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MEASURES OF OBESITY AND METABOLIC SYNDROME IN INDIAN AMERICANS IN NORTHERN CALIFORNIA

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Background: In populations predisposed to cardiovascular disease, type 2 diabetes and visceral obesity, use of additional measurements of waist girth and waist/hip ratio (WHR) can help define risk levels associated with body mass index (BMI) for screening and clinical purposes.

Purpose: To investigate measures of obesity associated with presence of metabolic syndrome and its risk factors in asymptomatic American adults of Asian Indian origin between 29 and 59 years of age.

Methods: Fifty-six apparently healthy men (43.7 years \pm 7.1, BMI 21–34 kg/m²) and women (43.1 years \pm 6.9, BMI 21–36 kg/m²) were recruited for participation in this cross-sectional study. Height, weight, hip girth, waist girth, and blood pressure were recorded by using standard procedures. Blood samples were taken after an overnight fast and analyzed for measures defined by the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) criteria for the metabolic syndrome.

Results: Prevalence of the metabolic syndrome was 33.9% (29–59 years, average BMI 26.1 \pm 3.7 kg/m²). Risk factors most prevalent were low high-density lipoprotein cholesterol (HDL-C) (55%), hypertriglyceridemia (61%), and high blood pressure (50%) in men and low HDL-C (56%), high waist circumference (44%), and high blood pressure (32%) in women. Waist girth of 90.8 \pm 6.8 cm (men) and 75 \pm 3 cm (women), waist/hip ratios (WHRs) of .89 \pm .06 (men) and .76 \pm .03 (women), and BMI values of 24.8 \pm 2.5 kg/m² (men) and 23.7 \pm 1 kg/m² (women) were associated with absence of all risk factors associated with metabolic syndrome. Average waist girth (men: 99.6 \pm 8.1 cm, P < .05; women: 95.5 \pm 5.2 cm, P < .001) of those positive was significantly higher than those negative for the metabolic syndrome. Waist girth in women was significantly associated with fasting glucose (r = .40, P < .05), two-hour glucose (r = .57, P < .05), triglyceride (r = .42, P < .05), and HDL-C (r = -.47, P < .05). Waist/hip ratio (WHR) for women with the metabolic syndrome was significantly higher (.87 \pm .07, P < .05) compared to those without (.79 \pm .05)

and most significantly correlated with two-hour glucose (r = .51, P < .05). Body mass index (BMI) in the overweight range for men (28.3 \pm 3 kg/m², P < .05) and women (30.0 \pm 3.5 kg/m², P < .05) was associated with metabolic syndrome and significantly correlated with low HDL-C levels in men (r = -.49, P < .05).

Conclusion: Prevalence of the metabolic syndrome in Indian Americans aged 29–59 years using the NCEP ATP III criteria was similar to rates reported in urban populations in India. Low HDL-C, hypertriglyceridemia, high waist circumference, and high blood pressure were most prevalent risk factors in this study. Among obesity measures, waist girth was significantly associated with most risk factors for the syndrome; WHR was most significant for two-hour glucose in women, whereas BMI mostly correlated with HDL-C for men. While BMI \leq 24.9 was associated with absence of all risk factors, BMI in overweight range was associated with presence of metabolic syndrome. These results point to clinical significance of using additional measures of obesity in addition to BMI to determine health risk in this population, particularly in premenopausal Asian Indian women. (*Ethn Dis* 2006;16:331–337)

Key Words: Asian Indians, Body Mass Index, Indian Americans, Metabolic Syndrome, Obesity, Waist Circumference, Waist-Hip Ratio

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INTRODUCTION

Impaired glucose tolerance and insulin resistance associated with pronounced central/abdominal obesity are especially prevalent in people of South Asian origins, which places them at high risk for coronary heart disease (CHD) and type 2 diabetes.^{1–4} Asian Indians tend to have higher glucose levels in fasting and in response to oral glucose load, lower fasting plasma high-density lipoprotein cholesterol (HDL-C), and high fasting plasma triglyceride (TG) levels.^{5–9} This clustering of risk factors appears to have its basis in insulin resistance associated with increased propensity towards central/abdominal obesity.^{5,10–11}

