

The Prevalence of the Metabolic Syndrome Among Arab Americans

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OBJECTIVE — To estimate the prevalence of the metabolic syndrome in Arab Americans by age, sex, and BMI and to examine the association between insulin resistance and each of the components of the metabolic syndrome.

RESEARCH DESIGN AND METHODS — We studied a representative, cross-sectional, population-based sample of 542 Arab Americans aged 20–75 years. The metabolic syndrome was defined by Adult Treatment Panel III (ATP III) and World Health Organization (WHO) diagnostic criteria. Insulin resistance was estimated by homeostasis model assessment (HOMA-IR).

RESULTS — The age-adjusted prevalence of the metabolic syndrome was 23% (95% CI 19–26%) by the ATP III definition and 28% (24–32%) by the WHO definition. Although the prevalence increased significantly with age and BMI in both sexes by both definitions, differences in estimates were noted. With ATP III, the age-specific rates were similar for men and women aged 20–49 years but were significantly higher for women aged ≥50 years. With WHO, rates were higher for men than women aged 20–49 years and similar for those aged ≥50 years. The most common component of the metabolic syndrome in men and women was low HDL cholesterol with the ATP III and the presence of glucose intolerance and HOMA-IR with the WHO. Strong associations between HOMA-IR and individual components of the metabolic syndrome were observed. After fitting a model with HOMA-IR as the outcome, waist circumference, triglyceride level, and fasting plasma glucose level were significantly associated with HOMA-IR.

CONCLUSIONS — The metabolic syndrome is common among Arab Americans and is related to modifiable risk factors.

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The metabolic syndrome, also known as the syndrome of insulin resistance, is characterized by obesity, glucose intolerance, hypertension, and dyslipidemia (1). Insulin resistance underlies many of the metabolic abnormalities (2). Although the pathogenesis of the syndrome is not completely understood,

genetic factors and environmental factors such as sedentary lifestyle and western dietary habits contribute to its development (2,3). Studies suggest an association between the metabolic syndrome and diabetes, cardiovascular disease, and mortality (4–7).

In the past, studies of the epidemiol-

ogy of the metabolic syndrome have been limited by a lack of consensus on the definition of the syndrome. The Adult Treatment Panel III (ATP III) and the World Health Organization (WHO) have published working definitions of the metabolic syndrome (8,9). The availability of these definitions provides the opportunity to assess and compare the prevalence of the metabolic syndrome in various populations.

We have previously shown that obesity and diabetes are prevalent in the Arab-American community of Dearborn, Michigan (10). The objective of this report was to describe the prevalence of the metabolic syndrome in this population by age, sex, and BMI by applying the ATP III and WHO definitions. A second objective was to examine the association between insulin resistance defined by homeostasis model assessment (HOMA-IR) and each of the individual components of the metabolic syndrome as defined by the ATP III.

RESEARCH DESIGN AND METHODS

Subjects participated in a cross-sectional, population-based study of diabetes in Arab Americans described in detail elsewhere (10). A random sample of 542 nonpregnant Arab Americans aged 20–75 years was selected from two defined geographic areas of Dearborn, Michigan. All subjects provided written informed consent. Participation rates were 78 and 93% among men and women, respectively.

Subjects reported to the clinic in the morning after a 12-h overnight fast. Standardized questionnaires translated into Arabic were administered by bilingual interviewers. Arab Americans were defined by self-report of Arab ancestry of the individual, a parent, or a grandparent. A standardized medical history was obtained. Height, body weight, as well as hip and waist circumferences were measured with the subjects wearing light clothing and no shoes. Three consecutive measurements of sitting blood pressure were recorded from the right arm. Systolic and diastolic blood pressures were computed as the mean of the three measurements.

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Abbreviations: ATP III, Adult Treatment Panel III; FPG, fasting plasma glucose; HOMA-IR, homeostasis model assessment of insulin resistance; IFG, impaired fasting glucose; IGT, impaired glucose tolerance; WHO, World Health Organization.

