Metabolic syndrome among Caribbean-born persons living in the U.S. Virgin Islands

Eugene S. Tull,[1] *Anne Thurland,*[2] *and Ronald E. LaPorte*[1]

Suggested citation Tull ES, Thurland A, LaPorte RE. Metabolic syndrome among Caribbean-born persons living in the U.S. Virgin Islands. Rev Panam Salud Publica. 2005;18(6):418–26.

ABSTRACT

Objectives. *To determine the frequency of the metabolic syndrome (MS) among four subpopulations in the United States Virgin Islands and to estimate the risk for the MS that is associated with waist circumference cutpoints among overweight and obese individuals.*

Methods. *In a study undertaken from 1995 to 1999, data on demographic characteristics, anthropometric measurements, blood pressure measurements, and a blood sample were obtained from a population-based cohort of 893 Caribbean-born persons from four population subgroups who were living on Saint Croix (the largest island of the U.S. Virgin Islands) and who did not have a history of diagnosed diabetes. The four subpopulations were: (1) Hispanic white, (2) Hispanic black, (3) non-Hispanic black born in the U.S. Virgin Islands, and (4) non-Hispanic black born elsewhere in the Caribbean. Fasting blood samples were analyzed for glucose, insulin, triglycerides, and high-density lipoprotein cholesterol (HDL-C). National Cholesterol Education Program Adult Treatment Panel III guidelines were used to identify the MS. Insulin resistance was estimated by the homeostasis model assessment (HOMA-IR) method.*

Results. *The overall prevalence of the MS in the sample was 20.5% (95% confidence interval (CI) = 15.3%–25.7%). Persons who had classified themselves as both Hispanic and black had the highest frequency (27.8% (95% CI = 16.3%–39.3%)) of the MS and the highest HOMA-IR scores. After controlling for lifestyle factors and HOMA-IR, Hispanic ethnicity was independently associated with an increased risk of having the MS (odds ratio (OR) = 1.82, (95% CI = 1.07–3.07)), high triglycerides (OR = 3.66 (95% CI = 2.18–6.15)), and low HDL-C (OR = 1.60 (95% CI = 1.04–2.45)). A waist circumference of > 88 cm was associated with an increased risk of metabolic abnormalities among overweight and obese women.*

Conclusions. *The frequency of the MS among Caribbean-born persons in the U.S. Virgin Islands is comparable to the frequency of the MS among the general population on the mainland of the United States. Among Caribbean-born persons living in the U.S. Virgin Islands, those who are Hispanic blacks may have a greater risk of cardiovascular disease than do other groups.*

Key words Metabolic syndrome X, continental population groups, risk factors, obesity, Virgin Islands of the United States.

[1] University of Pittsburgh, Graduate School of Public Health, Department of Epidemiology, Pittsburgh, Pennsylvania, United States of America. Send correspondence to: Eugene S. Tull, 512 Paran Hall, 130 DeSoto Street, Pittsburgh, Pennsylvania 15213, United States of America; fax: 412-624-2961; e-mail: drmirt@yahoo.com

[2] Virgin Islands Department of Health, Division of Health Promotion, Christiansted, U.S. Virgin Islands, United States of America.

An increased risk for developing cardiovascular disease and diabetes mellitus is associated with a clustering of metabolic abnormalities that is referred to as the metabolic syndrome and that includes hypertension, glucose intolerance, high triglycerides, low high-density lipoprotein cholesterol (HDL-C), and abdominal obesity (1, 2). The strong association of abdominal obesity with metabolic abnormalities has prompted the National Institutes of Health (NIH) of the United States of America (3) and the World Health Organization (WHO) (4) to issue guidelines for the use of gender-specific waist circumference cutpoints to identify abdominal obesity. Recently, it has been demonstrated that these waist circumference cutpoints can improve the prediction of health risk within ranges of body mass index (BMI) that characterize individuals who are overweight or obese (5). However, it is still not clear whether the various waist circumference cutpoints are associated with an increased risk of the metabolic syndrome among obese or overweight individuals in all ethnic groups.

Recent studies have documented high rates of obesity in several Caribbean countries (6, 7). Nevertheless, very little is known about the frequency of the metabolic syndrome and related metabolic abnormalities among Caribbean-born persons who are still living in the Caribbean. To address this concern, the Virgin Islands Diabetes Study (VIDS) (8), a population-based cross-sectional study of the prevalence of diabetes and related metabolic abnormalities, was undertaken between 1995 and 1999 on the island of Saint Croix in the United States Virgin Islands (USVI), a territory of the United States that is located in the eastern Caribbean, approximately 70 miles (113 km) east of the island of Puerto Rico. (Saint Croix is the largest island of the U.S. Virgin Islands.) The USVI is unique among Caribbean nations or territories because of its ethnic diversity. More than half of the adult residents of the USVI are immigrants from other Caribbean islands (mainly the eastern Caribbean islands of Antigua, Dominica, Saint Kitts and Nevis, and Saint Lucia). In addition, 20% of the USVI population is of Hispanic ethnicity, with origins in Puerto Rico or the Dominican Republic.

The study presented in this paper utilized data collected in the VIDS to determine if the frequency of the metabolic syndrome varied by race, ethnicity, or place of birth among Caribbean-born persons living in the USVI. Another objective of our metabolic syndrome study was to assess whether the waist circumference and BMI parameters based on NIH and WHO anthropometric guidelines are associated with increased risk of metabolic abnormalities in the USVI. This report presents a summary of our analyses.

MATERIALS AND METHODS

The population for this study of the metabolic syndrome consisted of a randomly selected sample of individuals, 20 years of age and older, who participated in the VIDS. Potential participants were recruited by in-home interview from households that were randomly selected from a list of customers of the Virgin Islands Water and Power Authority, which included 98% of the households on the island of Saint Croix. One participant was randomly selected from each household. The participation rate in the VIDS was around 77%, with the distribution by race and ethnicity being similar to that of the 1990 census on the island of St. Croix (8). The demographic characteristics of those who participated in the study did not differ significantly from those who did not participate (8). Each participant signed a consent form approved by the Biomedical Institutional Review Board of the University of Pittsburgh, where the principal investigator for the study is a faculty member.

