Prevalence of the Metabolic Syndrome Defined by the International Diabetes Federation Among Adults in the U.S.

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OBJECTIVE — The International Diabetes Federation (IDF) has proposed a new definition of the metabolic syndrome that emphasizes central adiposity as determined by ethnic group–specific thresholds of waist circumference. The objective of this study was to estimate the prevalence of this syndrome using the IDF definition among U.S. adults and to compare it with the prevalence estimated using the definition of the National Cholesterol Education Program (NCEP).

RESEARCH DESIGN AND METHODS — A total of 3,601 men and women aged ≥20 years from the National Health and Nutrition Examination Survey 1999–2002 were included in the analyses.

RESULTS — Based on the NCEP definition, the unadjusted prevalence of the metabolic syndrome was 34.5 ± 0.9% (percent ± SE) among all participants, 33.7 ± 1.6% among men, and 35.4 ± 1.2% among women. Based on the IDF definition, the unadjusted prevalence of the metabolic syndrome was 39.0 ± 1.1% among all participants, 39.9 ± 1.7% among men, and 38.1 ± 1.2% among women. The IDF definition led to higher estimates of prevalence in all of the demographic groups, especially among Mexican-American men. The two definitions similarly classified ~93% of the participants as having or not having the metabolic syndrome.

CONCLUSIONS — In the U.S., the use of the IDF definition of the metabolic syndrome leads to a higher prevalence estimate of the metabolic syndrome than the estimate based on the NCEP definition.

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In 1998, the World Health Organization (WHO) was the first organization to provide a definition of the metabolic syndrome (1). In response, the European Group for the Study of Insulin Resistance countered with a modification of the WHO definition (2). In 2001, the National Cholesterol Education Program (NCEP) released its definition (3). Subsequently, the American Association of Clinical Endocrinologists offered its views regarding the definition of the metabolic syndrome (4). The proliferation of definitions suggested that a single unifying definition was desirable (5). In the hope of accomplishing this, the International Diabetes Federation (IDF) proposed a new definition of the metabolic syndrome in April 2005 (6).

The main focus in this new definition is central obesity. To have the metabolic syndrome, a person must have central adiposity defined on the basis of waist circumference and two or more of the following four factors: elevated concentrations of triglycerides, reduced concentrations of HDL cholesterol, elevated blood pressure, and dysglycemia.

This new definition requires a fresh assessment of the prevalence of the metabolic syndrome as well as of the magnitude of the morbidity and mortality associated with the metabolic syndrome. The objectives of this article were *1*) to estimate the prevalence of the metabolic syndrome using the new IDF definition among U.S. adults, *2*) to compare the prevalence of the metabolic syndrome with that based on the NCEP definition, and *3*) to examine the concordance of the two definitions.

RESEARCH DESIGN AND METHODS

— In the National Health and Nutrition Examination Survey (NHANES) 1999–2002, the sample was recruited using a multistage, stratified sampling design. The survey was specifically designed to produce results that are representative of the civilian, noninstitutionalized U.S. population. The participants were interviewed at home and were invited to attend the mobile examination center, where they were asked to complete additional questionnaires, to undergo various examinations, and to provide a blood sample. Details about the survey may be found elsewhere (7).

According to the IDF definition, someone has the metabolic syndrome if he or she has central adiposity plus two or more of the following four factors (6): *1*) raised concentration of triglycerides: ≥150 mg/dl (1.7 mmol/l) or specific treatment for this lipid abnormality; *2*) reduced concentration of HDL cholesterol: <40 mg/dl (1.03 mmol/l) in men and <50 mg/dl (1.29 mmol/l) in women or specific treatment for this lipid abnormality; *3*) raised blood pressure: systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg or treatment of previously diagnosed hypertension; and *4*) raised fasting plasma glucose concentration ≥100 mg/dl (5.6 mmol/l) or previously diagnosed type 2 diabetes.

