.9	71.4 ± 8.3	<.0001
Body mass index (kg/m^2)	23.9 ± 3.2	22.2 ± 3.5	<.0001
Triglycerides (mmol/L)	1.48 ± 0.78	1.11 ± 0.62	<.0001
High-density-lipoprotein cholesterol (mmol/L)	1.24 ± 0.32	1.54 ± 0.38	<.0001
Systolic blood pressure (mmHg)	122.0 ± 16.6	115.7 ± 19.3	<.0001
Diastolic blood pressure (mmHg)	74.4 ± 10.8	68.9 ± 11.1	<.0001
Fasting plasma glucose (mmol/L)	5.60 ± 1.19	5.37 ± 1.19	<.0001
Hypertension (%)	20.4 (19.7-21.1)	15.6 (15.0-16.3)	<.0001
Diabetes (%)	5.4 (5.0-5.8)	4.4 (4.0-4.7)	0.0002

Parentheses are 95% confidence intervals.
The conversion factors are as follow: triglycerides, mg/dL = 0.01129 mmol/L; high-density-lipoprotein cholesterol, mg/dL = 0.02586 mmol/L; fasting glucose, mg/dL = 0.05551 mmol/L.

circumference and body mass index, higher triglycerides, systolic and diastolic blood pressure, fasting plasma glucose, and lower high-density-lipoprotein cholesterol than women. Men also had significantly higher prevalence of hypertension and diabetes than women.

Prevalences of the components of metabolic syndrome

The overall prevalences of the 5 components of metabolic syndrome according to the strict NCEP III criteria were high blood pressure (29.6%), low high-density-lipoprotein cholesterol (26.1%), high triglycerides (21.9%), high fasting glucose (10.4%), and abdominal obesity (3.0%), respectively. The prevalence of abdominal obesity was 14.7% when the Asian criteria for waist circumference > 90 cm in men or > 80 cm in women were applied. The age- and sex-stratified prevalences of the 5 components are shown in Table 3. Overall, men had

Table 3. Age- and sex-stratified prevalences of the metabolic syndrome and its components

