METABOLIC SYNDROME IN A MULTIETHNIC POPULATION IN RURAL HAWAII

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Objective: The National Cholesterol Education Program Adult Treatment Panel III diagnostic criteria for metabolic syndrome (MS) provide a standard for comparing various populations. Using these criteria, the Third National Health and Nutrition Examination Survey reported an overall US prevalence of 21.8%. With these same criteria, we estimated the prevalence of MS among a multiethnic population in rural Hawaii.

Design: These data are from a cross-sectional survey from 1997–2000.

Setting: The survey was conducted in the rural community of North Kohala.

Participants: More than 1,450 adult residents from five ethnic categories were included: Caucasian, Japanese, Filipino, Hawaiian/part-Hawaiian, Other/mixed non-Hawaiian. Ethnic ancestry was determined by self-report. Ethnic differences were compared by using logistic regression.

Main Outcomes: Blood pressure, height, weight, and waist circumference, fasting and two-hour post-oral glucose challenge plasma was obtained for lipid and glucose determinations.

Results: Overall prevalence was 33.4%. Prevalence was significantly higher among all ethnic groups when compared to Caucasians. Despite significant differences in the prevalence of overweight and abdominal obesity, the prevalence of MS was similar in all non-Caucasian ethnic groups. Filipinos had the highest adjusted odds for prevalent MS (prevalence OR=4.2; 95% CI=2.4–7.3).

Conclusion: Metabolic syndrome (MS) prevalence was high in Asian ethnic groups previously reported to have low cardiovascular disease (CVD) mortality. These findings suggest either a differential effect of CVD risk factors on mortality among some ethnic groups, or more likely, that future mortality rates will increase among those ethnic groups that currently enjoy low mortality rates. (*Ethn Dis*. 2005;15:233–237)

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INTRODUCTION

Reaven used the term syndrome X to refer to the association of dyslipidemia, hypertension, coronary artery disease, glucose intolerance, and insulin resistance.[1] The syndrome is also characterized by increased plasma triglyceride and decreased plasma high-density lipoprotein cholesterol (HDL-c) concentrations, hypercoagulability, and hyperuricemia.[2] This clustering has also been called insulin resistance syndrome (IRS) by investigators who hypothesize a causal relationship between hyperinsulinemia and/or insulin resistance and this cardiovascular disease (CVD) risk factor cluster.[3–5] A recent report from the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATPIII) renewed interest in this syndrome and provided a set of guidelines for a standardized definition of what the panel refers to as metabolic syndrome (MS).[6] Using the new definition, the Third National Health and Nutrition Examination Survey (NHANES III) reported an overall prevalence of 21.8%.[7] Prevalence was similar in men and women, but ethnic disparities in prevalence were noted, with Mexican Americans reported to have the highest prevalence of MS (31.9%).[7]

Asian and Pacific Island Americans have been the fastest growing minority in the United States for the past 25 years, but with the exception of Japanese Americans, these populations are among the least studied with regard to obesity and obesity-associated chronic diseases.[8,9] However, growing evidence shows that transition from traditional culture to Western culture may be spurring an epidemic of diabetes, insulin resistance, and associated CVD risk factors. Such an epidemiologic transition may explain the high prevalence of type 2 diabetes,[10] insulin resistance,[11] and obesity[12] reported among Native Hawaiians. In response to these findings and to previous reports of ethnic disparities in overall and CVD mortality in Hawaii,[13] the study was expanded to include a multiethnic population for the 1996 competitive renewal (now referred to as the Kohala Health Research Project). The aim of the new study was to investigate the prevalence of insulin resistance and MS among an ethnically diverse, rural population in Hawaii. We report the findings of this study with the latest NCEP-ATPIII criteria to estimate the prevalence of MS.

METHODS

The methods of the Kohala Health Research Project have been described previously.[14] In brief, the study entailed a cross-sectional survey conducted between 1997 and 2000. All men and non-pregnant women ≥18 years old residing in North Kohala, Hawaii were invited to participate. Participants were solicited by telephone with a cross-reference directory. Community support for the research project was fostered through local public television announcements, flyers posted at community centers and stores, and presentations given to community organizations.