The IDF lists the following ethnic group–specific thresholds for waist circumference to define central adiposity: Europid, sub-Saharan African men, and Eastern- and Middle-Eastern men, ≥94 cm; South Asian, Chinese, and ethnic South- and Central-American men, ≥90 cm; Japanese men, ≥85 cm; women ex-

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Abbreviations: IDF, International Diabetes Federation; NCEP, National Cholesterol Education Program; NHANES, National Health and Nutrition Examination Survey; WHO, World Health Organization.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

cept Japanese women, ≥80 cm; and Japanese women, ≥90 cm. In this analysis, the following thresholds for waist circumference were used: white men, ≥94 cm; African-American men, ≥94 cm; Mexican-American men, ≥90 cm; white women, ≥80 cm; African-American women, ≥80 cm; and Mexican-American women, ≥80 cm. For participants whose designation was "other race–including multiracial," thresholds that were once based on Europid cut points (≥94 cm for men and ≥80 cm for women) and once based on South Asian cut points (≥90 cm for men and ≥80 cm for women) were used. For participants who were considered "other Hispanic," the IDF thresholds for ethnic South and Central Americans were used.

According to the NCEP report, participants who had three or more of the following criteria were defined as having the metabolic syndrome (3,8): *1*) abdominal obesity (waist circumference >102 cm in men and >88 cm in women), *2*) concentration of triglycerides ≥150 mg/dl (1.7 mmol/l), *3*) concentration of HDL cholesterol <40 mg/dl (1.03 mmol/l) in men and <50 mg/dl (1.29 mmol/l) in women, *4*) a systolic blood pressure ≥130 mmHg or a diastolic blood pressure ≥85 mmHg), and *5*) fasting glucose: ≥100 mg/dl (≥5.6 mmol/l). The participants who currently reported using antihypertensive or antidiabetic medication (insulin or oral agents) were counted as having high blood pressure or diabetes, respectively.

The waist circumference was measured at the high point of the iliac crest at minimal respiration to the nearest 0.1 cm. Serum triglyceride concentration was measured enzymatically after hydrolyzation to glycerol, and HDL cholesterol was measured after the precipitation of other lipoproteins with a heparin-manganese chloride mixture. Plasma glucose concentration was measured using an enzymatic reaction.

Up to four blood pressure readings were obtained in the mobile examination center. The average of the last two measurements of blood pressure for the participants who had three or four measurements, the last measurement for the participants with only two measurements, and the only measurement for the participants who had one measurement were used to establish high blood pressure status.

The prevalence of the metabolic syndrome was examined according to strata of BMI, degree of glucose impairment, hypertension, smoking status, hypercholesterolemia, concentrations of C-reactive protein, and coronary heart disease status. BMI was calculated from measured height and weight. Four categories of glucose impairment were created: normoglycemia (fasting plasma glucose concentration <100 mg/dl), impaired fasting glucose (fasting plasma glucose concentration 100 to <126 mg/dl), undiagnosed diabetes (fasting plasma glucose concentration ≥126 mg/dl without self-reported diabetes), and diagnosed diabetes (based on self-report). Hypertension was defined as a systolic blood pressure ≥140 mmHg or a diastolic blood pressure ≥90 mmHg or the current use of antihypertensive medication. Current smokers were defined as participants who had smoked ≥100 cigarettes during their lifetime and were still smoking. Former smokers were defined as participants who had smoked ≥100 cigarettes during their lifetime but had stopped. Participants who had smoked <100 cigarettes during their lifetime were classified as never having smoked. Participants whose concentration of total cholesterol was ≥200 mg/dl or who reported currently using cholesterol-lowering medications were defined as having hypercholesterolemia. C-reactive protein was measured by a high-sensitivity assay (latex-enhanced nephelometry). Questions about doctor-diagnosed coronary heart disease, myocardial infarction, and angina pectoris were used to determine the presence of these conditions.