A total of 1 080 Caribbean-born persons participated in the VIDS. These individuals were asked to classify their own race and ethnicity based on a standardized form that had been used in the 1990 census done in the USVI. Based on these self-classifications, the participants were distributed in the following groupings: 174 Hispanic blacks, 68 Hispanic whites, 781 non-Hispanic blacks, 6 non-Hispanic whites, 3 non-Hispanic Asians, and 48 persons with unspecified race. Because of small sample sizes, the non-Hispanic whites and Asians, as well as persons with unspecified race, were excluded from further analyses. Although type 2 diabetes clusters with other metabolic abnormalities that comprise the metabolic syndrome, those persons who are diagnosed with diabetes are more likely to receive treatment that would affect serum levels of other metabolic components of the metabolic syndrome and insulin. Therefore, all persons with a prior history of diabetes were excluded from this assessment. The remaining sample consisted of 151 Hispanic blacks, 58 Hispanic whites, and 684 non-Hispanic blacks (440 immigrants and 240 USVI-born individuals).

Demographic data and information about lifestyle practices were collected by interview. Lifestyle variables included physical activity, fast food consumption, alcohol consumption, and smoking status. Physical activity was assessed as the presence or absence of leisure-time physical activity. The fast food consumption pattern was measured as the number of days each week spent eating at a fast food restaurant. The measurement of alcohol consumption was based on a "yes" or "no" response to having consumed at least one alcoholic beverage during the past month. Smoking status was measured as a "yes" or "no" response to being a current smoker.

Clinical procedures that were conducted included measurement of blood pressure and of anthropometric parameters (weight, height, waist circumference). Blood pressure was measured after an initial five-minute rest, using a standard mercury sphygmomanometer, with the participant in a seated position. Weight was measured on a balance beam scale without shoes, using standard procedures (9). Body mass index was calculated as weight in kilograms (kg) divided by height in meters squared (m^2). Individuals with a BMI value of 25.0–29.9 were classified as overweight, and those with a

value ≥ 30.0 were classified as obese. Based on NIH guidelines (3), abdominal obesity was classified as a waist circumference value > 80 cm in women and > 102 cm in men. The WHO guidelines (4) identified abdominal obesity as a waist circumference value > 80 cm in women and > 94 cm in men.

Blood samples, drawn after an overnight fast of 10–12 hours, were measured for serum glucose at the Juan F. Louis Hospital Clinical Laboratory on Saint Croix. All other tests, including measurement of fasting insulin, triglycerides, and HDL-C, were performed at the Heinz Nutrition Laboratory at the University of Pittsburgh. Insulin was measured using a radioimmunoassay procedure (kit HI-14K, Linco Research, Inc., St. Charles, Missouri, United States). Cross-reactivity with proinsulin was under 0.02%. Triglyceride levels were determined enzymatically, using the procedure of Bucolo et al. (10). The HDL-C level was determined using selective precipitation of other lipoproteins by heparin-manganese chloride (11). Insulin resistance was estimated by the homeostasis model assessment (HOMA-IR) method, according to the following formula: fasting glucose (mmol/L) × fasting insulin (μU/mL))/22.5 (12).

Classification of the metabolic syndrome

The metabolic syndrome was defined according to the most recent National Cholesterol Education Program Adult Treatment Panel (ATP III) guidelines (13) as being any three of the following five characteristics: (1) blood pressure > 130/85 mmHg, (2) fasting glucose level of ≥ 6.1 mmol/L (≥ 110 mg/dL), (3) triglyceride level ≥ 1.7 mmol/L (≥ 150 mg/dL), (4) HDL-C level < 1.0 mmol/L (< 40 mg/dL) in men or < 1.3 mmol/L (< 50 mg/dL) in women, or (5) waist circumference > 102 cm for men or > 88 cm for women.

Statistical analysis

Statistical analyses were conducted using Statistical Analysis System (SAS) software (14). Spearman correlation coefficients were used to examine interrelationships between variables. Maximum likelihood analysis of variance statistics in the CATMOD procedure was used to determine if the frequency of the metabolic syndrome differed among the ethnic/racial groups in the study. Pairwise comparisons of frequencies were performed with the chi-square (χ^2) test or Fisher's exact test. Logistic regression analyses were used to compute odds ratios for having the metabolic syndrome and other metabolic abnormalities associated with independent variables of interest. In these models, dummy variables were used to model variables that were dichotomized. The logarithm of HOMA-IR scores was used in analyses because of the skewed distribution of insulin values.

RESULTS

Demographic and anthropometric characteristic

Table 1 shows the demographic characteristics and anthropometric parameters of the four population subgroups in the sample. Compared to the other groups, USVI-born non-Hispanic blacks were younger and more educated. The USVI-born non-Hispanic black group also had a larger percentage of females. About one-third of the women in each of the four groups were either overweight or obese. An age-adjusted comparison of the frequency of overweight, obesity, and abdominal obesity revealed no significant differences among women

TABLE 1. Demographic characteristics and prevalence of abnormal anthropometric measurements, with 95% confidence intervals (95% CIs), for individuals without a prior history of diabetes from four population subgroups on the island of St. Croix, U.S. Virgin Islands (USVI), 1995–1999