The National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III)¹² defined metabolic syndrome as the presence of any three or more of the following five criteria: waist circumference (WC) \geq 102 cm for

Asian Indians tend to have higher glucose levels in fasting and in response to oral glucose load, lower fasting plasma high-density lipoprotein cholesterol (HDL-C), and high fasting plasma triglyceride (TG) levels.^{5–9}

men, ≥ 88 cm for women; fasting glucose (FG) ≥ 110 mg/dL; plasma TG ≥ 150 mg/dL; HDL-C < 40 mg/dL for men, < 50 mg/dL for women; and blood pressure $\geq 130/85$ mm Hg or treatment for hypertension. A major advantage of using these criteria is that the metabolic factors making up this definition are relevant to clustering of risk factors observed in Asian Indians and are routinely measured in clinical practice.

Migrant Asian Indian populations have been increasing in the United States and other western countries,¹³ but relatively little research has been done on the prevalence of chronic disease accompanying this migration. Higher glucose intolerance, insulin resistance, and hypertriglyceridemia have been reported previously for Indian Americans in a few clinical trials,^{1,4,14-16} but currently no community-based estimates for prevalence of the metabolic syndrome exist in this population. Findings from the third US National Health and Nutrition Examination Survey (NHANES III) on prevalence of the metabolic syndrome among US adults¹⁷ noted highest age-adjusted prevalence of metabolic syndrome among Mexican Americans (32%, 2449 participants), followed by Caucasian Americans (23.8%, 3599 participants), African Americans (21.6%, 2412 participants), and people reporting as "other" race or ethnicity (20.3%, 354 participants). As noted earlier,¹⁸ NHANES III data were not representative of Asian Americans. Among the six largest Asian American ethnic groups included in the "other" category were Chinese, Filipino, Asian Indian, Japanese, Korean, and Vietnamese. National data representative of subgroups within the Asian American category are lacking.

Since people of South Asian countries, including Asian Indians, have been reported to possess higher visceral fat percentage and abdominal obesity at lower BMI levels compared to other ethnic groups,^{13,19-20} we conducted a pilot study to examine measures of

WC, waist/hip ratio (WHR), and BMI associated with presence of the metabolic syndrome in Americans of Asian Indian origin by using the criteria adopted by the NCEP ATP III expert panel¹² and investigated the measures of obesity associated with presence of none or more risk factors of the metabolic syndrome. These results provide useful data for defining overweight or obesity in relation to risk factors associated with diagnosis of the metabolic syndrome in this population.

METHODS

Study Participants

The San Diego State University Institutional Review Board approved this study, and all participants provided written informed consent after risks, benefits, and procedures were explained to them in accordance with institutional guidelines. Asian Indian immigrants between the ages of 29-59 years residing in the San Francisco Bay Area were recruited for voluntary participation in this study. Participants were recruited by newspaper advertisement in a weekly West Coast Indian American Newspaper (*India West*) for a period of four weeks and through use of flyers posted at community centers, temples, doctors' offices, and community grocery stores, as well as by word of mouth. Free professional health counseling and no monetary incentive, was offered for participation in the study. Participants were screened for health risks with a health risk-screening questionnaire. Inclusion criteria included those with no self-reported physical limitations and willingness to comply with the study requirements. Exclusion criteria included those with known history of coronary artery disease, liver disease, diabetes mellitus, and endocrine disorders. A total of 70 apparently healthy men and women were available for participation in the study. Following initial enrollment, eight dropped out because of

time constraints, three dropped out for personal reasons, and two were non-compliant with the study protocol. Additionally, one subject was removed from the current analysis because of missing data. Based on available data, no apparent differences were seen between subjects who completed the study and those who dropped out. A total of 56 subjects were included in the present analysis (age range 29-59 years, men $n=31$, women $n=25$). This sample size was sufficient for correlation coefficient power of .80 and significance level of .05 using one-sided test to distinguish an effect size of .33 or higher.