Concentrations of plasma glucose and serum triglycerides were measured using reference analytic methods only for the participants who attended the morning examination. Therefore, the analyses were limited to men and nonpregnant women aged ≥20 years who attended the morning medical examination and who had fasted for ≥8 h. Because of limited sample size for the racial or ethnic groups designated as "other race–including multiracial" and "other Hispanic," no results were reported separately for these subgroups. To age adjust statistics, direct adjustment to the U.S. population aged ≥20 years in the year 2000 was performed (9). SUDAAN (Software for the Statistical Analysis of Correlated Data) was used for the analyses to account for the complex sampling design.

RESULTS — A total of 4,059 participants attended the morning mobile examination center. Excluding those who reported fasting for <8 h and the women who were pregnant left 3,821 participants. Of these, 3,601 had the data needed to define their metabolic syndrome status.

Using the NCEP definition, the unadjusted prevalence of the metabolic syndrome was 34.5% (men 33.7 ± 1.6% [percent ± SE]; women 35.4 ± 1.2%) and the age-adjusted prevalence was 34.6% (men 34.4 ± 1.5%; women 34.5 ± 1.4%) (Table 1). In comparison, the unadjusted and age-adjusted prevalences of the metabolic syndrome defined according to IDF criteria were 39.0% (men 39.9 ± 1.7%; women 38.1 ± 1.2%) and 39.1% (men 40.7 ± 1.6%; women 37.1 ± 1.3%). The IDF definition did not change the sex and racial or ethnic patterns other than that for Mexican-American men having a higher prevalence of the metabolic syndrome than Mexican-American women. The largest difference in prevalence was found among Mexican-American men, among whom the age-adjusted prevalence was 40.3% using the NCEP definition and 50.6% using the IDF definition. When the IDF criteria for waist circumference are used with the NCEP definition, the unadjusted prevalence of the metabolic syndrome was 40.3%, which was similar to the estimate produced by the IDF definition. Using NCEP criteria for waist circumference in conjunction with the IDF definition yielded an unadjusted prevalence of 29.4% (Table 1).

The two definitions identified 92.9% (95% CI 91.6–94.0) of the participants as either having or not having the metabolic syndrome. The percent agreement was 89.8% (87.6–91.6) among the men and 96.0% (94.6–97.0) among the women. In 1.3% (0.9–1.9) of the participants, the metabolic syndrome using the NCEP definition but not the IDF definition was present. Another 5.8% (4.8–6.9) of the participants had the metabolic syndrome using the IDF definition but not the NCEP definition.

For both of the definitions, the prevalence of the metabolic syndrome increased strongly with increasing levels of BMI (P for linear trend < 0.001 for both of the definitions), levels of dysglycemia (P for linear trend < 0.001 for both of the definitions), and concentrations of C-reactive protein (P for linear trend < 0.001 for both of the definitions) (Table 2). Participants with hypertension had more than twice the prevalence of the metabolic syndrome than those who did not have

Table 1—*Prevalence of the metabolic syndrome among U.S. adults aged ≥20 years, NHANES 1999–2002*