	Hispanic individuals		Non-Hispanic black individuals	
	White	Black	Immigrant	USVI-born
	(*n* = 58)	(*n* = 151)	(*n* = 440)	(*n* = 440)
Age (mean yr ± SD)[a]	47.7 ± 18.1[b]	47.3 ± 15.0[b]	48.5 ± 13.5[b]	41.7 ± 17.0[c,d,e]
Gender (female % (with 95% CI))	67.2 (58.7–75.7)	66.8 (61.5–72.1)	65.6 (62.4–68.8)[e]	73.1 (69.8–76.4)[d]
Education < high school (% (with 95% CI))	39.7 (24.0–55.4)[b]	50.9 (43.1–58.7)[b]	44.7 (39.5–49.9)[b]	22.2 (12.4–32)[c,d,e]
Overweight, BMI = 25.0–29.9[f]				
Male (% (with 95 % CI))	26.3 (0.0–56.3)	32.0 (12.96–51.04)	53.6 (46.2–61.02)[c,e]	37.5 (22.1–52.9)[d]
Female (% (with 95% CI))	30.7 (8.7–52.7)	35.6 (23.0–48.2)	33.9 (26.3–41.5)	26.7 (16.0–37.4)
Obesity, BMI > 30.0				
Male (% (with 95 % CI))	26.3 (0.0–56.7)	28.0 (7.8–48.2)	18.4 (5.4–31.4)	34.3 (18.1–50.5)[e]
Female (% (with 95 % CI))	43.5 (26.5–61.4)	35.6 (23.0–48.2)	44.3 (37.9–50.7)	38.8 (29.9–47.7)

[a] Age values are mean and standard deviation (SD).
[b] Values are significant at $P < 0.05$ compared to non-Hispanic black USVI-born.
[c] Values are significant at $P < 0.05$ compared to Hispanic white.
[d] Values are significant at $P < 0.05$ compared to Hispanic black.
[e] Values are significant at $P < 0.05$ compared to non-Hispanic black immigrant.
[f] BMI = body mass index.

TABLE 2. Frequency of metabolic abnormalities and age-adjusted mean insulin resistance score (HOMA-IR), with 95% confidence intervals (95% CIs), for individuals without a prior history of diagnosed diabetes among four population subgroups on the island of St. Croix, U.S. Virgin Islands (USVI), 1995–1999

	Hispanic individuals		Non-Hispanic black individuals	
	White	Black	Immigrant	USVI-born
	(*n* = 58)	(*n* = 151)	(*n* = 440)	(*n* = 244)
Metabolic syndrome (% (with 95% CI))	25.9 (6.7–45.1)	27.8 (16.3–39.3)	18.9 (11.3–26.3)[a]	17.6 (7.3–27.9)
High serum triglycerides (% (with 95% CI))	25.8 (6.6–45.0)[b,c]	27.8 (16.3–39.3)[b,c]	11.6 (3.3–19.8)[a,d]	9.4 (0.0–20.7)[a,d]
Low HDL-C (% (with 95% CI))[e]	63.8 (45.6–73.2)[a,b,c]	48.3 (40.0–56.6)[b,d]	37.9 (32.1–43.7)[a,d]	45.1 (38.2–52.0)[d]
Abnormal fasting blood glucose (% (with 95% CI))	6.9 (0.0–31.1)	11.9 (0.0–26.0)	13.8 (5.7–21.9)	8.6 (0.0–20.1)
Elevated blood pressure (% (with 95% CI))	46.5 (32.7–60.3)	45.7 (37.0–54.4)	51.1 (46.5–55.7)	43.8 (36.7–50.8)
HOMA–IR score (mean (with 95% CI))	1.23 (1.08–1.38)	1.46 (1.37–1.55)[b,c,d]	1.32 (1.27–1.38)[a]	1.34 (1.26–1.41)[a]

[a] Values are significant at $P < 0.05$ compared to Hispanic black.
[b] Values are significant at $P < 0.05$ compared to non-Hispanic black immigrant.
[c] Values are significant at $P < 0.05$ compared to non-Hispanic black USVI-born.
[d] Values are significant at $P < 0.05$ compared to Hispanic white.
[e] HDL-C = high-density lipoprotein cholesterol.

in the four groups. The frequency of overweight was highest among non-Hispanic black immigrant men. Conversely, non-Hispanic black immigrant men had the lowest frequency of obesity. Based on the 94-cm cutpoint, the highest frequency of abdominal obesity was among Hispanic black men, and the lowest was among non-Hispanic black immigrant men. The USVI-born non-Hispanic black men had the highest frequency of waist circumference > 102 cm.

Overall prevalence of the metabolic syndrome

In the entire sample the prevalence of the metabolic syndrome was 17.9% (95% confidence interval (CI) = 8.4%–27.4%) in men and 21.6% (95% CI = 15.3%–25.7%) in women. The overall prevalence of the metabolic syndrome was 20.5% (95% CI = 15.3%–25.7%).

Variation by ethnicity, race, and place of birth

Table 2 shows the frequency of the metabolic syndrome and related metabolic abnormalities, together with the age-adjusted mean of the logarithm of the HOMA-IR scores for the four population subgroups. Hispanic persons tended to have a higher prevalence of the metabolic syndrome, and they were also twice as likely to present with an elevated triglyceride value. The frequency of low HDL-C was higher among Hispanic white persons than in the other groups. There were no significant differences among the groups in the frequency of abnormal fasting glucose or elevated blood pressure. The mean logarithm of the HOMA-IR score for the Hispanic black group was higher than that of the other groups.

