Prevalence of the Metabolic Syndrome Among US Adults

Findings From the Third National Health and Nutrition Examination Survey

Earl S. Ford, MD, MPH
Wayne H. Giles, MD, MSc
William H. Dietz, MD, PhD

Context The Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (ATP III) highlights the importance of treating patients with the metabolic syndrome to prevent cardiovascular disease. Limited information is available about the prevalence of the metabolic syndrome in the United States, however.

Objective To estimate the prevalence of the metabolic syndrome in the United States as defined by the ATP III report.

Design, Setting, and Participants Analysis of data on 8814 men and women aged 20 years or older from the Third National Health and Nutrition Examination Survey (1988-1994), a cross-sectional health survey of a nationally representative sample of the noninstitutionalized civilian US population.

Main Outcome Measures Prevalence of the metabolic syndrome as defined by ATP III (≥3 of the following abnormalities): waist circumference greater than 102 cm in men and 88 cm in women; serum triglycerides level of at least 150 mg/dL (1.69 mmol/L); high-density lipoprotein cholesterol level of less than 40 mg/dL (1.04 mmol/L) in men and 50 mg/dL (1.29 mmol/L) in women; blood pressure of at least 130/85 mm Hg; or serum glucose level of at least 110 mg/dL (6.1 mmol/L).

Results The unadjusted and age-adjusted prevalences of the metabolic syndrome were 21.8% and 23.7%, respectively. The prevalence increased from 6.7% among participants aged 20 through 29 years to 43.5% and 42.0% for participants aged 60 through 69 years and aged at least 70 years, respectively. Mexican Americans had the highest age-adjusted prevalence of the metabolic syndrome (31.9%). The age-adjusted prevalence was similar for men (24.0%) and women (23.4%). However, among African Americans, women had about a 57% higher prevalence than men did and among Mexican Americans, women had about a 26% higher prevalence than men did. Using 2000 census data, about 47 million US residents have the metabolic syndrome.

Conclusions These results from a representative sample of US adults show that the metabolic syndrome is highly prevalent. The large numbers of US residents with the metabolic syndrome may have important implications for the health care sector.

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People with the metabolic syndrome are at increased risk for developing diabetes mellitus[1] and cardiovascular disease[2] as well as increased mortality from cardiovascular disease and all causes.[3] The recently released Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) (ATP III) draws attention to the importance of the metabolic syndrome and provides a working definition of this syndrome for the first time.[4] The prevalence of the metabolic syndrome as defined by ATP III in the United States is unknown. Because the implications of the metabolic syndrome for health care are substantial, we sought to establish the prevalence of this condition.

METHODS

Between 1988 and 1994, a representative sample of the civilian noninstitutionalized US population was recruited into the Third National Health and Nutrition Examination Survey (NHANES III) using a multistage, stratified sampling design.[5,6] After an interview in the home, participants were invited to attend 1 of 3 examination sessions: morning, afternoon, or evening.

As detailed in the ATP III report, participants having 3 or more of the following criteria were defined as having the metabolic syndrome:

1. Abdominal obesity: waist circumference >102 cm in men and >88 cm in women;

Author Affiliations: Division of Nutrition and Physical Activity (Drs Ford and Dietz) and the Division of Adult and Community Health (Dr Giles), National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Ga.
Corresponding Author and Reprints: Earl S. Ford, MD, MPH, Centers for Disease Control and Prevention, 1600 Clifton Rd NE, Mailstop E-17, Atlanta, GA 30333 (e-mail: esf2@cdc.gov).

2. Hypertriglyceridemia: ≥150 mg/dL (1.69 mmol/L);

3. Low high-density lipoprotein (HDL) cholesterol: <40 mg/dL (1.04 mmol/L) in men and <50 mg/dL (1.29 mmol/L) in women;

4. High blood pressure: ≥130/85 mm Hg;

5. High fasting glucose: ≥110 mg/dL (≥6.1 mmol/L).

We counted participants who reported currently using antihypertensive or antidiabetic medication (insulin or oral agents) as participants with high blood pressure or diabetes, respectively. Serum triglycerides were measured enzymatically after hydrolyzation to glycerol (Hitachi 704 Analyzer; Hitachi, Tokyo, Japan). High-density lipoprotein cholesterol was measured following the precipitation of other lipoproteins with a heparin-manganese chloride mixture (Hitachi 704 Analyzer). Serum glucose concentration was measured using an enzymatic reaction (Cobas Mira assay; Roche, Basel, Switzerland). Details about the laboratory procedures of all these tests are published elsewhere.[6] Three blood pressure readings were obtained in the mobile examination center. The average of the second and third systolic and diastolic blood pressure readings were used in the analyses.