	n	NCEP definition	IDF definition	NCEP definition using IDF waist circumference criteria	IDF definition using NCEP waist circumference criteria
Total					
Unadjusted	3,601	34.5 ± 0.9	39.0 ± 1.1	40.3 ± 1.1	29.4 ± 0.9
Age-adjusted	3,601	34.6 ± 0.9	39.1 ± 1.0	40.4 ± 1.1	29.5 ± 0.9
Men					
Unadjusted	1,825	33.7 ± 1.6	39.9 ± 1.7	41.9 ± 1.8	25.7 ± 1.5
Age-adjusted	1,825	34.4 ± 1.5	40.7 ± 1.6	42.8 ± 1.7	26.3 ± 1.5
20–29 years	305	14.9 ± 2.2	21.8 ± 2.7	22.2 ± 2.6	10.7 ± 2.2
30–39 years	317	23.4 ± 2.8	27.0 ± 2.5	29.5 ± 2.9	16.4 ± 2.4
40–49 years	320	37.0 ± 3.4	45.5 ± 4.5	47.3 ± 4.5	28.3 ± 3.1
50–59 years	255	47.4 ± 3.6	53.4 ± 3.7	55.1 ± 3.9	37.7 ± 3.0
60–69 years	293	51.6 ± 2.9	58.0 ± 2.9	60.6 ± 3.2	40.8 ± 2.7
≥70 years	335	46.6 ± 3.6	53.0 ± 2.9	57.3 ± 3.0	36.1 ± 3.2
Women					
Unadjusted	1,776	35.4 ± 1.2	38.1 ± 1.2	38.8 ± 1.2	33.0 ± 1.2
Age-adjusted	1,776	34.5 ± 1.4	37.1 ± 1.3	37.7 ± 1.3	32.2 ± 1.3
20–29 years	253	12.1 ± 2.6	14.6 ± 2.7	14.6 ± 2.7	12.1 ± 2.6
30–39 years	287	23.3 ± 2.3	23.4 ± 2.3	24.6 ± 2.0	21.8 ± 2.5
40–49 years	337	31.9 ± 3.3	33.3 ± 3.5	33.3 ± 3.5	29.8 ± 3.2
50–59 years	252	42.9 ± 3.6	49.0 ± 3.6	49.1 ± 3.6	40.3 ± 3.8
60–69 years	315	60.9 ± 2.7	62.6 ± 3.2	65.0 ± 2.7	55.0 ± 3.3
≥70 years	332	57.8 ± 3.7	63.2 ± 3.2	64.4 ± 3.4	54.1 ± 3.5
White men (total)					
Unadjusted	942	36.0 ± 1.9	42.6 ± 2.1	44.3 ± 2.2	28.7 ± 1.7
Age-adjusted	942	35.4 ± 1.7	41.9 ± 1.9	43.7 ± 2.0	28.0 ± 1.6
20–39 years	258	20.4 ± 3.0	25.3 ± 2.8	26.3 ± 3.0	15.2 ± 2.7
40–59 years	316	42.8 ± 2.9	50.7 ± 3.4	52.3 ± 3.4	34.9 ± 2.9
≥60 years	368	49.9 ± 2.6	56.8 ± 2.4	60.2 ± 2.5	40.0 ± 2.5
African-American men (total)					
Unadjusted	303	21.6 ± 2.5	24.2 ± 2.7	25.1 ± 2.6	17.0 ± 2.6
Age-adjusted	303	24.5 ± 2.4	27.1 ± 2.6	28.2 ± 2.5	19.2 ± 2.4
20–39 years	125	10.9 ± 3.0	12.5 ± 3.0	12.5 ± 3.0	9.3 ± 2.8*
40–59 years	98	25.9 ± 4.6	30.0 ± 4.9	30.7 ± 4.8	19.2 ± 4.5
≥60 years	80	46.7 ± 5.0	48.9 ± 5.5	52.9 ± 5.3	37.6 ± 4.5
Mexican-American men (total)					
Unadjusted	453	32.2 ± 3.6	42.3 ± 3.7	44.3 ± 3.7	20.5 ± 2.0
Age-adjusted	453	40.3 ± 2.8	50.6 ± 2.9	52.7 ± 3.1	25.8 ± 1.6
20–39 years	181	22.0 ± 4.5	31.6 ± 4.2	33.2 ± 4.3	14.0 ± 2.9
40–59 years	125	47.2 ± 4.4	58.7 ± 5.9	61.5 ± 5.8	28.7 ± 4.2
≥60 years	147	61.2 ± 4.0	70.6 ± 3.3	72.9 ± 3.8	43.0 ± 4.2
White women (total)					
Unadjusted	892	33.7 ± 1.2	36.9 ± 1.4	37.5 ± 1.3	31.6 ± 1.3
Age-adjusted	892	31.5 ± 1.4	34.4 ± 1.5	35.0 ± 1.4	29.5 ± 1.5
20–39 years	241	16.5 ± 2.1	17.6 ± 2.3	18.6 ± 2.1	15.2 ± 2.3
40–59 years	281	33.1 ± 2.6	37.1 ± 2.6	37.1 ± 2.6	31.6 ± 2.7
≥60 years	370	56.4 ± 2.5	60.9 ± 2.7	62.1 ± 2.5	52.5 ± 2.6
African-American women (total)					
Unadjusted	328	33.8 ± 2.5	35.8 ± 2.2	36.0 ± 2.2	33.4 ± 2.5
Age-adjusted	328	36.4 ± 2.6	38.8 ± 2.4	39.0 ± 2.4	36.0 ± 2.7
20–39 years	122	22.0 ± 3.9	23.7 ± 3.4	23.7 ± 3.4	22.0 ± 3.9
40–59 years	112	37.4 ± 4.9	39.3 ± 4.3	39.3 ± 4.3	36.7 ± 4.9
≥60 years	94	57.4 ± 4.0	60.6 ± 3.9	61.8 ± 3.7	56.3 ± 4.2
Mexican-American women (total)					
Unadjusted	431	37.8 ± 3.2	39.2 ± 3.3	39.6 ± 3.3	35.5 ± 3.2
Age-adjusted	431	44.0 ± 2.6	46.2 ± 2.5	46.7 ± 2.5	40.6 ± 2.6
20–39 years	134	21.2 ± 4.4	21.2 ± 4.4	21.2 ± 4.4	21.2 ± 4.4
40–59 years	152	51.3 ± 3.5	53.7 ± 3.3	54.4 ± 3.4	47.7 ± 3.5
≥60 years	145	73.8 ± 5.0	79.0 ± 5.3	80.4 ± 5.0	65.3 ± 5.3