Participants fasted (with the exception of water) for 10–14 hours before the appointment. The health screening examination took approximately 2–3 hours. Blood was drawn in the fasting state and after a 75-g oral glucose challenge. Plasma drawn from EDTA tubes were separated within two hours; one aliquot was stored at 4°C for lipid analyses within 7 days, and the other aliquot was frozen at −80°C for hormone analyses. Triglycerides and HDL-c levels

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were measured in duplicate by using a Beckman Synchron CX4 Analyzer (Beckman Coulter, Brea, Calif) with the manufacturer's enzymatic colorimetric reagents. Supernates containing HDL-c were obtained by precipitating very low-density lipoprotein (VLDL) and low-density lipoprotein (LDL) with dextran sulfate and magnesium chloride. The plasma concentration of insulin, C-peptide, and leptin levels were determined by radioimmunoassay (RIA) in duplicate. Insulin and leptin tests were performed by using kits from Linco Research Inc. (St. Charles, Mo), whereas C-peptide was from Diagnostic Products Corporation (Los Angeles, Calif). All measurements were performed with quality control procedures in place. Our laboratory also participated in the Centers for Disease Control and Prevention and National Heart, Lung, and Blood Institute (CDC-NHLBI) lipid standardization program. Intraassay and interassay coefficient of variances were all $<10\%$.

Anthropometric measurements were obtained while standing. Height and weight were measured with participants wearing lightweight clothing without shoes and were used to calculate body mass indices (BMI; weight [kg]/height^2 [m^2]). Waist circumferences were measured at the level of the navel and used as an estimate of central adiposity.

Blood pressure was measured after participants were seated in a quiet area for at least 5 minutes and was measured in triplicate from the right arm of each individual per standardized protocol with a standard mercury sphygmomanometer.[15] The mean of the last measurements were used for statistical analyses.

Ethnicity was estimated by self-report. A total of 1,447 participants completed the entire examination and reported their ethnic ancestry. The three largest non-mixed ethnic groups were Caucasians (N=291), Japanese Americans (N=203), and Filipino Americans (N=193). Only 10 Hawaiians reported 100% Hawaiian ancestry; the remainder was of mixed ancestry, therefore Native Hawaiian (N=510) was defined here as any participant who reported descent from the indigenous Polynesian population residing in the islands of Hawaii prior to initial Western contact in 1778. A fifth group composed of predominantly mixed, non-Hawaiian ancestry included 250 individuals.

For the purposes of this report each participant was evaluated for the presence of MS, defined by the criteria set forth by the NCEP-ATPIII.[6] Participants were considered to exhibit MS if three or more metabolic abnormalities were present. The NCEP-ATPIII definition of MS and the criteria for these metabolic abnormalities are as follows: 1) abdominal obesity, waist circumference$>$102 cm (40 in) for men and $>$88 cm (35 in) for women; 2) blood pressure $\geq$130 mm Hg systolic and/or $\geq$85 mm Hg diastolic; 3) fasting glucose $\geq$6.1 mmol/L (110 mg/dL); 4) triglycerides $\geq$1.69 mmol/L (150 mg/dL); and 5) HDL cholesterol$<$1.03 mmol/L (40 mg/dL) for men and $<$1.29 mmol/L (50 mg/dL) for women. Similarly to the NHANES report, we included use of antihypertensive or antidiabetic medication as indicators of metabolic abnormalities.

Statistical Methods

Prevalence of MS among the study population was calculated for each risk category, and standard errors were calculated by using the assumption of normality for a binomial distribution. Differences between group prevalence were tested by using logistic regression. Prevalence odds ratios (POR) were estimated by taking the exponential of the logistic regression coefficient as an estimate of the strength of association and reported with test-based 95% confidence limits. Multiple logistic regression models were used to adjust for between-group differences in distribution of age, sex, BMI, and educational attainment.

RESULTS

Overall, the prevalence of MS was 33.4%, apparently higher than the prevalence estimated by NHANES for the general US population. Table 1 summarizes the prevalence of each component of the MS (central obesity, hypertension, hyperglycemia, hypertriglyceridemia, and low HDL-c). With the exception of abdominal obesity, prevalence of each component of MS was similar in both men and women. With regards to racial/ethnic group, prevalence of abdominal obesity and low HDL-c was highest among Native Hawaiians and part-Hawaiians; however, the higher prevalence of both factors was accounted for by the significantly higher BMI observed in this ethnic group (81.1%, compared to 46.5%, 56.3%, 53.6%, and 64.3% among Caucasian, Filipino, Japanese, and Other/mixed ethnic groups, respectively). Japanese, Filipino, and Hawaiian ethnic groups had similar prevalence of high blood pressure and high triglyceride levels, while Caucasian participants had significantly lower prevalence of all MS components compared to all other racial/ethnic groups.

