Increasing Prevalence of the Metabolic Syndrome Among U.S. Adults

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OBJECTIVE — The prevalence of the metabolic syndrome is high among U.S. adults. Our purpose was to determine whether the prevalence of this syndrome has changed since 1988–1994.

RESEARCH DESIGN AND METHODS — A total of 6,436 men and women aged ≥20 years from the National Health and Nutrition Examination Survey (NHANES) III (1988–1994) and 1,677 participants from NHANES 1999–2000 were included in the analyses. We used the definition of the metabolic syndrome developed by the Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults.

RESULTS — The unadjusted prevalence of the metabolic syndrome was 23.1% in NHANES III and 26.7% in NHANES 1999–2000 ($P = 0.043$), and the age-adjusted prevalences were 24.1 and 27.0% ($P = 0.088$), respectively. The age-adjusted prevalence increased by 23.5% among women ($P = 0.021$) and 2.2% among men ($P = 0.831$). Increases in high blood pressure, waist circumference, and hypertriglyceridemia accounted for much of the increase in the prevalence of the metabolic syndrome, particularly among women.

CONCLUSIONS — The increased prevalence of the metabolic syndrome is likely to lead to future increases in diabetes and cardiovascular disease.

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In 2001, the Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (NCEP/ATP III) provided a working definition of the metabolic syndrome based on five commonly measured clinical criteria that clinicians could implement in their practices (1). Using these criteria, we estimated that the unadjusted prevalence of the metabolic syndrome among U.S. adults was 21.7% during 1988–1994 (2). Since then, the prevalence of the metabolic syndrome using NCEP/ATP III criteria has been described for other study populations. The prevalence of the metabolic syndrome among participants of the Framingham Offspring Study and San Antonio Heart Study ranged from 21.3 to 32.8% during the early to mid-1990s (3). High prevalences have been noted among patients infected with the human immunodeficiency virus (4), Filipina women (5), and Native Americans (6). In addition, the NCEP/ATP III criteria have been applied in other countries (7–9). Recent work has shown that people with the metabolic syndrome based on the NCEP/ATP III criteria are at increased risk for diabetes and cardiovascular disease (7,8,10,11).

Obesity and physical activity are two important determinants of the metabolic syndrome (12–15). Because the prevalence of obesity has continued to increase in the U.S. during the 1990s (16,17), we theorized that the prevalence of the metabolic syndrome among adults had increased as well. To test this hypothesis, we used data from two national surveys: the National Health and Nutrition Examination Survey (NHANES) III and NHANES 1999–2000.

RESEARCH DESIGN AND METHODS

According to the NCEP/ATP III report, participants who had three or more of the following criteria were defined as having the metabolic syndrome: abdominal obesity: waist circumference >102 cm in men and >88 cm in women; hypertriglyceridemia: ≥150 mg/dl (≥1.695 mmol/l); low HDL cholesterol: <40 mg/dl (<1.036 mmol/l) in men and <50 mg/dl (<1.295 mmol/l) in women; high blood pressure: ≥130/85 mmHg; and high fasting glucose: ≥110 mg/dl (≥6.1 mmol/l). Because a revision of the glucose criterion of the metabolic syndrome was recently announced (18), we also report the prevalence of the metabolic syndrome using a glucose cut point of ≥100 mg/dl (≥5.6 mmol/l).

In both NHANES III (1988–1994) and NHANES 1999–2000, the sample was recruited using a multistage stratified sampling design. Both surveys were specifically designed to produce results that are representative of the civilian noninstitutionalized U.S. population. Participants were interviewed at home and were invited to attend the mobile examination center, where they were asked to complete additional questionnaires, undergo various examinations, and provide a blood sample. Details about the surveys may be found elsewhere (19–21).

In both surveys, 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

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Abbreviations: NCEP/ATP III, Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults; NHANES, National Health and Nutrition Examination Survey.

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

Table 1—*Age-adjusted prevalence of individual metabolic abnormalities of the metabolic syndrome among U.S. adults aged ≥20 years: NHANES III (1988–1994) and NHANES 1999–2000*