	20-29	30-39	40-49	50-59	60-69	70+	Total
Number of subjects							
Men	1816	3904	2782	1538	1149	542	11731
Women	3222	3970	2584	2051	1285	386	12598
Total	4138	7874	5366	3589	2434	928	24329
High waist circumference							
Men	1.3 (0.8-1.8)	1.3 (0.9-1.7)	1.7 (1.2-2.2)	2.5 (1.7-3.3)	3.2 (2.2-4.2)	4.2 (2.5-5.9)	1.8 (1.6-2.0)
Women	1.3 (0.8-1.8)	1.0 (0.7-1.3)	2.6 (2.0-3.2)	6.9 (5.8-8.0)	13.2 (11.3-15.1)	20.0 (16.0-24.0)	4.1 (38.-4.4)
Total	1.3 (1.0-1.6)	1.1 (0.9-1.3)	2.1 (1.7-2.5)	5.0 (4.3-5.7)	8.5 (7.4-9.6)	10.8 (8.8-12.8)	3.0 (2.8-3.2)
High waist circumference†							
Men	8.7 (7.4-10.0)	11.9 (10.9-12.9)	17.7 (16.3-19.1)	23.7 (21.6-25.8)	24.7 (22.2-27.2)	31.4 (27.5-35.3)	16.5 (15.8-17.2)
Women	3.2 (2.5-3.9)	3.9 (3.3-4.5)	9.7 (8.6-10.8)	23.5 (21.7-25.3)	37.7 (35.1-40.3)	51.3 (46.3-56.3)	13.0 (12.4-13.6)
Total	5.6 (4.9-6.3)	7.9 (7.3-8.5)	13.8 (12.9-14.7)	23.6 (22.2-25.0)	31.6 (29.8-33.4)	39.7 (48.1-54.5)	14.7 (14.3-22.4)
High triglycerides							
Men	14.9 (13.3-16.5)	29.8 (28.4-31.2)	37.4 (35.6-39.2)	36.9 (34.5-39.3)	31.5 (28.8-34.2)	25.8 (22.1-29.5)	30.2 (29.4-31.0)
Women	3.5 (2.8-4.2)	7.0 (6.2-7.8)	13.0 (11.7-14.3)	24.5 (22.6-26.4)	34.1 (31.5-36.7)	36.8 (32.0-14.6)	14.1 (135.-14.7)
Total	8.5 (7.7-9.3)	18.3 (17.4-19.2)	25.7 (24.5-26.9)	20.1 (18.8-21.4)	32.9 (31.0-34.8)	30.4 (27.4-33.4)	21.9 (21.4-22.4)
Low high-density-lipoprotein cholesterol							
Men	19.5 (17.7-21.3)	26.9 (25.5-28.3)	27.9 (26.2-29.6)	28.5 (26.2-30.8)	28.7 (26.1-31.3)	24.2 (20.6-27.8)	26.1 (25.3-26.9)
Women	20.5 (18.9-22.1)	22.9 (21.6-24.2)	27.6 (25.9-29.3)	30.0 (28.0-32.0)	34.7 (32.1-37.3)	35.5 (30.7-40.3)	26.1 (25.3-26.9)
Total	20.1 (18.9-21.3)	24.9 (23.9-25.9)	27.5 (26.3-28.7)	29.1 (27.6-30.6)	31.9 (30.0-33.8)	28.9 (26.0-31.8)	26.1 (25.5-26.7)
High blood pressure							
Men	24.6 (22.6-26.6)	24.8 (23.4-26.2)	32.8 (31.1-34.5)	48.4 (45.9-50.9)	59.4 (56.6-62.2)	73.3 (69.6-77.0)	35.4 (34.5-36.3)
Women	5.5 (4.6-6.4)	7.5 (6.7-8.3)	19.5 (18.0-21.0)	47.0 (44.8-49.2)	65.9 (63.3-68.5)	83.2 (79.5-86.9)	24.3 (23.6-25.0)
Total	13.9 (12.8-15.0)	16.1 (15.3-16.9)	26.4 (25.2-27.6)	47.6 (46.0-49.2)	62.8 (60.9-64.7)	77.4 (74.7-80.1)	29.6 (29.0-30.2)
High fasting glucose							
Men	2.3 (1.6-3.0)	6.1 (5.3-6.9)	12.9 (11.7-14.1)	23.5 (21.4-25.6)	27.1 (24.5-29.7)	29.3 (25.5-33.1)	12.5 (11.9-13.1)
Women	1.0 (0.6-1.4)	2.3 (1.8-2.8)	6.4 (5.5-7.3)	17.5 (15.9-19.1)	23.9 (21.6-26.2)	30.3 (25.7-34.9)	8.4 (7.9-8.9)
Total	1.6 (1.2-2.0)	4.1 (3.7-4.5)	9.8 (9.0-10.6)	20.0 (18.7-21.3)	25.4 (23.7-27.1)	29.7 (26.8-32.6)	10.4 (10.0-10.8)
Metabolic syndrome							
Men	3.2 (2.4-4.0)	6.8 (6.0-7.6)	11.6 (10.4-12.8)	18.7 (16.8-20.6)	19.8 (17.5-22.1)	20.9 (17.5-24.3)	10.6 (10.0-11.2)
Women	1.1 (0.7-1.5)	1.5 (1.1-1.9)	6.0 (5.1-6.9)	15.1 (13.6-16.6)	26.4 (24.0-28.8)	35.2 (30.4-40.0)	8.1 (7.6-8.6)
Total	2.0 (1.6-2.4)	4.1 (3.7-4.5)	8.9 (8.1-9.7)	16.6 (15.4-17.8)	23.3 (21.6-25.0)	26.8 (24.0-29.6)	9.4 (9.0-9.8)
Metabolic syndrome†							
Men	5.4 (4.4-6.4)	10.1 (9.2-11.0)	16.3 (14.9-17.7)	25.4 (23.2-27.6)	26.7 (24.1-29.3)	31.4 (27.5-35.3)	15.5 (14.8-16.2)
Women	1.5 (1.0-2.0)	2.1 (1.7-2.5)	7.8 (6.8-8.8)	19.7 (18.0-21.4)	33.3 (30.7-35.9)	43.5 (38.6-48.4)	10.5 (10.0-11.0)
Total	3.2 (2.7-3.7)	6.1 (5.6-6.6)	12.2 (11.3-13.1)	22.1 (20.7-23.5)	30.2 (28.4-32.0)	36.4 (33.3-39.5)	12.9 (12.5-13.3)

†: abdominal obesity defined by Asian criteria: waist circumference > 90 cm in men and >80 cm in women, respectively. Parentheses are 95% confidence intervals.

higher prevalence of high triglycerides, high blood pressure, and high fasting glucose than women. It was interesting to find that women had higher prevalence of abdominal obesity by NCEP criteria but lower prevalence of abdominal obesity by Asian criteria than men. Men and women had similar prevalence of low high-density-lipoprotein cholesterol.