For men and nonpregnant women aged at least 20 years who attended the medical examination and who had fasted at least 8 hours, we calculated the prevalence of the metabolic syndrome by age, sex, and race or ethnicity (white, African American, Mexican American, other). We calculated estimates using the sampling weights so that the estimates are representative of the civilian noninstitutionalized US population. All analyses were done by using SUDAAN to obtain proper variance estimates because of the complex sampling design.[7]

RESULTS

Among men, whites and Mexican Americans had the highest age-adjusted prevalences of abdominal obesity, hypertriglyceridemia, and low HDL cholesterol concentration (TABLE 1). African American men had the highest age-adjusted prevalence of hypertension, and Mexican American men had the highest age-adjusted prevalence of hyperglycemia. Among women, Mexican Americans and African Americans had the highest age-adjusted prevalence of abdominal obesity. African American women had the highest age-adjusted prevalence of high blood pressure, and Mexican American women had the highest age-adjusted prevalences of hypertriglyceridemia, low HDL cholesterol concentration, and hyperglycemia.

Overall, the unadjusted and age-adjusted prevalences of the metabolic syndrome were 21.8% and 23.7%, respectively (TABLE 2). The prevalence increased from 6.7% among participants aged 20 through 29 years to 43.5% and 42.0% for participants aged 60 through 69 years and 70 years or older, respectively (FIGURE 1). The prevalence differed little among men (24.0%) and women (23.4%). It was highest among Mexican Americans (31.9%) and lowest among whites (23.8%), African Americans (21.6%), and people reporting an "other" race or ethnicity (20.3%). Among whites and participants of the other race or ethnic group, men and women had a similar prevalence of the metabolic syndrome (FIGURE 2). Among African Americans, women had about a 57% higher prevalence than men did. Among Mexi-

Table 1. Age-Adjusted Prevalence of Individual Metabolic Abnormalities of the Metabolic Syndrome Among 8814 US Adults Aged ≥20 Years, National Health and Nutrition Examination Survey III, 1988-1994*

	No. of Participants	% (SE)				
		Abdominal Obesity	Hypertriglyceridemia	Low HDL Cholesterol	High Blood Pressure or Medication Use	High Fasting Glucose or Medication Use
Total	8814	38.6 (0.8)	30.0 (1.1)	37.1 (1.2)	34.0 (0.8)	12.6 (0.5)
Men	4265	29.8 (1.2)	35.1 (1.7)	35.2 (1.5)	38.2 (1.4)	15.6 (0.8)
Women	4549	46.3 (1.2)	24.7 (0.9)	39.3 (1.4)	29.3 (0.8)	10.0 (0.6)
Race or ethnicity						
White	3599	37.2 (0.9)	31.1 (1.3)	37.9 (1.5)	32.8 (1.0)	11.9 (0.6)
African American	2412	44.6 (1.2)	17.7 (0.8)	28.8 (1.3)	46.3 (0.9)	15.1 (0.9)
Mexican American	2449	45.7 (1.3)	37.7 (1.0)	39.6 (1.5)	36.6 (1.2)	20.0 (1.0)
Other	354	33.6 (5.2)	27.3 (3.3)	37.1 (4.5)	29.6 (2.9)	14.3 (2.0)
Men						
White	1712	30.5 (1.2)	36.9 (2.0)	36.8 (1.6)	37.2 (1.8)	15.6 (1.0)
African American	1116	23.3 (1.3)	21.4 (1.2)	22.6 (1.7)	49.6 (1.5)	14.5 (1.1)
Mexican American	1277	30.6 (1.7)	39.7 (1.5)	33.7 (2.0)	40.2 (1.7)	21.4 (1.5)
Other	160	26.4 (7.5)	29.4 (4.0)	33.2 (5.2)	34.4 (4.0)	15.1 (3.3)
Women						
White	1887	43.5 (1.4)	25.0 (1.1)	39.3 (1.9)	27.8 (0.9)	8.5 (0.6)
African American	1296	62.1 (1.5)	14.4 (1.0)	34.0 (1.7)	43.3 (1.3)	15.5 (1.3)
Mexican American	1172	62.7 (1.7)	35.2 (1.3)	46.3 (1.7)	32.4 (1.7)	18.5 (1.2)
Other	194	40.0 (4.8)	26.0 (4.4)	39.6 (4.6)	23.7 (2.3)	14.4 (2.9)