	NHANES III (1988–1994)							NHANES 1999–2000						
	n	Abdominal obesity	Hypertri-glyceridemia	Low HDL cholesterol	High blood pressure or medication use	High fasting glucose (≥110 mg/dl) or medication use	High fasting glucose (≥100 mg/dl) or medication use	*n*	Abdominal obesity	Hypertri-glyceridemia	Low HDL cholesterol	High blood pressure or medication use	High fasting glucose (≥110 mg/dl) or medication use	High fasting glucose (≥100 mg/dl) or medication use
Total	6,436	38.3 (1.0)	30.2 (1.1)	37.9 (1.3)	32.2 (0.8)	13.6 (0.6)	32.4 (1.1)	1677	44.0 (2.0)	32.6 (1.5)	39.9 (2.0)	39.2 (1.4)	13.1 (1.0)	30.7 (1.3)
Men	3,069	30.1 (1.6)	35.9 (1.9)	36.2 (1.7)	36.4 (1.4)	17.2 (0.9)	41.4 (1.5)	841	36.0 (2.8)	35.6 (2.1)	36.6 (2.2)	40.9 (2.2)	16.3 (1.4)	37.7 (2.2)
Women	3,367	45.7 (1.3)	24.6 (1.1)	39.7 (1.4)	27.9 (0.9)	10.4 (0.7)	24.1 (1.1)	836	51.9 (2.4)	29.9 (2.1)	43.4 (2.6)	37.3 (1.8)	10.3 (1.0)	23.8 (1.5)

Data are percent (SE).

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 three blood pressure readings were obtained in the mobile examination center in NHANES III and up to four such readings in NHANES 1999–2000. To maintain consistency between the two surveys, we used the average of the last two measurements of blood pressure for participants who had three or four measurements, the last measurement for participants with only two measurements, and the only measurement for participants who had one measurement to establish high blood pressure status. For both surveys, we counted participants who reported currently using antihypertensive or antidiabetic medication (insulin or oral agents) as participants with high blood pressure or diabetes, respectively. Because of increases in the percentage of participants who reported using cholesterol-lowering medications between the two surveys (22) and because these medications can also reduce triglyceride concentration, we calculated the prevalence of the metabolic syndrome using hypertriglyceridemia once based on serum triglyceride concentration alone and again based on serum triglyceride concentration or the use of cholesterol-lowering medications.

Concentrations of plasma glucose and serum triglycerides were measured using reference analytic methods only for NHANES 1999–2000 participants who attended the morning examination. Therefore, we limited the analyses of both surveys to men and nonpregnant women aged ≥20 years who attended the morning medical examination and who had fasted ≥8 h. We calculated the prevalence of the metabolic syndrome by age and sex. Because of the limited sample size for the racial or ethnic groups in NHANES 1999–2000, we do not present results for these subgroups. To age-adjust statistics, we directly adjusted to the U.S. population aged ≥20 years in the year 2000. To test the statistical significance of the changes in the prevalence of the metabolic syndrome between the two surveys, we performed a *t* test. The pooled standard error for the difference in means was calculated by taking the square root of the sum of the squared standard errors. We used Software for the Statistical Analysis of Correlated Data (SUDAAN) for analyses to account for the complex sampling design. Prevalence estimates were calculated using the sampling weights so that the estimates are representative of the civilian noninstitutionalized U.S. population. Although we focus the presentation of results on the revised NCEP/ATP III definition of the metabolic syndrome, we also present results for the original definition of the metabolic syndrome.

RESULTS — The number of participants who were included in the analyses based on participants who attended the morning examination were 6,436 for NHANES III and 1,677 for NHANES 1999–2000. The age, sex, racial or ethnic, and educational status composition of the two analytic samples was similar.

Of the five metabolic syndrome components, significant increases in the prevalences of abdominal obesity, hypertriglyceridemia, and high blood pressure occurred among women between the two surveys (Table 1). Increases in the prevalences of abdominal obesity and high blood pressure were of borderline significance among men. Changes in hypertriglyceridemia, low HDL cholesterol concentration, and hyperglycemia were not statistically significant.

In both surveys, the prevalence of the metabolic syndrome increased with age (Table 2). In NHANES III, men had a slightly higher age-adjusted prevalence than women ($P = 0.610$). However, that was not found in NHANES 1999–2000, where the prevalence among women showed a trend to be greater than that among men ($P = 0.177$).

The unadjusted prevalence of the metabolic syndrome increased from 23.1% in NHANES III to 26.7% in NHANES 1999–2000 ($P = 0.043$). The age-adjusted prevalence of the metabolic syndrome increased from 24.1% in NHANES III to 27.0% in NHANES 1999–2000 ($P = 0.088$). Among women, the unadjusted prevalence increased by a relative 25.8% ($P = 0.016$), and the age-adjusted prevalence increased by 23.5% ($P = 0.021$). Corresponding increases among men were much smaller and were not statistically significant. Among women, increases occurred among all age-groups, and the increase among women aged 20–39 years was significant. Among men, nonsignificant increases oc-

