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Prevalence and cardiovascular disease risk of the metabolic syndrome using National Cholesterol Education Program and International Diabetes Federation definitions in the Korean population

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Abstract

To compare the prevalence of the metabolic syndrome using the National Cholesterol Education Program (NCEP) and the International Diabetes Federation (IDF) definitions and to contrast the association between the prevalence of cardiovascular disease and the metabolic syndrome using both definitions in the Korean population, we used data from the 2001 Korean Nation Health and Nutrition Survey, which is a nationally representative survey of the noninstitutionalized civilian population. The age-adjusted prevalence of the metabolic syndrome was 18.8% ± 0.5% (men, 17.8% ± 0.8%; women, 20.5% ± 0.7%) using the NCEP definition and 19.5% ± 0.5% (men 15.0% ± 0.8%, women 23.9% ± 0.7%) using the IDF definition among participants 20 years or older. The agreement rate, which is the percentage of participants who were classified as either having or not having the metabolic syndrome by both definitions of the metabolic syndrome, was 84.6% ± 0.5% (κ = 0.54). The prevalence of the metabolic syndrome using the NCEP definition was higher in participants with lower body mass index, whereas the prevalence using the IDF definition was higher in subjects with higher body mass index. The odds ratio (OR) for coronary artery disease was 3.5 (95% confidence interval [CI], 2.0-6.1) for participants with the metabolic syndrome defined by the NCEP definition, whereas it was 2.8 (95% CI, 1.6-5.0) for those with the metabolic syndrome defined by the IDF definition. Similarly, the OR for stroke was higher using the NCEP definition (OR, 3.0; 95% CI, 1.7-5.2) compared with that of the IDF definition (OR, 2.3; 95% CI, 1.3-4.0). However, the CIs by both definitions overlapped considerably. In conclusion, the prevalence of the metabolic syndrome using the IDF definition was higher than that using the NCEP definition, whereas the NCEP definition was more closely associated with cardiovascular disease in the Korean population.

1. Introduction

The metabolic syndrome is associated with global epidemics of type 2 diabetes mellitus and cardiovascular disease. The prevalence of the metabolic syndrome is estimated to be 20% to 25% of the population and increases in frequency with age [1]. In a European study, the risk for coronary heart disease and stroke was increased 3-fold in subjects with the metabolic syndrome [2]. In another study in the United States, the hazard ratio for participants with the metabolic syndrome was 1.37 (95% confidence interval [CI], 1.02-1.85) for mortality from cardiovascular disease compared with that of those without the syndrome after multiple adjustment [3]. Therefore, the metabolic syndrome has become a major health problem worldwide [4].

The World Health Organization (WHO) first proposed a definition for the metabolic syndrome in 1998 [5]. The European Group for the Study of Insulin Resistance published a modification of the WHO definition [6]. In 2001, the National Cholesterol Education Program (NCEP) provided another definition, which was rapidly accepted worldwide [7]. Subsequently, the American Association of Clinical Endocrinologists offered another definition of the metabolic syndrome [8]. However, a common problem to all

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definitions is their applicability to different ethnic groups, especially in relation to obesity cutoffs [9]. The prevalence of the metabolic syndrome in Asian populations has been regarded as relatively low by the NCEP definition, although the risk of type 2 diabetes mellitus is apparent at much lower levels of adiposity in Asian populations compared with European populations [10]. Furthermore, there is a global need for a single universally accepted diagnostic tool to address both clinical and research needs [11]. For these reasons, the International Diabetes Federation (IDF) proposed a new definition of the metabolic syndrome in 2005 [12]. The major difference in the IDF criteria compared with that of the NCEP criteria is its definition of central obesity. Central obesity is determined by the waist circumference using a guideline that is sex- and ethnic-group specific. Although a major impact of the new IDF definition is anticipated in Asian populations, there are few previous reports regarding the difference of the prevalence of the metabolic syndrome depending on the use of the NCEP or IDF definitions in Asian populations. Furthermore, there are limited data available on the association between cardiovascular disease and the metabolic syndrome under both definitions. In fact, little is known about how much the 2 definitions may predict the future risk of cardiovascular disease, although the metabolic syndrome is usually considered as a 'precursor' of cardiovascular diseases.