Physical Measurements

Demographic information, personal information, and family health history were obtained through use of interviewer-administered questionnaire. Demographic information included sex, date of birth, place of origin, number of years in the United States, and type of occupation. Health history questions included checklist of personal and family history for medical problems, including alcohol abuse, and specific questions pertaining to smoking, alcohol consumption, and current medications.

All anthropometric and blood chemistry measures were taken in the morning after an overnight fast. Body height was measured to the nearest .1 cm using a stadiometer. Weight was measured to the nearest .1 kg with a calibrated clinical scale. Both measurements were taken with shoes removed. Body mass index (BMI) was calculated as [weight (kg)]/[height (m)]². Waist and hip circumference was measured horizontally three times with the subject standing, feet together, by using a flexible measuring tape without undue pressure. Waist girth was measured at the narrowest circumference between the lower costal margin and the iliac crest. Hip girth was measured at the widest circumference of the buttocks and approximately at the level of the symphysis pubis anteriorly. A

total of three waist and hip measurements were taken to the nearest .1 cm. After five minutes of rest and subjects asked to void, resting blood pressure measurement was taken with a random-zero mercury sphygmomanometer. Three measurements were taken at five-minute intervals with the arm supported and at the heart level, and the mean systolic and diastolic blood pressures were calculated.

Blood Chemistry Measures

Venous blood samples were obtained for estimation of FG, TG, HDL-C, and two-hour post 75-g oral glucose tolerance test by using standard venipuncture techniques. Samples were collected and analyzed by an independent certified clinical laboratory (Quest Diagnostics Inc, Teleboro, NJ). Serum TG was measured enzymatically after hydrolyzing to glycerol (Olympus AU 5400 analyzer, Olympus America Inc., Mellville, NY). Serum HDL-C and glucose concentration were assayed by standard enzymatic techniques using Olympus AU 5400.

Classification for Metabolic Syndrome

The NCEP ATP III criteria¹² were used to identify metabolic syndrome. In addition, measurement of two-hour postprandial glucose was used to diagnose diabetes (two-hour glucose ≥ 200 mg/dL) or impaired glucose tolerance (two-hour glucose 140–199 mg/dL).²¹ Persons were classified as having the metabolic syndrome if they met three or more of the following NCEP ATP III criteria modified to include two-hour oral glucose tolerance test: waist girth >102 cm males, >88 cm females; fasting blood glucose ≥ 110 mg/dL and/or two-hour blood glucose ≥ 140 mg/dL; HDL-C <40 mg/dL males, <50 mg/dL females; TG ≥ 150 mg/dL; and systolic blood pressure ≥ 130 mm Hg and/or diastolic blood pressure ≥ 85 mm Hg or taking anti-hypertensive medications.

Statistical Analyses

All statistical analyses were performed by using SPSS, v11.0 (SPSS Inc, Chicago, Ill) for Windows. Means and standard deviations were calculated for descriptive purposes. All variables for the metabolic syndrome were normally distributed. Pearson correlations were calculated while controlling for age. Correlations involving blood pressure also controlled for use of anti-hypertensive medications and self-reported alcohol abuse. Correlations involving TG and HDL-C were controlled for use of lipid-lowering medication and alcohol abuse, while those involving waist girth were controlled for alcohol abuse. Analyses of covariance (ANCOVA) were then conducted, controlling for age, to determine if significant differences existed for BMI, waist girth, and WHR between normal and subjects with the metabolic syndrome. All statistical analyses were conducted for the whole sample and by sex. All reported *P* values are two-tailed, and the alpha level for statistical significance was set at .05.