Data are percent ± SE. *Estimate should be interpreted cautiously because the estimates does meet the criteria for reliability and precision.

Table 2—*Age-adjusted prevalence of the metabolic syndrome among U.S. adults aged ≥20 years by cardiovascular risk factors and conditions, NHANES 1999–2002*

	n	NCEP definition	IDF definition
BMI (kg/m^2)			
<18.5	50	5.2 ± 3.1*	0.0
18.5 to <25	1,136	10.4 ± 1.1	13.3 ± 0.8
25 to <30	1,310	34.3 ± 0.9	44.3 ± 1.5
≥30	1,063	64.2 ± 2.2	65.1 ± 2.2
Glucose status			
Normoglycemia	2,131	16.8 ± 0.9	21.1 ± 1.2
Impaired fasting glucose	1,068	60.1 ± 1.9	66.4 ± 1.7
Undiagnosed diabetes	142	75.0 ± 6.2	75.5 ± 6.4
Diagnosed diabetes	259	72.1 ± 5.1	84.4 ± 3.4
Hypertension			
Yes	1,311	62.9 ± 3.3	69.4 ± 2.8
No	2,290	25.0 ± 1.2	29.1 ± 1.1
Smoking status			
Current	799	35.2 ± 1.9	38.1 ± 2.1
Former	980	31.8 ± 1.6	39.2 ± 2.2
Never	1,816	34.3 ± 1.6	38.6 ± 1.6
Total cholesterol ≥200 mg/dl or use of cholesterol-lowering medications			
Yes	1,969	38.1 ± 1.5	44.2 ± 1.8
No	1,632	31.3 ± 1.4	34.4 ± 1.5
Concentrations of C-reactive protein (mg/l)			
<1	923	18.8 ± 1.3	23.5 ± 1.6
1–3	1,235	33.8 ± 1.1	38.4 ± 1.5
>3	1,443	47.3 ± 1.6	51.9 ± 1.5
Coronary heart disease			
Yes	136	72.4 ± 4.6	75.8 ± 4.7
No	3,443	34.3 ± 1.0	38.8 ± 1.1
Myocardial infarction			
Yes	148	36.1 ± 3.5	41.1 ± 3.8
No	3,448	34.3 ± 1.0	38.7 ± 1.0
Angina pectoris			
Yes	124	44.1 ± 4.3	46.5 ± 4.5
No	3,460	34.2 ± 0.9	38.8 ± 1.0

Data are percent ± SE. *Estimate should be interpreted cautiously because the estimates do not meet the criteria for reliability and precision.