Therefore, our aims in the present study were (1) to estimate the prevalence of the metabolic syndrome using the new IDF definition among Korean adults, (2) to compare its prevalence with that of the NCEP definition and to evaluate the concordance of the 2 definitions, and (3) to compare the association between the prevalence of cardiovascular disease and the metabolic syndrome using both definitions.

2. Materials and methods

2.1. Subjects and methods

The Korean National Health and Nutrition Survey (KNHNS) was performed by the Korean Ministry of Health and Welfare. The 2001 KNHNS was a cross-sectional and nationally representative survey, the details of which have been previously published [13]. The survey consisted of the following 4 components: a health interview survey, a health behavior survey, a health examination survey, and a nutrition survey. The targeted population for the survey was that of civilian, noninstitutionalized individuals older than 1 year (for the health interview and nutrition surveys) or older than 10 years (for health behavior and health examination surveys). A stratified multistage probability sampling design was used, and selections were made from sampling units based on geographic area, sex, and age based on household registries. There were 246 097 primary sampling units, each of which contained approximately 60 households. Two hundred sampling frames (12 180 households) from primary sampling units were randomly selected throughout South Korea, and 37 769 individuals from these sampling frames were included in the health interview survey. The survey was completed by 9770 of 12 642 individuals who participated in the health examination study, which gave a participation rate of 77.3%. We used the data of 6601 subjects older than 20 years for this study. Each respondent was assigned a weight based on geographic and demographic characteristics to allow findings to be extrapolated for the entire Korean population. Nurses were trained to carry out anthropometric measurements, serum collection, blood pressure measurement, and questionnaire management. The questionnaires included items concerning the demographic, socioeconomic, dietary, and medical history details of each respondent.

Body weight and height were measured with subjects wearing light clothing without shoes. Body mass index (BMI) was calculated as the weight in kilograms divided by the square of height in meters. Waist circumference was measured from the narrowest point between the lower borders of the rib cage and the iliac crest. Blood pressure was measured in a sitting position after a 10-minute rest period. Two systolic and diastolic blood pressure readings were recorded with a 5-minute interval and were averaged for analysis.

Fasting blood samples were taken in the morning after at least an 8-hour fast. Blood samples were centrifuged, refrigerated at the examination site, and transferred in iceboxes to a central laboratory in Seoul, Korea, on the same day that they were taken. Plasma glucose, total cholesterol, triglyceride, and high-density lipoprotein cholesterol (HDL-C) levels were measured using an auto-analyzer (Hitachi 747 auto-analyzer, Hitachi, Tokyo, Japan). Low-density lipoprotein cholesterol level was calculated using the Friedewald equation for those with serum triglyceride levels of 400 mg/dL or less [14].

At the time of the 2001 KNHNS survey, citizens had an obligation to participate in the nationwide survey if they were chosen in accordance to the National Health Enhancement Act supported by National Statistics Law of the Republic of Korea. The Department of Food and Drug Administration of Korea had also obtained a written informed consent for the use of sera for further blood tests.

2.2. Metabolic syndrome

According to the IDF definition, a participant was defined as having the metabolic syndrome if he or she had central obesity plus 2 or more of following criteria: (1) raised triglyceride levels of 1.69 mmol/L (150 mg/dL) or higher or specific treatment of this lipid abnormality; (2) reduced HDL-C levels of less than 1.04 mmol/L (40 mg/dL) in men, less than 1.29 mmol/L (50 mg/dL) in women, or specific treatment of this lipid abnormality; (3) raised systolic or diastolic blood pressure of 130/85 mm Hg or higher or previously diagnosed hypertension; and (4) raised fasting plasma glucose level of 5.6 mmol/L (100 mg/dL) or higher or previously diagnosed type 2 diabetes mellitus. To define central obesity, we used the criteria for South Asians

and Chinese; this is the same as the Asia-Pacific criteria for obesity based on waist circumference defined by WHO [15]. Specifically, the waist circumference threshold for central obesity is 90 cm or more in men and 80 cm or more in women.

According to the NCEP definition [7,16], participants who had 3 or more of the following criteria were defined as having the metabolic syndrome: (1) central obesity, with waist circumference of more than 102 cm in men and more than 88 cm in women; (2) hypertriglyceridemia, with fasting plasma triglyceride levels of 1.69 mmol/L (150 mg/dL) or higher; (3) low HDL-C, with fasting HDL-C levels of less than 1.04 mmol/L (40 mg/dL) in men and less than 1.29 mmol/L (50 mg/dL) in women; (4) hypertension, with systolic or diastolic blood pressure of 130/85 mm Hg or higher; and (5) hyperglycemia, with fasting plasma glucose levels of 5.6 mmol/L (100 mg/dL) or higher.