RESULTS

Demographic data revealed that participants had been living in the United States an average of 13 years; 72% had emigrated from the Punjab province, 8% from Gujarat, 12% from Maharashtra, and 8% from Kerala. Health history questionnaire indicated that 43% of respondents reported taking medication to treat hypertension, high cholesterol, and/or hypertriglyceridemia, and 39% reported positive family history of diabetes and/or heart disease in a parent or a grandparent. None of the women and 61% of the men reported drinking alcohol. Among men, 16% reported alcohol abuse as a medical problem, the rest of them reported varying levels of consumption of up to three drinks or less per week. None of the women and 10% of the

men reported past history of smoking. One respondent was a current smoker, others reported having quit smoking one or more years before the study.

Study participants were middle aged (>40 years), had nonobese WC (<102 cm for men; <88 cm for women), and had average BMI slightly above normal (26.1 ± 3.7 kg/m²). Forty percent of the men and 28% of the women had metabolic syndrome as defined by NCEP ATP III criteria. Among physiologic variables, the most prevalent risk factor in the combined group was low HDL-C levels (55%). Other common risk factors were hypertriglyceridemia (61%) and high blood pressure (50%) in men and high WC (44%) among women (Table 1).

The waist girth, WHR, and BMI in persons with and without metabolic syndrome according to NCEP ATP III criteria are shown in Table 2. Respondents were identified as being negative for metabolic syndrome if they possessed none, one, or two risk factors. All of the reported measures of obesity were significantly higher in persons having the metabolic syndrome (three or more risk factors) except for the WHRs in men. Average values associated with absence of the syndrome were waist girth: 89.1 ± 7.6 cm (men) vs 79.3 ± 6.9 cm (women), WHR: $.89 \pm .05$ (men) vs $.79 \pm .05$ (women), and BMI: 24.3 ± 2.1 kg/m² (men) vs 25.1 ± 3.8 kg/m² (women). Twenty percent of the sample had no definable risk factor for the metabolic syndrome. Average values associated with no risk factor for metabolic syndrome (Table 2) were waist girth: 90.8 ± 6.8 cm (men) and 75 ± 3 cm (women), WHR: $.89 \pm .06$ (men) and $.76 \pm .03$ (women), BMI: 24.8 ± 2.5 kg/m² (men) and 23.7 ± 1.0 kg/m² (women).

Body mass index (BMI), waist girth, and WHR correlations with risk factors for the metabolic syndrome are shown in Table 3. For the total sample, waist girth significantly correlated with FG ($r=.28$, $P<.05$), TG levels ($r=.36$,

Table 1. Characteristics of study participants [Mean ± SD, unless noted otherwise]

	Total	Men	Women
Subjects, n	56	31	25
Number of years in US	13.6 ± 7.7	14.2 ± 7.3	13 ± 8.1
Age (years)	43.4 ± 6.9	43.7 ± 7.1	43.1 ± 6.9
BMI (kg/m ²)	26.1 ± 3.7	25.9 ± 3.1	26.5 ± 4.3
Waist Circumference (cm)	89.0 ± 10.5	93.2 ± 9.2	83.8 ± 9.8
Systolic BP (mm Hg)	123.4 ± 14.7	125.2 ± 12.9	121.3 ± 16.5
Diastolic BP (mm Hg)	75.1 ± 8.1	76.7 ± 8.8	73.3 ± 6.7
Fasting Glucose (mg/dl)	91.5 ± 12.1	93.9 ± 12.4	88.4 ± 11.1
Two-Hour Glucose (mg/dl)	112.4 ± 46.3	110.6 ± 50.1	114.5 ± 42.0
Triglycerides (mg/dl)	147.1 ± 64.7	168.8 ± 73.7	121.9 ± 41.1
HDL-C (mg/dl)	44.0 ± 11.3	39.4 ± 8.1	49.7 ± 12.2
High fasting or 2-hr glucose* (%)	18	16	20
High waist circumference† (%)	32	23	44
Hypertriglyceridemia‡ (%)	45	61	24
Low HDL-C§ (%)	55	55	56
High Blood Pressure# (%)	42	50	32
Positive for Metabolic Syndrome** (%)	33.9	40	28