Among the non-Hispanic black persons, there were no significant differences by place of birth (i.e., USVI-born vs. immigrants) in the frequency of the metabolic syndrome or any individual metabolic abnormality (Table 2). A comparison of the frequency of the metabolic syndrome and individual metabolic abnormalities by place of birth among Hispanic persons is shown in Table 3. The crude frequencies for the metabolic syndrome, high triglycerides, abnormal fasting glucose, and elevated blood pressure are higher for Hispanic immigrants than they are for USVI-born Hispanics, but only the odds ratio (OR) for the comparison of the frequencies of elevated blood pressure was significant (OR = 2.14 (95% CI = 1.23–3.73),

TABLE 3. Prevalence (%), with 95% confidence intervals (95% CIs), of metabolic abnormalities for Hispanic immigrants and Hispanic persons born in the U.S. Virgin Islands (USVI) and odds ratio comparing prevalence of abnormalities by place of origin, Saint Croix, U.S. Virgin Islands, 1995–1999

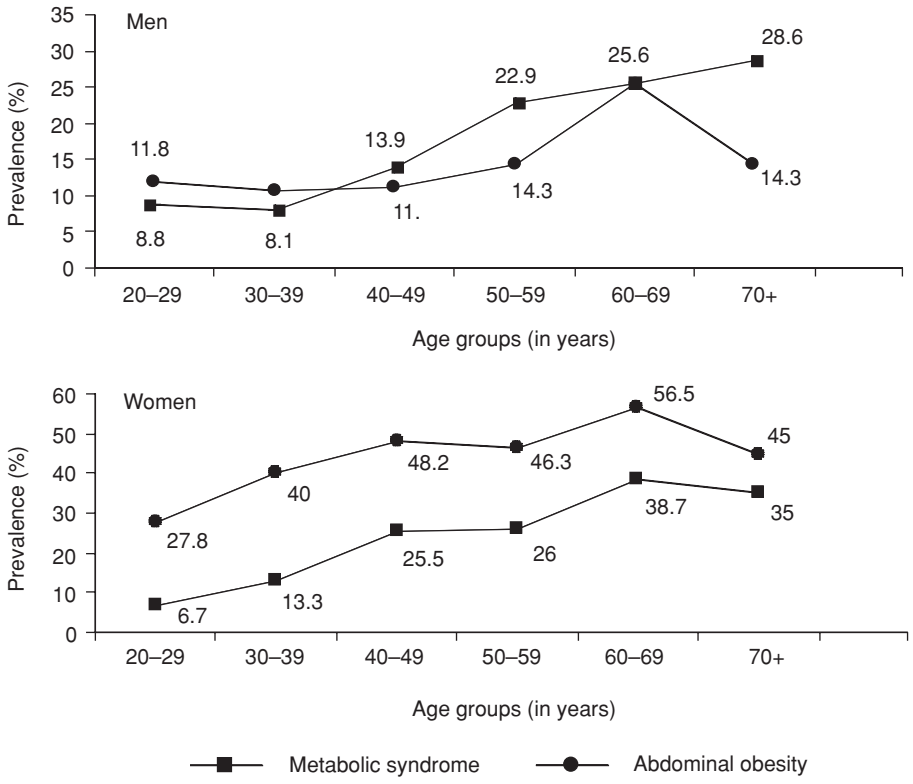
	Place of origin						
	Hispanic immigrant (*n* = 105)		USVI-born Hispanic (*n* = 104)		Odds ratio (OR)		
Variable	%	95% CI	%	95% CI	OR	95% CI	*P* value
Metabolic syndrome	30.5	17.1–43.9	24.0	9.3–38.7	1.38	0.75–2.55	0.2970
High serum triglycerides	30.8	25.0–36.6	24.0	9.3–38.7	1.38	0.75–2.55	0.2972
Low HDL cholesterol	50.4	40.9–59.9	54.8	46.1–63.5	0.84	0.48–1.44	0.5316
Abnormal fasting blood glucose	4.3	0.0–30.7	6.7	0.0–24.6	2.30	0.90–5.92	0.0759
Elevated blood pressure	55.2	46.6–63.8	36.5	24.3–48.7	2.14	1.23–3.72	0.0067

P = 0.0067). However, Hispanic immigrants were significantly older than were USVI-born Hispanic persons (53.1 yr (95% CI = 50.2–55.9) vs. 41.7 yr (95% CI = 38.9–44.6), respectively; P < 0.0001). After adjusting for the difference in age between immigrant Hispanics and USVI-born Hispanics, the odds ratio for elevated blood pressure became nonsignificant (OR = 1.25 (95% CI = 0.66–2.34), P = 0.4853).

Variations by age

Figure 1 shows the frequency of the metabolic syndrome and abdominal obesity by gender and 10-year age groups for the combined sample. While these data appear to show an increase in prevalence of the metabolic syndrome and abdominal obesity with advancing age among men and women, it is important to note that the population sizes in each of the age categories are small and that the prevalence estimates have wide confidence intervals (not shown), indicating a lack of precision in the estimates.

FIGURE 1. Age-specific prevalence of the metabolic syndrome and abdominal obesity[a] among men and women, Saint Croix, U.S. Virgin Islands, 1995–1999[b]



[a] Abdominal obesity = waist circumference > 102 cm in men and > 88 cm in women.
[b] Data are presented only for Hispanic persons and for non-Hispanic black persons without a prior history of diagnosed diabetes.

Risk factors for metabolic syndrome

We conducted logistic regression analyses to determine if the relationship of ethnicity and race to the frequency of the metabolic syndrome, elevated serum triglycerides, and low HDL-C would be attenuated after adjusting for possible confounders. In the models presented in Table 4, Hispanic ethnicity was independently associated with an increased risk of having the metabolic syndrome, elevated triglycerides, and low HDL-C in models that included demographic and lifestyle variables, BMI, and degree of insulin resistance. White race was also independently associated with an increased likelihood of having low HDL-C. Other independent risk factors for the metabolic syndrome included older age and a higher HOMA-IR (insulin resistance) score. The association between female gender and the risk of having the metabolic syndrome approached significance (P = 0.067).