In this study, 4 categories of blood glucose status were used: normoglycemia (fasting plasma glucose concentration of <100 mg/dL), impaired fasting glucose (fasting plasma glucose concentration of 100 to <126 mg/dL), undiagnosed diabetes (fasting plasma glucose concentration of ≥126 mg/dL without previously diagnosed diabetes), and diagnosed diabetes (previously physician-diagnosed diabetes or previous antidiabetic medication). *Hypertension* was defined as a systolic blood pressure of 140 mm Hg or higher, a diastolic blood pressure of 90 mm Hg or higher, or the current use of antihypertensive medication. *Hypercholesterolemia* was defined as a total cholesterol level of 200 mg/dL or higher or the current use of cholesterol-lowering medications. In the survey, individuals were classified as nonsmokers, ex-smokers, or current smokers. A family history of diabetes was considered positive if at least 1 of the parents or siblings of the patient had diabetes. Medical history taking about physician-diagnosed coronary artery disease (CAD) and stroke was used to determine the presence of these conditions.

2.3. Statistical analysis

All statistical analyses were performed using SUDAAN release 9.1 (SAS Institute, Cary, NC) to reflect the characteristics of the study's multistage sampling design. The demographic characteristics for the 2001 survey were presented as mean ± SD or as numbers and percentages, as appropriate. The age-adjusted prevalence of each component or a cluster of components of the metabolic syndrome was calculated using the direct-adjustment method and was presented as percentage ± SE. The 2001 National Census data from the Korea National Statistical Office was used to define the standard population. An agreement rate of the prevalence of metabolic syndrome between 2 definitions, the NECP and the IDF, was evaluated by the percentage of participants who were classified as either having or not having the metabolic syndrome and its SE. The κ coefficient and its 95% CI for the degree of agreement were also provided. To compare the age-adjusted prevalence of the metabolic syndrome across categories of BMI and glycemic status for each of the 2 definitions, we conducted a linear trend test using a contrast statement in the DESCRIPT procedure with SUDAAN. The same procedure was used to compare its prevalence between current smokers and ex-smokers as well as between those with and without family history of diabetes. Crude and adjusted odds ratios (ORs) for cardiovascular diseases with the metabolic syndrome were obtained using χ^2 test and multiple logistic regression analysis, respectively. Adjusted variables were age, sex, education level, smoking status, family history of diabetes, and non–HDL-C concentration. Comparisons of the age-adjusted prevalence between those with and without metabolic syndrome for each of cardiovascular diseases were also made by a contrast testing in SUDAAN. Survey weights were taken into account in all of the statistical analyses. The reported P values were 2-sided, and $P < .05$ was considered to be statistically significant.

3. Results

A total of 6601 participants older than 20 years were included in this study. After excluding subjects who fasted for too short a period (n = 401) and those without fasting time data (n = 236), a total of 5964 subjects (2583 men, 3381 women) were finally included in the analysis. The mean age ± SD of the study population was 45.0 ± 15.6 years (men, 44.8 ± 15.0 years; women, 45.1 ± 15.9 years). The age-adjusted prevalence of the metabolic syndrome according to age distribution is listed in Table 1. Using the NCEP definition, the age-adjusted prevalence of the metabolic syndrome was 18.8% ± 0.5% (men, 17.8% ± 0.8%; women, 20.5% ± 0.7%). In comparison, that defined according to the IDF criteria was 19.5% ± 0.5% (men, 15.0% ± 0.8%; women, 23.9% ± 0.7%). For women, the IDF definition showed higher estimates of prevalence compared with the NCEP definition, whereas the NCEP criteria showed a higher prevalence in men compared with the IDF criteria. The prevalence of central obesity was changed from 9.4% ± 0.4% (NCEP) to 32.6% ± 0.7% (IDF).

The agreement rate was 84.6% ± 0.5% (men, 82.7% ± 0.8%; women, 87.8% ± 0.6%). The percentage of participants who had the metabolic syndrome by the NCEP criteria but not by the IDF criteria was 7.4%. In another 8.1% of the participants, the presence of the metabolic syndrome was defined by the IDF definition but not by the NCEP definition. In addition, the κ value was 0.54 (95% CI, 0.51-0.56).