Table 2—*Unadjusted and age-adjusted prevalence (%) of the metabolic syndrome among U.S. adults aged ≥20 years: NHANES III (1988–1994) and NHANES 1999–2000*

	n		Original NCEP/ATP III definition					Revised NCEP/ATP III definition				
	NHANES III	NHANES 1999–2000	NHANES III	NHANES 1999–2000	Relative change (%)	Absolute difference (%)	*P*	NHANES III	NHANES 1999–2000	Relative change (%)	Absolute difference (%)	*P*
Total												
Unadjusted	6,436	1,677	23.1 (0.9)	26.7 (1.5)	15.7	3.6	0.043	28.0 (1.1)	31.9 (1.5)	13.8	3.9	0.041
Age adjusted	6,436	1,677	24.1 (0.8)	27.0 (1.5)	12.1	2.9	0.088	29.2 (0.9)	32.3 (1.5)	10.9	3.2	0.072
Men												
Total												
Unadjusted	3,069	841	22.9 (1.4)	24.1 (2.1)	5.4	1.2	0.625	29.3 (1.6)	30.6 (2.1)	4.2	1.2	0.648
Age adjusted	3,069	841	24.6 (1.4)	25.2 (2.1)	2.2	0.5	0.831	31.4 (1.4)	31.8 (2.2)	1.4	0.4	0.866
20–39 years	1,218	283	10.2 (1.7)	10.7 (1.9)	4.4	0.4	0.858	15.7 (2.1)	16.5 (2.5)	4.9	0.8	0.815
40–59 years	841	234	29.3 (2.4)	33.0 (3.8)	12.9	3.8	0.399	36.3 (2.3)	40.3 (4.4)	10.9	4.0	0.426
≥60 years	1,010	324	42.6 (2.4)	39.7 (4.3)	−6.8	−2.9	0.560	50.5 (2.3)	46.4 (4.3)	−8.2	−4.1	0.404
Women												
Total												
Unadjusted	3,367	836	23.3 (1.3)	29.3 (2.0)	25.8	6.0	0.016	26.8 (1.4)	33.2 (1.9)	24.0	6.4	0.010
Age adjusted	3,367	836	23.5 (1.1)	29.0 (2.0)	23.5	5.5	0.021	27.0 (1.2)	32.9 (2.0)	21.8	5.9	0.014
20–39 years	1,430	250	9.7 (1.6)	18.0 (2.8)	86.1	8.3	0.013	10.8 (1.7)	19.1 (2.9)	76.7	8.3	0.018
40–59 years	949	281	26.0 (2.3)	30.6 (3.8)	17.8	4.6	0.303	30.5 (2.3)	33.8 (3.8)	10.9	3.3	0.459
≥60 years	988	305	43.9 (2.0)	46.1 (3.7)	5.0	2.2	0.601	50.3 (2.2)	56.0 (4.0)	11.3	5.7	0.214

Data are percent (SE).

curred among participants aged 20–39 and 40–59 years. Changes in the prevalence of the metabolic syndrome using the proposed modification to the glucose criterion are shown in Table 2.

The NCEP/ATP III criteria include people with diabetes. In our analytic samples, 6.7 ± 0.4% (±SE) of participants in NHANES III and 6.6 ± 0.8% of participants in NHANES 1999–2000 reported having diabetes or had a fasting glucose concentration ≥126 mg/dl (≥6.99 mmol/l). Furthermore, 5.4 ± 0.4% of NHANES III participants and 5.6 ± 0.8% of NHANES 1999–2000 participants had both diabetes and the metabolic syndrome. Because there has been a debate about the appropriateness of including

Table 3—*Unadjusted and age-adjusted prevalence (%) of the metabolic syndrome among U.S. adults aged ≥20 years who did not have diabetes: NHANES III (1988–1994) and NHANES 1999–2000*