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

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Table 1—Age-adjusted prevalence of one or more components of the metabolic syndrome by sex

Metabolic Abnormalities	Total	Men	Women	P
<i>n</i>	542	214 (39.5)	328 (60.5)	
ATP III definition				
≥1	78.6 (75.0–82.3)	80.3 (74.8–85.8)	76.9 (72.2–81.6)	0.38
≥2	50.6 (46.4–54.7)	51.1 (44.4–57.9)	50.0 (45.3–54.7)	0.79
≥3	22.6 (19.4–25.8)	19.8 (14.9–24.8)	25.4 (21.5–29.4)	0.083
≥4	9.3 (7.0–11.6)	8.4 (4.9–11.8)	10.3 (7.4–13.2)	0.39
5	1.9 (0.8–2.9)	1.2 (0–2.6)	2.5 (1.0–4.0)	0.22
WHO definition				
Diabetes, IGT, IFG, or HOMA-IR	66.1 (62.1–70.1)	74.1 (68.1–80.2)	57.6 (52.3–62.9)	<0.01
Plus ≥1	53.7 (49.5–57.9)	60.8 (54.2–67.5)	46.1 (41.0–51.1)	<0.01
Plus ≥2	27.9 (24.2–31.7)	32.4 (26.3–38.6)	23.2 (18.9–27.4)	0.01
Plus ≥3	3.1 (1.8–4.5)	2.8 (0.8–4.7)	3.5 (1.7–5.4)	0.57

Data are percent (95% CI) or *n* (%).

BMI was calculated as body weight in kilograms divided by the square of height in meters (kg/m²).

Fasting blood samples were collected for measurement of plasma glucose, serum insulin, and lipid levels. All subjects without documented diabetes received a 75-g oral glucose load over 10 min, and blood samples were collected at 120 min for measurement of plasma glucose. All blood samples were centrifuged for 10 min, and plasma was stored at -70°C. Plasma glucose was measured with an automated glucose oxidase method using Behring Diagnostics Reagents (SVR Glucose Test; Behring, La Jolla, CA). Serum insulin was measured with a double antibody radioimmunoassay (Linco Research, St. Charles, MO) and was standardized against the International Reference Preparation (National Institute for Biological Standards and Control, England). The standard range for serum insulin was 2.1–260 μU/ml. Total cholesterol and triglycerides were measured using enzymatic colorimetric techniques (Roche for Cobas Mira Chemstation, Indianapolis, IN). HDL cholesterol was measured with an HDL direct assay using elimination approach and meeting the National Cholesterol Education Program (NCEP) guidelines for precision and accuracy (Roche for Cobas Mira Chemstation, Indianapolis, IN). LDL cholesterol was calculated using the Friedewald equation.

Individuals were considered to have diabetes if they reported a previous medical diagnosis of diabetes and/or were us-

ing antidiabetic medications. Glucose tolerance of individuals without diabetes was determined by 2-h 75-g oral glucose tolerance tests and the new diagnostic criteria of the World Health Organization and the American Diabetes Association (8,11).

ATP III criteria for the metabolic syndrome were met if an individual had three or more of the following criteria: waist circumference >102 cm in men and >88 cm in women; fasting plasma glucose (FPG) ≥110 mg/dl (6.1 mmol/l); blood pressure ≥130/85 mmHg; serum triglycerides ≥150 mg/dl (1.7 mmol/l); and serum HDL cholesterol <40 mg/dl (1.04 mmol/l) in men and <50 mg/dl (1.29 mmol/l) in women.

The WHO criteria for the metabolic syndrome for epidemiologic studies (12)

were met if an individual had diabetes, impaired glucose tolerance (IGT), impaired fasting glucose (IFG), or insulin resistance plus two or more of the following abnormalities: blood pressure ≥160/90 mmHg; serum triglycerides ≥150 mg/dl (1.7 mmol/l) and/or serum HDL cholesterol <35 mg/dl (0.9 mmol/l) in men and <39 mg/dl (1.0 mmol/l) in women; and central obesity with waist-to-hip ratio of >0.90 in men and >0.85 in women and/or BMI >30 kg/m².

Insulin resistance was estimated by HOMA-IR and was defined as fasting serum insulin (μU/ml) × FPG (mmol/l)/22.5 (13). The HOMA method has been shown to be a useful measure for assessing insulin resistance across a wide range of glucose levels (14).