Relationship to body mass index and to waist circumference cutpoints

Table 5 shows age- and- ethnicity-adjusted odds ratios relating abnormal levels of BMI and waist circumference to the likelihood of having the metabolic abnormalities associated with the metabolic syndrome. Among men, obesity was associated with an increased risk of having low HDL-C, abnormal blood glucose, and elevated blood pressure, while being overweight was associated only with an increased risk of having high serum triglycerides. Among women, obesity was associated with an increased likelihood of having elevated serum triglycerides and abnormal blood glucose. Women who were overweight did not show an increased risk of having any metabolic abnormality associated with the metabolic syndrome. In both men and women, waist circumference cutpoints were significantly associated with more individual metabolic abnormalities than the abnormal BMI categories were.

To examine whether the waist circumference cutpoints would be associated with an increased risk of metabolic abnormalities independent of BMI, odds ratios comparing high and low waist circumference levels were estimated within the overweight and obese categories of body weight. The results, which are presented in Table 6, show that the waist circumference cutpoint of 94 cm was not associated with an increased risk of any metabolic abnormality among men who were either overweight or obese. Because of sample size limitations, odds ratios

TABLE 4. Odds ratios (ORs), with 95% confidence intervals (95% CIs), from multiple logistic regression models that assessed the association of demographic, lifestyle, and metabolic factors to metabolic syndrome, high serum triglycerides, and low serum HDL cholesterol (HDL-C), Saint Croix, U.S. Virgin Islands, 1995–1999

Independent variable	Model for metabolic syndrome		Model for high triglycerides		Model for low HDL-C	
	OR	95% CI	OR	95% CI	OR	95% CI
Age (yr)	1.04	1.02–1.05[a]	1.03	1.01–1.05[a]	0.97	0.96–0.98[a]
Gender (0 = male, 1 = female)	1.56	0.96–2.52	0.46	0.28–0.72[a]	2.20	1.54–3.15[a]
Ethnicity (0 = non-Hispanic, 1 = Hispanic)	1.82	1.07–3.07[a]	3.66	2.18–6.15[a]	1.60	1.04–2.45[a]
Race (0 = black, 1 = white)	1.34	0.53–3.40	0.98	0.42–2.31	2.26	1.03–4.97[a]
Education (0 = ≥ high school, 1 = < high school)	1.49	0.92–2.39	0.77	0.44–1.25	1.23	0.85–1.78
Household income (US$/yr)	1.04	0.92–1.16	0.95	0.84–1.07	1.05	0.97–1.15
Smoking (0 = nonsmoker, 1 = current smoker)	0.49	0.15–1.51	1.02	0.42–2.49	0.75	0.37–1.50
Drinking (0 = no drinks, 1 = ≥ 1 drink in past month)	0.85	0.54–1.13	0.90	0.56–1.43	0.70	0.50–0.97[a]
Fast food eating (0 = < 2 days/wk, 1 = ≥ 2 days/wk)	1.36	0.84–2.21	1.55	0.93–2.59	1.02	0.70–1.48
Physical activity (0 = active, 1 = inactive)	0.87	0.49–1.54	0.81	0.44–1.49	1.02	0.66–1.56
BMI[b] (0 = BMI < 25 kg/m^2, 1 = BMI ≥ 25 kg/m^2)	1.69	0.96–2.98	1.08	0.62–1.88	1.34	0.90–1.91
HOMA-IR score[c]	5.59	3.69–8.46[a]	3.37	2.23–5.09[a]	1.52	1.13–2.0[a]

[a] Values are significant at $P < 0.05$.
[b] BMI = body mass index.
[c] HOMAR-IR = homeostasis model assessment.

could not be estimated using the 102-cm cutpoint among men. Among women, the waist circumference cutpoint of 80 cm was associated with an unadjusted increased risk of having elevated serum triglycerides. However, after adjusting for age and ethnicity, the cutpoint of 80 cm was not associated with any metabolic abnormality among women. The 88-cm cutpoint was associated with multiple metabolic abnormalities among both overweight and obese women.

DISCUSSION

We found that the overall prevalence of the metabolic syndrome among Caribbean-born residents of the USVI who were either of Hispanic ethnicity or of non-Hispanic black background is similar to the rate reported for the general population on the mainland of the United States (15). Also consistent with national data from the United States (16) is our observation that Hispanic ethnicity is associated with an increased risk of the metabolic syndrome in the USVI. The higher prevalence of the metabolic syndrome that we observed among the Caribbean-born Hispanic persons in the USVI appears to be closely related to their relatively greater tendency towards elevated serum triglycerides and low serum HDL-C compared to non-Hispanic USVI blacks. This observation is in accord with reports that have documented a more favorable triglyceride and HDL-C profile among non-Hispanic blacks

TABLE 5. Odds ratios (ORs), with 95% confidence intervals (95% CIs), for metabolic abnormalities associated with abnormal levels of body mass index (BMI) and waist circumference among men and women, Saint Croix, U.S. Virgin Islands, 1995–1999[a]

	High serum triglycerides		Low HDL-C[b]		Abnormal blood glucose		Elevated BP[c]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Men								
Overweight BMI[d]	2.27	1.04–4.94[d]	1.43	0.72–2.83	2.39	0.88–6.43	1.72	0.93–3.69
Obese BMI[e]	1.28	0.82–2.01	1.95	1.35–2.80[f]	2.30	1.33–3.96[f]	1.57	1.08–2.89[f]
Waist > 94 cm	1.62	0.90–2.91	2.83	1.67–4.77[f]	2.70	1.38–5.31[f]	2.23	1.31–3.94[f]
Waist > 102 cm	0.71	0.29–1.73	2.69	1.57–5.31[f]	3.27	1.49–7.14[f]	2.28	1.02–5.11[f]
Women								
Overweight BMI[d]	0.87	0.39–1.92	1.05	0.67–1.66	0.65	0.28–1.35	1.16	0.67–2.03
Obese BMI[e]	1.54	1.03–2.31[f]	1.29	0.97–1.50	1.44	1.10–1.87[f]	1.07	0.72–1.58
Waist > 80cm	4.04	1.88–8.64[f]	1.54	1.07–2.18[f]	1.83	0.91–3.78	1.79	1.19–2.71[f]
Waist > 88cm	2.98	1.75–5.06[f]	2.01	1.44–2.81[f]	3.08	1.68–5.64[f]	2.60	1.78–3.78[f]

[a] All odds ratios are adjusted for age and ethnicity.
[b] HDL-C = high-density lipoprotein cholesterol.
[c] Elevated BP = elevated blood pressure.
[d] Overweight category based on BMI = 25.0–29.9.
[e] Obese category based on BMI ≥ 30.0.
[f] Values are significant at $P < 0.05$.