*HDL indicates high-density lipoprotein.

can Americans, women had about a 26% higher prevalence than men did. Application of the age-specific prevalence rates to US census counts from 2000 suggests that 47 million US residents have the metabolic syndrome.

COMMENT

Using ATP III's new definition, we estimate that approximately 22% of US adults (24% after age adjustment) have the metabolic syndrome. Previous estimates of the prevalence of the metabolic syndrome in the United States and Europe have differed because of differences in definitions and populations studied.[2,8-16] The unrelenting increase in the prevalence of obesity in the United States[17] suggests that the current prevalence of the metabolic syndrome is now very likely higher than that estimated from 1988-1994 NHANES III data. Even if prevalence rates remained unchanged, the total number of people with the metabolic syndrome would have increased because of population growth during the 1990s.

Insulin resistance is thought to be an underlying feature of the metabolic syndrome.[18] Genetic abnormalities, fetal malnutrition, and visceral adiposity may play roles in the pathophysiology of insulin resistance and the metabolic syndrome.[19] Although insulin resistance among patients with the individual components of the metabolic syndrome is common, significant proportions of these patients do not have insulin resistance. Some studies have suggested that hypertension is not strongly linked to the metabolic syndrome.[20]

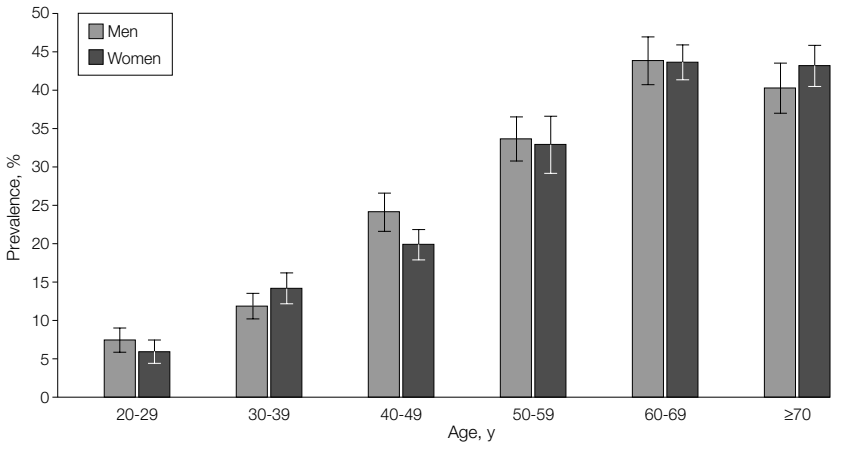
The cornerstones of treatment are the management of weight and ensuring appropriate levels of physical activity. Recent studies demonstrate that dietary modification and enhanced physical activity may delay or prevent the transition from impaired glucose tolerance to type 2 diabetes mellitus and provide relevant treatment paradigms for patients with the metabolic syndrome.[21-23] While proper management of the individual abnormalities of this syndrome can re-

Table 2. Age-Adjusted Prevalence of 1 or More Abnormalities of the Metabolic Syndrome Among 8814 US Adults ≥20 Years, National Health and Nutrition Examination Survey III, 1988-1994*