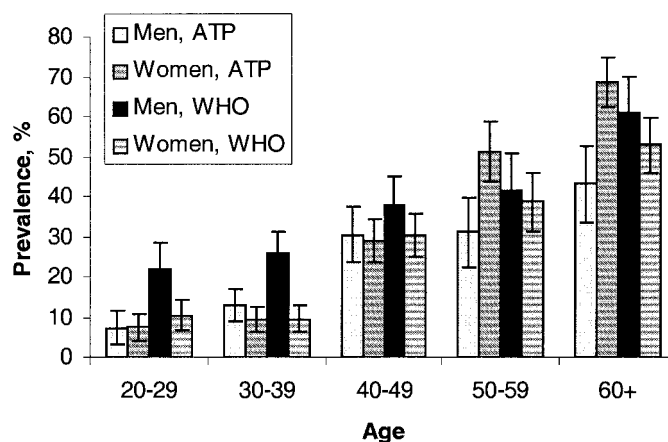


Figure 1—Prevalence of the metabolic syndrome by sex and age. Data are presented as percent (SE).

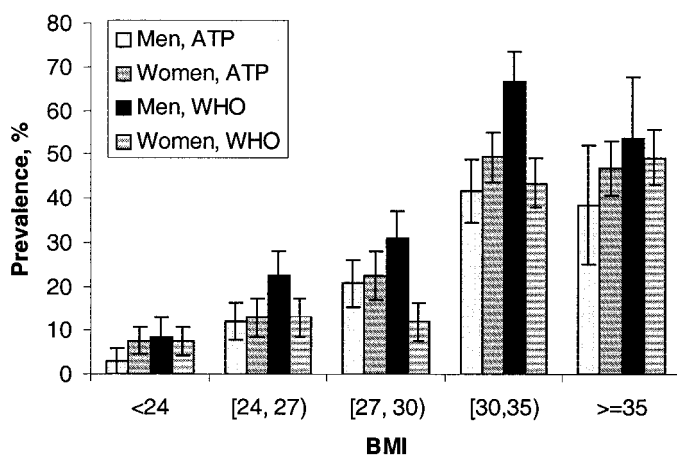


Figure 2—Prevalence of the metabolic syndrome by sex and BMI. Data are presented as percent (SE).

Statistical analyses

The selection of households containing Arab Americans was based on a random sample of the households in neighborhoods with a high proportion of Arab

Americans. Individuals within a household were enumerated and the participants (one or two) were randomly selected from the list. Because the enumeration contained the ages of all the

members in the household aged 20–75 years, the distribution of the enumerated ages and genders provides an estimate of the demographic distribution of these characteristics. The data in all analyses were weighted to adjust for these demographic characteristics.

All analyses were performed separately by sex. Results are expressed as means ± SD. Depending on whether the outcome measure was continuous or discrete, weighted one-way ANOVA or χ^2 test was performed to compare the two age groups or men versus women. In addition, regression and correlations were computed using weights.

RESULTS

A total of 214 men and 328 women participated in the study. Age was 38 ± 13 years (mean ± SD), and BMI was 28.4 ± 5.5 kg/m². As previously reported, diabetes was present in 20% of men and 16% of women and IGT and/or IFG was present in 30% of men and 17%

Table 2—The relative frequencies of the individual components of the metabolic syndrome by age and sex

n (%)	Total population	Men		P (young vs. old)	Total men	Women		P (young vs. old)	Total women	P (men vs. women)
		20–49 years	>49 years			20–49 years	>49 years			
ATP	542	157 (73.4%)	57 (26.6)		214 (39.5%)	229 (69.8%)	99 (30.2)		328 (60.5)	
Waist circumference (men >102; women >88 cm)	30.6	16.4	26.3	0.2023	17.7	31.9	79.4	<0.0001	40.3	<0.0001
Blood pressure ≥130/85 mmHg or medication use	23.2	19.6	52.5	0.0001	23.9	14.8	58.1	<0.0001	22.7	0.7498
Hypertriglyceridemia (≥150 mg/dl)	28.3	38.8	36.9	0.8471	38.5	16.4	40.3	<0.0001	20.8	<0.0001
Low HDL cholesterol (men <40; women <50 mg/dl)	48.0	41.7	40.2	0.8791	41.5	52.3	54.5	0.7598	52.7	0.0127
FPG (≥110 mg/dl) of medication use	24.9	30.9	45.7	0.1196	32.8	11.1	53.9	<0.0001	19.1	0.0003
WHO										
Diabetes, IGT, IFG, or HOMA-IR	62.5	70.5	84.2	0.1292	72.3	48.8	84.6	<0.0001	55.2	<0.0001
Blood pressure ≥160/<90 mmHg	7.0	6.0	26.3	0.0004	8.8	2.4	21.2	<0.0001	5.8	0.1842
Hypertriglyceridemia (≥150 mg/dl) or low HDL (men <35; women <39 mg/dl)	36.9	45.9	47.3	0.8871	46.1	26.0	48.3	0.0008	30.1	0.0002
Obesity: waist-to-hip ratio (men 0.9; women 0.85) or BMI (>30 kg/m ²)	51.0	51.9	73.5	0.0326	54.8	40.9	80.7	<0.0001	48.1	0.1306