For participants with a low BMI, the prevalence of the metabolic syndrome was higher using the NCEP definition compared with the IDF definition; on the other hand, for participants with a high BMI, the IDF definition had a higher prevalence than the NCEP definition (Table 2). Participants with normoglycemia had a higher prevalence of the metabolic syndrome using the IDF definition compared with that using the NCEP definition (P values for trend

Table 1
Age-adjusted prevalence of the metabolic syndrome among Korean adults 20 years or older (2001 KNHNS)

	NCEP						IDF		Agreement[a]
	Central obesity	High TG	Low HDL-C	High BP	Hyperglycemia	Metabolic syndrome	Central obesity	Metabolic syndrome	
Total	9.4 ± 0.4	31.1 ± 0.7	49.0 ± 0.7	32.3 ± 0.7	29.9 ± 0.7	18.8 ± 0.5	32.6 ± 0.7	19.5 ± 0.5	85.8 ± 0.5
Men	1.6 ± 0.3	41.9 ± 1.1	36.3 ± 1.1	40.8 ± 1.1	32.6 ± 1.0	17.8 ± 0.8	22.6 ± 0.9	15.0 ± 0.8	82.7 ± 0.8
20-29 y	1.7 ± 0.6	29.8 ± 2.5	31.9 ± 2.6	27.6 ± 2.6	21.5 ± 2.2	11.2 ± 1.8	13.7 ± 0.0	7.4 ± 1.5	91.6 ± 1.4
30-39 y	0.7 ± 0.3	41.0 ± 2.1	36.7 ± 2.0	34.1 ± 2.1	35.6 ± 2.1	17.0 ± 1.5	22.4 ± 1.8	15.2 ± 1.6	83.5 ± 1.6
40-49 y	1.7 ± 0.5	48.8 ± 2.3	37.2 ± 2.2	41.1 ± 2.3	37.5 ± 2.2	18.0 ± 1.6	28.3 ± 2.1	18.1 ± 1.7	79.1 ± 1.9
50-59 y	2.3 ± 0.9	52.4 ± 3.1	36.6 ± 2.8	53.9 ± 3.1	39.0 ± 2.9	21.7 ± 2.2	26.6 ± 2.5	19.6 ± 2.2	78.1 ± 2.3
60-69 y	2.2 ± 0.8	46.9 ± 3.5	39.2 ± 3.5	66.7 ± 3.3	34.1 ± 3.1	29.2 ± 3.3	26.1 ± 3.3	19.5 ± 3.2	74.2 ± 2.8
≥70 y	2.1 ± 1.1	40.9 ± 4.6	48.3 ± 4.5	65.7 ± 4.6	32.5 ± 4.1	25.2 ± 3.8	28.5 ± 3.7	18.2 ± 3.1	75.4 ± 3.8
Women	15.6 ± 0.7	24.3 ± 0.8	58.5 ± 1.0	27.3 ± 0.8	28.6 ± 0.9	20.5 ± 0.7	40.9 ± 0.9	23.9 ± 0.7	87.8 ± 0.6
20-29 y	6.0 ± 1.2	12.7 ± 1.5	49.6 ± 2.3	6.1 ± 1.3	16.4 ± 1.6	4.2 ± 0.9	18.4 ± 1.8	4.8 ± 0.9	95.8 ± 1.0
30-39 y	8.2 ± 1.1	16.9 ± 1.4	55.9 ± 2.0	10.6 ± 1.3	24.1 ± 1.7	10.8 ± 1.3	27.5 ± 1.7	13.2 ± 1.3	89.7 ± 1.3
40-49 y	13.5 ± 1.4	23.6 ± 1.8	55.2 ± 2.1	24.3 ± 1.9	28.6 ± 1.9	18.3 ± 1.6	40.4 ± 2.1	22.4 ± 1.7	88.6 ± 1.3
50-59 y	25.9 ± 2.4	33.9 ± 2.5	64.7 ± 2.6	42.8 ± 2.8	39.5 ± 2.7	32.6 ± 2.5	64.7 ± 2.6	38.6 ± 2.6	80.3 ± 2.1
60-69 y	32.9 ± 2.7	44.8 ± 2.9	73.2 ± 2.5	62.6 ± 2.8	41.5 ± 2.9	47.1 ± 2.8	72.8 ± 2.5	54.9 ± 2.8	81.0 ± 2.2
≥70 y	30.9 ± 3.0	37.9 ± 3.2	70.7 ± 3.0	72.2 ± 3.0	41.2 ± 3.2	45.7 ± 3.2	64.9 ± 3.0	48.9 ± 3.2	79.3 ± 2.5

Data are expressed as percentage ± SE. TG indicates triglyceride; BP, blood pressure.
[a] Percentage of participants who were classified as either having or not having the metabolic syndrome under both definitions of the metabolic syndrome.