	n		Original NCEP/ATP III definition					Revised NCEP/ATP III definition				
	NHANES III	NHANES 1999–2000	NHANES III	NHANES 1999–2000	Relative change (%)	Absolute difference (%)	*P*	NHANES III	NHANES 1999–2000	Relative change (%)	Absolute difference (%)	*P*
Total												
Unadjusted	5,775	1,514	18.9 (0.9)	22.6 (1.3)	19.4	3.7	0.022	24.1 (1.0)	28.1 (1.3)	16.6	4.0	0.019
Age adjusted	5,775	1,514	20.3 (0.8)	23.3 (1.3)	14.7	3.0	0.057	25.8 (0.8)	29.1 (1.3)	12.6	3.3	0.044
Men												
Total												
Unadjusted	2,758	759	18.3 (1.3)	19.2 (1.8)	5.1	0.9	0.674	25.2 (1.6)	26.1 (1.9)	3.6	0.9	0.716
Age adjusted	2,758	759	20.3 (1.3)	20.8 (1.8)	2.3	0.5	0.832	27.8 (1.3)	28.0 (2.0)	0.7	0.2	0.940
20–39 years	1,194	278	9.9 (1.6)	8.9 (1.7)	−10.3	−1.0	0.663	15.4 (2.0)	14.8 (2.5)	−4.1	−0.6	0.847
40–59 years	739	206	23.9 (2.5)	26.9 (3.4)	12.6	3.0	0.475	31.5 (2.4)	35.1 (4.4)	11.4	3.6	0.479
≥60 years	825	275	32.6 (2.4)	32.8 (4.0)	0.5	0.2	0.972	42.4 (2.7)	40.0 (4.1)	−5.6	−2.4	0.629
Women												
Total												
Unadjusted	3,017	755	19.5 (1.3)	25.9 (2.0)	32.9	6.4	0.009	23.1 (1.3)	30.0 (1.9)	30.1	7.0	0.004
Age adjusted	3,017	755	20.1 (1.1)	26.0 (2.0)	29.0	5.8	0.015	23.9 (1.2)	30.3 (2.0)	26.6	6.4	0.009
20–39 years	1,368	241	8.9 (1.5)	16.8 (2.6)	87.9	7.9	0.012	10.0 (1.6)	17.9 (2.8)	78.3	7.8	0.018
40–59 years	849	261	21.2 (2.3)	27.5 (3.8)	29.7	6.3	0.166	26.0 (2.4)	30.8 (3.8)	18.8	4.9	0.284
≥60 years	800	253	38.3 (2.2)	39.9 (3.7)	4.4	1.7	0.698	45.3 (2.3)	51.3 (4.3)	13.1	5.9	0.232

Data are percent (SE).

people with diabetes in prevalence estimates of the metabolic syndrome, we recalculated the prevalence estimates after excluding participants with self-reported diabetes or a fasting plasma glucose concentration ≥126 mg/dl (≥6.99 mmol/l) (Table 3). The unadjusted prevalence was 18.9% in NHANES III and 22.6% in NHANES 1999–2000 ($P = 0.019$), whereas the age-adjusted prevalence increased from 20.3 to 23.3% ($P = 0.044$). The relative increases in prevalence among participants without diabetes exceeded the increases for all participants shown in Table 2.

We examined the effect of counting participants who reported using cholesterol-lowering medications as having hypertriglyceridemia, because these agents can cause substantial reductions in triglyceride concentrations. The age-adjusted prevalence changed from 24.4% in NHANES III to 28.1% in NHANES 1999–2000 ($P = 0.016$). However, this analysis may have overestimated the prevalence of the metabolic syndrome because it assumes that all participants who used such medications may have had hypertriglyceridemia when some proportion of these participants had a normal concentration of triglycerides.

To examine the impact of the increase of obesity on the prevalence of the metabolic syndrome, we conducted two sets of analyses. First, after eliminating waist circumference as one of the criteria of the metabolic syndrome, the age-adjusted prevalence of having three or four of the remaining four criteria was 13.5% in NHANES III and 13.0% in NHANES 1999–2000. Second, we examined the prevalence of the metabolic syndrome stratified by BMI categories (<25, 25 to <30, 30 to <35, and ≥35 kg/m^2) and calculated the prevalence adjusted for the BMI distribution from NHANES III. In NHANES III, the prevalence adjusted for the four categories of BMI was 23.1% among all participants, 22.8% among men, and 23.8% among women. In NHANES 1999–2000, the prevalences were 23.5, 21.3, and 26.9%, respectively.

Because it is unclear how commonly health care professionals measure waist circumference on their patients and because the use of BMI to assess obesity has been heavily promoted, we examined what cut points for BMI would generate equivalent prevalences of the metabolic syndrome. A BMI ≥29.2 kg/m^2 among men and ≥24.9 kg/m^2 among women in NHANES III and a BMI ≥28.7 kg/m^2 among men and ≥24.8 kg/m^2 among women in NHANES 1999–2000 provided very close agreement in prevalence estimates using BMI instead of waist circumference. Although the cut points we identified for BMI may result in similar prevalence estimates for the population, using BMI instead of waist circumference to identify the metabolic syndrome in an individual may result in wrongly classifying that individual as having or not having the metabolic syndrome according to the NCEP/ATP III criteria.