Figure 1 illustrates the correlation between age and prevalence of MS. Table 2 summarizes the frequency of multiple metabolic abnormalities and MS by sex and ethnicity. Overall, approximately three out of four participants ex-

Table 1. Prevalence of individual components of metabolic syndrome among 1,503 participants of the Kohala Health Research Project ≥18 years of age, 1997–2001

	N	Abdominal Obesity	High Blood Pressure	High Triglycerides	Low HDL Cholesterol	High Fasting Blood Glucose
Total	1503	37.8 (1.3)	47.0 (1.3)	32.8 (1.2)	43.9 (1.3)	23.5 (1.1)
Men	684	27.9 (1.7)	50.4 (1.9)	38.0 (1.9)	41.8 (1.9)	25.9 (1.7)
Women	819	46.1 (1.7)	44.3 (1.7)	28.5 (1.6)	45.6 (1.7)	21.5 (1.4)
Ethnic group						
Caucasian	303	26.4 (2.5)	21.5 (2.4)	18.8 (2.2)	33.3 (2.7)	9.6 (1.7)
Filipino	197	34.0 (3.4)	59.9 (3.5)	42.6 (3.5)	40.6 (3.5)	28.4 (3.2)
Hawaiian	536	50.2 (2.2)	50.0 (2.2)	36.0 (2.1)	55.6 (2.1)	28.4 (1.9)
Japanese	211	26.5 (3.0)	66.8 (3.2)	43.6 (3.4)	37.4 (3.3)	30.3 (3.2)
Other/mixed	256	37.5 (3.0)	44.9 (3.1)	26.2 (2.7)	39.5 (3.1)	20.3 (2.5)
Men						
Caucasian	153	22.9 (3.4)	24.2 (3.5)	21.6 (3.3)	33.3 (3.8)	11.8 (2.6)
Filipino	76	15.8 (4.2)	65.8 (5.4)	43.4 (5.7)	35.5 (5.5)	26.3 (5.1)
Hawaiian	237	42.6 (3.2)	54.0 (3.2)	46.4 (3.2)	49.8 (3.2)	32.1 (3.0)
Japanese	100	12.0 (3.2)	71.0 (4.5)	45.0 (5.0)	40.0 (4.9)	34.0 (4.7)
Other/mixed	118	26.3 (4.1)	50.0 (4.6)	33.1 (4.3)	42.4 (4.5)	24.6 (4.0)
Women						
Caucasian	150	30.0 (3.7)	18.7 (3.2)	16.0 (3.0)	33.3 (3.8)	7.3 (2.1)
Filipino	121	45.5 (4.5)	56.2 (4.5)	42.2 (4.5)	43.8 (4.5)	29.6 (4.1)
Hawaiian	299	56.4 (2.9)	47.0 (2.9)	27.9 (2.6)	60.4 (2.8)	25.4 (2.5)
Japanese	111	39.6 (4.6)	63.1 (4.6)	42.3 (4.7)	35.1 (4.5)	27.0 (4.2)
Other/mixed	138	47.1 (4.2)	40.6 (4.2)	20.3 (3.4)	37.0 (4.1)	16.7 (3.2)

hibited one or more metabolic abnormalities, and one third exhibited three or more abnormalities, thus fulfilling the criteria for MS. All prevalence rates were similar for men and women. Again, Caucasians had lower prevalence of multiple abnormalities, with a prevalence of MS<15%, less than half the prevalence of any other ethnic group. Despite a high prevalence of overweight, Hawaiians and part-Hawaiians were observed to have only slightly higher prevalence of MS (42.0%) than Filipino (39.6%), Japanese (37.0%), and other/mixed non-Hawaiians (30.1%).