	No. of Metabolic Abnormalities, % (SE)				
	≥1	≥2	≥3	≥4	5
Total	71.2 (1.0)	43.9 (1.1)	23.7 (0.8)	10.4 (0.5)	2.7 (0.3)
Men	71.5 (1.2)	44.9 (1.3)	24.0 (1.1)	11.1 (0.9)	2.4 (0.4)
Women	70.9 (1.2)	42.7 (1.3)	23.4 (0.9)	9.6 (0.5)	2.9 (0.3)
Race or ethnicity					
White	70.1 (1.2)	43.2 (1.2)	23.8 (1.0)	10.8 (0.6)	2.9 (0.3)
African American	75.6 (0.8)	45.1 (1.0)	21.6 (0.8)	8.4 (0.7)	1.8 (0.4)
Mexican American	78.9 (1.0)	54.4 (1.1)	31.9 (1.3)	12.0 (1.0)	2.3 (0.4)
Other	71.2 (3.1)	41.8 (4.0)	20.3 (3.3)	7.1 (1.5)	1.5 (0.6)
Men					
White	71.5 (1.4)	45.5 (1.5)	24.8 (1.4)	12.4 (1.1)	2.8 (0.5)
African American	70.3 (1.3)	37.3 (1.5)	16.4 (1.1)	6.3 (0.8)	1.2 (0.3)
Mexican American	74.8 (1.5)	51.5 (1.5)	28.3 (1.8)	9.4 (1.0)	1.6 (0.4)
Other	70.2 (4.6)	42.9 (4.2)	20.9 (4.7)	3.6 (1.2)	0.9 (0.5)
Women					
White	68.4 (1.5)	40.7 (1.5)	22.8 (1.1)	9.2 (0.6)	3.0 (0.3)
African American	80.0 (1.0)	51.3 (1.3)	25.7 (1.3)	10.0 (0.9)	2.3 (0.5)
Mexican American	84.0 (0.9)	57.7 (1.4)	35.6 (1.5)	14.7 (1.3)	3.1 (0.6)
Other	71.3 (4.6)	40.0 (4.6)	19.9 (3.1)	10.5 (2.5)	2.1 (1.2)

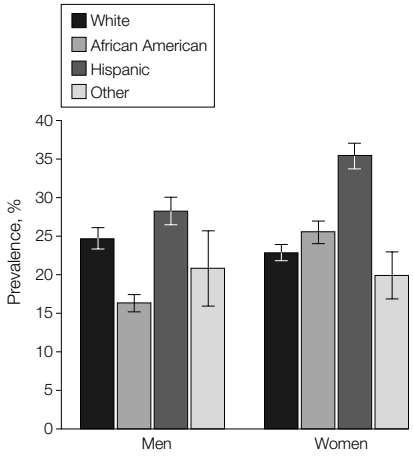
*See the "Methods" section for a description of the 5 criteria of the metabolic syndrome.

Figure 1. Age-Specific Prevalence of the Metabolic Syndrome Among 8814 US Adults Aged at Least 20 Years, by Sex, National Health and Nutrition Examination Survey III, 1988-1994



Data are presented as percentage (SE).

Figure 2. Age-Adjusted Prevalence of the Metabolic Syndrome Among 8814 US Adults Aged at Least 20 Years, by Sex and Race or Ethnicity, National Health and Nutrition Examination Survey III, 1988-1994



Data are presented as percentage (SE).

duce morbidity and mortality, it seems unlikely that management of the individual abnormalities of this syndrome provides better outcomes than a more integrated strategy.

Education and training will be critical to ensure that health care providers have the knowledge and skills necessary to properly treat patients with the metabolic syndrome. Lack of reimbursement for weight management and physical activity interventions constitutes a major barrier. Significant efforts are needed to close the gap between current and desirable practice patterns.

The high prevalence of this condition may also have serious implications for US health care costs. Thus, studies of the direct medical costs associated with the metabolic syndrome are urgently needed. Because the root causes of the metabolic syndrome for the overwhelming majority of patients are improper nutrition and inadequate physical activity, the high prevalence of this syndrome underscores the urgent need to develop comprehensive efforts directed at controlling the obesity epidemic and improving physical activity levels in the United States.

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Analysis and interpretation of data: Ford, Dietz.
Drafting of the manuscript: Ford, Dietz.
Critical revision of the manuscript for important intellectual content: Ford, Giles.
Statistical expertise: Ford, Giles.
Administrative, technical, or material support: Dietz.
Study supervision: Ford.