* Fasting glucose ≥ 110 mg/dl and/or post OGTT glucose ≥ 140 mg/dl
 † Waist circumference: males > 102 cm, females > 88 cm (NCEP ATP III criteria)
 ‡ Plasma TG ≥ 150 mg/dL
 § Plasma HDL-C: males < 40 mg/dL, females < 50 mg/dL
 # Systolic BP ≥ 130 mm Hg or diastolic BP ≥ 85 mm Hg or taking antihypertensive medications
 ** Meets at least three of the five criteria above (*, †, ‡, §, #)

$P < .05$) and HDL-C ($r = -.51$, $P < .05$). When analyzed by sex, moderately significant correlations were observed for women between waist girth and FG ($r = .40$, $P < .05$), TG levels ($r = .42$, $P < .05$), and HDL-C ($r = -.47$, $P < .05$). In addition, waist girth indicated a strong correlation with two-

hour glucose levels ($r = .57$, $P < .05$) for women. Waist/hip ratio (WHR) showed significant correlations in the total sample for FG ($r = .32$, $P < .05$), TG ($r = .38$, $P < .05$), HDL-C ($r = -.41$, $P < .05$) and diastolic blood pressure ($r = .33$, $P < .05$). When analyzed by sex, only two-hour glucose indicated a strong

Table 2. Obesity measures in normal and metabolic syndrome groups using NCEP ATP III criteria [mean ± SD]

	(-) Metabolic Syndrome (No risk factor)	(-) Metabolic Syndrome (≤ 2 risk factors)	(+) Metabolic Syndrome (≥ 3 risk factors)
Waist girth (cm)			
Total	83.6 ± 9.7	84.2 ± 8.7	98.1 ± 7.3†
Men	90.8 ± 6.8	89.1 ± 7.6	99.6 ± 8.1*
Women	75.0 ± 3.0	79.3 ± 6.9	95.5 ± 5.2†
Waist-to-hip ratio			
Total	0.84 ± 0.08	0.84 ± 0.07	0.90 ± 0.06*
Men	0.89 ± 0.06	0.89 ± 0.05	0.92 ± 0.04
Women	0.76 ± 0.03	0.79 ± 0.05	0.87 ± 0.07*
BMI (kg/m ²)			
Total	24.3 ± 1.9	24.7 ± 3.1	28.9 ± 3.2*
Men	24.8 ± 2.5	24.3 ± 2.1	28.3 ± 3.0*
Women	23.7 ± 1.0	25.1 ± 3.8	30.0 ± 3.5*

* $P < .05$ with (-) Metabolic Syndrome group
 † $P < .001$ with (-) Metabolic Syndrome group

Prevalence of the metabolic syndrome in our study was 33.9% at age 29–59 years and increased to 42% for those age 40–59 years.

correlation ($r = .51$, $P < .05$) with WHR in women. Body mass index (BMI) was negatively correlated with HDL-C for both men and women, although correlations were significantly higher for men ($r = -.49$, $P < .05$).

DISCUSSION

Prevalence of the metabolic syndrome in our study was 33.9% at age 29–59 years and increased to 42% for those age 40–59 years. These findings are similar to those of Gupta et al,²² who reported prevalence of 33.2% (30–59 years) and 40.3% (40–59 years) in a study conducted in urban India on 1091 adults by using NCEP ATP III criteria for defining the metabolic syndrome. The age-adjusted prevalence of 24.9% in the total sample (>20 years) reported by them was higher than the 20.8% age-adjusted prevalence reported in NHANES III for participants (>20 years of age) classified in the “other” race/ethnicity category. These findings suggest prevalence of the metabolic syndrome in Indian Americans may be higher than those interpreted from the NHANES III data for Asian Americans. Metabolic syndrome was more common in men (40%) compared to women (28%) in our study (Table 1). Since the average age of women in our sample was 43.1 ± 6.9 years (Table 1), 88% of whom were below age 50, lower prevalence in women compared to men was likely due to protection afforded by premenopausal status.²³