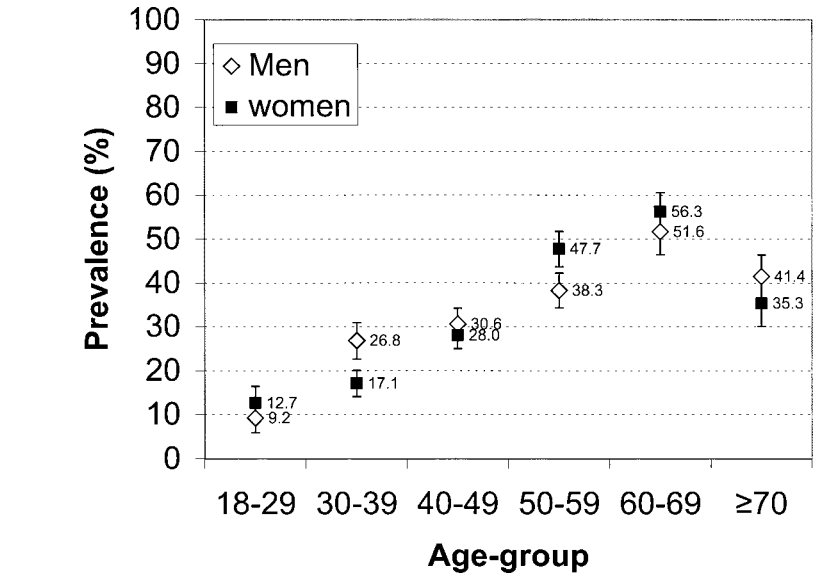

Fig 1. Age-specific prevalence of metabolic syndrome among 1,503 adults 18 years and older, Kohala Health Research Project, 1997–2001

Prevalence odds ratios (POR) estimated by logistic regression with Caucasians as the reference group were significantly higher than the null value for all non-Caucasian groups. After adjustment for BMI, age, sex, and years of education (Figure 2), the Filipino population appeared to have the highest odds for prevalent MS (prevalence OR=4.2; 95% CI=2.4–7.3).

DISCUSSION

In summary, prevalence of MS was significantly higher among all ethnic groups when compared to Caucasians. Despite significant differences in the prevalence of overweight and abdominal obesity, the prevalence of MS was similar in all non-Caucasian ethnic groups. Finally, after adjusting for age, BMI,

Table 2. Prevalence of one or more abnormalities of the Metabolic Syndrome among 1,503 adults ≥18 years, Kohala Health Research Project, 1997–2001

	N Metabolic Abnormalities % (SE)				
			Metabolic Syndrome		
	=1	=2	=3	=4	5
Total	76.5 (1.3)	53.8 (1.8)	33.4 (2.1)	15.4 (2.4)	5.9 (2.5)
Men	78.1 (1.8)	53.2 (2.6)	33.6 (3.1)	14.5 (3.5)	4.7 (3.7)
Women	75.2 (1.7)	54.3 (2.4)	33.2 (2.9)	16.2 (3.2)	6.8 (3.4)
Ethnic group					
White	56.8 (3.8)	32.7 (4.7)	14.5 (5.3)	4.6 (5.6)	1.0 (5.7)
Filipino	82.2 (3.0)	60.4 (4.5)	39.6 (5.5)	19.3 (6.4)	4.1 (7.0)
Hawaiian	84.0 (1.7)	64.2 (2.6)	42.0 (3.3)	20.9 (3.8)	9.3 (4.1)
Japanese	83.4 (2.8)	59.2 (4.4)	37.0 (5.5)	17.5 (6.3)	7.6 (6.6)
Other/mixed	74.2 (3.2)	47.7 (4.5)	30.1 (5.2)	12.1 (5.9)	4.3 (6.1)

and sex, prior type 2 diabetes mellitus, and C-peptide levels, Filipinos have the highest odds for prevalent MS.

Ethnic differences in CVD risk factors do not appear to parallel disparities in CVD mortality reported by Braun et al.[13] Mortality rates in Hawaii are reported to be lowest among Japanese, Chinese, and Filipino ancestry residents, while Hawaiians have been shown to have among the highest mortality rates.[13] In contrast, we observed that Japanese, Filipino, and Hawaiian ancestry groups appear to be similar with regards to prevalence of MS and its component CVD risk factors. On the other hand, Caucasians are reported to have mortality rates that are intermediate between Hawaiians/part-Hawaiians, and Japanese and Chinese, yet the prevalence of MS and all of its components was significantly lower among Caucasians than all other groups.