<.0001 in both definitions). For those having a family history of diabetes, the prevalence of the metabolic syndrome was higher with both NCEP and IDF criteria (NCEP, $P = .0007$; IDF, $P = .0047$). However, smoking status did not affect the prevalence of the metabolic syndrome by either definition (NCEP, $P = .3396$; IDF, $P = .3144$, comparing current with ex-smokers).

The OR for CAD was 3.5 (95% CI, 2.0-6.1) for participants with the metabolic syndrome defined by the NCEP definition, whereas it was 2.8 (95% CI, 1.6-5.0) for those defined by the IDF definition (Table 3). Similarly, the OR for stroke was higher using the NCEP definition (OR, 3.0; 95% CI, 1.7-5.2) compared with the IDF definition (OR, 2.3; 95% CI, 1.3-4.0); however, the CIs by both

Table 2
Age-adjusted prevalence of the metabolic syndrome among Korean adults 20 years or older by cardiovascular risk factors (2001 KNHNS)

Characteristics	n	NCEP	n	IDF	Agreement[a]
BMI (kg/m^2)					
<18.5	10	3.1 ± 1.2	0	–	96.9 ± 1.2
18.5-24.9	517	12.3 ± 0.6	360	8.7 ± 0.5	86.9 ± 0.6
25-29.9	585	32.9 ± 1.4	767	44.2 ± 1.4	78.6 ± 1.2
≥30	125	66.1 ± 4.1	131	69.0 ± 3.9	93.7 ± 2.0
Glucose status[b]					
Normoglycemia	346	9.1 ± 0.5	468	12.4 ± 0.6	90.9 ± 0.5
Impaired fasting glucose	632	39.0 ± 1.4	543	33.5 ± 1.3	73.5 ± 1.3
Undiagnosed diabetes	125	56.8 ± 4.8	106	50.4 ± 4.8	74.2 ± 2.8
Diagnosed diabetes	102	49.0 ± 6.8	93	58.6 ± 7.9	64.7 ± 8.5
Hypertension[c]					
Yes	672	41.5 ± 2.3	603	38.4 ± 2.3	76.3 ± 1.9
No	517	12.6 ± 0.6	583	14.4 ± 0.6	88.2 ± 0.6
Total cholesterol ≥200 mg/dL or use of cholesterol-lowering medications					
Yes	601	24.8 ± 1.2	630	25.9 ± 1.1	83.6 ± 1.0
No	618	16.1 ± 0.6	604	16.3 ± 0.7	86.3 ± 0.6
Smoking					
Current	325	19.2 ± 1.1	262	16.1 ± 1.0	83.3 ± 1.0
Former	106	17.1 ± 1.9	101	18.4 ± 2.1	80.5 ± 2.2
Never	716	19.2 ± 0.7	802	21.5 ± 0.7	87.4 ± 0.6
Family history of diabetes					
Yes	147	25.1 ± 2.0	140	24.6 ± 1.9	82.8 ± 1.8
No	1092	18.2 ± 0.6	1118	19.1 ± 0.6	86.2 ± 0.5

Data are expressed as percentage ± SE.
[a] Percentage of participants who were classified as either having or not having the metabolic syndrome under both definitions of the metabolic syndrome. For BMI less than 18.5, the agreement represents those who are not having the metabolic syndrome only.
[b] Defined by normoglycemia (fasting blood glucose [FBG] of <100 mg/dL), impaired fasting glucose (100 ≤ FBG < 126 mg/dL), undiagnosed diabetes (FBG of ≥126 mg/dL without self-reported diabetes), and diagnosed diabetes (self-reported diabetes).
[c] Blood pressure of 140/90 mm Hg or higher or the current use of antihypertensive medication.