In both men and women, the prevalences of the components of the metabolic syndrome were affected substantially by age. In women, each prevalence of the components increased sharply with age (Table 3). In contrast, the prevalences of high waist circumference (by Asian criteria), high blood pressure, and high fasting glucose increased with age, while the prevalences of high triglycerides and low high-density-lipoprotein cholesterol increased with age until about 50 years and then declined thereafter in men (Table 3).

Clustering of the components of metabolic syndrome

Overall, 35.5% of men had zero components, 29.5% had one component, 19.5% had two components, 10.6% had three components, 4.2% had four components, and 0.7% had all five components of the metabolic syndrome, respectively. The corresponding numbers for women were 52.3%, 24.8%, 12.4%, 6.3%, 3.3%, and 0.9%, respectively. The most commonly observed single component was high blood pressure (43.4%) in men and low high-density-lipoprotein cholesterol (45.7%) in women, respectively. In women, the percentages of subjects with the clustering of more than one component increased obviously with age and the percentage of with subjects without any one component decreased sharply with age (Fig. 1). Similar but less obvious trends could also be observed in men (Fig. 1).

Prevalence rates of metabolic syndrome

The overall prevalence of metabolic syndrome in this health check-up population was 12.9% (abdominal obesity defined by Asian criteria)(Table 3). The prevalence was higher in men (15.5%) than in women (10.5%) ($p < .0001$)(Table 3). The standardized prevalences (adjustment according to the age and sex structure of the population in Taiwan area in 2003) of metabolic syndrome for the whole population, men, and women were 13.9%, 15.7%, and 12.0%, respectively. The prevalence of metabolic syndrome increased with age in both sexes ($p < .0001$ for a linear trend)(Table 3). Because of the different trends of the prevalences of high triglycerides and low high-density-lipoprotein cholesterol related to age between men and women, there was a crossover of the age-stratified prevalences of the metabolic syndrome between men and women at the age of 60. Namely, before age 60, men had higher prevalence of metabolic syn-

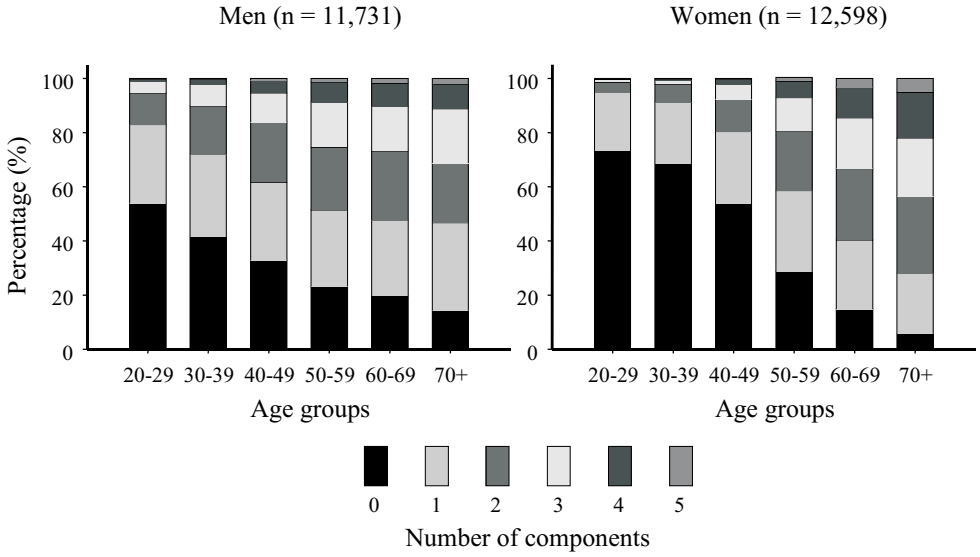

Fig. 1. Clustering of the components of the metabolic syndrome. Percentages of subjects with zero to 5 components in each age strata are shown in stacked bars for men (left panel) and women (right panel), respectively.