For risk factors associated with the syndrome, prevalence of high TG

Table 3. Obesity correlations with physiological indicators of the metabolic syndrome (r)

	Fasting Glucose†	2-hour Glucose†	TG‡	HDL-C‡	SBP§	DBP§
Waist Girth						
Total	0.28*	0.08	0.36*	-0.51*	0.07	0.15
Men	0.06	-0.20	0.16	-0.28	0.01	0.04
Women	0.40*	0.57*	0.42*	-0.47*	0.06	0.06
Waist-to-Hip Ratio						
Total	0.32*	0.20	0.38*	-0.41*	0.12	0.33*
Men	0.19	-0.01	0.08	-0.04	0.24	0.25
Women	0.27	0.51*	0.34	-0.23	0.01	0.33
BMI						
Total	0.02	-0.04	0.06	-0.27	0.06	0.02
Men	-0.06	-0.10	0.12	-0.49*	0.07	0.13
Women	0.24	0.25	0.29	-0.37	-0.03	-0.06

* $p < 0.05$

† Adjusted for age

‡ Adjusted for age, use of cholesterol medication and alcohol abuse

§ Adjusted for age and use of blood pressure medication

(45%), high FG (18%), high BP (42%), high WC (32%), and low HDL-C (55%) in the total sample in our study was similar to those reported by Ramachandran et al²⁴ for the elevated TG (45.6%) and WC (30%), and Gupta et al²² for high FG (16.7%) and BP (41.6%). Three of the most prevalent risk factors in our study were high TG (61%), low HDL-C (55%), and high BP (50%) in men, and low HDL-C (56%), high WC (44%), and high BP (32%) in women. Similar prevalence of high blood pressure has been noted in India by others,^{22,24} when NCEP ATP III criteria were used to define this measure ($\geq 130/85$ mm Hg or antihypertensive medication). Low HDL-C levels have been reported in Asian Indians of both sexes.^{13,24} Gupta et al²² reported similar age-specific (30–59 years) sex-based pattern of metabolic abnormalities, although prevalence of low HDL-C (90.1%) for women in their study was disproportionately high. Hypertriglyceridemia has been previously observed in migrant South Asians^{25–27} and appears to be related inversely to leisure time physical activity levels²⁷ and proportionately to change in socioeconomic status.^{28–31} Hypertriglyceridemia is also related to alcohol consumption, which

increases among Indian Americans in proportion to length of residency in the United States.³² As noted earlier, 61% of men in our study reported consuming alcohol on a regular basis, while 16% reported alcohol abuse as a medical problem.

Genetic predisposition for low HDL-C and high TG dyslipidemia has been noted for Asian Indians.^{33–38} In addition, dyslipidemia has been attributed to changes in lifestyle associated with migration.^{39–41} Higher than average HDL-C levels have been reported in rural compared to the urban and migrant Asian Indian populations.³⁰ Lower levels of leisure time activity have been associated with greater prevalence of low HDL-C and hypertriglyceridemia in Indian Americans.²⁷ Moderate levels of physical activity averaging 18–20 min per week was associated with lower serum triglyceride levels in Indian American men.²⁷ These results suggest that dyslipidemia in Indian Americans was related to increasingly sedentary lifestyle associated with migration.

Body mass index (BMI) provides an estimate of generalized obesity. Average BMI of those with metabolic syndrome (28.9 kg/m^2) was significantly higher than BMI of those without the syn-

drome (24.7 , $P < .001$, Table 2) and showed a strong negative correlation with HDL-C for men ($r = -.49$, $P < .05$, Table 3). Body mass index (BMI) representing healthy weight range for general US population^{42,43} (< 24.9) was associated with absence of all risk factors for the metabolic syndrome, and a value of 28.3 kg/m^2 was associated with three or more risk factors (Table 2). Body mass index (BMI) of 28.3 kg/m^2 is considered overweight, but not obese by traditional obesity criteria for the general US population.^{42,43} These findings are consistent with those of studies reporting clustering of risk factors, insulin resistance, coronary heart disease, and diabetes at BMI in the upper normal or slightly above normal range for Asian Indians living in the United Kingdom,⁵ the United States,^{1,4,14–16} and India.^{8,19}