Table 3—The relative frequencies of the individual components of the metabolic syndrome by sex and BMI

	Men			Women		
	BMI <30 kg/m ²	BMI ≥30 kg/m ²	P value (BMI <30 vs. ≥30 kg/m ²)	BMI <30 kg/m ²	BMI ≥30 kg/m ²	P value (BMI <30 vs. ≥30 kg/m ²)
n (%)	151 (71.2%)	61 (28.8%)		186 (57.2%)	139 (42.8%)	
ATP						
Waist circumference (men >102 cm; women >88 cm)	3.7	51.8	<0.0001	16.3	81.0	<0.0001
Blood pressure ≥130/85 mmHg or medication use	19.8	33.4	0.035	16.4	32.7	0.0006
Hypertriglyceridemia (≥150 mg/dl)	34.2	47.5	0.070	15.5	29.1	0.0032
Low HDL cholesterol (men <40; women <50 mg/dl)	35.5	55.5	0.0072	45.8	64.1	0.0014
FPG (≥110 mg/dl) or medication use	29.6	39.2	0.18	9.4	34.6	<0.0001
WHO						
Diabetes IGT, IFG, or HOMA-IR	66.0	87.2	0.0016	40.6	80.8	<0.0001
Blood pressure ≥160/≥90 mmHg	8.9	8.6	0.9509	2.2	12.1	0.0003
Hypertriglyceridemia (≥150 mg/dl) or low HDL (men <35; women <39 mg/dl)	40.6	58.9	0.0143	22.9	42.6	0.0002
Obesity: waist-to-hip ratio (men >0.9, women >0.85)	35.8	100.0	<0.0001	18.2	100.0	<0.0001

of women (10). Nineteen percent (101/536) of subjects were diagnosed as having the metabolic syndrome by both ATP III and WHO criteria, and 64% (342/536) were diagnosed as not having the metabolic syndrome by both criteria. Seven percent (38/536) were diagnosed as having the metabolic syndrome by ATP III but not WHO criteria, and 10% (55/536) were diagnosed as having the metabolic syndrome by WHO but not ATP III criteria.

The age-adjusted prevalences of one or more components of the metabolic syndrome in men and women are summarized in Table 1. The overall age-adjusted prevalences of the metabolic syndrome were 23% by the ATP III criteria and 28% by the WHO criteria. By the ATP III definition, the age-adjusted prevalence was 20% in men and 25% in women ($P = 0.08$). The prevalence of the metabolic syndrome by the ATP III definition was 12% among subjects with normal glucose tolerance, 32% in those with IGT/IFG, and 34% in those with diabetes. By the WHO criteria, the age-adjusted prevalence was 32% in men and 23% in women ($P = 0.01$).

The prevalence of the metabolic syndrome in men and women by age and BMI are shown in Figs. 1 and 2. The prevalence of the metabolic syndrome in-

creased significantly with age in men and women by either definition. According to the ATP III, the prevalence rose from 17 and 15% in men and women aged 20–49 years to 37 and 61% in men and women aged 50–75 years. The prevalence of metabolic syndrome was similar for men and women aged 20–49 years but was significantly higher in women aged ≥50 years compared with men aged ≥50 years. According to the WHO criteria, the prevalence rose from 28 and 17% in men and women aged 20–49 years to 51 and 46% in men and women aged 50–75 years. The rates were significantly higher for men than woman in the 20- to 49-year age-groups and similar in those aged ≥50 years. The prevalence of metabolic syndrome rose rapidly with increasing BMI until 35 kg/m² in both men and women using either definition.