Table 4. Prevalences of the metabolic syndrome stratified by educational levels, uses of cigarette and alcohol, and physical activities in the study population

	MEN			WOMEN		
	%	(95% C.I.)		%	(95% C.I.)	
Years of education						
≤ 6 years	26.5	(24.0-28.9)		28.8	(27.1-30.5)	
9 years	19.1	(16.3-21.9)		13.6	(11.3-15.9)	
12 years	16.0	(14.6-17.5)		5.6	(4.8-6.4)	
14 years	12.5	(11.3-13.6)		3.4	(2.7-4.0)	
≥ 16 years	12.3	(11.3-13.4)	$p < 0.0001$	2.5	(1.9-3.1)	$p < 0.0001$
Smoking						
Never	14.4	(13.6-15.3)		10.5	(9.9-11.0)	
Ex-smoker	17.9	(15.8-20.1)		6.7	(3.1-10.4)	
1-3 times per week	16.3	(12.3-20.3)		3.3	(-0.4-7.0)	
≥ 4- times per week	15.8	(14.6-16.9)	$p = 0.0121$	8.0	(5.8-10.2)	$p = 0.0121$
Drinking						
< 1 Time per week	14.0	(13.2-14.8)		10.1	(9.5-10.6)	
Refrain	21.5	(18.2-24.9)		11.4	(6.9-15.9)	
1-2 times per week	15.2	(13.6-16.9)		8.8	(5.8-11.7)	
3-4 times per week	19.5	(16.5-22.4)		6.2	(1.7-10.6)	
Every day per week	22.1	(17.9-26.3)	$p < 0.0001$	13.2	(5.6-20.8)	$p = 0.4491$
Working style						
Seating	16.0	(15.1-16.9)		9.6	(8.9-10.3)	
Seating and walking repeatedly	13.2	(11.9-14.4)		11.1	(10.1-12.2)	
Walking and standing	14.8	(13.0-16.6)		10.5	(8.2-12.8)	
Use the whole body muscle	12.0	(8.9-15.0)	$p < 0.0001$	7.8	(1.8-13.8)	$p < 0.0001$
Regular exercise						
< 1 hr per week	14.7	(13.6-15.7)		8.8	(8.1-9.5)	
1-2 hrs per week	14.1	(12.8-15.3)		8.6	(7.6-9.7)	
3-4 hrs per week	15.4	(13.7-17.1)		10.2	(8.7-11.7)	
5-6 hrs per week	17.6	(15.1-20.1)		17.6	(14.9-20.3)	
≥ 7 hrs per week	18.7	(16.3-21.2)	$p < 0.0001$	21.8	(18.8-24.8)	$p < 0.0001$

drome than women. After the age of 60, women had higher prevalence of metabolic syndrome than men.

The potential impacts of the socioeconomic status and lifestyle factors on the prevalence of the metabolic syndrome are shown in Table 4. Except for the use of alcohol in women, the prevalence of metabolic syndrome in each stratum of years of education, smoking, drinking, working style, and regular exercise appeared to be significantly different in both men and women.

Metabolic syndrome and history of cardiovascular disease

Based on the self-administered questionnaire, 0.52% of men and 0.36% of women had a history of stroke. Men and women with metabolic syndrome had increased risk of stroke (in men, odds ratio 4.38, 95% confidence interval 2.64-7.29; in women, odds ratio 4.32, 95% confidence interval 2.32-8.04). Similarly, 2.70% of men and 2.92% of women had a history of heart disease. In comparison to those without the metabolic syndrome, men and women with the metabolic syndrome had increased risk of heart disease (in men, odds ratio 2.68, 95% confidence interval 2.10-3.42; in women, odds ratio 4.76, 95% confidence interval 3.91-5.95).

DISCUSSION

The presence of metabolic syndrome is associated with risk of stroke, heart disease, and the development of diabetes mellitus,[7] which were the second, third, and fourth leading causes of death in Taiwan in 2002.[13] The

prevalence of metabolic syndrome may vary substantially by ethnicity, age, and body mass index, and is associated with several potentially modifiable lifestyle factors.[14] In the present study, the overall prevalence of metabolic syndrome in the health check-up population from Taiwan area was 12.9% (abdominal obesity defined by Asian criteria), which was substantially lower than that (21.2%) reported in Kinmen.[9] The prevalence in Taiwan was higher in men (15.5%) than in women (10.5%). In contrast, the metabolic syndrome was present in 17.7% of men and 23.8% of women in Kinmen, respectively.[9]