REFERENCES

1. Haffner SM, Valdez RA, Hazuda HP, Mitchell BD, Morales PA, Stern MP. Prospective analysis of the insulin-resistance syndrome (syndrome X). *Diabetes*. 1992;41:715-722.
2. Isomaa B, Almgren P, Tuomi T, et al. Cardiovascular morbidity and mortality associated with the metabolic syndrome. *Diabetes Care*. 2001;24:683-689.
3. Trevisan M, Liu J, Bahsas FB, Menotti A. Syndrome X and mortality: a population-based study. *Am J Epidemiol*. 1998;148:958-966.
4. National Institutes of Health. *Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III)*. Bethesda, Md: National Institutes of Health; 2001. NIH Publication 01-3670.
5. Plan and operation of the Third National Health and Nutrition Examination Survey, 1988-94. *Vital Health Stat 1*. 1994;(32):1-407.
6. Centers for Disease Control and Prevention. *The Third National Health and Nutrition Examination Survey (NHANES III 1988-94) Reference Manuals and Reports* [CD-ROM]. Bethesda, Md: National Center for Health Statistics; 1996.
7. Shah BV, Barnwell BG, Bieler GS. *SUDAAN User's Manual, Version 7.5*. Research Triangle Park, NC: Research Triangle Institute; 1997.
8. Rantala AO, Kauma H, Lilja M, Savolainen MJ, Reunanen A, Kesaniemi YA. Prevalence of the metabolic syndrome in drug-treated hypertensive patients and control subjects. *J Intern Med*. 1999;245:163-174.
9. Haffner SM, Howard G, Mayer E, et al. Insulin sensitivity and acute insulin response in African-Americans, non-Hispanic whites, and Hispanics with NIDDM: the Insulin Resistance Atherosclerosis Study. *Diabetes*. 1997;46:63-69.
10. Schmidt MI, Duncan BB, Watson RL, Sharrett AR, Brancati FL, Heiss G. A metabolic syndrome in whites and African-Americans: the Atherosclerosis Risk in Communities baseline study. *Diabetes Care*. 1996; 19:414-418.
11. Liese AD, Mayer-Davis EJ, Tyroler HA, et al. Development of the multiple metabolic syndrome in the ARIC cohort: joint contribution of insulin, BMI, and WHR. *Ann Epidemiol*. 1997;7:407-416.
12. Meigs JB, D'Agostino RB Sr, Wilson PW, Cupples LA, Nathan DM, Singer DE. Risk variable clustering in the insulin resistance syndrome: the Framingham Offspring Study. *Diabetes*. 1997;46: 1594-1600.
13. Kannel WB. Risk stratification in hypertension: new insights from the Framingham Study. *Am J Hypertens*. 2000;13(1 pt 2):3S-10S.
14. Bonora E, Kiechl S, Willeit J, et al. Prevalence of insulin resistance in metabolic disorders: the Bruneck Study. *Diabetes*. 1998;47:1643-1649.
15. Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications, part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. *Diabet Med*. 1998;15:539-553.
16. Hulthe J, Bokemark L, Wikstrand J, Fagerberg B. The metabolic syndrome, LDL particle size, and atherosclerosis: the Atherosclerosis and Insulin Resistance (AIR) study. *Arterioscler Thromb Vasc Biol*. 2000; 20:2140-2147.
17. Mokdad AH, Serdula MK, Dietz WH, Bowman BA, Marks JS, Koplan JP. The continuing epidemic of obesity in the United States. *JAMA*. 2000;284: 1650-1651.
18. Grundy SM. Hypertriglyceridemia, insulin resistance, and the metabolic syndrome. *Am J Cardiol*. 1999;83:25F-29F.
19. Lebovitz HE. Insulin resistance: definition and consequences. *Exp Clin Endocrinol Diabetes*. 2001;109 (suppl 2):S135-S148.
20. Meigs JB. Invited commentary: insulin resistance syndrome? syndrome X? multiple metabolic syndrome? a syndrome at all? factor analysis reveals patterns in the fabric of correlated metabolic risk factors. *Am J Epidemiol*. 2000;152:908-911.
21. Eriksson KF, Lindgarde F. Prevention of type 2 (non-insulin-dependent) diabetes mellitus by diet and physical exercise: the 6-year Malmo feasibility study. *Diabetologia*. 1991;34:891-898.
22. Pan XR, Li GW, Hu YH, et al. Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance: the Da Qing IGT and Diabetes Study. *Diabetes Care*. 1997;20:537-544.
23. Tuomilehto J, Lindstrom J, Eriksson JG, et al. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med*. 2001;344:1343-1350.