Table 3
Odds ratios and their 95% CIs of self-reported CAD, stroke, diabetes, and hypertension for metabolic syndrome among Korean adults 20 years or older (2001 KNHNS)

	Metabolic syndrome		No metabolic syndrome					
	Sample size	Age-adjusted prevalence[a]	Sample size	Age-adjusted prevalence	*P*	Sample size	Crude OR (95% CI)	Adjusted OR[b] (95% CI)
NCEP								
CAD	1239	1.4 ± 0.3	4723	0.7 ± 0.1	.0389	5962	3.5 (2.0-6.1)	2.3 (1.2- 4.3)
Stroke	1239	0.9 ± 0.2	4723	0.7 ± 0.1	.2856	5962	3.0 (1.7-5.2)	1.4 (0.8-2.4)
CAD + stroke	1239	2.3 ± 0.4	4723	1.3 ± 0.2	.0154	5962	3.4 (2.2-5.1)	1.9 (1.2-2.9)
Hypertension	1239	15.0 ± 1.0	4723	7.5 ± 0.4	<.0001	5962	4.1 (3.4-5.0)	2.5 (2.0-3.1)
Diabetes	1239	5.8 ± 0.6	4723	2.8 ± 0.3	<.0001	5962	3.8 (2.9-5.1)	2.3 (1.7-3.1)
Any of the above	1239	18.8 ± 1.1	4723	9.9 ± 0.5	<.0001	5962	4.1 (3.5-4.9)	2.5 (2.0-3.1)
IDF								
CAD	1279	1.2 ± 0.3	4668	0.8 ± 0.1	.1336	5947	2.8 (1.6-5.0)	1.5 (0.8-2.7)
Stroke	1279	0.9 ± 0.2	4668	0.7 ± 0.1	.5318	5947	2.3 (1.3-4.0)	1.1 (0.6-2.1)
CAD + stroke	1279	2.1 ± 0.3	4668	1.4 ± 0.2	.0728	5947	2.7 (1.8-4.1)	1.4 (0.9-2.2)
Hypertension	1279	15.4 ± 1.0	4668	7.3 ± 0.4	<.0001	5947	4.2 (3.5-5.1)	2.3 (1.9-3.0)
Diabetes	1279	6.3 ± 0.8	4668	2.7 ± 0.3	<.0001	5947	4.0 (3.0-5.3)	2.3 (1.7-3.3)
Any of the above	1279	19.7 ± 1.2	4668	9.7 ± 0.5	<.0001	5947	4.2 (3.6-5.1)	2.5 (2.0-3.1)

[a] Values provided are prevalence ± SE.

[b] Values provided are odds ratios (95% confidence intervals). Odds ratios are adjusted for age, sex, education, smoking status, family history of diabetes, and non–HDL-C concentration.

definitions are considerably overlapped. The ORs for hypertension and diabetes were not significantly different by both definitions.

4. Discussion

The present study showed that the age-adjusted prevalence of the metabolic syndrome was 19.5% ± 0.5% (men, 15.0% ± 0.8%; women, 23.9% ± 0.7%) in Korean adults using the IDF definition. By contrast, the prevalence by the NCEP definition was 18.8% ± 0.5% (men, 17.8% ± 0.8%; women, 20.5% ± 0.7%). The difference for defining central obesity in the IDF criteria appeared to account for most of the differences in the prevalence observed. Besides, the IDF definition requires the presence of central obesity as a prerequisite.