TABLE 6. Crude and adjusted odds ratios (ORs), with 95% confidence intervals (95% CIs), for metabolic abnormalities associated with National Institutes of Health and World Health Organization waist circumference cutpoints among overweight and obese men and women, Saint Croix, U.S. Virgin Islands, 1995–1999

	Overweight[a]				Obese[b]			
	Crude		Adjusted[c]		Crude		Adjusted[c]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Men								
Waist > 94 cm								
High serum triglycerides	2.24	0.97–5.17	1.92	0.76–4.18	1.59	0.47–14.91	1.98	0.16–24.18
Low HDL cholesterol	1.97	0.86–4.49	1.90	0.73–4.88	2.84	0.51–1.79	2.46	0.39–15.40
Abnormal fasting blood glucose	2.06	0.78–5.42	1.69	0.57–5.02	0.87	0.15–4.93	0.75	0.11–5.32
Elevated blood pressure	1.59	0.68–3.69	1.06	0.46–2.89	3.83	0.79–19.01	3.74	0.58–24.01
Waist >102 cm								
High serum triglycerides		—[d]		—[d]		—[d]		—[d]
Low HDL cholesterol		—[d]		—[d]		—[d]		—[d]
Abnormal fasting blood glucose		—[d]		—[d]		—[d]		—[d]
Elevated blood pressure		—[d]		—[d]		—[d]		—[d]
Women								
Waist > 80 cm								
High serum triglycerides	9.01	1.17–69.38[e]	6.62	0.83–52.69	2.20	0.27–17.05	2.17	0.25–18.94
Low HDL cholesterol	1.14	0.62–2.10	1.21	0.63–2.35	0.98	0.32–3.00	0.97	0.31–3.05
Abnormal fasting blood glucose	0.83	0.26–2.60	0.57	0.16–1.93	—[d]	—[d]		
Elevated blood pressure	1.16	0.63–2.16	0.74	0.36–1.51	2.28	0.68–7.63	2.72	0.71–10.30
Waist > 88 cm								
High serum triglycerides	4.86	1.77–13.31[e]	4.01	1.41–11.44[e]	1.81	0.51–2.73	1.22	0.50–2.99
Low HDL cholesterol	2.93	1.52–5.64[e]	3.47	1.72–7.00[e]	1.24	0.69–2.33	1.34	0.74–2.45
Abnormal fasting blood glucose	2.06	1.18–4.26[e]	1.94	0.59–6.33	8.68	1.51–65.65[e]	8.62	1.22–63.30[e]
Elevated blood pressure	2.25	1.18–4.26[e]	1.99	0.97–4.07	2.09	1.14–3.80[e]	2.12	1.09–4.15[e]

[a] Overweight category based on body mass index = 25.0 to 29.9.
[b] Obese category based on body mass index ≥ 30.0.
[c] Odds ratios are adjusted for age and ethnicity.
[d] Sample size too small to estimate odds ratio.
[e] Values significant at $P < 0.05$.

compared to people of Hispanic or white European origins in the United Kingdom and in the United States (17, 18). Studies among Mexican-Americans have shown that place of birth can influence the frequency of risk factors for cardiovascular disease (CVD) (19). However, we found no difference in the USVI in the frequency of metabolic abnormalities by place of birth; nevertheless, among men, place of birth was associated with differences in the level of obesity.

Hyperinsulinemia and visceral adiposity are closely associated with lipid and glucose abnormalities (20). Therefore, ethnic variations in the prevalence of the metabolic syndrome may reflect differences in the degree of insulin resistance or abdominal obesity. In this study we found that for the combined study samples the HOMA-IR score (a measure of the degree of insulin resistance) was a significant positive indicator of an increased risk of having the metabolic syndrome. However, in multiple logistic regression models that included the HOMA-IR score, Hispanic ethnicity remained an independent risk factor for having the metabolic syndrome. Thus, it is unlikely that a greater tendency to be insulin-resistant is the sole reason that being Hispanic is associated with an increased risk of the metabolic syndrome in the USVI. Ethnic differences in the frequency of abdominal obesity were found among men in the study, but odds ratios for the metabolic syndrome associated with ethnicity were not adjusted for waist circumference because the ATP III definition of the metabolic syndrome includes abdominal obesity. In supplemental analyses not presented in this article, Hispanic ethnicity was associated with a significantly increased odds ratio for the clustering of metabolic abnormalities, after adjusting for abdominal obesity. Natal and prenatal factors, such as birthweight or fetal malnutrition, are also thought to play a role in the pathophysiology of the metabolic syndrome (21). The extent to which these and possibly other undiscovered genetic factors might account for the observed higher risk for the metabolic syndrome associated with Hispanic ethnicity in the USVI is unknown.