The relative frequencies of the individual components of the metabolic syndrome by age and BMI are shown in Tables 2 and 3. By the ATP III definition, low HDL cholesterol was the most common abnormality in both men and women. Men had higher prevalence of hypertriglyceridemia ($P < 0.0001$) and hyperglycemia ($P = 0.0003$) than women. The frequencies of abdominal obesity or large waist circumference ($P < 0.0001$) and low HDL concentration ($P =$

0.0127) were higher in women than men. By the WHO criteria, the presence of glucose intolerance or insulin resistance was the most common abnormality in both men and women.

The frequencies of the individual components of the metabolic syndrome varied by age and BMI in both men and women. Among men, high blood pressure was significantly more prevalent in the participants aged 50–75 years than those aged 20–49 years. Women aged 50–75 years had significantly higher prevalence of obesity, high blood pressure, hypertriglyceridemia, hyperglycemia, and/or insulin resistance than those aged 20–49 years. Individual components of the metabolic syndrome were generally more prevalent in obese compared with nonobese men and women.

HOMA-IR was significantly and positively associated with waist circumference (odds ratio 0.44; $P < 0.01$), blood pressure (0.30; $P < 0.1$), triglyceride (0.40; $P < 0.1$), and FPG (0.57; $P < 0.1$) and was negatively correlated with HDL (-0.23 ; $P < 0.01$). After fitting a model with HOMA-IR as the outcome, waist circumference, triglyceride level, and FPG were significantly associated with HOMA-IR ($P < 0.01$).

Among subjects with normal glucose tolerance, 25% had a HOMA-IR >4.0 and

5% had a HOMA-IR >7.5. Among those with IGT/IFG, 56% had HOMA-IR >4.0 and 20% had HOMA-IR >7.5. Among those with undiagnosed diabetes, 72% exceeded 4.0 and 43% exceeded 7.5, whereas among those with previously diagnosed diabetes, 89% exceeded 4.0 and 43% exceeded 7.5.

CONCLUSIONS— This study provides the first reported estimates of the prevalence of the metabolic syndrome among Arab Americans. The high prevalence of the metabolic syndrome among Arab Americans by either the ATP III or WHO definitions is not surprising, given that both use variables considered surrogate markers for insulin resistance. Using the ATP III diagnostic criteria, we found a 26% prevalence of the metabolic syndrome in the population 20–75 years of age (23% after adjustment for age). These estimates are similar to the National Health and Nutrition Examination Survey (NHANES III)-derived unadjusted and age-adjusted prevalences of the metabolic syndrome in the U.S. population (22 and 24%, respectively) (15). In the Arab world, the prevalence of the metabolic syndrome was 17% among Palestinians in the West Bank, using the WHO criteria, and 21% among Omanis, using the ATP III criteria (16,17).

The prevalence of the metabolic syndrome increased with age in both men and women, with sharp increases after the third and fifth decades of life. Age-related changes in body size, fat distribution, and insulin sensitivity contribute to the increased prevalence of this syndrome with age. This is especially true among women after menopause; women aged ≥ 50 years had a higher frequency of large waist circumference than men or younger women. Only $\sim 5\%$ of women aged > 50 years used hormone replacement therapy.

Low HDL cholesterol was the most common component of the metabolic syndrome using the ATP III criteria in both men and women, a finding that was also reported in urban Palestinians and Omani adults (16,17). Several factors, including insulin resistance, smoking, or an inherited genetic defect among Arabs, may be responsible. Insulin resistance was quite prevalent in this population.

The high prevalence of low HDL cholesterol in this study is of prognostic significance. The atherogenic lipoprotein

profile characterized by high triglyceride and low HDL cholesterol is a more powerful predictor of insulin resistance than obesity, elevated blood pressure, or FPG and, in the presence of obesity, greatly increases the risk of coronary heart disease (18). Programs aimed at smoking cessation and weight loss in this subset of insulin-resistant obese individuals are extremely beneficial. In a 12-month study of obese individuals, weight loss resulted in reduction of insulin levels and improvement of dyslipidemia in those classified as insulin resistant (high triglyceride and low HDL); no beneficial effects were seen in the insulin-sensitive obese individuals with low triglycerides and high HDL (19).

Given the prevalence of the metabolic syndrome in the Arab-American community and the associated health risks, establishing community-based intervention programs aimed at reducing the frequency of this syndrome may have major health benefits.

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