The current study enrolled subjects aged 20 years and above (mean age 42 years), who were substantially younger than those reported in the Kinmen study (aged 30 years and above, mean age 52 years, military personnel not included). The prevalence rates of the metabolic syndrome were 14.9%, 17.3%, and 12.5% for overall, men, and women aged 30 years and above in the Taiwan physical check-up population. Therefore, it appears that the prevalence of metabolic syndrome was similar in men but was substantially different in women when comparing Taiwan and Kinmen populations. One reason that women in Kinmen had the highest prevalence rate of metabolic syndrome among men and women in both Kinmen and Taiwan is that Kinmen women were more obese.[9] Women in Kinmen used to marry and bear children in their early 20s so they started to gain weight in their 30s, when Kinmen was under control of martial law.[9] Alternatively, because of the lower socioeconomic status in Kinmen in comparison to that in Taiwan, it would be anticipated that both men and women in Kinmen should have had higher prevalences of metabolic syndrome than their counterparts in Taiwan. The fact that men in Kinmen had similar prevalence of metabolic syndrome to men in the current study population might indicate that men in Kinmen had had been "protected" from the development of metabolic syndrome, probably due to the regular heavy military training during the period of martial law control.

Prevalence of metabolic syndrome

Compared with World Health Organization guidelines,[11] the new NCEP III guidelines[4] define criteria readily measured in clinical practice. Although the predictive validity of the NCEP III criteria for the development of disease remains to be established by future longitudinal studies, these consensus-generated criteria provide the opportunity to assess the overall prevalence in various populations according to an accepted standard definition.[14]

The prevalence rates of metabolic syndrome vary among ethnicities and countries. According to the Third National Health and Nutrition Examination Survey (1988-1994), the percentages of participants with metabolic syndrome were 13.9%, 20.8%, and 24.3%, for black, Mexican American, and white men, and 20.9%, 27.2%, and 22.9%, for black, Mexican American, and white women, respectively.[14] The percentage of men with metabolic syndrome was significantly higher in Mexican American and white men than in black men.[14] The percentage of Mexican American women with the metabolic syndrome was significantly higher than that of black and white women.[14] In Iran, the age-standardized prevalences of the metabolic syndrome in 10,368 adults aged ≥ 20 years were 24% for men and 42% for women, respectively.[15] In western India, the prevalences of the metabolic syndrome among 1123 urban subjects aged ≥ 20 years were 7.9% in men and 17.5% in women, respectively.[16] In Korea, the prevalences of metabolic syndrome among 40,698 participants aged 20-82 years for a medical check-up were 5.2% in men and 9.2% in women, respectively.[17] Using the strict NCEP III criteria for waist circumference, the prevalences of the metabolic syndrome among 8,320 residents ≥ 30 years in Kinmen were 11.2% in men and 18.6% in women, respectively.[9] In contrast, the prevalences of the metabolic syndrome in the current study were 10.6% in men and 8.1% in women (Table 3). The large variation in the prevalence rates of metabolic syndrome mainly reflects the difference in lifestyles,[1] and is partly due to the inappropriate criteria of abdominal obesity for East Asian populations.[12]

A gender difference in metabolic syndrome prevalence rates can be observed in most ethnicities and countries. In American whites and Taiwan area, the metabolic syndrome was slightly more prevalent in men than in women.[14] In American blacks, Mexican Americans, Iran, India, Oman, Korea, and Kinmen, women had higher prevalence of the metabolic syndrome than men.[9,14-18] The gender difference is probably due to the difference in the

frequency of each metabolic syndrome component between men and women. For example, according to the Third National Health and Nutrition Examination Survey (1988-1994), the most frequent abnormalities of the components of the metabolic syndrome were high blood pressure and a high triglyceride level in men, and large waist circumference, low high-density-lipoprotein cholesterol, and high blood pressure in women.[14] In the Taiwan physical check-up population, the most common abnormalities were high blood pressure in men and low high-density-lipoprotein cholesterol in women. In Kinmen, the most common abnormalities was high blood pressure in men and large waist circumference in women.[9] In the Iran population, low high-density-lipoprotein cholesterol was the most common metabolic abnormality in both sexes.[15] In western India, the prevalence of low high-density lipoprotein cholesterol was 90.2% in women and 54.9% in men.[16] Thus, it appears that low high-density lipoprotein cholesterol and large waist circumference are responsible for the high prevalence of metabolic syndrome in women in many populations.