Recently, Ford [17] reported that the prevalence of the metabolic syndrome in the United States was 39.0% ± 1.1% among all participants, 39.9% ± 1.7% among men, and 38.1% ± 1.2% among women based on the IDF definition. Using the NCEP definition, the findings were 34.5% ± 0.9%, 33.7% ± 1.6%, and 35.4% ± 1.2%, respectively. In another population study from South Australia, the metabolic syndrome was found in 22.8% (men, 26.4%; women, 15.7%) using the IDF definition, whereas it was 15.0% (men, 19.4%; women, 14.4%) with the NCEP definition [18]. In both studies based on a predominantly Europid population, the IDF definition led to a slightly higher estimated prevalence. In the IDF definition, *Europids* means ¡°white people of European origin, regardless of where they live in the world.” Although the sociodemographic patterns in prevalence were similar for the 2 definitions in the US study, Mexican American men showed a higher prevalence of the metabolic syndrome compared with those using the NCEP definition. These results suggest that ethnicity has an impact on the prevalence of the metabolic syndrome. Although the application of the IDF definition will probably have a major effect on the estimates in Asian populations, Asian participants were not included in both previously mentioned studies. In fact, many previous studies repeatedly proposed the use of different thresholds of waist circumference specific to race and ethnicity for defining abdominal obesity [19-21]. In addition, the IDF definition has established different criteria for abdominal obesity according to the ethnic group, especially in the Chinese and Japanese population. Because Korea is located between China and Japan and shares many ethnic and environmental similarities with these countries, a study with Korean data concerning the difference in the prevalence of the metabolic syndrome according to the definition used for the metabolic syndrome could be generalized to Far East Asians. Unfortunately, specific criteria for Koreans did not exist in the original IDF definition at that moment. Therefore, we used the central obesity criteria for South Asians and Chinese; this is consistent with the obesity criteria recommended by the WHO Asia-Pacific Region [15]. In the present study using nationally representative data for Koreans, the prevalence of the metabolic syndrome was relatively low compared with the prevalence found in the United States based on both definitions. In a study reported in Thailand using the NCEP definition, the prevalence of the metabolic syndrome was lower (15.7% for men, 11.7% for women) than that in ours or in the US studies [22]. Gu et al [23] also reported relatively low prevalence of the metabolic syndrome in China using the same definition (9.8% for men, 17.8% for women).

The prevalence of the metabolic syndrome in men was higher with the NCEP definition compared with the IDF definition, whereas it was reversed in women. In addition, the difference in the prevalence between the NECP and IDF definition was larger among women than among men. Among all of the participants, 84.6% would be classified as having or not having the metabolic syndrome by both definitions. A high concordance of both definitions is perhaps not surprising given that the 2 definitions use almost identical variables except for the central obesity criteria. The κ value was 0.54 (95% CI, 0.51-0.56), which implies a slight to good agreement [24]. However, 15.4% of the participants were classified differently based on either definition; this discordance rate is larger than that found in US adults (agreement rate, 92.9%) [17]. The reason for this discrepancy is likely due to racial or ethnic difference.

In the present study, the NCEP definition showed relatively higher prevalence of the metabolic syndrome in lower BMI levels, whereas the IDF definition revealed higher prevalence in higher BMI levels. Among US adults, similar results were reported using National Health and Nutrition Examination Survey (NHANES) 1999-2002 data [17]. The higher prevalence of the metabolic syndrome in more obese people with the IDF definition may be because central obesity is a prerequisite in the definition. However, the agreement rate between both definitions was very high.

Higher association of the definition with cardiovascular disease may be considered as a more important precursor of the disease. In this respect, we examined which definition of the metabolic syndrome may be more closely related to the risk for cardiovascular disease by comparing the ORs of metabolic syndrome for CAD, stroke, diabetes, hypertension, as well as any of these diseases. The NCEP definition showed higher association with cardiovascular disease than did the IDF definition in our data. However, their CIs overlapped considerably. In addition, according to Ford and Giles [25], adjusted ORs for myocardial infarction and congestive heart failure were higher using the WHO definition compared with those using the NCEP definition.

Several limitations of this study, however, need to be considered. First of all, it is a cross-sectional study; hence, a causal relationship could not be defined. Therefore, although it was impossible to evaluate how much the 2 definitions can predict the risk of future cardiovascular diseases, we examined the cross-sectional association between the metabolic syndrome and the prevalence of cardiovascular diseases for both definitions. Second, the IDF recommends measuring the waist circumference midway between the inferior margin of the ribs and the superior border of the iliac crest. In contrast, the NCEP recommends measuring the waist circumference at the iliac crest. In our study, however, waist circumference was measured at the narrowest point of the waist between the lower borders of the rib cage and the iliac crest. We should admit that because of these discrepancies, our study results may not reflect the true features of both definitions for the metabolic syndrome; hence, any comparison between them would be limited. Nevertheless, our study has its strong points. This study was conducted based on nationally representative data of the civilian, noninstitutionalized Korean population. Furthermore, this is a non-Europid study comparing the prevalence of the metabolic syndrome as well as cardiovascular risk of the metabolic syndrome under both definitions.

In conclusion, although the prevalence of the metabolic syndrome has shown to be common with both the IDF and NCEP definitions, the prevalence using the IDF criteria was higher compared with that of the NCEP criteria in Korean adults. However, participants with the metabolic syndrome defined by the NCEP definition showed a higher relationship with cardiovascular disease than those identified by the IDF definition.

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