South Asians and migrant Asian Indians have been reported to possess higher percentage of body fat (and lower lean body mass) compared to Caucasians and African Americans^{13–14,44–45}; as a result, lower WC criteria than those employed by the NCEP ATP III panel for defining metabolic syndrome have been suggested for this population.^{13,24} In the present study, measures of waist girth associated with absence of all risk factors for the metabolic syndrome (men: 90.8 ± 6.8 cm; women: 75 ± 3 cm, Table 2) and of those negative (two or fewer risk factors) for the syndrome (men: 89.1 ± 7.6 cm; women: 79.3 ± 6.9 cm, Table 2) were under cutoff points suggested by Ramachandran et al²⁴ (≥ 90 cm for men and ≥ 85 cm for women). Average WC of those positive for the syndrome was higher (men: 99.6 ± 8.1 cm, $P < .05$; women: 95.5 ± 5.2 cm, $P < .001$, Table 2), with specific values closer to (102 cm for men) or higher than (88 cm for women) the NCEP ATP III waist criteria. These results indicate that NCEP waist girth criteria were useful measures of the clustering of risk factors to diagnose metabolic syndrome (more than three

risk factors) but that optimal levels of WC for primary prevention were much lower (two or fewer risk factors).

High waist circumference (>88 cm, NCEP criteria) was a prominent risk factor for women in this study (40%, Table 1), suggesting that premenopausal abdominal obesity may have a role in the development of metabolic syndrome.²³ Waist girth significantly correlated with all risk factors for the metabolic syndrome in women except blood pressure (Table 3). Average WHRs were in the obese range (>.80)⁴³ for women with metabolic syndrome (.87±.07, Table 2) and significantly correlated with two-hour glucose ($r=.51$, $P<.05$, Table 3). In a previous study, higher percentage of body fat and thicker truncal skinfolds were significant determinants of dyslipidemia observed in premenopausal migrant Asian Indian women.⁴⁴

Average WHRs associated with absence of all of the risk factors for the metabolic syndrome (men: .89±.06; women: .76±.03, Table 2) were below cutoff values used to define abdominal obesity in US men (>.95) and women (>.80).⁴³ Average WHRs of men with metabolic syndrome (.92±.04) were also under cutoff value for defining abdominal obesity but were not significantly different from those negative for the syndrome (.89±.05, Table 2). Among obesity measures, only WHR correlated with blood pressure ($r=.33$, $P<.05$, Table 3), whereas WC rather than WHR was a better indicator of other risk factors defining the metabolic syndrome.

This study has some limitations. First, the overall sample size was small and may not be representative of the overall Asian Indian immigrant population. Second, although no baseline differences were seen between participants and dropouts, bias may have been introduced because of possible differences between persons who did or didn't respond to the study advertisement.

This study also has strengths that contribute to our understanding of the

prevalence of metabolic syndrome in apparently healthy Indian Americans and illustrate potentially meaningful observations in the debate surrounding measures of obesity associated with risk of chronic disease in Indian Americans.

Studies conducted in India have shown that migration, urbanization, and affluence have led to increase in sedentary lifestyle particularly for women, in addition to "westernization" of the traditional Indian diet.⁴⁶ Sedentary Indians had higher average values of BMI, serum TG levels, and blood pressure.¹³ Therefore, period of residency in the adopted country, degree of acculturation, psychosocial stress level associated with migration, changes in dietary intake, and physical activity level can be determinants of risk for chronic disease in Indian Americans that need further investigation. Results of our study provide useful data for generating hypothesis-driven, large-scale investigations on the prevalence of metabolic syndrome in Indian American and other minority groups in the United States.

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