While Hispanic ethnicity is an important indicator of risk, it appears that being both Hispanic and black confers additional risk. Individuals in the USVI who characterized themselves as Hispanic blacks had the highest prevalence of the metabolic syndrome and the highest HOMA-IR score. The majority of Hispanic persons in the USVI have origins on the island of Puerto Rico, where the gene pool is a trihybrid mix of white European, black African, and Amerindian genes (22). A larger propor-

tion of Amerindian admixture among Hispanic blacks compared to other population groups living in the USVI might have resulted in their higher levels of insulin resistance as well as their greater prevalence of elevated serum triglycerides and of the metabolic syndrome that we found in this study. Native Americans have been shown to be more insulin-resistant than African-Americans and non-Hispanic whites are (23). In the Strong Heart Study (24) the prevalence of the metabolic syndrome among American Indians (35%) was higher than the rates reported for Mexican-Americans, African-Americans, and non-Hispanic whites in the National Health and Nutrition Examination Survey III (NHANES III). Given their greater tendency to be more insulin-resistant and to have the metabolic syndrome, it appears that special emphasis should be placed on CVD risk reduction among the Hispanic black subpopulation in the USVI.

The NIH and the WHO have advocated the use of cutpoints for waist circumference, in addition to those for BMI, to identify those persons with the highest CVD risk. However, it remains uncertain whether the proposed waist circumference cutpoints are associated with an increased risk for metabolic abnormalities independent of BMI across a variety of demographic and ethnic subgroups. In the Baltimore Longitudinal Study of Aging (25) a waist circumference > 94 cm in men and > 80 cm in women was associated with an increased risk of metabolic abnormalities after controlling for BMI in persons under age 65, but not in older individuals. Janssen et al. (5) found that in the NHANES III cohort the cutpoint of 88 cm was associated with additional risk for metabolic abnormalities among overweight and obese women, while among men the 102-cm cutpoint was associated with increased risk of metabolic abnormalities primarily among those who were obese. A study by Arden et al. (26) showed that in a nationally representative sample from the Canada Heart Health Surveys, the NIH waist circumference cutpoints were associated with increased risk of metabolic abnormalities among overweight and obese women but not among men. With respect to women, the results of our USVI study are consistent with the findings of the NHANES III (5) and Canadian (26) studies. In our USVI study the 94-cm cutpoint showed no significant association with metabolic abnormalities among men who were overweight or obese. However, sample size limitations prevented a similar assessment from being performed using the 102-cm cutpoint.

Our USVI study has weaknesses and strengths. The cross-sectional design does not allow for conclusions about causality to be drawn from the study results. The small sample sizes of the four population groups in the study limited the precision of the estimates of prevalence in each group and prevented more detailed stratification and analyses using subgroups. In addition, smoking status, alcohol consumption, and physical activity were determined based on the presence or absence of each variable. Significant relationships of these variables to the metabolic syndrome might have been found if we had used more detailed measures of each variable. The inclusion of a measure of insulin resistance in the logistic regression models is a strong point of this study. Most other studies that have compared rates of the metabolic syndrome among ethnic groups have not controlled for possible ethnic differences in the level of insulin resistance. As far as we know, this is the first study that has reported the frequency of the metabolic syndrome using both race and ethnic groupings among Caribbean-born persons.

In conclusion, our study indicates that in the U.S. Virgin Islands, Hispanic ethnicity is associated with increased risk of the metabolic syndrome. Those who classify themselves as being both black and Hispanic appear to be at highest risk. Using the waist circumference cutpoint of 88 cm among USVI women with BMI > 25 may help to identify those persons who most need lifestyle interventions to reduce CVD risk.

Acknowledgments. This study was supported by a grant (1 RO1 DK46502) from the National Institute of Diabetes and Digestive and Kidney Diseases of the United States. Sincere thanks go to the staff of the Virgin Islands Center for Chronic Disease Research and the St. Croix Hospital Laboratory for their assistance, and to the people of the U.S. Virgin Islands for their participation.

REFERENCES

1. Hansen BC. The metabolic syndrome X. Ann NY Acad Sci. 1999;892:1–24.
2. Bjorntorp P. Abdominal obesity and the metabolic syndrome. Ann Med. 1992;24(6):465–8.
3. United States of America, National Institutes of Health. The practical guide to the identification, evaluation and treatment of overweight and obesity in adults. Bethesda: NIH; 2000.
4. World Health Organization Consultation on Obesity. Obesity: preventing and managing the global epidemic. Geneva: WHO, Division of Noncommunicable Diseases, Programme of Nutrition, Family and Reproductive Health; 1998.
5. Janssen I, Katzmarzyk PT, Ross R. Body mass index, waist circumference, and health risk: evidence in support of current NIH guidelines. Arch Intern Med. 2002;162(18):2074–9.
6. Martorell R, Kettel Khan, Hughes ML, Grummer-Strawn LM. Overweight and obesity in preschool children from developing countries. Int J Obes Relat Metab Disord. 2000; 24(8):959–67.
7. Okosun IS, Forrester TE, Rotimi CN, Osotimehin BO, Muna WF, Cooper RS. Abdominal adiposity in six populations of West African descent: prevalence and population attributable fraction of hypertension. Obes Res. 1999; 7(5):453–62.
8. Tull ES, LaPorte RE, Kriska A, Mark J, Hatcher AT. Glucose intolerance by race and ethnicity in the U.S. Virgin Islands. J Natl Med Assoc. 2002;9(3):135–42.
9. Lohman TG, Roche AF, Martorell R, eds. Anthropometric standardization reference manual. Champaign: Human Kinetics; 1988.
10. Bucolo G, David H. Quantitative determination of serum triglycerides by use of enzymes. Clin Chem. 1973;19(5):476–82.
11. Warnick GR, Albers JJ. A comprehensive evaluation of heparin manganese precipitation procedure for estimating high lipoprotein cholesterol. J Lipid Res. 1978;19(1): 65–76.

12. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia. 1985;28(7):412–9.
13. The Expert Panel. Executive summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). JAMA. 2001;285(19):2486–97.
14. SAS Institute. SAS procedures guide. Version 6. Third edition. Cary: SAS Institute; 1990.
15. Ford ES, Giles WH, Dieta WH. Prevalence of the metabolic syndrome among U.S. adults: findings from the Third National Health and Nutrition Examination Survey. JAMA. 2002; 287(3):356–9.
16. Park YW, Zhu S, Palaniappan I, Heshka S. Carneton MR, Heymsfield SB. The metabolic syndrome: prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey, 1988–1994. Arch Intern Med. 2003;163(4):427–36.
17. Zoratti R, Godsland IF, Chaturvedi N, Crook D, Crook D, Stevenson JC, et al. Relation of plasma lipids to insulin resistance, nonesterified fatty acid levels, and body fat in men from three ethnic groups: relevance to variation in risk of diabetes and coronary disease. Metabolism. 2000;49(2):245–52.
18. Haffner SM, D'Agostino R Jr., Goff D, Howard B, Festa A, Saad MF, et al. LDL size in African Americans, Hispanics and non-Hispanic whites: the Insulin Resistance Atherosclerosis Study. Arterioscler Thromb Vasc Biol. 1999;19(9):2234–40.
19. Sundquist J, Winkleby MA. Cardiovascular risk factors in Mexican American adults: a transcultural analysis of NHANES III, 1988–1994. Am J Public Health. 1999;89(5):723–30.
20. Reaven GM. Banting lecture 1988. Role of insulin resistance in human disease. Diabetes. 1988;37(12):1595–1607.
21. Barker DJ, Hales CN, Fall CH, Osmond C, Phipps K, Clark PM. Type 2 (non-insulin-dependent) diabetes mellitus, hypertension and hyperlipidaemia (syndrome X): relation to reduced fetal growth. Diabetologia. 1993; 36(1):62–7.
22. Hanis CL, Hewett-Emmett D, Bertin TK, Schull WJ. Origins of U.S. Hispanics. Implications for diabetes. Diabetes Care. 1991;14(7): 618–27.
23. Saad MF, Lillioja S, Nyomba BL, Castillo C, Ferraro R, De Gregorio M, et al. Racial differences in the relation between blood pressure and insulin resistance. N Engl J Med. 1991; 324(11):733–9.
24. Resnick HE, Jones K, Ruotolo G, Jain AK, Henderson J, Lu W, et al. Insulin resistance, the metabolic syndrome, and risk of incident cardiovascular disease in nondiabetic American Indians: the Strong Heart Study. Diabetes Care. 2003;26(3):861–7.
25. Iwao S, Iwao N, Muller DC, Elahi D, Shimokata H, Andres R. Does waist circumference add to the predictive power of the body mass index for coronary risk? Obes Res. 2001; 9(11):685–95.
26. Ardern C, Katzmarzyk PT, Janssen I, Ross R. Discrimination of health risk by combined body mass index and waist circumference. Obes Res. 2003;11(1):135–42.

Manuscript received 2 April 2003. Revised version accepted for publication 3 December 2004.

RESUMEN

Síndrome metabólico en personas nacidas en el Caribe con residencia en las Islas Vírgenes estadounidenses

Objetivos. Determinar la frecuencia del síndrome metabólico (SM) en cuatro subpoblaciones de residentes de las Islas Vírgenes estadounidenses y calcular el riesgo de sufrir SM asociado con una circunferencia abdominal superior a determinados puntos de corte en personas con sobrepeso y obesidad.

Métodos. En un estudio realizado entre 1995 y 1999 se obtuvieron las características demográficas, medidas antropométricas, presión arterial y muestras de sangre de miembros de una cohorte poblacional de 893 personas que pertenecían a cuatro subgrupos poblacionales en Saint Croix (la mayor de las Islas Vírgenes estadounidenses) y que nunca habían recibido un diagnóstico de diabetes.

Las cuatro subpoblaciones fueron: 1) hispanos de raza blanca; 2) hispanos de raza negra; 3) personas no hispanas de raza negra nacidas en las Islas Vírgenes estadounidenses y 4) personas no hispanas de raza negra nacidas en otras partes del Caribe. A las muestras de sangre en ayunas se les midieron las concentraciones de glucosa, insulina, triglicéridos y colesterol transportado por lipoproteínas de alta densidad (HDLc). Para identificar el SM se aplicaron las pautas generadas por el Panel III en torno al Tratamiento de Adultos, del Programa Educativo Nacional sobre el Colesterol [*National Cholesterol Education Program Adult Treatment Panel III*]. La resistencia a la insulina se calculó mediante la valoración de un modelo homeostásico (HOMA-IR).

Resultados. La prevalencia general de síndrome metabólico en la muestra fue de 20,5% (intervalo de confianza de 95% [IC95%]: 15,3% a 25,7%). Las personas que se habían clasificado a sí mismas como hispanas y de raza negra tuvieron la frecuencia más alta (27,8% (IC95% = 16,3% a 39,3%)) de SM y los puntajes más altos en el HOMA-IR. Después de hacer ajustes en función de los factores asociados con el estilo de vida y el HOMA-IR, la etnia hispana mostró una asociación independiente con un mayor riesgo de tener SM (razón de posibilidades [RP] = 1,82 (IC95%: 1,07 a 3,07)), triglicéridos séricos elevados (RP = 3,66 (IC95% = 2,18 a 6,15)) y concentraciones séricas bajas de HDLc (RP = 1,60 (IC 95% = 1,04 a 2,45)). Una circunferencia abdominal > 88 cm se asoció con un mayor riesgo de anomalías metabólicas en mujeres con sobrepeso y obesidad.

Conclusiones. La frecuencia de SM en personas nacidas en el Caribe con residencia en las Islas Vírgenes estadounidenses se asemeja a la observada en el territorio continental de los Estados Unidos. Dentro de esa misma categoría de personas, las de origen hispano y raza negra podrían tener un mayor riesgo de sufrir enfermedades cardiovasculares que las pertenecientes a otros grupos.

Palabras clave Síndrome metabólico X, grupos de población continental, factores de riesgo, obesidad, Islas Vírgenes.