hypertension ($P < 0.001$ for both of the definitions). In addition, participants with hypercholesterolemia had a higher prevalence of the metabolic syndrome than participants who had concentrations of total cholesterol <200 mg/dl ($P < 0.005$ for both of the definitions). However, the prevalence of the metabolic syndrome did not vary by smoking status (P for all comparisons > 0.05 for both of the definitions). In addition, the participants who reported having coronary heart disease had more than twice the age-adjusted prevalence as did those who did not report having coronary heart disease ($P < 0.001$ for both definitions). However, the participants who had experienced a myocardial infarction had a similar prevalence of the metabolic syndrome as participants who had not had a myocardial infarction ($P > 0.05$ for both definitions). The participants who reported having angina pectoris were also more likely to report having the metabolic syndrome than the participants who did not have it ($P = 0.020$ for the NCEP definition and $P = 0.073$ for the IDF definition).

CONCLUSIONS — With the most recent national data from U.S. adults and the definition of the metabolic syndrome proposed by the IDF, almost 40% of U.S. adults were classified as having the metabolic syndrome, a prevalence that is higher than that estimated by the NCEP definition (34.5%). The IDF criteria for defining central obesity appeared to account for much of this difference. The change was larger among men than among women and can be explained by the fact that the NCEP thresholds for waist circumference of 102 cm for men and 88 cm for women reflect much different percentiles of the distribution among U.S. adults than the IDF thresholds of 90 cm for men and 80 cm for women (10). The use of thresholds for waist circumference that are specific to different populations around the globe has been repeatedly advocated (11–16). Because the differences in estimates of prevalence were especially pronounced for Mexican Americans, the application of the IDF definition to estimate the prevalence of the metabolic syndrome will probably have a substantial effect on the estimates in Asian and Latin American countries. In general, the sociodemographic patterns in prevalence were similar for the two definitions.

The two definitions similarly classified ~93% of the participants as having or not having the metabolic syndrome. The high degree of overlap is not surprising considering the fact that the two definitions use the same five components and that four of the five criteria are defined identically or nearly identically. However, there are several noteworthy differences. The IDF definition requires the presence of central obesity. In contrast, the NCEP definition makes central obesity one of the five equally weighted criteria. Furthermore, the thresholds for central obesity under the IDF definition are far lower than those under the NCEP definition and vary according to ethnicity. The thresholds for concentrations of triglycerides, HDL cholesterol, and glucose and for systolic and diastolic blood pressure are the same. However, the IDF definition explicitly allows for the treatment of hypertriglyceridemia, a low concentration of HDL cholesterol, and hypertension to be counted. Furthermore, under the IDF definition people who have diagnosed type 2 diabetes are automatically considered to have hyperglycemia even if their concentration of glucose is <100 mg/dl.

Only three major ethnic groups in the NHANES 1999–2000 dataset had sufficient numbers to allow for results to be presented separately. Identification of participants of South Asian, Chinese, or Japanese descent who were included in

the category "other race–including multiracial" was not possible. Although the Europid waist circumference thresholds were used for this ethnic group to generate the results shown in this article, the unadjusted prevalence estimate changed little (39.1%) when thresholds of 90 cm for men and 80 cm for women were used.

Only time will tell whether medical professionals and researchers will embrace this new definition of the metabolic syndrome. Prospective studies will be needed to determine the risks for adverse events associated with the metabolic syndrome as defined by the IDF. Because of the similarities between the NCEP and IDF definitions, risk estimates for all-cause mortality, cardiovascular disease, diabetes, and other adverse events based on the IDF definition are likely to be similar to those observed for the NCEP definition. The evolution of definitions of the metabolic syndrome since 1998 suggests that the future will probably bring further changes. In addition, the development of a classification scheme of the metabolic syndrome that correlates with the degree of risk of experiencing adverse events and the development of a formal pediatric definition merit consideration. Regardless of which definition is used, large numbers of U.S. adults have the metabolic syndrome. This fact underscores the importance of promoting healthy lifestyles (proper nutrition, weight management, and adequate physical activity) among U.S. adults.

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