Components of the metabolic syndrome

The pathophysiology of the metabolic syndrome may involve the interplay of 3 potential etiological categories: obesity; insulin resistance; and other independent factors that mediate specific components of the metabolic syndrome.[1] Obesity, especially abdominal obesity, contributes to hypertension, high serum cholesterol, low high-density-lipoprotein cholesterol, and hyperglycemia, and itself is an independent cardiovascular risk factor. Adipose tissue is a major endocrine organ that releases several products that may exacerbate other cardiovascular risk factors when in excess. According to NCEP III, the metabolic syndrome is essentially defined as a clustering of metabolic complications of obesity.[1] Insulin resistance and/or hyperinsulinemia may directly cause other metabolic risk factors.[19] However, dissociation of obesity and primary insulin resistance in patients with metabolic syndrome is difficult because insulin resistance is linked to obesity and a broad range of insulin sensitivities exists at any given level of body fat. Beyond obesity and insulin resistance, each risk factor of the metabolic syndrome is subject to its own regulation through both genetic and environmental factors. Therefore, the observed variability in expression of individual risk factors in different populations is not unexpected.

Based on the NCEP III guidelines, high blood pressure is always the most common component of metabolic syndrome in men.[9,20] Although the causal relationship between hypertension and the insulin resistance remains obscure, hypertension alone confers a substantial risk of cardiovascular morbidity and mortality, which is not necessarily lower than that from metabolic syndrome. It has been estimated that in men and women, blood pressure control to normal levels "prevented" 28.1% and 12.5% of coronary heart disease events, respectively; control to optimal levels resulted in preventing 28.2% and 45.2% of events, respectively.[21] Many coronary heart disease events in patients with the metabolic syndrome may be preventable by nominal or optimal control of lipids and/or blood pressure.[21]

The prevalence rates of the metabolic syndrome increased slowly in the normal weight adults and increased rapidly in overweight participants and reached a prevalence of approximately 60% in moderately obese participants with a body mass index of approximately 35 in the Third National Health and Nutrition Examination Survey (1988-1994).[14] Although body mass index serves as a useful marker of obesity and the related insulin resistance, stronger correlations are observed between abdominal obesity and metabolic risk factors.[14] Waist circumference is a measure of abdominal obesity and is well correlated with visceral adipose tissue.[14] Large waist circumference is the most common component of metabolic syndrome in women in some populations.[9,20] In the physical check-up population in Taiwan, abdominal obesity contributed less significantly to the prevalence of the metabolic syndrome in both men and women. However, it should be noted that the prevalence of abdominal obesity increased steeply over 40 years of age in the present study (Table 3). Abdominal obesity and female sex were associated with increased undiagnosed diabetes in Taiwanese with the impaired fasting hyperglycemia.[22]

In the present study, low high-density-lipoprotein cholesterol level was the most frequent abnormality in women. Asian people usually have a high prevalence of low high-density-lipoprotein cholesterol level. The prevalence rates of low high-density-lipoprotein in white

women, African American women, and Mexican American women were 39.3%, 34.0%, and 46.3%, respectively.[20] On the other hand, the prevalence rates of the low high-density-lipoprotein cholesterol were 73% in Iranian women,[15] 90.2% in Indian women[16], and 75.4% in Omani women.[18] Low high-density-lipoprotein cholesterol was more important relative to other abnormalities in young women in the present study (Table 3). Effective elevation of the high-density-lipoprotein cholesterol level may reduce the risk of coronary heart disease. Control of the high-density-lipoprotein to normal levels and optimal levels may result in preventing 27.3% and 50.6% of coronary heart disease events in women, respectively.[21]

Limitations of present study

The participants of the present study who were the members of the private health check-up clinics might represent a sub-group with high socioeconomic status and health knowledge (Table 4). Many studies have reported that low socioeconomic status is associated with a high mortality rate for cardiovascular disease.[14] The odds ratio for the metabolic syndrome was significantly increased in a low household income group.[14] Therefore, the prevalence rates of metabolic syndrome in the present study may not be representative of the general population in Taiwan.

In conclusion, the prevalence of metabolic syndrome in a physical check-up population is significantly affected by age and gender. Age- and gender-specific strategies may be useful in the control of the syndrome.

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