CONCLUSIONS — Between 1988–1994 and 1999–2000, a significant increase in the prevalence of the metabolic syndrome occurred among U.S. adults aged ≥20 years, particularly women. Among people without diabetes, the relative increase exceeded that among all participants. Increases in the prevalence of abdominal obesity and high blood pressure, and to a lesser degree hypertriglyceridemia and low HDL cholesterol concentration, most likely accounted for much of this increase.

Recently, the American Diabetes Association changed the definition of impaired fasting glucose by lowering the glucose threshold to 100 mg/dl from 110 mg/dl (23). This change, which was incorporated into the NCEP/ATP III definition of the metabolic syndrome (18), raised the prevalence of this syndrome by about an absolute 5%. Under the original NCEP/ATP III definition, the unadjusted prevalence in this analysis was 23.1% in NHANES III and 26.7% in NHANES 1999–2000. With the modification of the glucose threshold, the prevalence increased to 28.0 and 31.9%, respectively.

On the basis of the 1990 census numbers for U.S. adults aged ≥20 years (~177 million) and the prevalence of the metabolic syndrome based on the original definition calculated from NHANES III data, about 41 million people had the metabolic syndrome in 1990. Because of growth of the population (~201 million people were aged ≥20 years in 2000) and the increase in the prevalence of the metabolic syndrome, ~55 million people had the metabolic syndrome in 2000. Using prevalence estimates of the metabolic syndrome based on the revised definition, we estimate that ~50 million people had the metabolic syndrome in 1990 and ~64 million people in 2000.

The five components of the metabolic syndrome were measured similarly in the two surveys. Thus, the changes in the prevalence of the metabolic syndrome were not due to methodological changes. Because we only included participants who attended the morning examination in this analysis, the estimates of the prevalence of the metabolic syndrome differ slightly from those of our previous analysis of NHANES III data. The smaller sample size of NHANES 1999–20000 reduced the statistical power to detect significant changes in many demographic subgroups.

A noteworthy finding was the large increases in the prevalence of the metabolic syndrome among women compared with men. In particular, the prevalence of this syndrome escalated rapidly among women aged 20–39 years. Large increases in the prevalences of hypertriglyceridemia and high blood pressure were largely responsible for the increase among women.

Two important determinants of the metabolic syndrome are obesity and physical activity. The prevalence of obesity increased from 22.9 to 30.5% in the U.S. between NHANES III and NHANES 1999–2000 (16). Our analyses show that the increase in BMI accounted for much of the increase in the prevalence of the metabolic syndrome. Leisure-time physical activity levels have been relatively stable from 1990 to 1998 (24). Little is known about trends in other components of physical activity such as occupational physical activity and transportation-related physical activity. Some information suggests that people are relying increasingly on their cars for transportation instead of nonmotorized forms of transportation such as walking or bicycling (25).

The clinical significance of the metabolic syndrome remains controversial, and much remains to be learned about it. It is not clear if the syndrome is a disease or simply a constellation of risk factors (26). The etiology of the metabolic syndrome is also controversial, with obesity, insulin resistance, and other etiologies being advocated. By focusing on the metabolic syndrome, the NCEP/ATP III reinforced the need for health care professionals to take a more comprehensive approach to their patients and to address all

relevant risk factors that increase the risk for type 2 diabetes and cardiovascular events. The metabolic syndrome may be viewed as a useful window on the health of the U.S. population. Consequently, the increase in the prevalence of this syndrome is a worrisome indicator of future increases in diabetes and cardiovascular disease.

Because the metabolic syndrome is extremely common in the U.S. population and its prevalence is increasing, health care professionals are likely to encounter patients with this syndrome in their practice. It remains unknown to what extent health care professionals have adopted the recommendations concerning the metabolic syndrome made by the NCEP/ATP III and are screening their patients for this syndrome. Measurements of blood pressure and concentrations of triglycerides, HDL cholesterol, and glucose are commonly collected in clinical practice. Whether waist circumference is routinely measured at present is unknown.

To stem the rising tides of obesity and the metabolic syndrome, comprehensive approaches for improving nutrition and physical activity habits that target both individuals and the population are required (27). Health care professionals have a critical role in preventing the development of the metabolic syndrome in their patients through weight management and the achievement of proper physical activity levels. Because the syndrome is reversible, health care professionals can help their patients with this syndrome adopt preventive lifestyles that are conducive to developing and reversing this syndrome. In addition, health care professionals must assist patients with the metabolic syndrome in averting or delaying progression to diabetes, cardiovascular disease, and other complications. Although pharmacological therapy for each of the components of this syndrome is available, the role of such therapy in the absence of lifestyle changes deserves clarification. Furthermore, pharmacological approaches specific to patients with this syndrome await development.

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