Several possible explanations exist for the apparent discrepancy between our observations on MS prevalence and previous reports of ethnic disparities in CVD mortality. One explanation may be that high mortality rates among Native Hawaiians reflect differences in healthcare access and utilization arising from historical, geographic, cultural, and socio-economic factors rather than higher prevalence of CVD risk factors.

While differences in socio-economic status may explain higher mortality rates among Hawaiians, they are unlikely to fully explain the mortality differences between Asian ancestry ethnic groups and Caucasians.

An alternative explanation may be that differential effects of CVD risk factors on mortality may exist in different ethnic groups. A comparison of stroke incidence among the Framingham and Honolulu Heart Program cohorts reported by Rodriguez et al revealed that incidence of thromboembolic stroke was 40% lower among Japanese Americans even after adjustment for age and other risk factors.[16] Reduced CVD incidence and mortality despite high prevalence of CVD risk factors may thus be a result of culturally determined protective factors. Another study by Rodriguez et al reported that fish consumption reduced risk for CVD morbidity and mortality among Japanese-American smokers.[17]

Finally, mortality differences are based on cross-sectional observations of mortality and may be greatly affected by cohort effects. Conventional methods of comparing mortality rates effectively ignore cohort effects.[18] Thus, low mortality among the currently elderly populations, who may have had healthier lifestyles at younger ages, might skew the current, observable mortality rates among Japanese and Chinese ethnic groups. If this supposition is true, the high MS prevalence among Asians will lead to drastic increases in CVD morbidity and mortality as younger, at-risk cohorts progressively age.

The prevalence of MS and all of its component abnormalities were not only lower among Caucasian-ancestry participants than participants of other ethnic ancestries, but are lower than observed among Caucasian participants of the NHANES III survey (age-adjusted prevalence 23.8%).[7] In fact, the prevalence among Caucasian-ancestry participants was lower than all ethnic groups described in the NHANES report. This finding may indicate that Caucasians residing in Kohala are not representative of Caucasians elsewhere, or representative of Kohala residents, possibly because of selection bias. Moreover, the

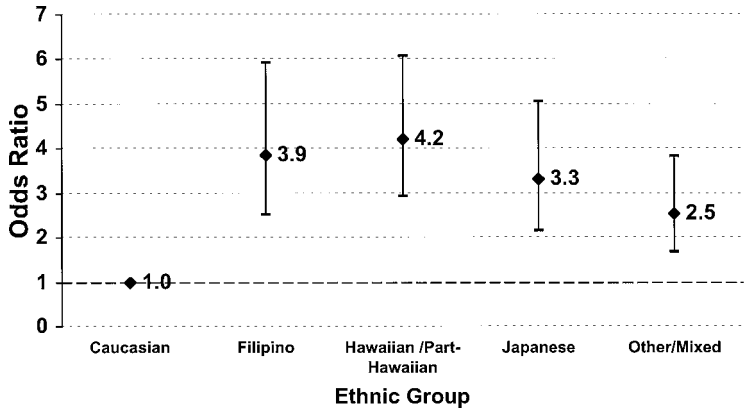

Fig 2. Crude odds ratios for prevalent metabolic syndrome by ethnic group, Kohala Health Research Project, 1997–2001

One important finding of our study was that, after adjusting for BMI and age, Filipinos had the highest prevalence of metabolic syndrome.

NHANES surveys include a representative sample based on US Census data, of which only approximately 21% are from rural areas. However, although Caucasians participating in the study reported an average of 15 years of education, about three years more education than other ethnic groups, statistical adjustment for education did not account entirely for the significantly lower prevalence of MS among Caucasians.

One important finding of our study was that, after adjusting for BMI and age, Filipinos had the highest prevalence of MS. This finding is consistent with a recent report by Areneta et al[19] that estimated prevalence of diabetes and MS in Filipino-ancestry women residing in the San Diego area. Filipinos represent one of the most recent waves of immigration to Hawaii, and approximately one third of the KHRP participants in this ethnic group were born in the Philippines. Approximately three out of four Filipino-ancestry participants indicated that they consume a traditional Filipino diet (data not shown). Therefore, these collective observations may indicate that this population could be at particularly high risk in the future for epidemic increases in diabetes and cardiovascular disease as future generations abandon traditional diet and lifestyle for a more Western lifestyle. Currently, little data on Filipino health exist; therefore, further studies are needed to examine what impact the high prevalence of MS may have on future CVD incidence and mortality among this ethnic group.

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